

# Dortmund International Research Conference 2018



## CONFERENCE PROCEEDINGS – 29-30 JUNE 2018

- IT & Engineering Projects
- ICT, Embedded Systems, Automotive Software
- Project-oriented Business
- Project Management and Education
- Quality Management and Sustainable Project Management

## **International Research Conference in Dortmund 2018**

The International Research Conference (IRC) at the Dortmund University of Applied Sciences and Arts took place on June 29<sup>th</sup> -June 30<sup>th</sup> 2018 for the eighth time.

All information about the conference can be found on <https://irc.go-study-europe.de>

The conference was initiated by the community of the European Master in Project Management – EuroMPM. It is our main tool for giving our master students, our PhD students and our partners from Bilbao, Leuven, Kaunas, Trondheim, Kiev, Ternopil, Zaporoshje, Astana, Almaty, the Netherlands, Pakistan, Palestine, and many more countries a forum for meeting, presenting new results and thoughts, and discussing future research and cooperation. The conference was supported by the DAAD Strategic Partnership “European Partnership for Project and Innovation Management (EuroPIM)” which we set up based on the EuroMPM with our partners in Bilbao, Kaunas, Leuven and Trondheim. Furthermore, the Ruhr Master School (<https://www.ruhrmasterschool.de>, established by the Universities of Applied Sciences in Dortmund, Bochum and Gelsenkirchen and funded by Stiftung Mercator) supported the conference. The conference has become the central event of our partnership and an attractive meeting point in the middle of the academic year.

The scope of the conference covered a wide range of topics. This goes beyond project management and covers the digital transformation, emerging technologies, the handling of competences and knowledge, the trends in higher education and insights into a sustainable project management taking the environment into account. The special quality of the research is the transdisciplinary and applied character. Many contributions show results from cooperation with industry and society.

This conference has its own spirit and power since it was founded by our honored and very much missed teacher and friend Prof. Dr. Dr. h.c. mult. Peter A. Reusch in 2010.

A special thank you goes to the organizing team, headed by Clara Decelis Grewe, with the EuroPIM team, the student support team, the doctoral group facilitated by Ala Nuseibah, and all the active and supportive members of the team & IRC family.

For the second time, the conference was followed by summer school in Dortmund, starting on July 2<sup>nd</sup> and ending at July 6<sup>th</sup>. The summer school was taking some of the topics of the conference and developed them further into new results and new teaching modules. The summer school was organized into the following 7 streams:

- Sustainability and Quality management in Project Management (Jose Ramon Otegi)
- Usability Engineering (Rimante Hopeniene, Christian Reimann)
- Data Analytics Hackathon with IBM Watson (Thorsten Ruben)
- Automotive Software Engineering (Robert Höttger, Carsten Wolff)
- Digital Marketing (Elena Vitkauskaite, Wojciech Czart)
- International PhD Summer School (Beverly Pasain, Ala Nuseibah)
- General Project Management (Ruta Ciutiene, Asta Daunoriene)

In 2018 the conference had 8 sessions, covered on two days:

Friday, June 29<sup>th</sup>:

#### Session on Project Management (André Dechange)

- Antifragile Open Ecosystem for Innovation in the Society of Knowledge, Enara Mardaras Andrés, Sebastian Duarte Alcántara and José Ramón Otegi Olaso
- The role of soft factors in the implementation of maintenance regimes, Bertha Ngereja and Bassam Hussein
- Projects – engine for corporate development, Werner Wetekamp
- Supply Chain Planning: Approach for Automatic Selection of Coordination Mechanism Based on Changing Relations, David Grimm, Hirsch Martin and Sebastian Bab
- Role of sustainability in achieving project success, Rao Aamir Ali Khan and Muhammad Farhan Malik
- Project alignment with growth strategy, Chinelo Chioma Ntagu

#### Session on Education & Partner Universities (Carsten Wolff)

- LEANABILITY: is Lean Thinking applicable to all types of projects? Including IT ones?, José Ramón Otegi Olaso
- The use of information and communication technologies in education, Nurzhan Duzbayev, Gulnara Zakirova, Yevgeniya Daineko, Madina Ipalakova, Zhiger Bolatov and Gulnara Zakirova
- The Role of ICT in preparing students to work on projects in the virtual workplace, Joshua Olusegun Fayomi and Kestutis Duoba
- What is rhrvalley and if yes, how many?, Jessica Leinen

#### Session on Technology & Projects (José Ramón Otegi Olaso)

- Taxonomy for Smart Cities in the Context of Project Management, Beverly Pasion
- Investigating challenges in the communication for interconnecting test-laboratories through the IoT, Noura Sleibi and Philipp Tendyra
- Human pose matching, Timothy Callemeyn, Luc Geurts, Toon Goedemé, Gil Beckers and Jochen Wilms
- Adaptive learning in virtual reality: current state and new approach, Andreas Wojtok, Martin Hirsch and Sebastian Bab
- Over-the-Air Update Compliant Device Management Approaches for Automotive Systems, Philipp Tendyra

#### Poster Session & Exhibition

- Sustainability Knowledge Model for Project Management – Theoretical Framework, Leticia Fuentes Ardeo and José Ramón Otegi Olaso
- Agent Based use case for an intelligent medical image processing system, Hanane Alloui, Mohamed Sadgal and Aziz El Faziki
- Requirements for a software development process for 2D and 3D models in construction, Vladislav Kontsevyi and Oleksandr Voitenko

- Project management under the influence of psychological phenomena and empirical laws, Olha Kukhta and Iryna Turchenko

Session on Knowledge Management & IT, Part 1 (Galyna Tabunshchuk)

- Digital Transformation Enabler Framework, Olha Mikhieieva
- The value of knowledge management in start-ups in the age of digital transformation, Elena Schneider, Jorina Erdmann, Nargiza Mikhridinova and Ala Nuseibah
- Contribution of knowledge management to innovation projects, Gul Bano, Luis Carlos Montenegro Lugo, Misagh Rostami, Jiwandono Agung Sari Putro and Ala Nuseibah
- Knowledge management in distributed agile projects, Suhail Barakeh, Katia Agurto, Maria Mantilla and Ala Nuseibah
- Key Success Factors in IT Project Management, Anastasiia Berezhna and Carsten Wolff

Saturday, June 30<sup>th</sup>:

Session on People and Project Management (Anatoliy Sachenko)

- Immune mechanisms of projects management in the context of the "behavior economy", Sergey Bushuyev, Denis Bushuiev and Natalia Bushuyeva
- Managing stakeholders in the project implementation process in the context of an integrated understanding of project processes, Olena Verenysh
- Behavior models of project manager, Svitlana Kevorkova
- A review of people perspective on project management, Nargiza Mikhridinova
- Research and projects at Al-Quds University, Research and projects at Al-Quds University, Rashid Jayousi

Session on Technology: IDiAL & friends (Christian Reimann)

- Trends in Modeling and Simulation of Sensors, Igor Khimchenko and Peter Schulz
- Comparison of the product structure of the conventional and digitalised car, Dennis Meyer, Jan Krakau and Daniel Fruhner
- Managing the multidisciplinary engineering projects in digital transformation era, Galyna Tabunshchuk and Peter Arras
- Impacts on automotive supply chain due to fuel cell electric vehicles, Lennart Scholz and Konrad Pawlikowski
- Quality Management and Standards Compliance for Agile Development of Automotive Software, Syeda Komal Anjum

Session on Knowledge Management, Part 2 (Sergey Bushuyev)

- Increasing absorptive capacity in project management: process improvement through the application of lean management, Marzhan Amanzholova, Katalin Szász, Natalia Gurina and Ala Nuseibah
- Knowledge management concerning the factors of project success, Ekaterina Mikhaylova, Frank Windham, Iuliia Shkalikova, Miguel Pavez and Ala Nuseibah
- Implementation of Agriculture Information Management (AIM) in Palestine, Mohammad Qabha, Amer Kanan, Ala Nuseibah and Christian Reimann

- Assessing Project Management Maturity and its relation with project success: a case study in a German Automotive Company, Sarosh Khan

Session on Competence & Organization (chair: Ruta Ciutiene)

- Aspects from education & research in Palestine: Birzeit University, Iyad Tumar
- Knowledge management as a basis of organization competence, Oleksandr Voitenko
- Model of organizational development based on the three components of success, Maryna Kutsenko and Olena Verenych
- Managing a project of real-time face recognition system development using the agile methodology, Maksym Kovalchuk, Carsten Wolff and Anatoliy Sachenko
- Method of spatial displaying the graphic information, Andrii Kanyovskyi, Kochan Volodymyr and Anatoliy Sachenko

We say thank you to all authors for the contributions to the International Research Conference in Dortmund 2018. The contributions are important – as well as the discussions – for the evolution of the community and the growing power to meet the requirements of the future.

Greetings from the flow of strong projects

Clara Decelis Grewe, Christian Reimann, Thorsten Ruben, Carsten Wolff

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# ANTIFRAGILE OPEN ECOSYSTEM FOR INNOVATION IN THE SOCIETY OF KNOWLEDGE

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**Abstract:** *R & D project management, complex and "high technology", is always working under pressure due to programming, cost control, risk management and the management of team members. Within this unstable environment, the decision processes are in situations of uncertainty, poorly structured, with little or excessive information, or even erroneous at some point. Knowledge Management (KM), Intuition and Improvisation are tools that will help innovative teams to become antifragile. . This project aims to analyze and study the relationship between KM and Intuition and Improvisation. With this purpose, a Q methodology based exercise is planned. Its results will provide insight on the application and fostering of improvisation and intuition techniques by Open Ecosystems Antifragile Innovation teams.*

**Keywords:** Innovation teams, antifragility, knowledge management, creativity.

## 1. Introduction

In anti-fragile open ecosystems for innovation (AOEI) organizations develop in environments of stress and uncertainty and must be agile in their organizational approaches and in decision-making. Agile organizations that support innovation and learning capacity to, in a feedback process, encourage and increase the knowledge and innovative capacity of both the people who compose them and the organization itself. Innovation teams [1] are part of these categories of organizations.

The innovation teams, formed by knowledge workers and working in environments of creativity, improvisation and learning, are antifragile [2, 3]: the stress of their work environment forces them to adapt and improve, to create knowledge that can be used later in the next situation. And innovative organizations, knowledge organizations, are adaptive, and knowledge management (KM) systems must support them.

The Antifragile innovation teams (AIT) have as main features:

- ✓ Innovation as a main activity,
- ✓ Management of diversity, fundamentally gender diversity,
- ✓ Equipment of self-management as the main behavior of the team,
- ✓ Free knowledge as a source of knowledge of the team,
- ✓ Project-based management as the main technique for project management
- ✓ A transdisciplinary culture [4]

A review of the literature on the environments that work with the innovative anti-fragile teams of intuition and improvisation has been carried out. In general management is broad, while the literature examined on the relationship between intuition and improvisation in the areas of project management and innovation and research teams is not extensive [5, 6]. Therefore, this article will address the management concepts of innovation teams that operate in stressful environments and turbulent surroundings, where intuition and improvisation are an inherent part of decision making and practices applied to resolution. of problems and conflicts. Among these practices, a very

important specific weight belongs to those related to knowledge management. For example, ICT and its application revolutionize the concepts of acquisition, transformation, generation, distribution and storage of knowledge. The teams use this knowledge to generate responses to the situations posed, while returning the new knowledge of the organization that can be used in the future, in an iterative cycle that supports and encourages creativity and innovation.

## **2. Knowledge Management, intuition/improvisation and antifragile innovation teams. Literature Review.**

### *Knowledge Management*

Knowledge management is defined as the full range of strategies and tactics designed to capture, manage, and gain advantage of the organization's intellectual capital and knowledge [7].

Knowledge that academic literature divides into explicit and tacit. The first is easily codifiable, easy to express verbally and in writing, and therefore easy to publish. On the other hand, the second, intrinsic to the individual, is more difficult to codify, to articulate and to transmit. As tacit knowledge, we distinguish technical understanding: personal competences, know-how or know-how; and cognitive understanding: ideals, values, beliefs and mental models, as well as insight, hunches, etc.

The goal of any organization is to externalize and share both types of knowledge and learn from it to in turn generate more knowledge. Therefore, the ability to learn in the organization, and the transformation of explicit knowledge into tacit becomes strategic objective, since this is what creates intellectual capital and adds competitive value to the organization [7].

*Does all the knowledge that the organization can process through knowledge management techniques is effectively transformed into assets for the ability to innovate?*

In lifecycle models of KM, the knowledge that is shared or transferred is supposed to be ready to be used to reach new innovative levels. One way to achieve this goal, and therefore try to resolve this doubt, is to enhance the learning capacity: organizations must "absorb" the knowledge to implement it effectively [8].

It is evident that for organizations and / or teams dedicated to innovation, because of their nature and objectives, the learning capacity and the transformation of this learning into practical knowledge becomes an intrinsic objective. The concept of learning, from a strategic perspective, becomes a source of possible competitive advantage.

The learning capacity of the organization and KM are therefore complementary, although the relationship between the two has not been studied so far. It can be considered that the learning in the organization focuses on the process and KM in the content of knowledge that an organization acquires, creates, processes and eventually uses as a potential to learn. Therefore, we can affirm that a KM system with added mechanisms that favor learning will have a positive and synergistic effect on the capacity for innovation [8] and on the achievement of objectives.

The culture of the organization must foster trust [7, 9] and credibility, and KM practices must be supported and intertwined with an ethical dimension [7] that provides the culture of the organization so that the members of the teams can feel involved and involved. The need for empathy and concern for others is essential to share knowledge. In several previous studies, it has been found that cooperative behaviors arise when trust exists [7].

### Intuition/ Improvisation

Improvisation and intuition are two aspects related to management in general. And they help us to better understand the previously used "antifragile" concept.

When a work team is subjected to stress, it resists, but based on these two concepts of intuition and improvisation, it also grows and improves. Therefore, knowledge management has to contemplate all aspects, such as explicit and tacit knowledge, rational thinking, intuition, improvisation and innovation.

In recent years the need to increase the capacity for innovation and competitiveness has developed the use of improvisation. Organizations are creating time, space and the opportunity for people to use improvisational work practices to develop new ways of performing tasks. This poses challenges for the control and supervision of the work, and creates opportunities for learning within each organization, and the creation of knowledge (through mechanisms such as those suggested by Nonaka et al, achieving that tacit knowledge can be made explicit) [6].

Intuition can be defined as a creative knowledge management tool. It is the opposite action to cognitive thinking. Without the need of reasoning, an adequate decision-making based on intuition can be made. It moves away from the rational system of managing and planning, therefore, it is a process of certain (high) innovative level. But, the need to intuit obliges unconsciously to manage internal knowledge and with the help of creativity, perform an improvisation (bricolage).

Table 1. Compares the use of more cognitive thinking with the use of intuition.

<i>Differences</i>	<i>Rational Thinking/Cognitive</i>	<i>Intuition</i>
Management	High	Low
Planning	High	Low
Work in team	Low	High
Explicit knowledge	Low/medium	High
Tacit knowledge	Low	High
Decision-making	Self sufficient	In group
Improvisation	Low	High
Creativity	Low	High
Innovation	Low	High

**Table 1. Differences between rational thinking vs. Intuition (Source: Prepared by the author)**

This Intuition increases the level of internal knowledge and experience. At the same time, the level of intuition unconsciously increases. The intuition of a work team has a higher capacity level than the individual. Individually the members of the work team have explicit and tacit knowledge; in a group, knowledge passes to be explicit. The definition capacity rises, due to this internal knowledge elaborated in equipment, greater range of bricolage and the intuition is more adapted using the result like objective. The use of intuition has increased in recent years due to the turbulent environment that society finds itself in, the current crisis and the need to compete to be leaders and not become obsolete and innovate.

Individual intuition, nowadays, is being studied by neuroscience. Instead, intuition in team or group is not very studied, and the effectiveness of that intuition in the result.

### Antifragile innovation teams

In order to define the anti-fragile innovation teams, building on the theory of innovation teams of Ayestarán y Gómez [1], the general hypothesis is that innovation teams are teams open to the organizational environment and favor the improvement of the intellectual capital of that environment. In addition, they favor the creation of a more participatory culture, implying a more shared leadership. In their internal functioning, they apply the principle of continuous reflection, the technique of creativity and innovation [1]. Teams of innovation nuclear components of the AEI, interacting among its members, with other equipment and also with the outside will undoubtedly acquire the behavior of the complex system that it is.

Using the definition of antifragility, an anti-fragile team will be able to improve during and after stress situations. Therefore, it will be primarily a learning team [10]. With a transdisciplinary approach, capable of integrating knowledge to deal with complex problems, in an exercise of generosity given that in many cases not all the actors that participate can expect useful results for themselves or for their disciplinary area [4].

Likewise, it will be a team with the capacity to manage diversity [1]. Diversity in all senses, including of course diversity of gender, opinions, race, age and experiences, etc ... Individual knowledge is obviously limited. The resolution of the problems described within the changing environments requires collective participation and learning, which in the words of Xiang [11] allows "to celebrate diversity in opinions and perspectives, and [to be] a defender of transdisciplinarity."

A third essential element, widely collected in the literature that deals with management issues in general [1,12], is the involvement of the directions, from the top management to the rest of executives. Essential rule in any process of change management, is the assumption of the direction of the basic leadership functions so that the new approaches reach a successful situation.

The fourth basic point is, equally inherent to anti-fragility, the concept "open": open innovation, open knowledge, freedom of communication, exchange of ideas, etc ...

### **3. Theory of the work**

#### Conceptual Framework: Relationship between Intuition / Improvisation and Management of Knowledge

Complex projects pass by contrast to traditional projects: the latter are characterized by being almost completely specified, and it is possible to address them in advance in learning concepts. In contrast, complexes cannot be fully specified and throughout their life cycle they require a continuous learning process [13].

Teams that work with complex projects, and in a turbulent environment, can only achieve the objectives set if they understand that individual and team learning is intrinsic to the achievement of those objectives. The management and management of knowledge, even with the uncertainty of what kind of knowledge to use, is a central aspect of the development capacity of the organization, of the team. The main implication of these concepts is the need to continually generate knowledge throughout the life cycle of the project, knowledge that cannot be specified at the beginning [13].

One of the effective ways of generating knowledge occurs when teams use their intuitions, improvise and "do DIY" with the knowledge and tools at their disposal, and finally develop new knowledge where the existing one does not meet objectives [6]. The teams thus become anti-

fragile Innovation Teams, which take advantage of the stress generated by the project to learn and emerge reinforced from the situation.

In Figure 1 we can analyze the KM life cycle. This learning process was already defined [8] by King et al. in 2002.

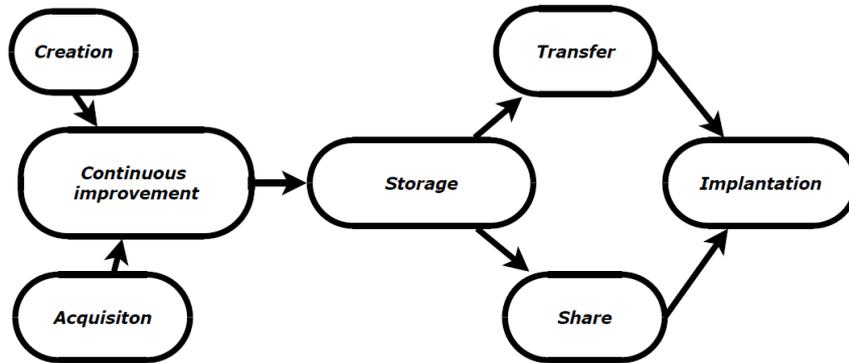


Fig. 1: KM Conceptual model (Source: King et al., 2002).

The initial conceptual model has recently been refined by Gonsel et al. [8] in 2011, Figure 2, where it already incorporates the vision of learning in the process, and defines for the first time, because of this process, the final concept of innovative organization.

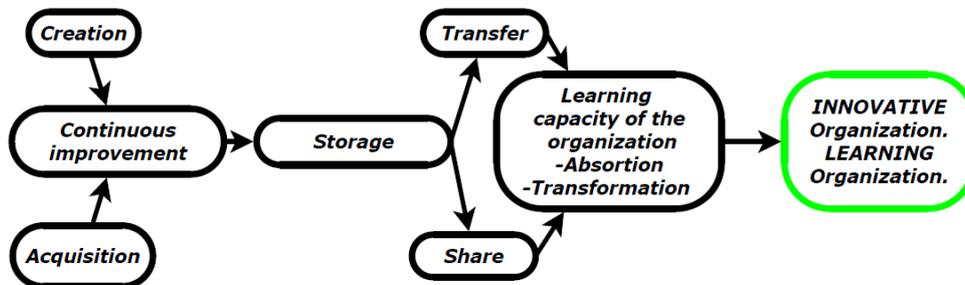


Fig. 2: Improved KM conceptual model (Source: Gonsel et al., 2011)

Finally, taking into account the concepts developed so far, and that the innovation teams that handle complex projects must be anti-fragile, the updated life cycle that relates intuition / improvisation with knowledge management and antifragility is proposed (Figure 3) . The engine of innovation of any open ecosystem of antifragile innovation are the antifragile innovation teams, the objective of them being to learn to generate and improve knowledge.

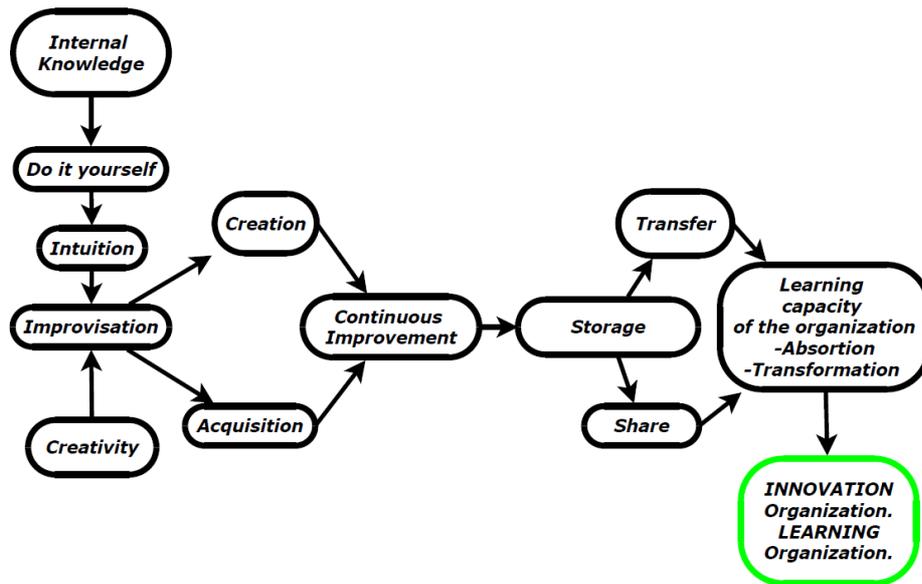


Fig. 3: KM Anti-fragile conceptual model (Source: Prepared by the author)

The final proposal of this article is to demonstrate that an adequate management of knowledge facilitates improvisation and intuition in antifragile innovation teams.

#### 4. Design of field Research. Q-Methodology study.

The study considers real data in our innovation infrastructure, for example, if an adequate knowledge management facilitates the improvisation and intuition of the anti-fragility innovation teams. Without statistical data, official parameters, etc.

In addition, we can see that the study hypothesis, all of them, are subjective: there are no "physical units of measure" that allow us, for example, to control how much improvisation and intuition facilitates.

Therefore, it has been decided to use Q-M as a recognized tool for the study of subjectivity. In the following points, we describe what Q-M is and how this field study will be implemented.

##### What is Q-M?:

"Q methodology provides a foundation for the systematic study of subjectivity, a person's viewpoint, opinion, beliefs, attitude, and the like (Brown 1993). Typically, in a Q methodological study people are presented with a sample of statements about some topic, called the Q-set. Respondents, called the P-set, are asked to rank-order the statements from their individual point of view, according to some preference, judgement or feeling about them, mostly using a quasi-normal distribution"[14].

Study deployment consist in interview, fooling Q-M techniques, certain number of people that are working in different R&D centers, and obtain their opinion about hypothesis situation and their possible evolution on next years.

Performing a Q methodological study involves the following steps:

- (1) definition of the concourse;
- (2) development of the Q sample;
- (3) selection of the P set;
- (4) Q sorting
- (5) analysis and interpretation[14].

Result of steps 1 and 2 is Q-Set definition. Between 40 to 50 statements is drawn to be presented of participants.

Q-M study requires only a limited number of respondents[14]. Thus, P-set is what have been defined as OBI (good informed opinion, from its initials in spanish: opinión bien informada). There are different people selected, which are carry out their professional activities into innovation and research centres, or in private companies development departments.

Q-set is given to each P-set respondent. This is instructed to sort them following Q-M general rules and always under researcher help in interviews that enable him (to the researcher) to understand the results better. Other Q-sorts methods, like mail or computer based, only may be desirable if sample has a wider geographical distribution.

Finally, the analysis of the Q sorts is a purely technical, objective procedure. Nowadays many software packages are available to perform the analysis. For this research, we will use Q-sortware[15] for collect the Q-sort results, and for analysing an application called “qmethod”[16][17].

## 5. Conclusion

The conclusions are based on the results of the surveys. There are in process.

However, it can be affirmed that, from the theoretical point of view, the teams that manage and develop complex projects, in this exponentially changing social environment; where apparently stable knowledge evolve and change in a dizzying way, must evolve towards anti-fragile states. Its ability to adapt, learn and generate knowledge useful and adapted to each situation, is already a critical element and it seems that it will remain so.

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# THE ROLE OF SOFT FACTORS IN THE IMPLEMENTATION OF MAINTENANCE REGIMES

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**Abstract:** *Over the past three decades, there has been a significant increase in the interest of human aspects and their influence on organizational performance. The proper knowledge and implementation of soft factors can act as a distinguishing feature between normal functioning and best-in-class maintenance regimes. Due to the complexity of soft factors, extant literature has shown a tendency to focus more on hard than soft factors in determining performance facilitating factors. This paper adopted the use of semi-structured interviews to identify soft factors and its underlying influence on maintenance operations with the aim of uncovering if national contexts such as culture and level of national development can determine which soft factors are perceived to be more important than others. This study identified the important soft factors influencing maintenance regime to be; (1) top management commitment, (2) training, coaching and mentoring (3) education and career growth, (4) communication, (5) inter-departmental relationship, (6) employee involvement, (7) safety and security, (8) motivational programs, and (9) ergonomics. These findings can be used to assist the decision makers to understand which factors should be incorporated in their operations to facilitate higher performance in the implementation of daily maintenance operations. Apart from identifying the soft factors, this study also revealed that the national context has less influence on determining or perceiving soft factors compared to the nature of the industry and operations performed by an organization.*

**Keywords:** soft factors, human factors, organizational performance, maintenance operations

## 1. Introduction

In project management literature, various studies have examined and identified critical success factors (CSFs) in projects [1]. One category of these studies has examined the importance of structural success factors such as project planning, project organization, risk assessment, and client involvement [2], [3], [4], [5]. Another category of success factors in projects that was reported in project management literature focused on softer values such as culture [6], competencies [7], [8] and factors related to development of human resources [9], [10]. Although measuring project success includes both successful project completion and benefits acquired from the long-term objectives of the project, most literature on project management focused on the project management phase and not on the long-term benefits after project completion [5]. This study focuses on the daily maintenance operations conducted to ensure the project is beneficial. Maintenance operations are necessary to ensure continuation of operations but are also the most at-risk areas to be affected by human reliability [11]. This was supported by Antonovsky [12] who found that maintenance failure is associated with both technical and non-technical factors. Technological advancement has reduced the human dependence to a certain extent but has not completely substituted it. Humans are assets that ensure the safe functioning of any technological system. A reliable operator is one whose intrinsic and extrinsic factors such as personal, task/job, physical design of equipment, workplace and organizational factors have been considered in the design of the workplace and in the implementation of the task at hand [13]. The human aspects highlighted in this study are based on soft factors which are identified as “*the behavioral aspects of management or the human aspect such as leadership and people management*” [14]. There has

been a shift of focus in organizations from considering only the technical and design issues to including the human oriented aspects such as leadership, alertness, communication skills, and employee motivation. This has provided an understanding that organizations have discerned the relevance of human reliability and are now incorporating them in operations.

## **2. Problem description and justification of the study**

Although Sheikhalishani [11] uncovered that the most pressing issues influencing maintenance operations were non-technical in nature. There is still a gap between the focuses given on hard and soft factors. Several authors have emphasized on the importance of incorporating both hard and soft factors in order to achieve a more effective system performance [15], [16], [17], [18]. Incorporating the human aspects has proven to be of great significance towards effective management of operations in organizations [13], [14], [19]. Recognizing that existing literature has on a larger extent based on developed countries led into questioning whether similar factors would affect developing countries homogenously considering the difference in cultures and level of economic development. Hofstede [20] stated in his study that people from different countries behave different depending on what they have experienced and how they have evolved as a nation. It would be meaningful for decision makers to know what factors their employees perceive as important, so they can understand what to implement to facilitate performance. This prompted the need to study if the cultural context determines which human aspects are considered more important.

## **3. Methodology**

After examining the relevant soft factors that directly influence maintenance regimes from various literature, an interview guide was formulated with the aim to identify two aspects: (1) *which soft factors are practiced and lacking in maintenance operations* and (2) *Does culture play a role in determining which soft factors are to be considered important?* A total of (N=17) successful interviews were conducted out of (N=22) personnel available; including supervisors, engineers, technicians, management, safety, security and procurement staff. Semi-structured interviews were conducted at a natural gas processing plant in a developing country using a set of open-ended questions. Most of the process is automated as the plant uses high-tech equipment and only requires few maintenance personnel to ensure smooth running of operations. The interviewees were queried on their understanding about soft factors and their perception on how the incorporation or lack thereof of soft factors influence their performance. To uncover the soft factors practiced and those not practiced, the interviewees were asked to give their opinions on what non-technical strategies the organization was using to make them feel valued, enabled and considered in performing their tasks. The interviews were recorded with the interviewee's permission to enable an efficient qualitative review of the responses and in the cases where the interviewee felt unease, notetaking was used.

## **4. Results and discussion**

The maintenance personnel appeared to be quite knowledgeable on the aspect of human consideration in technical operations. One technician expressed "soft factor is not a new aspect because in operation it is humans who are involved so these factors will influence their performance in operations". Another said, "Human factor in terms of operations is one of the factors that can hinder or push operations". Although only few were observed to be familiar with the terms 'human' and 'soft' factors; the rest were still able to describe the relevant factors without knowing what they were termed. The term 'human factors' appeared to be the most familiar compared to 'soft factors'.

### 3.1 Practised soft factors

Most of the soft factors uncovered from the interviews were consistent with what was identified in reviewed literature. *Training, coaching and mentoring* was said to be the most important soft factor that facilitated worker performance as it determines the ability of workers to perform their tasks. A supervisor commented, “For the workers to perform their tasks we give them trainings. Operators and technicians all go for trainings”. It so happened that it was the first time for the company to venture in gas operations so the trainings were inevitable to build capacity and competence as one mentioned, “We have more short term than long term training courses due to the newness of the industry so we focus on building capacity and competence at the moment”. Personnel were satisfied with the trainings provided but recommended the need for refresher trainings to keep the knowledge alive and consistently present. Coaching and mentoring are implemented to build confidence to the team members.

From the interviews, it was observed that there was a *very good communication relationship* between lower and higher ranked maintenance personnel. One technician said “There is very good relationship between workers. We work with very high collaboration with our supervisors. There are no harsh treatments. In the beginning, they happened but over time we have found a good way to sort out conflicts between management/ supervisors and operators”. This relationship has extended into other departments such that in cases where there is a need for personnel in one department, it is easily handled between supervisors without the need to go higher in the organizational ranks. This has assisted to speed up the process and increase efficiency in operations as one supervisor commented, “My team is very competent and comfortable. In the beginning supervision was high but as time goes very little supervision is required”.

The interviews also revealed *high involvement of the team members in all aspects of planning and implementation of tasks*. Daily meetings are held in each department between team members and the supervisors to discuss the tasks of the day and how to perform them to ensure the personnel are competent to perform the assigned task and in cases where he/she is not competent, the supervisor shows how such task is performed. One technician expressed “Every evening there is a discussion with my supervisor to discuss the tasks accomplished and to see what was not accomplished, then we plan accordingly for the next tasks”. Azadeh [21] mentioned task planning as the most cost-effective solution for performing human factors. This involvement of team members in task planning has built a sense of autonomy in the job and team commitment in performing the tasks. Autonomy is a sense of freedom and independence in one’s work. It is an important factor in creating what organizational theorists call intellectual stimulation [22]. Autonomy is also important for maintaining motivation, dedication, and learning.

Due to the nature of the industry, the maintenance personnel perceived that their *compensation* should be higher to compensate their exposure to risk. An interviewee expressed “When people decide to work in this high-risk environment they come with high expectations. If these expectations are not met, one feels discouraged and it affects their performance”. This perception created a feeling of dissatisfaction and inequity and it decreases the morale and in worse situations resulted to some people seeking employment elsewhere. Compensation was also observed to be of influence in daily maintenance especially in cases where the salary was late to be paid the morale of personnel went down. A supervisor mentioned “when the salary is late you will see that the morale is low and that people are not happy and do not give extra effort in their work”. This indicates an association between compensation and performance.

*Ergonomics* was found to be influential to maintenance operations; three ergonomics principles were checked. These were: (i) task design, (ii) work place environment and (iii) maintenance tools and safety gears. The workplace design was found to be conducive, appropriate maintenance tools and safety gears were available in bulk and some tasks were observed to be properly designed while others were not. Generally, ergonomics has been considered but there is still need to design more comfortable tasks to avoid maintenance issues as Sheikhalishani [11] stipulates that poor ergonomics is an issue that influences maintenance operations.

The company was found to support *career growth* through provision of scholarships to pursue

undergraduate, postgraduate and doctorate programs. This appeared to have a positive impact to the workers and creates a conducive and rewarding working environment as one technician expressed, “I think the opportunity to pursue further studies for us can be regarded as motivation”. The interviews also revealed that it was the *commitment from the top management* that fostered the incorporation of soft factors in the maintenance operations. Commitment is ‘*a sense of loyalty and belonging to the organization, the group or tasks that one works with*’ [24]. For instance, in setting and measuring objectives, the performance objectives are derived top to bottom and therefore nothing can be done in the lower ranks if it is not supported from the top hierarchy. Top management supports and approves the long-term education programs and trainings, promotes safety programs that ensure workers have all the safety gears needed and so forth. An interviewee commented, “The employer is very open to attending trainings and going to school” and another said, “Top management have supported the safety programs which has helped to facilitate the safety culture”. Management commitment is therefore an important soft factor that supports the existence and implementation of other soft factors. This is supported by the findings of Joo [24] who stipulated in their study that leaders have immediate and critical effect on employees’ performance.

Although most soft factors were consistent with reviewed literature, *safety and security* was the soft factor that was identified from the interviews but was not mentioned in reviewed literature. This was due to the case company been involved in high risk operations. The perception of risk by workers appeared to have an influence in their performance. Workers tend to perform better when they feel safe and secure. For instance, one interviewee mentioned, “Whenever there is news or events of political restlessness and security issues you can sense the tension and fear among the workers and it affects their performance and a worker is more prone to making errors when he is psychologically affected”.

### **3.2 Lacking Soft factors**

*Motivation programs* appeared to be of importance in facilitating performance and morale building but was not practised at the plant. It appeared to be important for the workers to be recognized when they perform beyond the objectives given. They mentioned that they would be more creative in their job if they were rewarded or recognized as one interviewee mentioned, “I have not seen people being rewarded or recognized although I work with people who are extremely hardworking, and I feel they deserve the recognition. Also, these rewards may motivate others by knowing that if they work harder they will be rewarded”. Maurer [25] suggested that rewards and recognition influence the formation of trust, knowledge acquisition and product innovation.

### **3.3 The Role of Culture in determining Soft Factors**

*‘National culture is the collective mindset that distinguishes members of one nation from another’* [26]. These differences influence the way people communicate and make decision in their work. For instance, during the initial phases of the operation of the company, expatriate contractors were hired to operate the company and impart the technical knowledge to the local staff. The most recurring challenges encountered at this period was communication issues caused by language barrier. Although language is not a cultural aspect, it is a communication facilitating tool. Due to the language differences, a mediator was used which made the process time consuming and there was no way to verify the credibility of the information translated. The local staff felt less involved as they were unable to communicate their ideas hence lacked the sense of responsibility, autonomy and confidence. However, positive change was observed when the local staff took over managing the company as one interviewee mentioned “There is a difference in terms of performance compared to the time when the contractors were responsible as now we perform the job ourselves we have the sense of ownership and responsibility and authority in our tasks” which has led to an increased overall performance of the plant.

## 5. Conclusion

The aim of this paper was to identify the soft factors that influence maintenance operations and to identify if culture has a role to play in the implementation of these factors. The authors learnt that soft factors are crucial in facilitating the performance of maintenance operations. Soft factors identified include: top management commitment; need for training regimes, coaching and mentoring; providing education opportunities and career growth; communication; inter-departmental relationship; employee involvement in planning tasks; safety and security; motivational programs; and ergonomics. Most of these factors are consistent with those found in reviewed literature with the exception of safety and security factor which was found to be directly associated with the high-risk environment of the plant. Since this study was conducted in a developing country with its own culture, and still most of the factors appeared to be consistent with those identified in developed countries with differing cultures, we can therefore stipulate that soft factors are influenced by the nature of the industry and the tasks performed as opposed to culture or level of economic development.

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# PROJECTS – ENGINE FOR CORPORATE DEVELOPMENT

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***Abstract:** In the area of Project Management we discuss how to manage projects in the right way, how to avoid mistakes in Project Management or how to avoid deviations from the schedule or budget of a project. We learn how to handle diverse projects in project portfolios or to use team spirit, negotiation skills or time management in projects. In this assignment I would like to speak about projects itself.*

**Keywords:** corporate development, advantages of projects, key to company's success

## **1. Introduction**

Let's assume, we are able to manage projects in the right way: how can we use projects to achieve targets or advantages? If Project Management is important, projects must be important too. If not: why to manage them carefully and efficient? But which advantages do projects have? This article deals with the question, in which situations we can use the projects and which advantages projects have and which good prospects they offer.

All occasions how and why to use projects and which advantages and opportunities they offer will be discussed in chapter two. Beside the last chapter 3 as a summary (and praise for projects) the only relevant chapter is this following chapter two. The structure of just one relevant chapter is chosen because of the structure of these advantages is not derived or scientifically developed by deduction or induction but just described like in a list. These points in the lists are sometimes connected but normally just listed and discussed from the first till the last point of this list.

Projects – if done in an efficient way – have a huge positive impact on corporations. Let's have a look at them.

## **2. Advantages and Opportunities of Projects**

A company and the traditional science of Business Administration are based on stable conditions and repetitive work like purchasing, financing, booking, controlling, producing and selling. If you need to change the conditions of your company (entry to a new market, usage of better software, introduce digitalization and so on), you need to do this in multidisciplinary projects because of the high complexity [1]. So projects are the engine or tool to develop corporations. Basement of project decision is a positive Net Present Value (NPV) so projects are suitable to develop the value of a company by performing projects with a positive NPV only. The employees working in these projects normally work under high pressure of success, together with a lot of diverse specialist and in a parallel temporary hierarchy where they can develop skills like presenting, leading, finding solutions and being successful mostly in front of the top-management.

From this introduction to chapter 2 we can differentiate the following points of the agenda in this chapter as results, advantages or targets of projects:

- a) Projects as the engine of corporate development e.g. introducing new strategy, entities, products, IT, locations, employees' development e.g. (projects as driver of corporate development)
- b) Developing the value of the company by introducing projects with secured positive Net Present Value (projects as value-driver)

- c) Connecting project targets with individual targets through bonuses and variable salaries (projects as motivation-driver)
- d) Boosting your career by showing your performance in front of the management board (projects as career-boost 1)
- e) Success in projects is evaluated higher than in repetitive work and trains you to become leader (projects as career-boost 2)
- f) Developing your skills in projects like time management, target orientation and presenting (projects as skill-boost)
- g) Get known to different areas of the company within projects (projects as opportunity to look beyond one's own nose)
- h) Get known to driver specialists within projects (projects as networking-development)
- i) Get known to the future of the company within projects (projects as focal points of changes in the company)

## **2.1 Projects as driver of Corporate Development**

“Only if you actively participate in changes you will not be overrun by the changes” [1], Litke later names as the tool of these participations in changes the Project Management. The Project Management is the science of doing projects in the right way. I guess Litke wanted to say: use projects! (and do them in the right way) to participate in changes, to develop your business, to found new locations and introduce new products or tools or strategies.

It is the target of the top-management to give a direction. If the decision is taken, the top management delegates the tasks derived from this new direction to projects or at first to a project leader who then will create her/his team to introduce the novelties [2]. So, success in management of a corporation means to manage through projects [3]. It sounds like a very easy recipe: become top manager – define new targets - delegate the introduction to projects and the success is almost achieved. Although we know how difficult it might be to open a new factory in china or develop a new car the truth is, that the recipe is really as easy as described. So, use the project as scalpel. To use the scalpel “project” in the right way we need the science of project management. So, if we look to the area of being really successful with the project, we would need now to enter to the area of Project Management – the efficiency of doing projects. If you want to implement new ideas and directions to a corporation use projects to achieve your targets. Top-management does not need to lead the project or to lead the hand of the scalpel. They have to understand projects as the driver of corporations [4].

## **2.2 Projects as Value-Driver**

One of the most important targets in leading a company is to lead the company to a financial success based on yearly profit, growth of the company's (shareholders) value and future cash-in [5]. The problem of reaching these financial targets is to take the right decisions and then doing the right projects (chapter 2.1). In large sized companies you will find investment guidelines and they force every project leader and decision taker to use Discounted-Cash-Flow-Method to be able to take decisions “now” based on future cash-in/cash out [3]. The Discounted Cash Flow Method condenses the result of a project to one NPV which (bigger than “0”) increases the shareholder value by exactly this NPV [6]. In this case the easy recipe is: do projects with a positive NPV and your company will distribute high dividends (current and future profits) and will increase the shareholders' value. In combination with 2.1 we can summarize like this: do projects to develop your company and do them only, if they have a suitable positive NPV. To avoid the risk, that imaginary figures and results of the Project-Planning-Team lead only to nice calculations but the reality will look different, you can add tools like hedging, key-turn-contracts, flexible-price-clauses with clients, long-term-contracts and connection between the salaries of the project manager with the deviation of real figures from the NPV-Base-Case and so on [6].

### **2.3 Projects as Motivation-Driver**

The last sentences of 2.2 are related to the achievement of project targets in real life and not only in business cases, excel calculations and on smart presentation slides. It is crucial to reach the NPV-goals of a project in order really to achieve the advantages of projects like named in chapter 2.1 and 2.2. Projects are the key to success and the key might fit to the door lock but without lubrication you might not be able to turn the key. We know a lot of other occasions where the idea is nice or even gorgeous like communism or FIFA but the egoistic targets of the leaders lead to missing target achievement of the whole organization. It is not needed to blame all people on the world who doesn't act altruistic but self-orientated. All of us do the same. It is important to understand the real motivation of mankind: the individual viewpoint, the own profit, the egoistic approach. If we understand this, we need to individualize the global project target down to the project participants and mainly the project leader [7]. As an example: if you achieve 1 Mio euro NPV with your new project, why not to give 2% of the NPV to the project leader (20.000 €) if she/he leads the project to success? And why not to add 10% bonus in addition, if the project success is higher than 1 Mio - for example 2 Mio Euro. So, the project leader earns a bonus of 120.000 Euro after the project is finished successfully. The additional 100.000 Bonus on the additional profit seems to be high, but the company has additional 900.000 Euros NPV because of the effort of the project manager. In general, we can observe that projects increase the motivation of the participants even without bonuses. Only being able to change something, to design and to develop means for a lot of project participants additional motivation and satisfaction. Projects itself are motivation-sources and in combination with bonuses they lead to extremely high identification with the corporation.

### **2.4 Projects as Career-Boost I**

As described in 2.1 the top management uses projects to develop, change and extend the corporation. The attention of top management is focused on the success of these projects [8]. They assume that the running business is well organized and needs no additional care. But new projects like building huge new factories or investments abroad or the design of new products are in their focus. Top management is part of steering committees and they are sponsors of the projects. They help, observe and support the project team especially the project leader if needed to achieve the project target. Most of the employees in a company the first time get known to the big bosses of a company on Christmas parties or in projects. That's what my former boss told me 20 years ago. Raise your arms if someone asks you or your team to participate in a project. You will perform this project in front of the top management and they will get aware of you if you perform, present, explain and advise them well. They will remember and give you more responsibility the next time. Top Management has no time to do the things on their own – this is your chance: do the things well in projects and you will be supported and encouraged further.

The top management's interest is not going to the year to year business of physical inventory or employees who place day by day goods to the shelves. If you work in projects and you are successful, the defined goals of the big bosses are achieved, and this will be recognized and combined with your name.

### **2.5 Projects as Career-Boost II**

Young applicants for positions like head of a department get very often the negative feedback after their interview: your skills as specialist are enormous but we have to reject you because of missing experience in leadership and management. Bosses tend to give long-term oriented positions in the lower management only to applicants with first experiences in leadership. But you will not get experiences in these jobs of lower management if nobody gives you a job because of the missing skills. This vicious circle you can disrupt by gaining management skills in projects. Projects are temporary and normally performed in parallel structures beside normal hierarchies.

Projects allow you to train and develop leadership in a temporary way which allows you to get experiences and then allows you to say in an interview to become head of a long-term department: I have a lot of leadership experience because I worked in this and that projects as project leader.

## **2.6 Projects as Skill-Boost**

In point 2.7 we will speak about the opportunity to get know to other areas of knowledge in a company by attending projects. The focus in 2.6 is different. Here we speak about skills you need beside or in addition (!) to your knowledge as specialist of technique or legal affairs or IT. Here we speak about management skills [9]. On your ladder up to the higher management you need to change your skills dramatically from being the best engineer or the best lawyer to be able to lead a team, to present in a convincing way and to steer things to success [3]. In these projects you have to do several things besides being specialist: you have to present, to report, to communicate, to negotiate, to care about time and budget management and if you are the project leader you can build skills in conflict management, team building, tracking success, risk management or resource management [1].

## **2.7 Projects to look beyond one's own nose**

If you introduce complex novelties to your company, you need to care about all elements in your company which are affected by the novelty [1]. This is needed to A) use/introduce the novelty in a full range so for example a new IT-System in all needed areas. It is needed B) to let the novelty run by the agreement of all needed departments in the company (legal approval? IT approval? Impact on HR?..), C) because we need the help of several departments to let it happen (technical department, educational department, administration...) and D) everybody even in the surrounding of the novelty should be involved/informed and not be surprised by observing the changes by the first time in the moment of introduction. So, we know that projects are multidisciplinary, and we know that if you only work in bookkeeping or in purchase department you might be an expert in bookkeeping, but you have no knowledge and orientation about the whole company. Project participation widens the view. We understand that our knowledge is just one viewpoint to activities like a bookkeeper needs only to evaluate and book in the right way but does not need to understand the legal impact or the impact on the market by this action or project. Projects open the horizon from a narrow tunnel to a 360-degree-view. Participants by contributing all their individual knowledge as a specialist in projects develop in the same second the team knowledge and at least the awareness of complexity – sometimes after a lot of projects the participants become specialist in other special areas too. Participation in projects means automatically gaining knowledge in other areas than the own one and develops cross-linked thinking.

## **2.8 Projects as Networking-Development**

In the last chapter we discussed the advantage of projects to get known to different knowledge areas in you company – not only your knowledge you developed in your department. This look beyond one's own nose is not only an advantage because of the knowledge itself but also in relation to the people in the surrounding of your department [8]. You can be sure, that you are a good employee if they give you tasks in projects. And the same is valid for other participants in your project team. This is a group which invents new, founds something or introduces something. The best specialists and project managers work in projects and to be team member means to get know to the current hard-working core of a company and later on to know the young generation in the management. This helps to manage future task in an easy way by just phoning members of your network to get quick respond from experts from all departments in your company. And you get know to the sponsors and founder of projects in the upper management – these managers can help you already now to fulfill your tasks in a better way. This circle of people in the center of

the storm of changes in a company on a working level (so project level) very often stays for decades in contact to support each other in difficult tasks and situations. So, projects help to build trust to various people in corporations and this network is an investment in future success [10].

## **2.9 Projects as Focal Points of Changes in the Company**

We all know the changes in our environment, in our private life and our business life. Changes come and come and come and never stop and one day you stop participating in adapting to them and you survive with the knowledge you have till now. Our grandparents may not use different languages, our bosses have problems with apps and mobile phones and professors sometimes teach what they learned during their research projects 15 years before. We all agree that companies have only one chance to survive: always to be up to date – 5 years behind the time means to declare bankruptcy. Employees can use their participation in projects to define the future, to be up to date, to develop further than those who stick to old systems. To set the new standards in your own projects means to work at the edge between present to future. And this means to have advantages in knowledge, orientation and opportunities to career.

At the ending of chapter 2 I would like to reduce the enthusiasm of using projects. We can have changes too often (e.g. changing the structure/hierarchy of our corporation too often with the effect that clients and ordinary employees lose orientation and the feeling of continuity). The high effort you use in projects you cannot show in parallel in your ordinary work/department you are working for. This means that ordinary work for example with clients sometimes suffers from a too intense usage of projects. Projects increase the motivation of the employees in the project team and especially of the project leader. This leads to the fact that lots of successful project leaders lose work-life-balance and sometimes even get divorced because of caring about projects like own children [8].

## **3. Summary**

The usage of projects is suitable to develop corporations further – to develop skills, interaction, networking and manager-skills. If you are willing to use projects you can manage your company, develop your employees, let managers train leadership and at the end you will be up to date in relation to the market and the competitors to survive sustainably as a corporation.

As former CFO in huge corporations I can recommend projects to force the company to success and as a current professor I can recommend to future employees to raise their arm if bosses ask for volunteers for projects to boost their skills and career and to develop networks.

This article sounds like to sing the praises of projects. And if you understood it like this you understood the article in the right way. High effectiveness in corporations means to use projects.

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# SUPPLY CHAIN PLANNING: APPROACH FOR AUTOMATIC SELECTION OF COORDINATION MECHANISM BASED ON CHANGING RELATIONS

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## Abstract

Optimizing the own production process is nowadays no longer sufficient to meet the customers requirements. Therefore a optimization of the whole supply chain is necessary. This forces companies alongside the supply chain to cooperate and exchange sensitive information. There are several approaches to optimize the supply chain with central, decentralized or other planning approaches. None of these approaches takes in concern that the relation between the companies in the supply chain is complex and subject to changes. This paper outlines, why it is important to concern the changing relation in supply chain.

**Keywords**— supply chain planning, coordination, trust based model, bullwhip, decomposition, demand uncertainty, collaborative planning

## 1. Introduction

To meet the customers requirements for individual products with short delivery time it is no longer sufficient for small and medium enterprises to optimize their production process. Besides the optimization of the own production process an optimization of the whole supply chain is necessary. Companies like HP, Dell or Walmart [1, 2, 3] already have recognized the potential the optimization of the Supply Chain is bearing. Cooperation in the supply chain can yield benefits in the competitive market [4].

Changes in demand result in a decreased forecast accuracy as one moves upstream along the supply chain. Leading to consistent consumption at retail but the consumption is more unpredictable as the focus moves away from consumer purchasing behavior. This effect is called the Bullwhip effect as the demand signal has a wave pattern similar to a bullwhip. The bullwhip effect leads to big variations in demand. "The common symptoms of such variations could be excessive inventory, poor product forecasts, insufficient or excessive capacities, poor customer service due to unavailable products or long backlogs, uncertain production planning (i.e., excessive revisions), and high costs for corrections, such as for expedited shipments and overtime" [5]. Collaboration along the supply chain can reduce the Bullwhip effect and its negative symptoms.

## 2. Related Work

Several approaches exists for a better collaboration along the supply chain due to planning [6]. They differ in the expected planning result, sensitivity of information and degree of centralization. In figure 1 one can see the differences between the most common planning approaches, the x axis represents the expected planning result, the y-axis shows the degree of centralization and the z-axis the sensitivity of information. As seen in the figure the more central a approach is the more information are needed and the better are the planning results. The most common approaches will be discussed in the following.

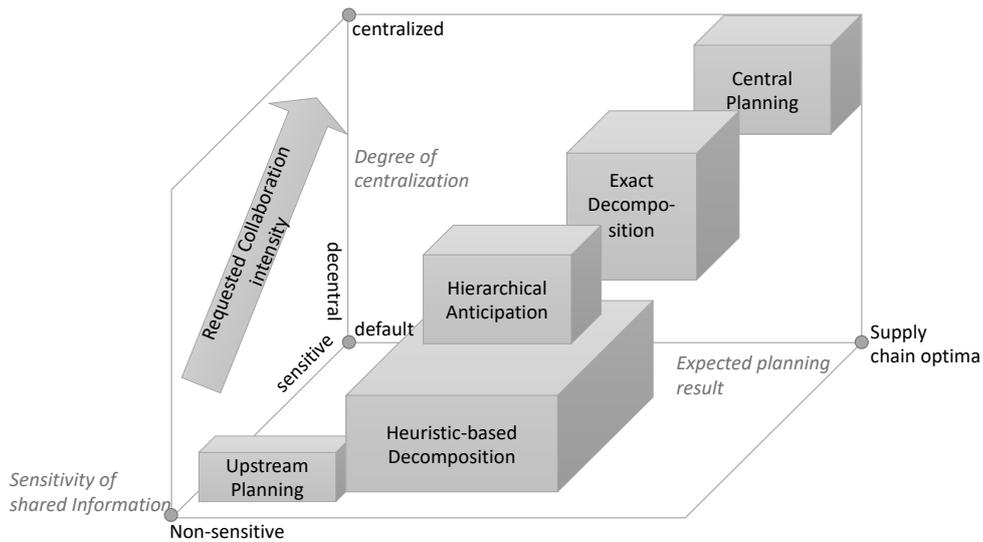


Figure 1: Comparison of supply chain coordination techniques. Own representation based on [9]

- **Central planning** The central planning approach requires information transparency. As sensitive information, about production capacity, stock, resources and more from all supply chain actors, are used to find an optimal solution at a central planning authority.
- **Upstream planning** Upstream planning is an idea to improve the information exchange of supply chain actors [7]. Customer provide planned orders to their suppliers for a previously agreed planning horizon and therefore reduce demand uncertainties.
- **Mathematical decomposition** Mathematical decomposition techniques are applicable for supply chain planning [8]. Mathematic decomposition uses an underlying decision model like constraints to find an optimal solution. Mathematical decomposition can be splitted up "into exact mathematical decomposition, heuristic mathematical decomposition, and meta-heuristics, economic order quantity (EOQ) models and simple contracts, inventory systems, and hierarchical planning approaches" [9].
- **Hierarchical anticipation** Hierarchical anticipation is a technique used for hierarchical planning problems [10]. In hierarchical anticipation the supply chain is seen as a sequence of planning models, higher planning models influence the decision of lower planning models.

Furthermore other methods exists as contract based coordination [11] or Collaborative Planning, Forecasting and Replenishment(CPFR)[12]. This methods are based on exchange of information and less on model-based decision support.

None of this approaches takes in concern that the relation between the companies in the supply chain is complex and subject to changes.

### 3. Coordination Mechanism Based on Changing Relations

The supply chain consist of different actors with various complex relations exchanging goods, money, services and information. This actors need to trust each other to cooperate [13, 14]. "Trust is defined as a willingness to rely on an exchange partner in whom one has confidence"[15]. This trust changes during the business relationship and is influenced by several variables [16].

Information exchange is part of cooperation. The more actors in the supply chain trust each other the more willing they are to exchange sensitive information, and a coordination model with better planning results can be introduced (see Fig. 1). However the costs and efforts for using softwarebased supply chain planning are high. In some cases these software systems even need customizing to meet the requirements of the supply chain actors.

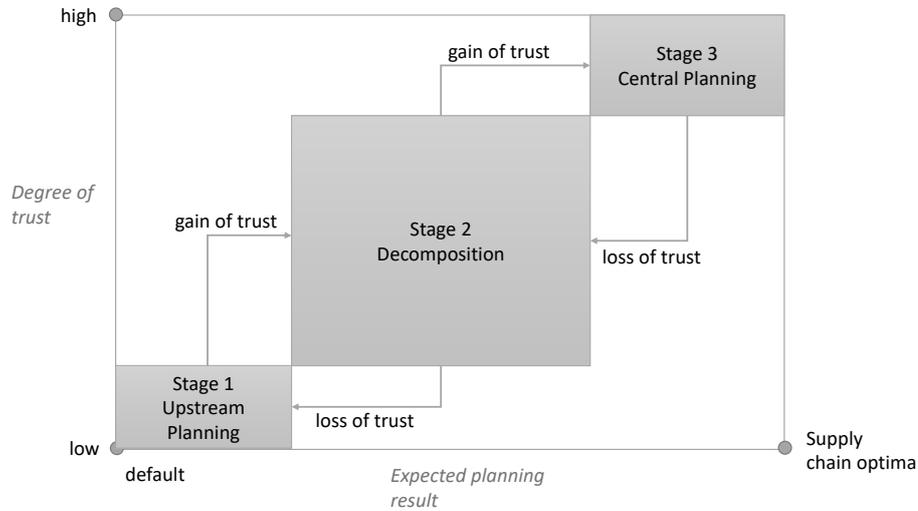


Figure 2: Flexible supply planning model based on the degree of trust

Planning a long term business relation with a supplier and therefore investing in software and tools to optimize the production process is controversial [17] as customer are in a locked-in-situation [18]. This strategy is called single sourcing [17]. The customer invested money and time for a better relationship leading to sunk costs [19] when switching suppliers.

Therefore a flexible planning approach is needed where the degree of collaboration is connected with the degree of trust. The higher the trust the more information are shared between the actors in the supply chain and this leads to better planning results (see Fig. 1) and the other way around. Such planning model could have for example three stages (see Fig. 2).

- In stage one there is a decent amount of trust between customer and supplier leading to a planning technique which only needs insensitive information like upstream planning.
- In stage two customer and supplier are trusting each other therefore more sensitive information are shared and a decentral planning approach like decomposition is used.
- In stage three demands information transparency and therefore a huge amount of trust. Due to information transparency a central planning result can be used to achieve optimal supply chain planning results.

In this planning model successful transactions between supplier and customer lead to a gain of trust and therefore to a closer collaboration. In addition delay in delivery, price increase, worse quality also have impact on the collaboration they result in a loss of trust and therefore in a fewer collaboration. Through this approach customers will not get in Locked-in situations.

#### 4. Towards a new Planning Approach

To measure the degree of trust a common supplier review, the supplier scoring, or other multi criteria decision approaches [20] can be used. The supplier scoring was developed by Feldman [21], it is a supplier rating schema consisting assessments and resulting in a supplier scoring. The higher the score the higher the confidence in the supplier.

Furthermore a machine learning algorithm for a scoring forecast can be considered, to evaluate if the business relation is increasing or decreasing. Through this scoring the stage of trust between supplier and consumer can be determined and therefore the best planning method can be chosen.

Combining different supply chain planning approaches is a key element in the discussed model. Therefore it is necessary to evaluate which planning method can be used in which stage.

As there are several actors in the supply chain and the sunk costs should be reduced it is necessary for the introduced planning model to make use of standard data exchange protocols like EDIFACT. Those protocols are in need of extension to fit the requirements of central and decentralized planning.

Forecasting the supplier score with machine learning requires data. First this data will be generated through an economic simulation. The test data will be used to develop a machine learning algorithm. If the forecasting results are promising the algorithm can be evaluated in a study with real data from small and medium sized companies.

The economic simulation, developed to generate test data, can be extended to benchmark the planning results of a flexible supply planning model based on the degree of trust. With this simulation it would be possible to determine whether the discussed model results in better planning results than the common approaches. The discussed model needs a simulation of several years, as the gain of trust and expansion of business relations is a long process. The advantages of combining several planning approaches and concerning the changing business relations are only noticeable on the long run.

## 5. Conclusion

In this paper an approach was presented, which combines several planning techniques to concern the changing relations between supply chain actors. With the provided approach it is possible to optimize the production along the whole supply chain, without the negative effects of sunk costs or Locked-in situations. An optimization along the whole supply chain enables companies to stand out in the competitive market. Besides providing an approach, the next step is to develop such a model. Developing such a system will be part of the authors doctoral thesis.

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# ROLE OF SUSTAINABILITY IN ACHIEVING PROJECT SUCCESS

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**Abstract:** *Sustainability is centered upon maintaining an equilibrium between environmental, economic and social factors. Sustainability is related to project management lately because sustainability requires a change and projects are always changing. Project management act as a gateway to integrate the dimensions of sustainability in the projects. Tools and techniques can be applied in Triple Bottom Line (TBL) viewpoint which includes environmental, economic and social sustainability which positively impact project success. Sustainability and project complexity are two important aspects of a project success, where sustainability is positively influencing project success on the other hand project complexity is having a negative impact on project success.*

*With the growth of complex projects, the elevator industry of Pakistan is also flourishing. Based on the types of complexities involved which occur during the execution phase of the projects, it is very difficult for the project managers to keep the project sustainable due to complexity of such projects which affects the project success in terms of cost overruns, schedule delays and failing to meet safety standards. This research aims to determine the influence of sustainability on project success of elevator industry projects in Pakistan. The research also examines the moderating effect of project complexity on the relationship between sustainability and project success. To achieve the objectives, organizations executing such projects were surveyed in the two cities namely Rawalpindi and Islamabad. For this research, survey was conducted by distributing a questionnaire to elevator organizations. Data analysis was done using the SPSS software. The results confirmed that sustainability practices implementation has positive impact on project success whereas project complexity negatively moderates the relationship between sustainability and project success. Based on the findings of this research recommendations were made to practitioners to implement dimensions of sustainability to achieve greater project success in their projects.*

**Keywords:** sustainability, project success, project complexity

# PROJECT ALIGNMENT WITH GROWTH STRATEGY

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**Abstract:** *In the current business organization, ideas in business strategy has moved from strategic way of thinking, to how strategy should be implemented in the daily business operations. Literature has shown the method adopted in strategy and implementation. Formulation of strategy therefore, expedite actions, which results to solutions that would be otherwise difficult to attain. Strategy formulation leads to envisioning of the company, which in turn brings about project initiation creating a wave of change for enhancement either in a section of a company or as a whole process change for an organization. In addition, strategies can be a prolongation of already existing strategies, but with smaller adjustments on a general note. The literature from earlier researchers maintains a very narrow view, when stating that projects plans, or strategies originate from the parent organization's strategies, assuming a static structure other than a dynamic one, which seeks to attain a position from its environment. As such, it can be a two-way dimension. The results of the research provide valuable information for business organizations by serving them with adequate and detailed information, fundamental for the successful alignment of projects and their business strategies.*

**Keywords:** Business Strategy, Project Alignment, Portfolio Performance Management,

## 1. Introduction

Research has shown that portfolio management is an alignment method between strategy and implementation. In addition, Morris & Pinto (2004) suggest that plans and goals of projects are aligned with the organization's strategy. Nonetheless, there is not always a one-to-one link between strategy and project, and It is not always practical that projects follow the organization's strategy in formulating its project strategies. However, variations from research have also shown that projects can influence change in the organization's strategy as a result of market dynamics (Artto, et al., 2008).

The literature from earlier researchers maintains a very narrow view when stating that projects plans or strategies originate from the parent organization's strategies, assuming a static structure other than a dynamic one, which seeks to attain a position from its environment. As such, it can be a two-way dimension (Artto, et al., 2008).

Strategy formulation leads to envisioning of the company, which in turn brings about project initiation creating a wave of change for enhancement either in a section of a company or as a whole process change for an organization. In addition, strategies can be a prolongation of already existing strategies, but with smaller adjustments on a general note.

According to Bob de Wit [1], strategy is divided into three major types, (1) Corporate strategy where the organizations formulate what type of business to partake in, (2) Business or competitive strategy, in which structure for successful achievement in a particular line of business is set in place and (3) Network Strategy where various organizations interact with each other in a network of partners, creating an inter-organizational relationship, which may result in a shared alliance strategy. For project-oriented organizations, most literature talks about an overall project strategy, portfolio strategy, program strategy, project office strategy, and project strategy. In this report, a strategy is not about the firm's environment alone but on a broader network environment. Based on these researches, the research will focus on strategic portfolio management comprising

of the Business type of strategy as mentioned above. In this formulation of strategy, the organization orchestrates and prioritizes its various portfolio of investments into projects which acts as a tool to drive the goals of the organization to achieve its strategic objectives while benefiting from synergies that can be achieved through this portfolio management. However, it is more common that portfolios exist for longer than one or two strategic cycles. For example, the company might keep a product development portfolio even when the strategy changes. The consequence is not to create a new portfolio but to change the criteria for selecting and aligning projects related to the business portfolio.

A project is said to align if it meets the criteria of the business goals and in most projects, alignment has a different meaning to different people. For example, a machine installation project may be referred to be aligned or successful if the engineering was technically compact and completed on time. The installation of the machine might also be successful if it was completed on schedule. The machine installation project was successful as it operated according to design or the maintenance procedure was easy and executed effectively which made it successful [2]. Although the issues of alignment have been discussed in other literature, the aim of this research is to review and analyse alignment of projects in business enterprises/ organizations. To determine/ evaluate how well project management elements are aligned with the growth strategy, the following questions are stated: (i) What are the mechanisms that strengthen project management practice and growth strategy alignment? (ii) What are project management components that influence the growth strategy in organizations? The general objective of this study is to develop an effective framework for aligning project management with various growth strategies/Project Alignment model. To achieve this general objective, the following specific research objectives were established from the research questions which shall be the guide throughout the thesis – (i) To analyse current situations of frameworks used for aligning project management with growth strategy in organizations. (ii) To proffer solution to the current problems faced with the alignment of organizational strategic growth and project goals.

## **2. Literature Review**

The concept of alignment has been used in similar terms in literature such as fit, bridge, fusion, harmony, linkage, integration, consensus [3, 4, 5, 6, 7, 8] which was created from IT and alignment [9]. Alignment of project benefit organizations in terms of yielding a return on investment when aligned with organizational business strategy, competitive advantage in the marketplace and growth in economic performance, promoting business plans of the organization through the increase of efficiency and profitability [9, 10]. Due to uncertainties in the nature of human conditions, alignment is hardly controlled fully which made it an illusion [10, 11]. According to Venkatraman [12], alignments are of six types which are obtained in two categories – alignment with distinct principles and alignment formed with regards to certainty. Collis & Montgomery [13] further analyze alignment into two dimensions – Functional Units (Vertical alignment) and business unit strategy (Horizontal alignment).

### **Project Alignment and Change Management**

Effective change management for organizations in order to achieve successful change project, involves alignment of internal and external parties, within the project team and the organization. Project teams consisting of individuals are aligned with each other. When aligned with the organizational goal, then full potential of teams can be deployed which allows more concentration of energy and effectiveness to surge into attaining the desired results [14]. Misalignment can result into diminished productivity, internal conflicts, waste of money, time, demotivation of the project team, confusion, power struggles, and overall, leads to project failure. Literature shows that project management and change management have various topics related to the alignment where different principles of change process are combined with organizational and project alignment models which serve as guidelines for maintaining project alignment.

Simon Box & Ken Platts [15] developed a project alignment model to help maintain and establish project alignment in organizations. The model is divided into three sections – environment, leadership, and management. The environment detailed the understanding of the internal organization and external business environments when executing a project and monitoring, throughout the life cycle of the project to align with the current business strategy of the organization as shown in Figure 4. Leadership according to [16] defines the future by aligning project teams with the organization business strategy and effective change projects combined with alignment [14]. Leadership involves the creation of purpose and shared vision, establishment of project identity, demonstration commitment, responsibility and engaging style.

The management section of the model deals with establish alignment and maintain alignment. Establish alignment focuses on aligning project goals with the organizational business strategy for ensuring that the desirable projects are undertaken [17]. Maintain alignment focuses on the external environment, periodically assess and correct project alignment and effective communication. In aligning projects with business strategy, various literature will be considered to understand the topology of business strategy and different types of strategy, identifying the elements of project management processes that can be aligned with organizational business strategy by identifying the missing part of project alignment in literature. There are different definitions of business strategy which ranges from dealing with competition, creating competitive advantages, sustainability benefits [18, 19, 20]. According to Porter [21], organizations must strengthen its selected strategies to attain a sustainable competitive advantage. Porter's generic strategies can result in three which include – Cost leadership, differentiation, and focus. Organizations adopting a cost-leadership strategy, gain market competitive advantages and share showing a low cost of production in that industry. Organizations with a differentiation strategy show distinctive identity in terms of quality, innovative features, etc. to their customers. In the case of the Best-Cost Strategy, various researchers support the combination of strategies to attain sustainable competitive advantages [22].

According to Jamieson & Morris [23], project management serves as an indispensable business process which indicates that when organizations' projects and business strategy are linked together, it yields a better way to accomplish their organizational goals. Some of the project management elements that can be aligned with organizational business strategy, according to Shenhar's framework [24], include – project tools, project strategy, project metrics, project culture, project process, and project organization. Recent research shows that project management processes and strategic planning process have strong links together showing the strategic planning processes – control systems, organizational structure, internal analysis, having strong links with project activities [23, 25]. An Organizational business strategy is the result of the resolution reached to serve as guidelines for the organization on what should be engaged with and allocation of resources with respect to the processes, structure, and environment that have an impact on the organizational performance. According to Hambrick [26], identifying business strategies are typological, multivariate or textual. Identifying business strategy using the typological approach create an understanding of the strategic facts of the existence of an organization. Aligning projects have been identified and discussed in isolation with organization strategy [27]. According to Porter, project team members and the project management office need to understand what the organization's strategy encompasses before they can properly align projects with business strategy. Project alignment implementation is often challenging in achieving the desired concept with accurate techniques and tools in creating the alignment. According to Crawford, et al. [28], one of the practical tools and technique is categorization, which helps in connecting project delivery with business strategy. And this assumes that assessment of projects should also be done during the completion phase, not only at the initiation phase to ascertain result about the outcomes to avoid future occurrence. Categorization process is faced with three challenges which are control, comparability, and visibility. These challenges are dependent on each other in such a way that increases in visibility and comparability lead to a reduction in control. On the other hand, increase in control lead to decrease in comparability in the process of categorization [28]. According to [29], identified project failure caused by an internal conflict between line

organization and project management Office and given guidelines against the causes stating two strategies that lie within the circle of project alignment knowledge: project procedures creation guidelines and project charter issuance. The project charter issuance provides the duties and authority of both line manager and project manager, spelling out sufficient resources, listing the project team members and their various rules and provided with the top management support. While the procedures creation guidelines explain the day-to-day activities of the project that should occur.

### **Misalignment and Alignment with Strategic Growth Objectives**

The main aim of alignment of a project is to see that given project is properly aligned with the strategic growth objectives of the company. The strategic growth objectives of the organization are specific, and the measurable goals fit in-line with the overall organization goals at all levels. When the objectives of the project are properly aligned with organization objectives, one can consider the project successfully aligned. This makes project alignment more important in the sense that misalignment of the project with organization objectives leads to failed development programs in the organizations [30]. According to [31], research conducted on the growth strategy of organization and project alignment shows the poor performance results in companies involving in various types or many projects. The study shows that the major reason for failed projects in organizations is as a result of misalignment with strategic growth of the organization objectives even if the projects are on time and within budget. Understanding the linkage of projects to the strategic growth of an organization, the project manager, and the team members need to understand the vision, mission, goal, objectives, and strategy of the organization [31]

The different models used for project's selection and evaluation share common attributes and approaches which made the models have the same weaknesses and gaps which decrease the efficiency of project alignment with respect to the organization's strategic growth.

The Models have various steps, serving as guidelines for project alignment process with more than eleven steps making the process complex and creating the chances for errors and mistakes. In addition, many tools are applied to all the steps and giving rooms for duplication of their usages and functionality. One of the most important gaps found in all the models that exist in literature is the disconnection of quantitative financial considerations from the qualitative strategic issues, without any technique connecting them into an integrated process that depends on quantifying the qualitative strategic issues [32].

### **Hypotheses**

(a)  $H_0$ : There is no significant relationship between alignment of portfolio, program & project management activities with organisational enablers (cultural, structural, technological, and human resource practices).

$H_1$ : There is significant relationship between alignment of portfolio, program & project management activities with organisational enablers (cultural, structural, technological, and human resource practices).

(b)  $H_0$ : There is no significant relationship of alignment between organisational strategic growth and project goals.

$H_1$ : There is significant relationship of alignment between organisational strategic growth and project goals.

### **3. Research Methodology**

The population of research consists of small, medium and large organizations involving in projects. The target population in these organizations are the senior management/owners – Chief Executive Officers CEO, Chief Operation Officers COO, Chief Information Officers CIO, Chief Security Officers CSO, Chief Technology Officers CTO and Chief Procurement Officer CPO (who make decisions about the projects); Technical support personnel (computer specialists, data

analysts, network, system, and application); system and application programmers; project managers/ risk project managers; quality assurance personnel (who test and ensure the standard of the projects); Information system auditors; consultants (who support customers in risk management); and Business or functional managers (who are accountable for the procurement process).

**Decision Rule**

When  $r \geq 0.70$  = very strong relationship,

$0.50 \leq r \leq 0.70$  = strong relationships,

$0.10 \leq r \leq 0.50$  = weak relationships.

The t-test is used to proof or disproof the hypothesis put forward  $t = r \sqrt{\frac{n-1}{1-r^2}}$

**Decision Rule:**

1. When the tabulated t is greater than the calculated t, accept the null hypothesis ( $H_0$ ) and reject the alternative hypothesis ( $H_1$ ) i.e.  $t_{tab} > t_{cal} = \text{Accept } H_0$

2. When the tabulated t is less than the calculated t, reject the null hypothesis ( $H_0$ ) and accept the alternative hypothesis ( $H_1$ ) i.e.  $t_{tab} < t_{cal} = \text{reject } H_0$

To find the critical value, the degree of freedom (df) is determined. The formula is  $n - 1$ . Since the number of variable options agreements is 5. That is  $df = n - 1 = 5 - 1 = 4$ .

**4. Results**

Table 1 shows the distribution of the respondents’ personal characteristics – gender, educational qualification, years of project management experience, and certified project manager. The data in table 1 shows that there are more male respondents 151(70%) than female respondents 66(30%). The distribution of the respondents by educational qualification in the table shows literacy level with MBA/M.Sc. 151(71%) as the highest, B.Sc./Diploma 31(14%), HND/Technical Certificate 0(0%), Ph.D. is 30(14%) and Prof. 1(1%).

From the calculation in table 2, the correlation coefficient is 0.729. This shows that the relationship between alignment of portfolio, program & project management activities and organisational enablers (cultural, structural, technological, and human resource practices) is a strong positive correlation.

Also, the calculated t is 2.1298 while the tabulated t is 2.132. Since the table t is greater than the calculated t, we accept the null hypothesis and reject the alternative hypothesis. This confirms the statement that there is no significant relationship between alignment of portfolio, program & project management activities and organisational enablers (cultural, structural, technological, and human resource practices).

**Table 1: Personal Respondents' Characteristics**

	No	%
<b>Gender of the Respondents</b>		
Male	151	70
Female	66	30
<b>Educational Qualification</b>		
B.Sc./Diploma	31	14
HND/Technical Certificate	0	0
MBA/M.Sc.	151	71
Ph.D.	30	14
Prof.	1	1

<b>Project Management Experience (years)</b>		
0-4	3	1
5-10	12	6
11-above	202	93
<b>Certified Project Manager</b>		
No	67	31
Yes	150	69

Source: author's field survey, 2018

**Table 2: Correlation Coefficients for Hypothesis A**

$H_0$  : There is no significant relationship between alignment of portfolio, program & project management activities with organisational enablers (cultural, structural, technological, and human resource practices).

$H_1$  : There is significant relationship between alignment of portfolio, program & project management activities with organisational enablers (cultural, structural, technological, and human resource practices).

Pearson Correlation ( $r$ )	0.729
$t_{cal}$	2.129
N	217

$t_{tab}$  at 5% significant level = 2.132

In Table 3, From the calculation above, the correlation coefficient is 0.7689. This shows that the relationship of alignment between organisational strategic growth and project goals is a strong positive correlation.

Also, the calculated t is 2.4052 while the tabulated t is 2.132. Since the table t is less than the calculated t, we reject the null hypothesis and accept the alternative hypothesis. This confirms the statement that there is significant relationship of alignment between organisational strategic growth and project goals (The  $t$ -value is -1.88436. The  $p$ -value is .048129. The result is significant at  $p < .05$ ).

**Table 3: Correlation Coefficients for Hypothesis B**

$H_0$  : There is no significant relationship of alignment between organisational strategic growth and project goals.

$H_1$  : There is significant relationship of alignment between organisational strategic growth and project goals.

Pearson Correlation ( $r$ )	0.7689
$t_{cal}$	2.4052
N	217

$t_{tab}$  at 5% significant level = 2.132

## Proposed Strategic Alignment Model and Weighted Criteria

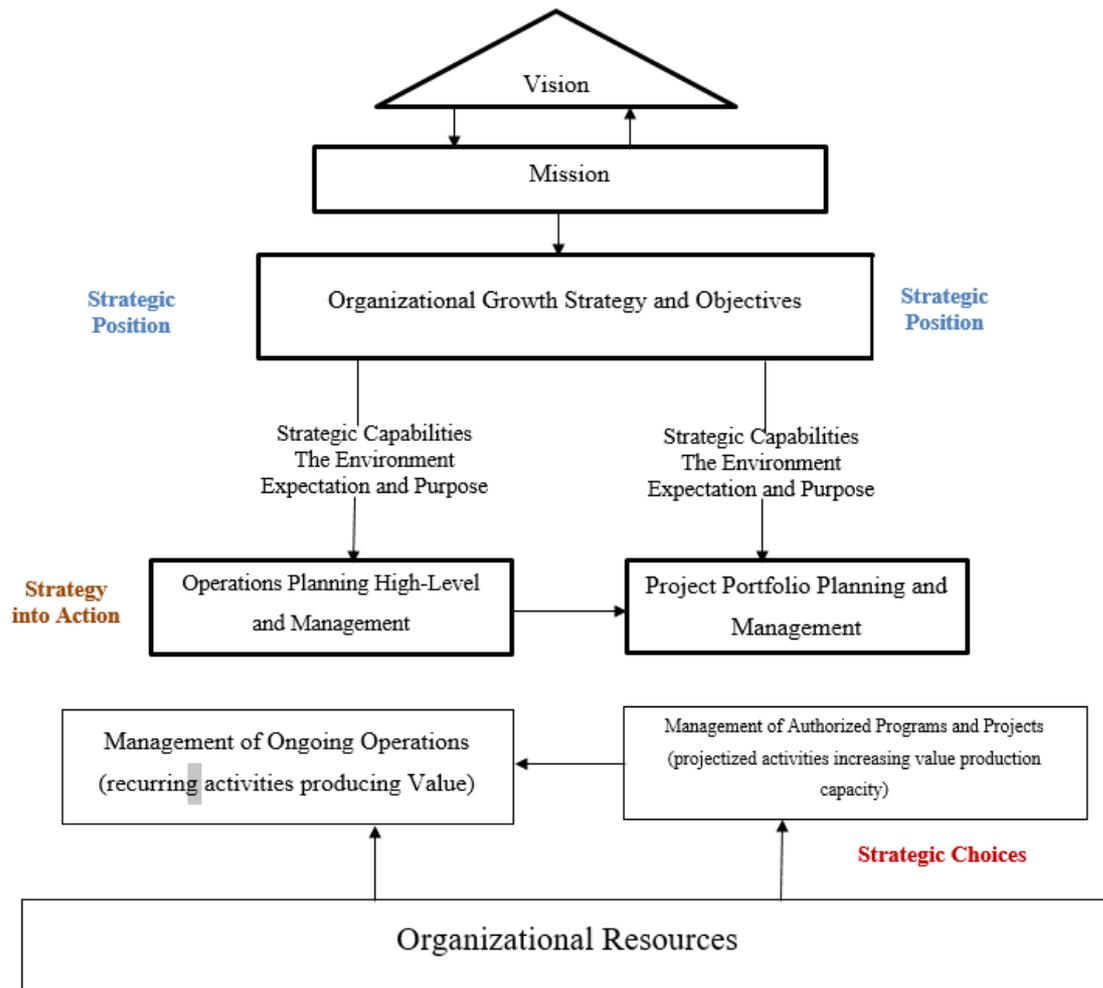


Figure 1: Proposed Strategic Project Alignment Model [33]

The proposed Strategic Project Alignment model alongside the weighted criteria are used in the selection process of project portfolio and balancing the project portfolio. The proposed Strategic Project Alignment model is combined with weighted criteria for project portfolio selection. Figure 1 and 2 show the proposed Strategic Alignment model for projects portfolio selection. Objectives 1,2,3,4 and 5 are weighted with number between 0 and 1 given that the total sum of the weights equal 1. The assigned weights indicate the relative importance of all the objectives compared to one another. Budget is allocated to each objective/Strategy, showing the total budget of €20 Million. A total number of 10 projects are being put into consideration for the project's portfolio showing the allocated budgets for each project with the total sum of €25 Million. In the above case, one project can have more than one objective/Strategy. Each project is assigned with a weight by putting into account the strength of the relationship of that project assigned with weight to the related objectives given that the sum of the weight for any project equal 1.0, and the weight comes as a result of the evaluation carried out in the alignment to the strategic growth/objectives of the organization. To find out the priority order to the 10 projects considered, the objective weight is multiplied by the project weight itself, and then add up the numbers to give us the score for each project. The priority order, which is based on the higher the project score, the higher the priority of that project on the list. From the figure 2 shown below, Project 7 indicated the top priority project that needs to be considered first before others, while project 10 shows the least or

lowest priority project that needs to be considered last on the list. €25 Million was requested for the projects. The total budget is €20 Million and after carrying out the evaluation and allocation process, €19.4 Million is the final allocation for the 10 projects with €0.6 Million remaining. The 0.6 Million of the budgets cannot be channeled to projects that are not supported or not aligning with the growth strategy of the organization, instead the remaining is held pending reallocation purposes for supported projects.

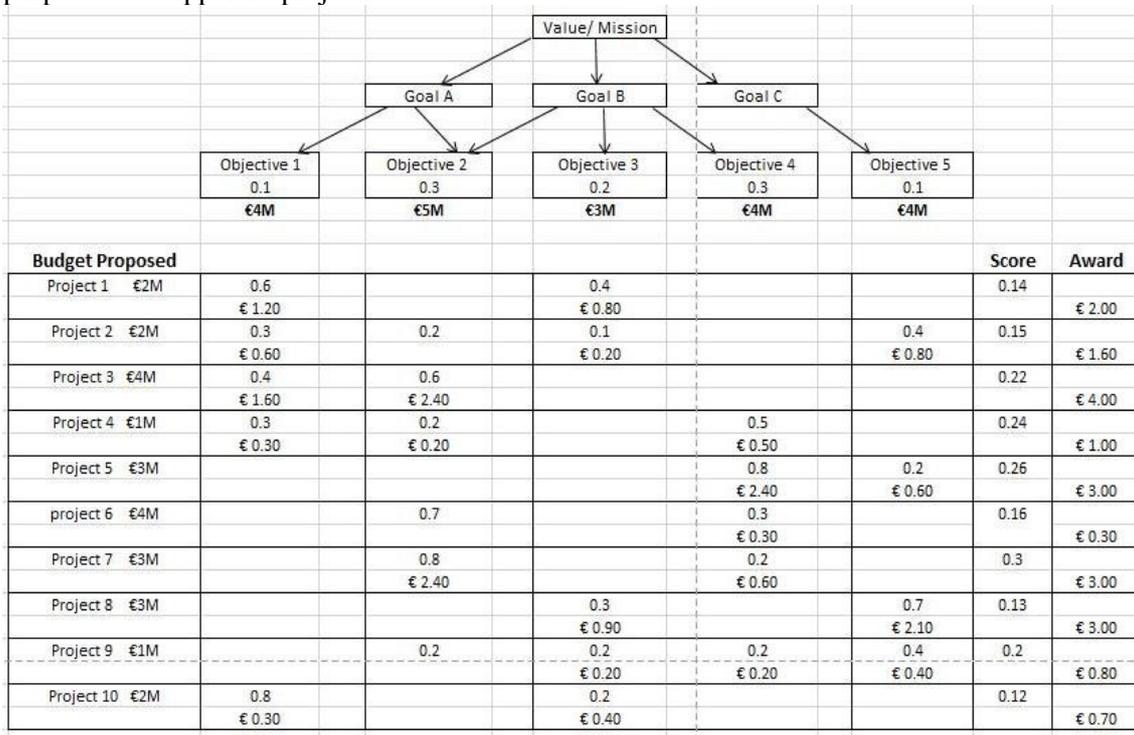


Figure 2: The proposed Strategic Project Alignment model alongside the weighted criteria [34]

## 5. Conclusion

Based on this research, the research focus on strategic portfolio management comprising of the growth type of strategy as mentioned above. In this formulation of strategy, the organization orchestrate and prioritize its various portfolio of investments into projects which acts as a tool to drive the goals of the organization to achieve its strategic objectives while benefiting from synergies that can be achieved through these portfolio management. However, it is more common that portfolios exist for longer than one or two strategic cycles. For example, the company might keep a product development portfolio even when the strategy changes. The consequence is not to create a new portfolio but to change the criteria for selecting and aligning projects related to the business portfolio. The literature from earlier researchers maintains a very narrow view, when stating that projects plans, or strategies originate from the parent organization's strategies, assuming a static structure other than a dynamic one, which seeks to attain a position from its environment. As such, it can be a two-way dimension. Although the issues of alignment have been discussed in other literatures, this research reviewed and analysed alignment of projects in business enterprises/ organizations. Change management is on the rise and relevant in all business environment, and this change will rise more in the future. In these business environments, project managers must possess more than technical know-how, they need to be reliable and good leaders who are able to influence strategic change and knowledgeable in managing economic and political dimensions of their projects. The results of the research provide valuable information for business organizations by serving them with adequate and detailed information, fundamental for the successful alignment of projects and their business strategies.

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# THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN EDUCATION

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**Abstract:** *This article is devoted to the application of information and communication technologies in the educational process in IITU. The authors described the methods and programs for IT specialists training, presented the developed virtual laboratory with elements of 3D computer modeling, the applications with the use of AR and VR and their advantages in the educational process. The article stresses that the use of ICT in education allows to create highly qualified and demanded IT specialists.*

**Keywords:** ICT, virtual physics laboratory, higher education, innovative teaching methods.

## 1. Introduction

Currently, the rapid development of information and communication technologies (ICT) leads to the fact that they invariably penetrate into all spheres of our lives, radically affecting the processes and changing them [1, 2]. The scope of education in general and higher education in particular are no exception [3, 4, 5]. The introduction of new ICT, along with the computerization of educational institutions and the innovative activity of the teaching staff of higher education institutions, are the main directions of the comprehensive modernization of education, which are given special attention not only in Kazakhstan but throughout the world [6, 7, 8, 9]. The program "Digital Kazakhstan", developed by the government of the republic, is an example. One of the goals of this program is to increase the digital literacy of the people, including average, technical and vocational, higher education, training and retraining of personnel. The world trend is industry 4.0, the massive introduction of cyberphysical systems, such as artificial intelligence, virtual and augmented reality, quantum computing, 3D printing, autonomous robots in production and everyday life, including education.

## 2. General

The application of innovative teaching methods and new ways of interaction between teachers and students also leads to the renewal of the educational process. At the International Information Technology University (IITU), Almaty, Kazakhstan, which is the leader in Central Asia for the preparation of highly qualified, internationally recognized IT specialists for the region, 40 educational programs are being developed jointly with the leading universities of the Republic of Kazakhstan. 28 educational programs out of 40 in 9 specialties are tested in IITU. For example, the specialty «Computing engineering and telecommunication» offers students a choice of 4 educational programs: applied cybernetics, data mining, Networking, System Administration and Software Development. There are 3 programs on the specialty «Information Security Systems»: Computer security, Network security and Hardware security. There are 2 programs on the specialty «Radio engineering, electronics and telecommunications»: Radio technical information transmission systems and Telecommunication systems and networks. These educational programs make possible to train demanded and qualified specialists who possess new knowledge and technologies.

A significant impact on the educational process has the participation of the university in the projects Erasmus+ of the European Commission on Education. Two projects Erasmus + ECCUM and ACADEMICA involved a significant amount of the university teaching staff.

The project ACADEMICA («Accessibility and Harmonization of Higher Education in Central Asia through Curriculum Modernization and Development») is a three-year project co-funded by the European Commission in the framework of ERASMUS Plus Programme: Cooperation for innovation and the exchange of good practices. The Project is carried out under the centralized activity «Capacity-building in the Field of Higher Education». The Project Consortium comprises 15 organizations from seven European and Central Asian countries – Bulgaria, Austria, Italy, Spain, Kazakhstan, Turkmenistan, and Uzbekistan. The motivation behind the Project is to bring together European institutions in higher education, which possess and supply cutting-edge developments, innovative learning practices and extensive international experience, and higher educational institutions from the abovementioned partner countries in Central Asia, which demand the same developments, practices and experience.

In the framework of the ACADEMICA Project the following objectives were set:

- Provision of an innovative methodology designed to integrate the theoretical and practical aspects of the courseware that would equip HE lecturers with transversal and key competences and skills necessary for their active inclusion in the global digital teaching and learning space.
- Provision of a more flexible accessibility to training chances thanks to the ICT-based training approaches implemented in learning environments with modern technological infrastructure;
- Modernization of the University curricula where the contemporary ICT-enhanced approaches and contents are integrated.
- Establishment of a joint, accessible and successful system of transnational co-operation among Universities thus achieving excellence by linking education and innovation on international basis.

The project ACADEMICA has allowed get acquainted wider and deeper with various methods of information technologies application, using them in teaching of their courses, enriching the contents and forms of the courses. The aims of the proposed methodology are: to facilitate the fast adaptation of the University education to rapidly changing demand of the labor market as well as to assure the attractive access, innovative preparation and new ways of knowledge deliverance, thus providing a great potential for the work force to acquire highly needed skills and competences.

48 teachers of IITU have been trained in the use of this methodology. During the experiment phase of the project, the teachers applied the acquired knowledge in the teaching of their courses. They used such tools as LMS, Online library, virtual classes, virtual labs, online questionnaires, Communication tools (messaging systems, forums, audio and video conferencing tools, social networks and channels, etc.) were used.

The project ECCUM (Establishment of Computing Centers and Curriculum Development in Mathematical Engineering Master program) stresses that Engineering mathematics is at the core of all branches of engineering, from aerospace engineering to electronics; from mechanical engineering to computer science. The reasons of the project are the need for the use of high-hume technologies to strengthen industrial, economic capacities, insufficient awareness of available appropriate technologies; existing educational programs in mathematics sometimes has lack of practical outcome. So, IITU participating in the project aims to strengthen academic capacity of experts on mathematical engineering via development and implementation of interdisciplinary Master programme "Mathematical Engineering" through collaboration with all stakeholders for enhancing the scientific potential on Mathematical engineering and professional development of in-service specialists.

The IITU has experience of using IT in the educational process. For example, in the discipline «Physics» classes are conducted with the use of technologies of augmented and virtual realities. There are virtual laboratory works, 3D animations, mobile application training developed by university teachers and students.

Virtual labs are gaining popularity among new learning tools. This is explained by the following. First, not always universities are able to equip real laboratories for carrying out educational experiments in various disciplines. This is related to financial issues, as well as to the safety of students. In addition, not all experiments can be done on the basis of a training laboratory. In such cases, the use of virtual laboratories is an excellent way out of this situation. They allow you to set up experiments many times with minimal costs and absolutely safe for others. And with the development of ICT, the use of virtual laboratories in the educational process is becoming more accessible. Secondly, such teaching aids are indispensable in cases of impossibility of access to real facilities, for example, in distance education, which is also becoming more common with the development of ICT.

### 3. Results

At the IITU, the Department of Computer Engineering and Telecommunication has been working on the development of virtual laboratory in three languages (Kazakh, Russian and English) with elements of 3D computer modeling in the discipline «Physics».

The developed virtual laboratory on discipline «Physics» (Fig. 1) consists of laboratory works on such topics as mechanics, dynamics, thermodynamics, hydrodynamics, electricity and magnetism, optics, atomic and quantum physics.

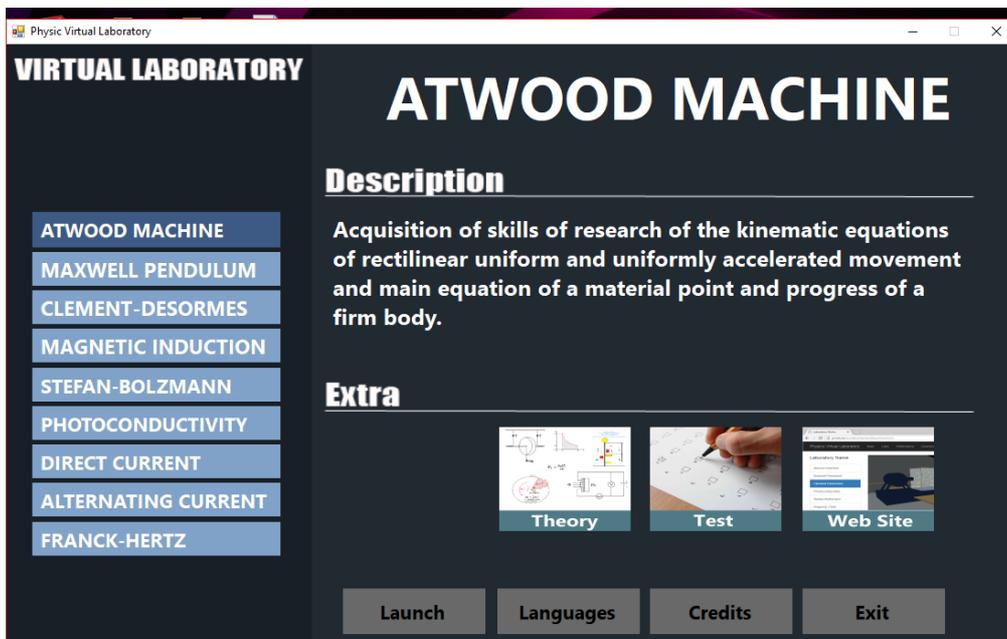


Figure 1. Main window of the Virtual physics laboratory

Virtual physics laboratory contains instructions and methodological instructions for the execution of works constructed in a uniform manner, in an approximate form:

- goal of the work,
- theoretical material,
- experimental installation,
- the order of performance of work,
- report.

A mobile application with the use of Augmented Reality (AR) technology, a set of practical tasks and experiments in physics shown in Fig. 2. This technology has a positive impact on motivation, attention, concentration and discipline. The application allows you to change the parameters of the task, which allow you to observe the change in the process under different conditions. This approach makes the user to be an active participant in the assignment, the

material becomes more accessible for understanding through a visual demonstration of the studied processes.



Figure 2. Example of a mobile application with Augmented Reality technology

The developed application using Virtual Reality (VR) technology (Fig. 3) allows users to conduct experiments on physics in a virtual laboratory, as if they were in a real one. The application works with a wired motion sensor Leap Motion, designed for manual tracking in virtual reality.

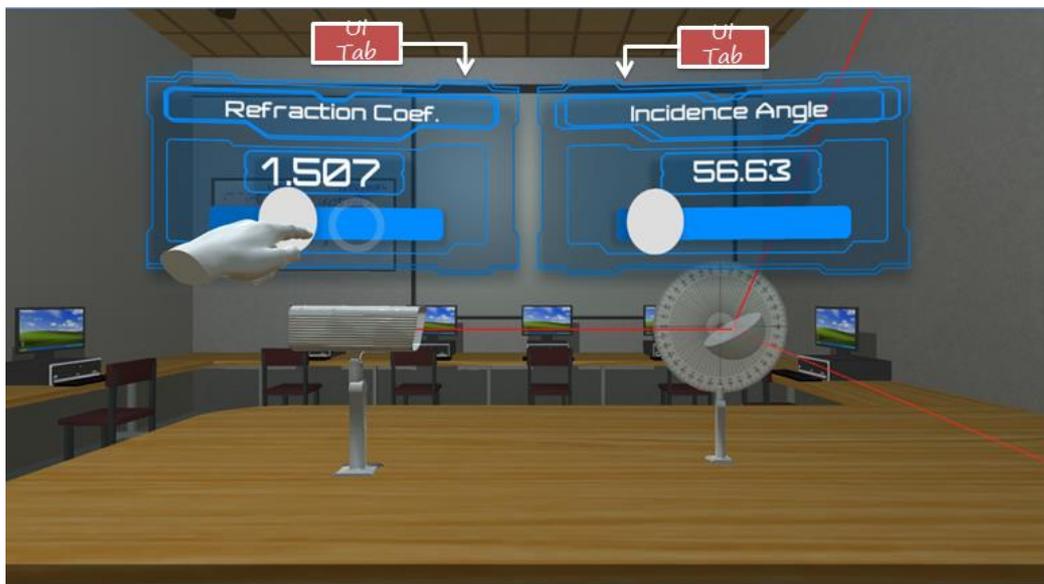


Figure 3. Screenshot of the application using virtual reality technology

The application contains virtual laboratory works from the sections of electricity and magnetism, wave and geometric optics. This development is a good example of the use of new technologies in the educational process.

#### 4. Conclusion

Thus, modern ICT allow for any form of educational activities, open up broad prospects for the creation of original and sometimes radically new training programs. We believe that developed

virtual laboratory on discipline «Physics» for students of higher educational institutions of science and technical specialties, is a modern incarnation of an innovative new generation of computerized learning systems. Currently, the authors are constantly working on the development of the new virtual laboratory and work over the integration into it. It became possible thanks to the funding of the Ministry of Education and Science of the Republic of Kazakhstan 2018-2020 (No. AP05135692).

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# THE ROLE OF ICT IN PREPARING STUDENTS TO WORK ON PROJECTS IN THE VIRTUAL WORKPLACE

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**Abstract:** *Virtual workplaces are adopted increasingly by organizations that wish to attract the right kind of talents and in many cases for the purpose of carrying out specific kinds of projects which might require more skills than the current employee competence might cover. The current students been trained to enter the workplace provide researchers necessary insight into how the workplace could be shaped to provide more benefits to organizations and ensure employee satisfaction. There has been attempts to identify the necessary conditions and factors that ensure the success of projects in light of the role of tasks that are carried out in the virtual workplace, and Information and Communication Technology (ICT) is said to be the pivot on which this work form is built. The evaluation of the perception of the importance of ICT to the readiness of students of technology management provides an insight into how successful projects that require diverse skillset and competence could be organizations. Qualitative research is carried out through interviews of randomly selected students over 3 academic semesters with most having the perception that ICT training and skill development has played a role in preparing them for virtual workplaces in future and those who did not have same perception indicated that individual disposition, Nature of the project and The structure and leadership of the assigned team might play greater roles in their readiness to work in such virtual workplaces.*

**Keywords:** virtual workplaces, project teams, Information and communication technology, Workplace readiness

## **1. Introduction**

The way the workplace is shaped today is dynamic and very disruptive of the traditional workplace configuration in many organizations. Employees are expected to have diverse skills and be able to fit into functions and processes that takes takes the work task away from a physical space (traditional office) and makes it possible to perform such tasks virtually. [6] have argued that virtual workplaces depend on effective communication through Information and Communication Technologies (ICT) usage, and other dimensions of inquiry has been attempted for understanding the importance and place of ICT in the success of virtual work [6, 7, 8]. ICT has been conceptualised over time by many scholars in many areas of inquiry usage such as business, education, society among others [12]. And the range of influence for ICT and professionals in the field would include “academic disciplinary bodies, educationalists, government, industry, professional standards bodies, students, and community”. There is however a need to understand how ready new entrants into the organizations that have at least some part of their work functions in the virtual workplace, and evaluate using developed frameworks their perceived readiness and satisfaction.

There have been many frameworks that have tried to map out the skills needed in the 21st century for work and life satisfaction. The 21st century is quite different than the 20th in the capabilities people need for work, citizenship, and self-actualization. 21st century skills are different than 20th century skills primarily due to the emergence of very

sophisticated information and communications technologies. For example, the types of work done by people as opposed to the kinds of labour done by machines are continually shifting as computers and telecommunications expand their capabilities to accomplish human tasks.

## 2. Virtual workplace and ICT

[4] have argued that the term “virtual” is often used to differentiate work environments where individuals are physically or temporally dispersed. Such work environments include individuals working at home (telecommuting) as well as teams of employees from different organizations who manage a supply chain, pulled together based on skill and not location. Other than being physically dispersed and not located in the same place, individuals who work under such circumstances could describe their work as “virtual” since the medium for carrying out work is via computer, employing simulated images and processes rather than exchanges of physical materials and performance of physical processes. Central to the adoption of virtual work in organizations is the use of ICT, and other technologies geared towards easy communication, information sharing and collaboration under a safe and controlled environment [4, 5, 6].

Some of the earlier investigations into virtual work involved a closer look at employees – employers’ relationships. [9] states that a “virtual worker” might be a contingent or contract employee who is self-employed and has no dominant organizational affiliation but has temporary relationships with multiple organizations, this paradigm has changed greatly in present day, more and more organizations are opening up to virtual work forms. These electronically connected contractors, or e-lancers, are part of the move from an economy whose fundamental unit is command-and-control organizations to one based on the work of individuals [10]. According to [11] “virtual” is also used to describe new kinds of inter-organizational relationships. For example, employees of multiple organizations may collaborate to develop a product, provide a service, or foster new legislation on a project bases. Even as individuals cooperate to achieve a common goal, they retain their membership in different organizations. These inter-organizational partnerships may be temporary, as in the case of a product-development team, or may be more long-standing, such as a procurement team in a supply chain. There is therefore a need to understand how future employees of these organizations see this workplaces, the roles they are expected to play in this settings as well as their perception about the role of ICT skills and competences to their success in this kind of workplace.

Insights from The Partnership for 21st Century Skills Framework [13] suggest that Information and communications technology (ICT) literacy is the ability to use technology to develop 21st century **content knowledge and skills**, in the context of learning core subjects. Students must be able to use technology to learn content and skills – so that:

- they know how to learn,
- think critically,
- solve problems,
- use information,
- communicate,
- innovate and collaborate.

## 3. Research Method

To investigate how well students, think their university education prepared them for the working on projects in the virtual workplace, we conducted qualitative case study of 3 groups over 3 academic semesters. As is typical in qualitative research, our sample was relatively small. We interviewed university students, 4 students were interviewed from the first cohort, 4 from the second cohort and 3 selected from the third group of students who were all students of Technology Management, they were all studying and utilizing Information and communication technology

extensively especially for carry out collaborative assignments and group work making them a suitable sample for the current study. The students were chosen randomly from a list of participants in a new product development course which exposed students to collaborative work and projects which simulated the real situation in a standard workplace that allowed employees to work virtually with their colleagues on projects. All but one student was in their 3th year of studies, all but two were in their early 20s, all had English as their first language, and five of the eleven were female.

#### **4. Results and Conclusion**

This paper identifies the student's standards for technology in curriculum obtained from the review of the frameworks listed above, and applies it as an evaluation mechanism for evaluating the perceived role ICT has in enabling students develop needed skills for working on projects in the virtual workplace.

In our bid to emphasize the ways in which information and communications technology skills are central to the 21st century projects especially the ones executed in the virtual workplace we propose a research framework that is based off the revised International Society for Technology in Education (ISTE 2007) conceptual framework for digital literacy, With focus on the following six dimensions:

- Creativity and Innovation
- Communication and Collaboration
- Research and Information Fluency
- Critical Thinking, Problem Solving, and Decision Making
- Digital Citizenship
- Technology Operations and Concepts

As a result, our findings from interview responses aligns in some cases with the proposals of the International Society for Technology in Education (ISTE 2007) conceptual framework for digital literacy. Since as suggested by the ISTE ICT skills, “creating original works as a means of personal or group expression,” “identifying trends and forecasting possibilities.” were the most important elements that indicated how ICT prepared students to work on projects in the virtual workplace. Furthermore “identifying and defining authentic problems and significant questions for investigation” was one of the skills that drove collaboration and the desire to work together in teams. Other capabilities include “using multiple processes and diverse perspectives to explore alternative solutions.” “Safe, legal” use of information and technology is highlighted, as is “digital citizenship.”

“Troubleshooting systems and applications” and “transferring current knowledge to learning of new technologies” are seen as key skills ICT provides students with to prepare them for virtual projects. Potential factors in the differences in perception of students that thought ICT played a role in preparing them for virtual workplaces in future and those who did not have same perception may be isolated to include individual disposition, Nature of the project and The structure and leadership of the assigned team.

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# WHAT IS RUHRVALLEY – AND IF YES, HOW MANY?

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**Abstract:** *Identity-based brand development is a process which, in its initial phase, exclusively involves internal target groups and their view on and description of intended brand characteristics. These form the “Brand Identity”. Analogous to human identity development, a brand identity is formed over time through interaction, reflection and further development, with the difference that it equates a group self-understanding. A strong brand develops when intended brand benefits (internal side) match with externally perceived benefits and requirements (external side). Considering a brand’s long-term contribution to business success, the importance of brand management as a strategic approach is not to be underestimated. ruhrvalley, an innovation ecosystem in which a large, heterogeneous consortium of partners from industry and academia cooperates interdisciplinary, aims to develop a strong brand. It faces the challenge of multiple brand perceptions. Given these circumstances, it gets more and more important for the strategic marketing and brand development to provide illustrated information on functions ruhrvalley takes, domains it operates in and also the impact it can have on the region.*

**Keywords:** brand identity development, identity-based brand management, innovation ecosystem

## 1. Introduction

First priority in marketing and communication for the industry-university cooperation ruhrvalley is the formulation of a (brand) identity: What is ruhrvalley? Can it be formulated as one identity? ruhrvalley equals something that nowadays is called “innovation ecosystem”, a structure that shapes an environment for innovation to grow. In particular, the ruhrvalley ecosystem covers a cooperating consortium from industry and academia located in the Ruhr Valley (or Ruhr area, “Ruhrgebiet”) [12] that aims to initiate innovation and thus new businesses and jobs in the area. By a projectized approach of collaboration, it composes local partners, technical projects and project cooperation formats. The ruhrvalley marketing is currently facing the challenge to develop a strong brand.

Nowadays, in order to be economically successful, products and services offered on the market need to be unique more than ever. Increasingly saturated markets as well as the big variety of services and their functional interchangeability triggered by globalization challenges companies and all sorts of organisations to stand out. Customer demands grow due to the large supply and must be served beyond the mere functionality of services [6]. This causes brands to enormously gain in importance. Strong brands add significant economic value by helping to differentiate from the competition. They are defined as a benefit bundle with specific characteristics that, from the relevant target groups’ perspective, sustainably differentiates the benefit bundle from others that meet the same basic needs [2]. To serve these changing demands, abstract brand elements complement the so called brand identity in the brand development process.

The following paper provides insights on the topic of brand identity development and its challenges for large, heterogeneous project organisations like the *ruhrvalley innovation ecosystem*. Section 2 presents the idea of identity-based brand management (marketing and brand theory) while section 3 focusses on innovation ecosystems and illustrates different views on the ruhrvalley innovation ecosystem in particular (object to be branded). In section 4 the focus shifts

to the challenges of branding the ruhrvalley innovation ecosystem, giving and explaining possible reasons and providing an overview of the multiple and diverging perceptions on ruhrvalley functions. As this perception diversity and also unresolved issues exist, further research becomes even more important (suggested in section 5). Section 6 ultimately concludes the paper.

## 2. State of the Art: Identity-based Brand Management

Over time, the understanding of brands and strategic brand management has evolved to an identity-based understanding, attributing an identity-creating role that empowers consumers (partners) to express their beliefs and attitudes through purchase (here rather membership). Such a symbolic benefit allows the fulfilment of customer needs beyond functional features [5]. The elements shaping a brand identity are summarized in the concept of identity-based brand management.

The model complements to the approach in business economics that brand success is solely depending on the optimal adaptation to customer demand (“outside-in perspective”) an “inside-out perspective”. This in turn analyses the internal target groups’ self-perception of sustainable brand characteristics, called brand identity, and attaches great importance to it in the process of brand development. The identity-based approach thus regards brand management as a holistic concept, which is characterized by the integration of the internal and external viewpoint on a brand and their reciprocal relationship [4] [8] [2].

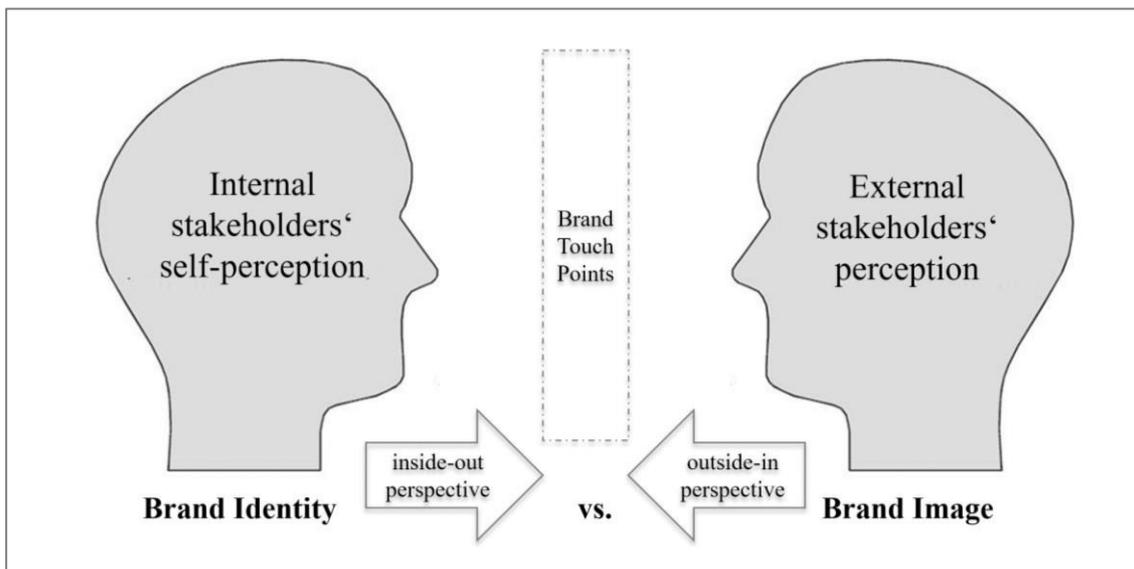


Fig. 1: Brand Identity vs. Brand Image - Visualisation of internal and external brand perception and interrelation (own illustration, following Burmann [4])

The left side of fig. 1 shows the internal stakeholders’ self-perception (**brand identity**) encountering the external stakeholders’ perception (**brand image**) through contact points (**brand touch points**). Strong, authentic brands develop when perceptions correspond [3]. In case of ruhrvalley, matching internal and external perception is subordinate. The precondition to build a strong, authentic brand is to consider unique characteristics from an endogenous perspective. This results in internal stakeholders being the most relevant target group.

A brand identity is created by the combination of the different, compatible characteristics and features of the six identity components shown in fig. 2. They interrelate and influence each other. The importance of the individual components varies among context and time. However, a coherent picture is indispensable to be perceived as an authentic brand [4].

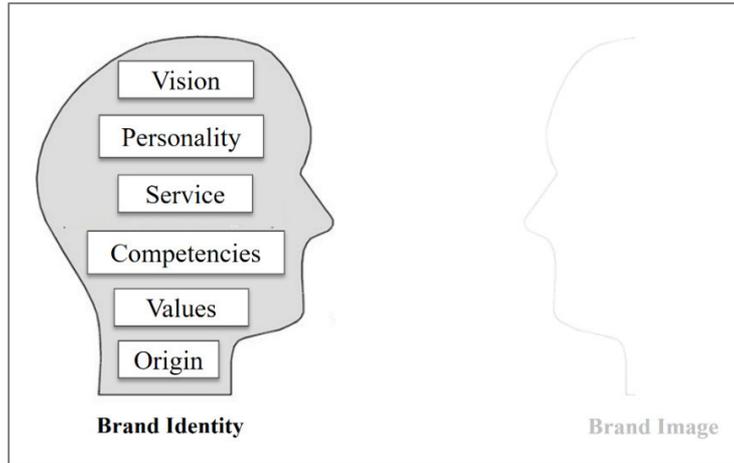


Fig. 2: Brand identity components (own illustration, following Burmann [4])

Tab. 1 further describes the brand identity components named in fig. 2.

Tab. 1: Description of brand identity components

Component	Question	Description
<b>Origin</b>	Where do we come from?	Regional, cultural and institutional origin or background; institutional character often determined by founders or leaders [2] [3]
<b>Values</b>	What do we believe in?	Core beliefs of internal stakeholders; non-functional and symbolic utility; rather emotional facet in brand identity [3]
<b>Competencies</b>	What are our capabilities?	Abilities, that create customer value and which initiate a willingness to purchase; mostly based on advanced (level and time) knowledge of individuals, thus of temporary character [2], which causes competency development seen to be an outcome of human capital investments [2] [4] [3]
<b>Service</b>	What do we offer?	Functional utility for customers (products, services); based on competencies [2]
<b>Personality</b>	How do we communicate?	Defining the rather human traits in brand identity; verbal and non-verbal style of communication by internal stakeholders functioning as brand ambassadors [2]
<b>Vision</b>	Where do we want to go?	Medium- and long-term direction of development; Motivational function [3]

As the long-term direction of development is of high interest for the ruhrvalley stakeholders at present due to a, so far, missing verbalized consensus, the **vision** component is ranked a very influential one in the brand identity creation. Moreover, institutional backgrounds of partners/stakeholders (like universities, large companies, start-ups, SME, government) are, by experience, estimated to be a potential explanation for occurring inconsistencies which therefore attribute an influential role in shaping the internal brand perception to the component **origin**. The following section 3 therefore describes future prospects for ruhrvalley (vision) whereas section 4 deals with explanations for the lack of an agreed verbalized vision tracing it back to origin-related reasons.

### 3. ruhrvalley Innovation Ecosystem

Collaboration in ruhrvalley works on a projectized level in different project formats and with various partners from electric mobility, energy systems, digital transformation involved, claiming “Mobility and Energy for Metropolitan Change” [13]. In 2015 several players located in the Ruhr

area joined forces and, along with clusters from other areas, participated in the competitive funding programme “FH Impuls” by the German Federal Government. Ultimately ruhrvalley was one of the ten winning clusters in the competition. The government’s monetary input (8-year-plan with 10 Mio. EUR and several Mio. EUR industry funding) is now used funding and implementing several research projects in order to intensify collaborative work between universities and industry, to create innovative solutions and generate new projects that ultimately lead to business ideas and start-up formation. At present, ruhrvalley contains three large universities of applied sciences (Hochschule Bochum, Fachhochschule Dortmund, Westfälische Hochschule), seven of their research institutes, 20 spin off companies and 35+ associated and project partners. The project portfolio is orchestrated by a management entity complemented by several governance boards.

These industry-university research activities contribute to an overall system which ruhrvalley participants associate with an *innovation ecosystem*.

### *Innovation Ecosystem*

Literature suggests only approximate definitions of the phenomenon “innovation ecosystem”. Concentrating on the word’s origin it can easily be understood. “Ecosystem” in ecology is defined as a “biological community of interacting organisms and their physical environment” and transmitted to general use “a complex network or interconnected system” [9]. “Innovation” adds the focus. Probably one of the most known innovation ecosystems is the Silicon Valley [10] which creates innovation constantly. Ecosystems allow companies/organizations to create value that no single company/organisation could create alone [1].

The traditional view on a (eco)system that creates innovation in a cooperation of academia and industry is called knowledge triangle. It links three components: **education, research** and **business**. Innovation is seen to be created when fostering the systemic interaction of these three forms of activities [11].

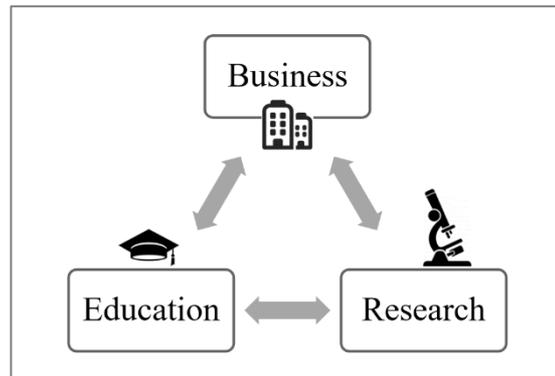


Fig. 3: Knowledge triangle (own illustration, following [11])

### *The Innovation Ecosystem ruhrvalley*

The successful implementation of the ruhrvalley ecosystem is expected to be more complex and difficult to describe. In this case, the knowledge triangle needs a redesign as it lacks a sufficient explanation on key determinants for successful collaboration between industry and academia. The two views (or perspectives) provided below (see fig. 4 and 5) can be regarded as an extended version of fig. 3. They try to formulate specific descriptions of the ruhrvalley innovation ecosystem based on generalized **cause-and-effect-chains** [13] whose content in turn is derived from a comprehensive **illustration of the relevant domains** (see fig. 5) of ruhrvalley activities or functions.



Fig. 4: Vision-driven cause-and-effect-chain (following [13])

As seen in fig. 4, the base for interaction in the ruhrvalley ecosystem is a large and diverse community of entrepreneurs and scientists with their ideas (**input**), that in turn creates projects, cooperation and know-how transfer across disciplines (**output**) and therefore produces innovation, products, services and new businesses (**outcome**). These outcomes generate benefits for economy, society, environment and urban development which ultimately widen the scope of influence of the Ruhr metropolis in an international comparison (**impact**). Understanding the cause-and-effect-chain encourages innovative people to realize their ideas on the spot, in the Ruhr area. Having an impact on the region's transformation in terms of sustainability in mobility and energy is in fact indirect but nevertheless powered by visionary orientation. The vision to make the Ruhr Valley a desirable and inspiring environment to work and live therefore can trigger an accelerated innovation pace and performance improvements. In order to attract likewise innovation-affine people, not only the vision but the strong connection of all parts that are substantial and unique in the ruhrvalley system (at large: **brand identity**) needs to be communicated.

The implementation of such a holistic idea requires a logical illustration of thematic domains covered in the ecosystem. Fig. 5 therefore visualizes the five domains of the ruhrvalley innovation ecosystem as well as their interconnections while tab. 2 provides the domain's descriptions.

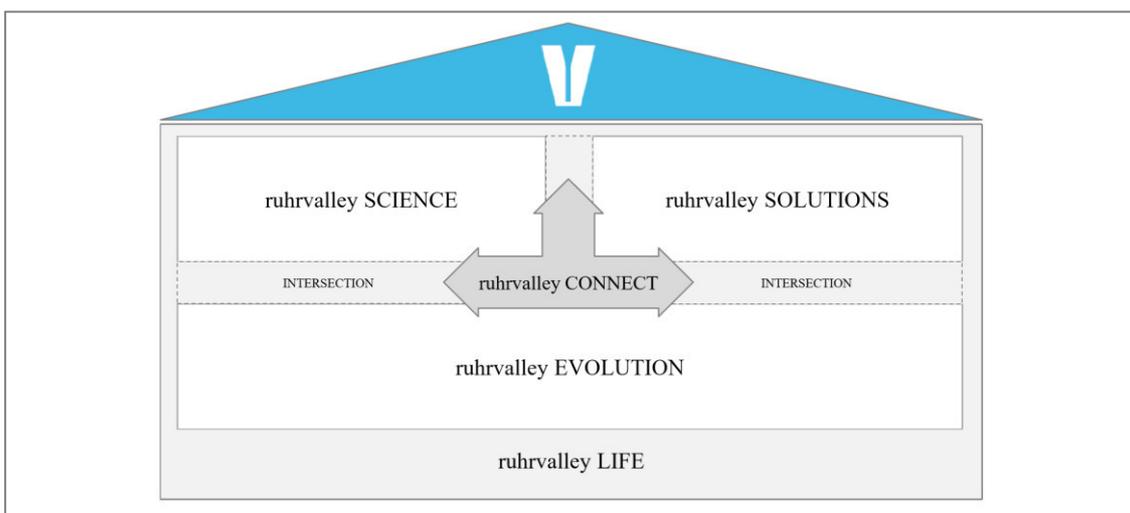


Fig. 5: Domains in ruhrvalley innovation ecosystem [7]

Tab. 2: Descriptions of ruhrvalley domains [7]

Domain	Description
<b>ruhrvalley science</b>	Scientific research and cooperation with focus on universities
<b>ruhrvalley solutions</b>	Turning innovation into products and service; main focus on businesses and entrepreneurship; involving the establishment of a start-up community
<b>ruhrvalley evolution</b>	Change as a chance! Openness towards new approaches and the search for inspiration; experimental space for e.g. business models or innovation resulting from projects (esp. from solutions domain)
<b>ruhrvalley connect</b>	Management and networking entity; ensuring communication and event organisation; covering also B2B management, marketing and brand development, public relations, personnel development ...)
<b>ruhrvalley life</b>	Turning the region into the place to be, to work, to live; addressing innovative people and topics like culture, community; making innovation tangible and available; socio-economic contribution

The domains shown in fig. 5 are not be considered in isolation, as they mutually influence each other and naturally entail thematic overlaps which are pictured as **intersections**. Complementary areas like academia (**ruhrvalley science**), industry (**ruhrvalley solutions**) and society (**ruhrvalley life**) focus topics like innovation, technology and collaboration, stimulate each other, foster application-oriented and sustainable innovation and can only fully evolve (**ruhrvalley evolution**) when being interconnected. Functioning as a management and control cockpit, **ruhrvalley connect** in turn focusses on bringing together and balancing all areas and is therefore characterised as the bridging component in the innovation ecosystem ruhrvalley. The claim “Mobility and Energy for Metropolitan Change” marks a thematic starting point and leaves a wide margin for future influential topics to be added.

By the cause-and-effect view (fig. 4) and the domain view (fig. 5), different aspects of the same innovation ecosystem (ruhrvalley) are emphasized. The domains can be considered as vertical columns in the horizontal layers of the cause-and-effect-chain. Nevertheless, cause-and-effects do not spread over domains equally. ruhrvalley science and ruhrvalley solutions for example mainly cover the input-output-outcome layers aiming especially for innovation outcomes. The impact layer is the main domain of ruhrvalley life while ruhrvalley connect and ruhrvalley evolution address the input layer to a certain extent.

#### 4. Problem Statement: How Many Is ruhrvalley?

After two years of work on marketing-related topics within the ruhrvalley context, it has been experienced that the name “ruhrvalley” triggers several and diverging mental associations that partly differ from one another or have only small overlaps. In order to enable people to comprehend the overall ideas, time and effort needs to be invested in communication. As a whole, ruhrvalley encounters multiple and diverging classifications concerning:

- a) **functions** it takes and the prioritisation of these (see tab. 3)
- b) reasonable **domains** that need to be covered (see fig. 5) in order to pursuit **vision-derived goals** (see fig. 4)
- c) **understandable, significant and consistent explanation** of the construct *ruhrvalley innovation ecosystem*, (strongly derived from a) and b)) which leads to an overall picture, namely the brand identity, and only then can support the development of a strong brand

An emerging assumption, based on the mentioned two-year-ruhrvalley-marketing experiences, is that these diverging classifications can be traced back to individual experiences of stakeholders, which build the base for viewing issues like e.g. goals or motivation. Transmitted to brand theory,

this justifies a “conflicting” relation of origin and vision. Partners of several institutional backgrounds (origin) participate in ruhrvalley and interpret the vision, a driving force and verbalization of the intended impact under uncertainty, with individual experiences taken into account.

Why does ruhrvalley require from partners to move ahead of their origins and why does this push them into a zone outside known thinking patterns? The following three reasons try to provide explanations for the phenomena mentioned above:

### *Complexity*

ruhrvalley as a whole might be characterised as

- a new type of organization
- with a limited degree of structure that
- works in agile, dynamic project teams and is
- consisting of a heterogeneous consortium from academia and industry,
- collaborating across disciplines and
- with indeterminate boundaries (in terms of target groups and topic relations).

This new and complex system is, so far, perceived confusing. Other reasons are related to diverging perceptions in terms of the factors *time* and *scope*.

### *Diverging Perception of Timeline*

A brand identity is created by self-attributed features and by then experiencing what they suggest. When a predetermined “self”-perception is externally dictated, no one will identify oneself with the ideas given. Consequently, a brand identity takes time to evolve, needs to be accepted as constant work that has no predefined outcome to be communicated from the start and requires likewise patience and acceptance as a value-adding part in any business. The ability and willingness to accept time-consuming processes vary from person to person. For ruhrvalley, by experience, this willingness has been limited so far, since stakeholders believed to have already fully understood and at once to be able to predefine the ecosystem. This limited also the acceptance for time-consuming communication and brand evolution.

Also, the extent to which people perceive a timeframe tangible/acceptable or not cannot be standardized. For instance, the classification whether a target achievement (meaning vision and vision-derived goals) within a given timeframe is perceived realistic or unrealistic is highly individual. That especially affects the extent of the ruhrvalley vision being able to provide a motivational function.

Working in the field of innovation in a fast moving environment of technical progress, there is a high conflict potential when it comes to estimating and implementing an appropriate pace of work and collaboration in projects. By experience, compromises in these terms potentially weaken two partner’s motivations to enter collaborative projects. Taking e.g. a research institute and an industry partner: The research side is interested in finding customers and application for their detailed research findings, while the industry side’s motivation is the extraction of fast inspiration or full solutions within a short period of time. Detailed research implies time-consuming processes and therefore conflicts with fast solution extraction. Ultimately it needs patience from all participants to get a feeling for realistic project outcome expectations.

### *Diverging Perception of Scope*

Any stakeholder, on a personal as well as professional level, lives in his or her own reality of life that finds overlaps with topics and circumstances in ruhrvalley but in turn will never cover the

full picture. The boundaries set by every of these individuals shape their own understanding of issues and willingness to understand other views. Each stakeholder group or individual contributes to areas covered in the overall ruhrvalley innovation ecosystem and therefore mainly sees the things happening within their familiar scope. Conflict potential then occurs when it comes to the question of power that requests a decision on the “correct” view of the “true” ruhrvalley purpose (see tab. 3). However, each contribution supports the brand, simply in different functions. Concluding, each perceived function is somehow justified.

In addition, there can be a serious potential of misunderstanding and conflicts when assumed that every ruhrvalley participant’s scope (which can be compared to the ruhrvalley function an individual sees), is equal (see tab. 3). The following orientation therefore provides observations of different functions (**description**) that were voiced and attributed to ruhrvalley by stakeholders (**target group**) within the past three years. Outcomes (**interest, motivation**) these stakeholders had in mind are covered in ruhrvalley domains (**allocation**) but again do not cover the full picture.

Tab. 3: Observed point of views on ruhrvalley functions

Description	Target Group	Interest, Motivation	Allocation
Research Project, Research Partnership, University Cooperation	Universities, Institutes, Scientists, Scientific staff	Public funds, Political attention, University reputation	SCIENCE
Industry-University- Cluster/ Cooperation	Companies, Universities, Government	Innovation, Business success, Patents	SCIENCE, SOLUTIONS
Innovation and Technology Region	Regional Economic Development Agencies	New businesses, Business success, Economic development	SOLUTIONS, CONNECT
Innovation Community	Young Entrepreneurs, Innovators, Students	More young entrepreneurs	SOLUTIONS, EVOLUTION
Partner Network, Partner Association	Entrepreneurs, Start- ups, SME, Students	Matching: Partners or staff (Start-ups, SME), Jobs (Students)	SCIENCE, SOLUTIONS, CONNECT
Lobby Organisation, Topic-Related Cluster	Cities, Companies, Research Institutions	Promotion of the topic, Funding, Political influence	CONNECT
Special Place: Transformed Ruhr Area	Local Visionaries	Sentimental value: Place to be (Germany, Europe, globally)	EVOLUTION, LIFE

Consequently, each row shows different sections of a holistic view on ruhrvalley, covering parts of the overall innovation ecosystem. These existing views can be either: the personal perception of already lived reality or estimated functions that are seen to be met in future.

## 5. Further Research: Meeting the Challenges

Facing a huge variety of mental associations, ideas and perceptions offers the chance to have a holistic impact on the Ruhr area’s development and at the same time the risk of brand dilution due to inconsistent purpose confusion. There is a need for further research due to unresolved issues.

### *Emerging Questions*

- Can a brand identity (on complex and unfamiliar ground) be defined/created from inside or does it necessarily and exclusively evolve over time? Is therefore temporary confusion justified?
- In terms of highly dynamic and agile styles of cooperation: Wouldn't a description of a brand like ruhrvalley always be just a snapshot of the potential one sees at that specific point in time?
- Is it possible to explain comprehensively what ruhrvalley really is since it will only be an individual's perception/a group's view which is naturally not able to cover all potential?
- Is it realistic to reach a consistent self-perception in such a large and heterogeneous group like the ruhrvalley consortium? Does the classification "innovation ecosystem" meet all demands/cover all elements?
- Are the diverging mental associations and the creation of something "vague" a chance and an opportunity to trigger a "real" transformation?

### **6. Conclusion**

A consistent description of ruhrvalley is difficult. Creating an acceptance of the different ruhrvalley facets and empowering this diversity is therefore the primary challenge. Thus, constant communication, willingness to be addressed with topics outside known thinking-patterns and patience is indispensable for the brand to evolve and ruhrvalley to perform as a coherent overall (eco)system.

Further research on marketing and organizational development is to be pursued, so that in the near future an understandable, significant and consistent explanation (see section 4c) of "What is ruhrvalley – and if yes, how many?" can be provided intuitively.

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# SUSTAINABILITY KNOWLEDGE MODEL FOR PROJECT MANAGEMENT – THEORETICAL FRAMEWORK

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**Abstract:** *The project manager profession is quickly evolving to update the needs of the profession to the society and government requirements. There are more and more projects where the sustainability aspects have been a key factor for the project success. The project management standards and the academia are slowly modifying the theories but there is still working to be done. Mainly in the phase of transferring the knowledge generated in the academia to the practitioners. In this paper, the idea is to expose which are the main fields that are affected when the project manager focusses on the project success, without omitting the sustainability.*

**Keywords:** sustainability in project management, project knowledge management, project success.

## **1. Introduction**

There is a tendency on the academia to study how to integrate the sustainability in project management field [1]-[4]. To face this challenge and to transfer the generated knowledge from the academia to the practitioners, the authors have identified as key fields the following ones: Sustainability in Project Management, Project Knowledge Management and Project Success. There are studies that proposed that defining a project success framework, will positively impact on the acquisition and transfer stages of the knowledge management.[7]. Indeed, recent research results show that the sustainable perspective in PM can help to improve project success to reduce negative impact[8].

Indeed, while researching regarding the sustainability dimension, the authors have reached to the conclusion that this aspect is closely related with the knowledge dimension[9]. Knowledge is the most important resource needed for a project [6]. The literature review regarding the knowledge management that is involved in project management field is not sufficient; as the development of this research area has been started since the last 20 decades.

In previous works [5], there has been presented a model, where the existing Project Knowledge Model [6] has been modified, integrating the sustainability aspect. In this work, there has been an extended analysis of the knowledge that has been merged to construct the proposed model.

The structure of this paper is going to be the following: there is a section for the literature review, where it is going to be reviewed the three fields that are considered for building the theoretical framework. This output will be developed in the third section. At the end, there is a conclusion section to sum up the main ideas,

## **2. Literature review**

In this section, there has been done a summary of the main ideas and concepts that have been used to build the theoretical framework. There is a subsection for each of the fields that have been studied.

### **a. Sustainability in Project Management**

In the term “Sustainability in Project Management” there is an integration of two concepts: sustainability and project management. Nowadays, there are several works and researches made about how this integration could be done. There are many researches oriented to find the best way to merge the sustainability concept into project management [10]-[12]. As it has been mentioned before the sustainability is a key factor nowadays and it need to be included in the field like project management.

As it is referenced by Mauro Luiz Martens[13] the integration of sustainability issues in project management has a lack of research. It has not been considered for long time. In contrast, nowadays, there are many working group analysing and studying how this combination of concepts could be performed; as it was pointed there is no clear definition for this concept among practitioners. Nonetheless, the majority see this concept as the future tool in order to stay in business [14].

Based on the state of the art, related to sustainability in Project Management, it is broadly accepted the approach that has been proposed by the academia. This proposal considers that in order to be more sustainable, it needs to bear in mind six dimensions: people, planet, profit, short/mid/long term, local/regional/global orientation and value orientation. The six dimensions’ model is broadly accepted as it has been used as reference by other researchers [11].

#### **b. Project Knowledge Management**

The Project Management Body of Knowledge defines in the collection of processes that there are many explicit knowledge artefacts created, stored, accessed, used and updated throughout a project. However, there is not a specific area that works with the knowledge as the main agent. The knowledge management creates specific bodies of knowledge within a project; knowledge is essential to the successful completion of project goals. Some of this knowledge will remain tacit, but much of it needs to be made explicit, so that can be examined, verified, shared and made correct and complete. This is sometimes also collected as the lessons learned of the project; but in many occasions this is lost, due to the lack consciousness regarding the importance of the used knowledge.

Based on the ideas proposed by Nonaka [15], there has been developed different research work regarding the knowledge that is included in the project environment. Although, knowledge management in project environment is an insufficiently explored topic in project management as has been pointed by studies [16]. There are already research works that exposes that the mix of knowledge and expertise developed within project teams positively influences an organization’s long-term success.

As Gasik has exposed, knowledge is the most important resource needed for project management: proper knowledge is a basic prerequisite for effective project management. Basically, as Sankarasubramian pointed, all projects have one thing in common: knowledge.

#### **c. Project success**

Kerzner and Turner have been the first defining the criteria in order to measure the project success [17]. Project Management scholars generally agree on two component that define project success: success criteria and critical success factors [18]. The success criteria are oriented to objective measures; which has been pointed out that just these criteria fail to address broader factors of the project, as for instance, it is not considered the behavioural skills [19]. Besides, the success criteria are more commonly considered in the project management standards.

The researchers have developed different models for measure the project success [21]. Defining success factors represents a prerequisite for an organization’s success and an option for measuring its maturity level.

In contrast, the critical success factors are oriented to measure the “soft” aspects of the project; as customer satisfaction and are not usually considered. This evaluation has a more realistic approach, considering the soft dimension of the project.

The concepts that have been considered along the time have been modified for adapting; lately there are more and more projects that include the Triple Bottom Line dimensions to define the success ratio of a project that include more success criteria [18], [20].

Judged and Müller in their retrospective at project success; pointed that the approach of Pinto and Slevin [22] related to the Critical Success Factors is the most widely recognised and used measures of success factors. Besides, as the sustainability and the knowledge are closely related with the people, and considering the approach made in previous studies; for this study they are going to be used the four factors that are classified as “people related”. Researchers have consistently identified these factors as the keys to project success [23].

This critical success factors, based on the analysed made by Pinto [24] are the followings:

- 1) Troubleshooting; “handle unexpected crises and deviations from the plan”.
- 2) Effective communication with internal and external stakeholders; “the provision of an appropriate network and necessary data to all key actors in the project”.
- 3) Clear project mission; “initial clarify of goals and general directions”.
- 4) Top Management Support “willingness of top management to provide the necessary resources and authority power for project success”.

The correct definition of these aspects at the beginning of the project will collaborate in a positive output, as the objectives will be clear; and they could be correctly communicated inside the project team.

### 3. Theoretical framework

Based on the idea that sustainability in project management is characterize by the six key dimensions, these are going to be identified as the dimensions that need to be consider in the model [11].

The project success field has many approaches and varieties; based on the literature review described in the previous section, the four critical success factors have been selected as input as they are frequently used and are closely related to the project success, from the “soft” point of view.

Finally, the Project Knowledge Management Model has been used as reference to include the previously exposed dimensions and factors input to the processes of knowledge elements defined by Stanislaw Gasik [6] at project level. In that model, it was the first time, that the knowledge involved in a project is analysed in detailed manner. Indeed, the idea of having into account the knowledge as a key driver for the project success it has been already studied [7].

In the following Fig. 1, there is an extended graphical representation of which knowledge of each field mentioned above has been identified and used as input in the theoretical framework.

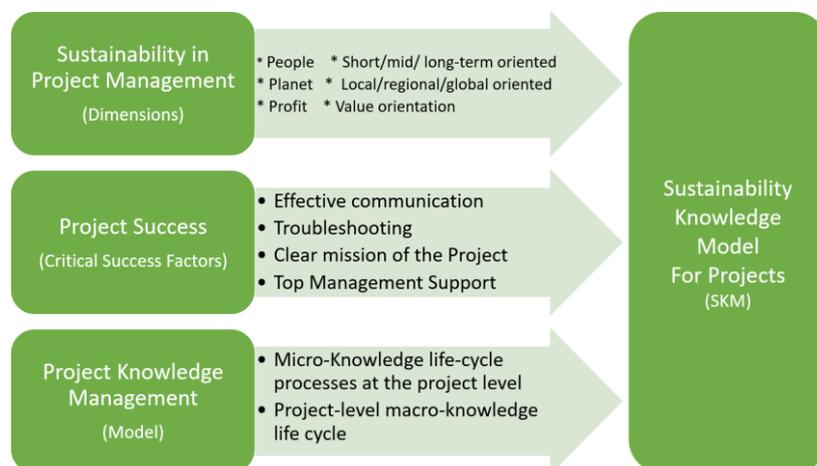


Figure 1. Theoretical Framework

The Sustainability Knowledge Model (SKM) for projects identifies the key factors that need to be considered in the process of integrating the sustainability in project management. The model is divided in three parts, as it has been explained in the literature review, in this integration there are implications from three fields. For each of it, there has been extracted the dimensions, factors and models that are going to be used as explicit input of the proposed model.

#### 4. Conclusions

The considerations explained in this contribution raised that the lack of knowledge management is one of the main reasons for project failure. Based on this idea, including sustainability aspects in the knowledge that is involved in project environment can be considered as a key factor to get to the integration.

The Sustainability Knowledge Model for project that is proposed in this study aims to identify which knowledge is required in order to perform the integration of sustainability in project management.

The proposal pushes the idea of developing a specific knowledge area in project management books where the sustainability knowledge of the project is included. Including these new concepts in the bodies of knowledge will directly contribute to step forward in the integration of sustainability in project management.

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# INVESTIGATING CHALLENGES IN THE COMMUNICATION FOR INTERCONNECTING TEST-LABORATORIES THROUGH THE IOT

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**Abstract:** Typically, undertaking tests in different test benches have been realized as complex, stationary, and usually locally operated systems. With the advances of IoT, this operation can be simplified, and test benches can be spread over different locations instead of being confined in one geographic place. The design of a network, which has its main test components connected through internet technologies, has to take care of certain aspects like real-time communication, safety while operating test benches, security of data, and more. The special feature compared to purely locally operating systems is the use of communication via an infrastructure shared with the public. Netlab therefore aims on interconnecting test benches, test simulations and test management distributed to different locations. This also includes the integration of mobile testing with live data from a test vehicle later on. Its main goal is to provide links for a technology chain, which enables companies to engineer and develop car components in a cooperative process independent of their location.

**Keywords:** distributed hardware testing, IOT, real-time communication

## 1. Introduction

The development of a new technical system, like the drive train of electrical vehicles is a cooperative process and includes different manufactures. Each manufacturer brings own hardware components into the system. Within the development process, testing of combined components poses a certain challenge. Typically, the hardware components need specialized test benches. When it comes down to integration tests, where multiple components are connected and tested simultaneously, tests have so far been realized as complex and stationary in local operated facilities. The challenge is to create a system, which enables the manufacturers to perform integration tests without being bound to one facility. The networking of systems is relevant for small and medium-sized enterprises (SMEs), since they usually have a high-level expertise for a partial component of the technical system but have to test it in complete system tests with corresponding system test benches. SMEs build up a cooperative development process, where the contributing partners form links of a technology chain.

The Netlab project addresses the development and implementation of a system for the digitization of test systems for distributed system testing. The project goal is the establishment of a test management and component testing, which are distributed to different facilities. The networking of tests and test bench components across locations raises problems, which are investigated in the project. Especially for the communication requirements in terms of real-time transmission, safety and security, as well as standards for interfaces and protocols have to be considered.

## 2. Current problem

The current problem with the test benches located in different geographical places is that they are not connected. Each test bench has its own local network with a local server controlling the

machines in the test benches. The server therefore manages test sequences. The local network within this test bench provides a real-time environment. Further, all data, which is accumulated during test, is stored locally. Apart from the local connections, there is no intersection with an external network or even the internet. Due to this architecture and to the developing and demanding requirements, problems have risen, such as:

- Complex tests may require the use of different test benches, distributed to the different facilities of the manufacturers. Having the electrical drive train as example, the battery is tested at location A against the motors in location B. The test includes exchange of values such as current and voltage from the battery to the motor test bench. At the same time, the motors use those as input values and send feedback to location A. In this case the need of precise timing is inevitable, bringing in the real-time requirements for the network and internet connection in one test.
- Online access to test benches for managing test runs is only available locally or through the server access using tools like TeamViewer. Still this does not allow controlling different test benches simultaneously. In a distributed system, the results must be available online.
- Processing the data is a complicated procedure, which is done after the completion of all the tests and the aggregation of test results from different test benches.
- The customer often has no direct access to the test bench. Initiating, controlling and reviewing the results of a test run then comes with a delay.

### **3. Netlab project solution**

At this specific subject Netlab researches on the usability of well-known IoT technology to achieve the suggested distributed test system. We choose the IoT domain as vantage point, as its paradigm of establishing machine-to-machine networks through the internet fits our project goals. IoT includes approaches for communication, middleware and applications, and also delivers solutions in the aspects of security and service management [1] [2]. Many features will be obtained by this new solution, such as:

- Connected test benches, which allows better data sharing, and task distribution.
- Online access to different test benches through cloud services.
- Remote control of tests and test benches through cloud services.
- Automated data processing through the lifespan of the test, which makes the process less complicated.
- Online data availability of measurements and additional customer information.

### **4. Discussion**

To establish a real-time communication between test management, system simulation, test benches and test cars we propose a high-level system architecture, which is depicted in Fig.1. As shown in the figure, the system represents a modular architecture, in which the complete test is divided into several sub tests, each representing a single component. These tests run on different test benches, which can be located in different geographical places. Each partial test is running on a different test bench within a LAN. The components of a test plant are being managed by a gateway, which manages the functionality of the test plant, resource sharing, etc. The tests include hardware test on test benches, but also simulations can be added.

Due to the splitting of the vehicle tests into different test benches, data has to be transferred from one system to the other to enable a simultaneous testing of all components, thus the full test. The data, which is exchanged between the models to enable a distributed test, is referred to as high-speed data with real-time requirements. Additional data is also communicated, but with a lower priority and can be said to have no real-time requirements, that is because it is not important for

the functioning of the test run. This data is mainly informative for the user; it can be information about the tests, measurements, logs, status, results, etc. The user can not only view information about the test, but also order and schedule tests to be undergone.

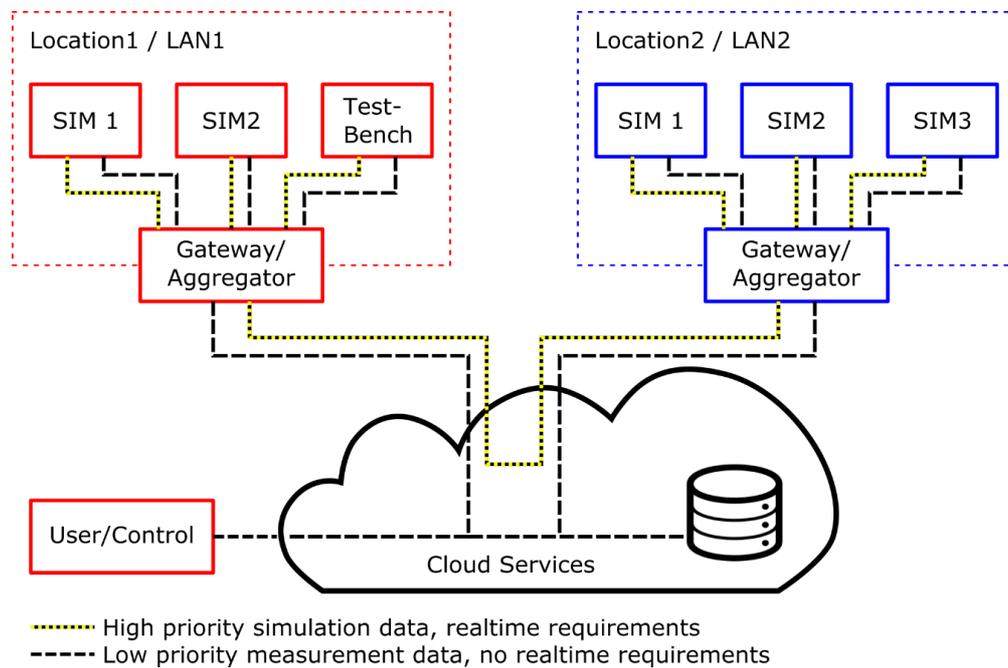


Figure 1. High level system architecture

A tests complexity increases with the number of components included. Each component adds an individual complexity to the system, as its amount and type of interfaces and internal processes differ from another component. In addition, components may run in a blocking-mode, interfering with the overall test concurrency. If not configured and timed correctly, deadlocks will shut down the test run. Here we identified the dependability as a major requirement for the communication. The concept of dependability is to make sure the system is not only running but also functioning correctly [3]. We further split up dependability in the subjects of availability, reliability, safety and security.

In terms of availability, at least all sub-systems mandatory for a test run must be available during that run. In certain cases, sub-systems of lesser priority like result presentation do not have to be highly available. The key features for availability have to be implemented in both the hardware and software.

In addition to availability, reliability of the overall test system should be ensured throughout the period of the testing time and to deliver its correct services; unreliability in the real-time communication will lead to long delays, loss of data, which will cause at some point wrong decisions to be made, which will result in an undependable system. Looking at the communication lanes or connections between single test benches, a full-meshed network can compensate dropouts of single connections or data loss due to bandwidth constraints. This increases the reliability. However, in the architecture depicted in Figure1, we decided that those meshes are not useful in our system, as they only add local reliability. Further, we assume that constraints and problems are related more to the internet connection than the local network. The idea of using test benches as local relays for concatenated benches is part of further work. In order to keep the system available and reliable, both attributes should be regarded by means of fault avoidance, fault detection, and fault toleration [4].

Besides the functional safety requirements, also the safety of hardware systems and interacting personal is under investigation. This includes preventive actions but also reactive routines that

are compliant with the distributed system. We are putting efforts in designing the systems specifications accordingly to also anticipating potential hardware failures.

Since the system is connected to the internet, security is more important as more attack vectors are included. For the Netlab project, testing facilities are being networked together through the cloud, and this connection should be secured. Adding network security protocols will enhance confidentiality, integrity and availability, however it will also add some serious demands on the system as well [5]. For example, encryption of the data will utilize network and system resources, such as bandwidth, processing power and memory. This can cause more delays, which can eventually result, for example, in deadlines being missed.

## 5. Conclusion

With the Netlab project, we introduced a possible approach in building up a distributed test system for hardware components like those of an electrical drive train. In this paper, we focus on the communication and its challenges. Especially the communication over shared connections through the internet, using cloud services raises demands in regards of dependability. Therefore, dependability is split in four subjects, which are discussed individually. This discussion shows the high-level challenges and decisions made in the proposed architecture. However, in further work the discussion has to get more into detail in the single subjects of dependability. In addition, the impacts of improving single sections like securing a connection and the impact on the delay have to be investigated in more detail.

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# HUMAN POSE MATCHING

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**Abstract:** *We present a novel approach to accurately compare poses of multiple persons in 2D pictures. The algorithm compares a model picture with an input picture and returns a score on how well they match disregarding the physiques of the persons. The poses on the pictures are defined by a pose estimator for both the model and input picture. A pose is composed by key points. Using these key points an affine transformation is computed. This searches for the best fit between the key points with only performing a translation, rotation, shear and scaling on the key point set. All these transformations don't affect the pose except for the rotation factor. This factor is used in the calculation of the score as well as the euclidean distance between the transformed input and the original model key points. The algorithm also compares the spatial relation between multiple persons on picture. To handle multiple persons in a picture, all the poses are correlated individually. To compare the interaction between poses, an affine transformation is again calculated with the key points of all poses*

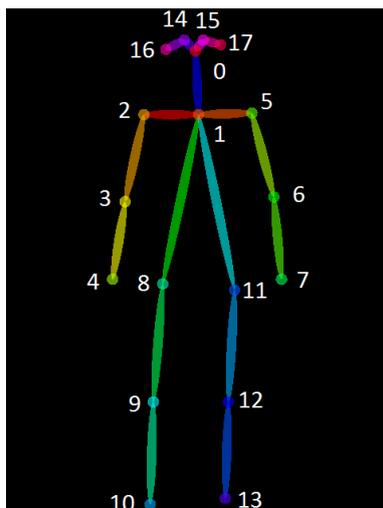
**Keywords:** Affine Transformation, Pose matching , human pose estimation, computer vision

## 1. Introduction

A social platform where people add or mimic poses in front of popular building all over the world, that's what Geoteam wanted to create. Geoteam (<https://www.geoteam.be/>) is an innovating company specialized in city games. The idea emerged from the famous photo where everyone is holding the Tower of Pisa from falling down. We want to challenge people to do as much poses possible all over the world and add some creative new ones to our platform. For this platform we need to compare poses. With our algorithm we are able to give feedback to the user on how well they mimicked the model pose with a score. A score is preferred above a boolean because even with the human eye it is difficult to decide which pose is right and which one is wrong. There are already a lot of image matching features extractors like SIFT, SURF, ORB and more [6]. But with these technologies we can't match different persons performing the same pose. That's why we used a pose estimator, named openpose and work with the 18 key points returned by openpose. In the first part of the paper we explain how we compare this 18 key points. In the second part we explain how to match multiple persons posing together on the photo.

## 2. Pose matching

In order to compare two human body poses with each other, we describe the human body in function of anatomical body key points. This discretization of the human body in a set of features, reduces the problem of matching human poses to the common problem of matching point sets in 2D. As mentioned before we use a pose estimator which returns these 18 body key point features in Fig. 1 for all persons in an image.



**Fig. 1.** Openpose 18 keypoints

(<https://github.com/CMU-Perceptual-Computing-Lab/openpose/blob/master/doc/output.md>)

A challenge presents itself when we try to match key point sets of different people due to the variances in physiques of persons and error margins of the pose estimator. The same poses of tall, skinny, heavy, etc. people should all match with each other. This means that we can't rely on absolute distances between points to describe a pose.

Our first and intuitive approach was measuring the angles between different sets of points. Using this method we can determine if the same sets of points have an equal angle between them. By combining all the angles and their differences we can calculate an overall score on how well poses match. While trying this approach we found out that the precision of the angle principle couldn't satisfy our wanted precision

Our second approach is calculating an affine transformation between all the key points of model and input poses. The devices our application aims for, makes pictures in different resolutions. Comparing key points on different resolutions requires normalizing. We normalize by extracting a box around the pose and redefine the key points in this box. For x values this means we look for the minimum and maximum x position of the pose. Then we use equation 1 for all the x values in the key point set. When the x values are normalized, we apply the same actions on the y values.

$$newx = \frac{x - Minx}{Maxx - Minx} (1)$$

With the normalized pose we can calculate the affine transformation. An affine transformation will search for a mathematical transformations to fit the input pose on the model pose. Rotation, shear, translation and scaling are the four transformations an affine transformation can apply. Scaling is needed to overcome the challenge of variations in the physique of people. A translation is needed when the person moves from the left of the picture to the right. Shear can be made when the position of the camera in relation to the position of the person changes. A big rotation factor does change the pose, requiring us to use the rotation factor in the compiling of the final score.

To calculate the final score we use two factors, the maximum normalized Euclidean distance between the transformed input pose key points and the corresponding model pose key points and the rotation factor. Because these two factors have a big difference in order of magnitude, we need to divide them by their order of magnitude. Resulting in a score that is equally influenced by both factors.

After testing the previous algorithms on multiple different persons performing the same pose, we concluded that body ratios still influence the final score of the algorithm. With body ratios we mean the ratios between the length of legs, arms, torso, ... . To reduce this error, we split poses in 3 different parts as shown in Fig. 2. For all the parts we apply an affine transformation and calculate an Euclidean distance and a rotation factor. Because we divided those errors with their order of magnitude, we can actually fine tune our algorithm and give different weights to body parts.

### 3. Multiple poses matching

The next step is matching multiple persons and the spatial relation of them on a picture. First we perform some logical checks like are there enough people recognized in the input picture needed to match all the model poses. When this checks are all positive, we calculate scores between every model and input pose with the previous explained algorithm. When keeping in mind that the outer left model pose can't give a possible match with the outer right input pose, you can improve the algorithm by sorting the poses from left to right and only calculate the possible combinations with some logic.

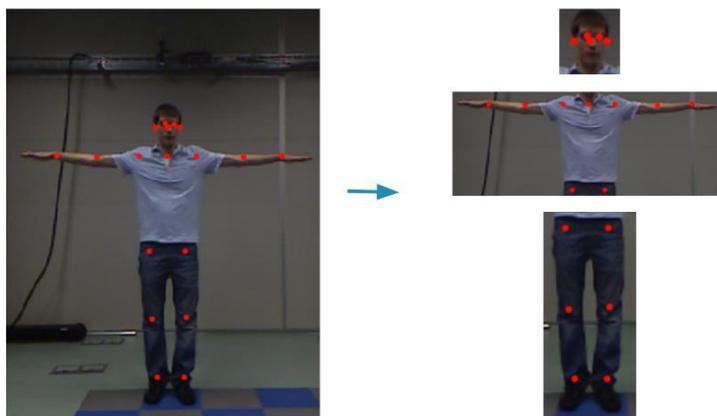
Thereafter we need to find the spatial error between the poses. Therefore we list all possible combination between model and input poses. When there are two model poses and three input poses for example, then these are the possible combinations with the sorted poses.

1. model 1 with input 1, model 2 with input 2
2. model 1 with input 1, model 2 with input 3
3. model 1 with input 2, model 2 with input 3

To calculate the spatial error on all these possible combinations we can describe the poses. Because we ordered the poses from left to right, we can describe the distance between a pose and the pose left from it. Or we can use again an affine transformation.

An affine transformation with all the key points of poses used in the combination. A normalized Euclidean distance and rotation factor is found. Normalizing is analogous to the normalizing with one pose, but in this case the box is around all the poses in the combination. a problem arises when the physique of the persons in the pictures differs a lot. Because that would influence the Euclidean distances between input and model poses. A solution is to paste the model pose with the model physique on the input pose. Because we only want the spatial relation, the pose can be replaced with the model one.

For all the listed possible combinations we can now calculate a final score on how well they match. We do this by averaging the error scores of all the pose comparisons used in the combination. To this average we add the spatial relation error, resulting in the final error score. We can again divide the two error scores with a parameter to fine tune the algorithm to your own needs.



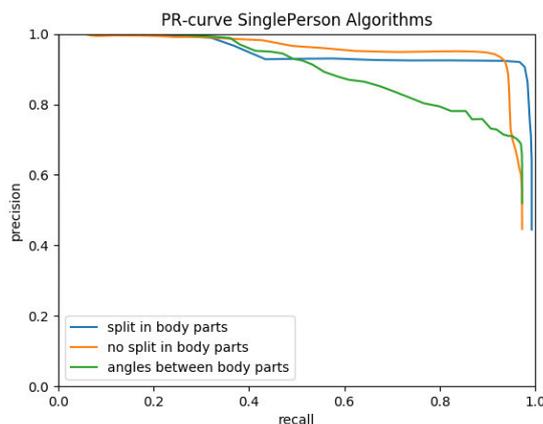
**Fig. 2.** Image of split body parts  
(<https://imatge.upc.edu/web/resources/body-pose-dataset>)

#### 4. Results and Conclusion

To take results from our algorithms and deciding which one is working better, we compute the true positives, false positives, true negatives and the false negatives on a dataset. To define a positive or a negative we need to compare the final error score with a threshold. By increasing this threshold a PR-curve is calculated.

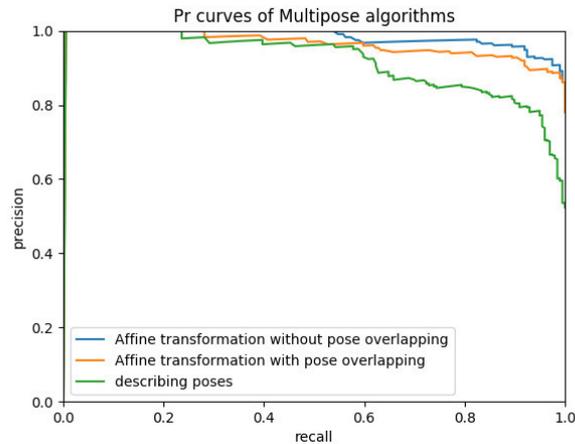
The results are based on two datasets. One dataset contains only pictures of one person with all body parts detected (<https://imatge.upc.edu/web/resources/body-pose-dataset>). This one is used for calculating pr-curves for the single poses. The other one is full of picture with people interacting with each other. We made this dataset on our own because we couldn't find a good dataset. This dataset contains 460 pictures with 199 positives and 261 negatives. This dataset is more challenging than the first one but the algorithm should be challenged more to find limits. It is also important to know that the pose estimator influences the results. We tried pictures taken on a gala but people standing close to each other results in openpose errors.

On Fig. 3, we see a pr-curve showing the results for all the single pose algorithms. We can quickly conclude that the angle algorithm loses a lot of precision when reaching more recall. This is because the angle algorithm is not that accurate. The no split has better precision in the beginning with lower threshold. This is because the affine transformation can perform better with more points. When the threshold rises the body ratios become more important and the split function starts to have a better precision. For our application the recall is more important than the precision.



**Fig. 3.** PR-curve evaluating the single person matching techniques

The multipose algorithms are tested on the more challenging dataset. The results are illustrated on Fig. 4. We can clearly decide on the PR-curve that describing poses in relation to each other does not have a good precision. The algorithms with an affine transformation are comparable. Although the algorithm where model poses overlap input poses, looks to perform slightly worse. But because the margins are small, we can't conclude which one is better.



**Fig. 4.** PR-curve evaluating the multiple person matching techniques

What we can conclude is that with the use of an affine transformation we can make a distinction between poses. And even compare the spatial relation between persons in pictures. Although we need to test further to find the limits of these algorithm and don't get stopped by the limits of a pose estimator.

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# ADAPTIVE LEARNING IN VIRTUAL REALITY: CURRENT STATE AND NEW APPROACH

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## Abstract

Learning in virtual reality has the possibility to gain a lot of popularity because of virtual realities unique features like: visualize abstract concepts, observe events at atomic to planetary scale, visit environments and interact with events that distance, time, or safety factors make unavailable. Using virtual reality in engineering classes showed that it can enhance student motivation and attitude to gain knowledge, permit experiential learning through understanding real-life products and provide an opportunity for the students to explore technology through actual use. The problem with current implementations of learning in virtual reality is that they are not using an adaptive learning approach. In an adaptive learning approach the systems considers the goals, preferences, and knowledge of the user to adapt the representation or interaction with the learning material to meet his or her needs. In this paper an approach is presented that considers the requirements of adaptive learning in the context of virtual reality.

**Keywords**— adaptive, learning, teaching, education, virtual reality, immersive, hmd, emotions

## 1 Introduction

Virtual Reality that is known from products like the HTC Vive<sup>1</sup> or the Oculus Rift<sup>2</sup> started to gain attention in the consumer market since 2016 [1]. Both systems are using a head mounted display (HMD) to create the illusion of a virtual reality. The HMD is equipped with displays that show a unique picture for each eye to create a depth, where no depth is available. Figure 1 shows a person using the HTC Vive with its HMD and the corresponding controllers. The desire to create a virtual reality is not new. The first HMD was created by Ivan E. Sutherland in 1968. "The fundamental idea behind the three-dimensional display is to present the user with a perspective image which changes as he moves." [2]. His idea was simple, because the image we see in the real world is only two-dimensional, but unique for each eye, we can trick the eyes by displaying a two-dimensional computer generated representation of a 3d world for each eye to create the illusion of a virtual reality. Mainly because of the high price and the early technological stage, Sutherlands HMD was not an option for the consumer market. However with the above mentioned products it is now possible to experience virtual reality with a consumer friendly price and a far more advanced technological stage.

Since the availability of virtual reality different disciplines are using the unique experience and possibility in their field of study. A very promising use case for virtual reality is the education sector. Already in 1998 Christine Youngblut recognized that because of the need to provide life-long education for all citizens, virtual reality can offer significant support for such education and enable new ways of educating. "One of its unique capabilities is the ability to allow students to visualize abstract concepts, to observe events

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<sup>1</sup><https://www.vive.com/>

<sup>2</sup><https://www.oculus.com/rift/>



Figure 1: Person using the HTC Vive. "HTC Vive and Google Tilt Brush"<sup>6</sup> by Ars Electronica<sup>7</sup> is licensed under CC BY-NC-ND 2.0<sup>8</sup>

at atomic or planetary scales, and to visit environments and interact with events that distance, time, or safety factors make unavailable." [3].

Additionally Abulrub et al. found several reasons for using virtual reality while evaluating the usage of virtual reality in engineering education: "It can enhance student motivation and attitude to gain knowledge. Permit experiential learning through understanding real-life products. Provide an opportunity for the students to explore technology through actual use. Encourage active participation and amplify student interaction." [4].

An important factor for the success of virtual reality in general but also especially in the education sector is the so called immersion. Immersion defined by Jennett et al. is the combination of "Lack of awareness of time. Loss of awareness of the real world. Involvement and a sense of being in the task environment." [5]. All these factors apply for virtual reality but can also be true for other activities like video games. However virtual reality has a unique factor which sometimes is called *spatial immersion* and is described as "[...] being physically present in a non-physical world." [6] or *presence* "[...] you're in a demo room and there's nothing really there, you can't help reaching out to try to touch a cube; when you automatically duck your head to avoid a pipe dangling from the ceiling; when you feel uneasy because there's a huge block hanging over you [...]. Presence is one of the most powerful experiences you can have outside reality, precisely because it operates by engaging you along many of the same channels as reality." [7].

## 2 Current State

There are a lot of possible benefits for using virtual reality in the education sector, but how is the current state in the field? A study was done in Germany with 2.316 people who are students doing distance learning<sup>9</sup> 78,8%, distance learning alumni 6,5%, and people that are interested in distance learning 14,7% were asked on trends in digital learning [8]. The results show that 34,9% requested that the teaching material should be available and customized for augmented<sup>10</sup> / virtual reality. On the contrary only 1,4% said that this kind of material is already available at universities. One could have assumed that most participants that demanded that kind of learning material came from IT related studies, but 55,5% rather came from business related studies. Considering that the consumer ready products, to enable virtual reality, were released in 2016 the people already demand and see the potential of using this kind of technology for their learning experience. This supports the statement that the combination of virtual reality and the education sector does not only make sense on a theoretically level but is also asked for by the people. However, "The growing interest, access, and development of VR experiences is continuously shifting, and the role of VR in education has yet to be defined." [9].

To show different approaches to involve virtual reality into education three examples are provided. The first example was created by Usui et al. from Japan [10]. In Japan it is required for students to take art

<sup>6</sup><https://www.flickr.com/photos/arselectronica/31838245814/>

<sup>7</sup><https://www.flickr.com/photos/arselectronica/>

<sup>8</sup><https://creativecommons.org/licenses/by-nc-nd/2.0/>

<sup>9</sup>German: Fernstudium

<sup>10</sup>"Augmented reality, in computer programming, a process of combining or "augmenting" video or photographic displays by overlaying the images with useful computer-generated data." <https://www.britannica.com/technology/augmented-reality>

courses from elementary school through high school. These art courses are divided into two parts, creating art and appreciating other artists' art. Usui et al. used virtual reality to enhance the ability of appreciating art. The first benefit of using virtual reality was to present the art in its actual size. For smaller paintings and sculptures it is easy to display them in their actual size by using pictures or videos. But especially for very large art, students can get a sense of its dimensions, which is an important aspect. Another benefit is the possibility to enable a multidirectional view of the artwork. Students are able to view the art from different sides and angles, which again helps to appreciate the art. After testing their development with a group of students the researchers hypothesis got confirmed. In comparison, for appreciating artwork from multiple directions students liked using virtual reality the most, as opposed to textbooks, posters, replicas or the use of tablets.

The second example was created by Seo et al. from the USA [11]. They developed an application called Anatomy Builder VR. Their main goal was to use virtual reality to support learning in anatomy education. "Our goal is to develop a virtual reality learning environment that supports a constructivist learning approach and a flexible learning environment. This environment allows a student to make/manipulate a skeletal system using a digital bone box, as well as learn from any mistakes made throughout that process." [11]. After developing the system they did a study with undergraduate students that never took a college level anatomy class before. The results are that almost all participants "[...] enjoyed using virtual reality to complete the activity." [11].

The third example was created by Puttawong et al. from Thailand and Japan [12]. They developed an application called VRFiWall. "[...] universities and institutes of higher education publish firewall security as part of network security education and include traditional lecture-based security classes. In this context, the VRFiWall application was designed to support learners with an alternative, engaging, and more efficient way for learning firewall security. The overall aim of the application is to help computer science students to learn about firewall security, definition, types, mechanisms, capabilities, and limitations." [12]. The developers, in this example, didn't take the conventional way. VRFiWall is build as a "[...] fantasy role-playing game (RPG) that the player can interact with non-player characters (NPCs), get items, and battle with a monster." [12]. This can be considered as an quite unusual way to teach students how a firewall works. But this implementation is a good example how the unique experience using virtual reality can be used to teach topics in different ways. By using different learning approaches the goal is to enhance the ability to gain knowledge.

### 3 Problem

Life-long education is important for a lot of people [13, 3]. Since the 1950s we know that the way people learn differs from person to person [14]. Especially teachers are interested in providing different ways to teach their students based on their goals and needs [15]. To address this request adaptive learning was created as a field of study. The goal of adaptive learning is to consider goals, preferences, and knowledge from a student and then adapt the representation and interaction with the learning material to meet his or her needs [16]. Considering the three examples described, none of them had an adaptive approach. All examples had the 'one-size-fits-all'-approach, comparable to teaching material in form of textbooks. Already in 1946 Edgar Dale found out that we remember 10% of what we read in contrast to 90% of what we experience [17]. Considering the representation and interaction made possible through virtual reality the opportunity should be taken to implement an adaptive approach to enhance the possibility to gain knowledge. "Augmenting VEs[virtual environments] with adaptive capabilities could greatly increase their usability and effectiveness." [18].

### 4 Adaptive Learning

The goal of adaptive learning is to consider goals, preferences, and knowledge from a student and then adapt the representation and interaction with the learning material to meet his or her needs [16]. One of the first adaptive learning system was created by Jaime R. Carbonell in 1970 called 'Scholar' [16]. "SCHOLAR is capable of reviewing the knowledge of a student in a given context (e.g., geography of South America) by maintaining a mixed-initiative dialogue with him in a rather comfortable subset of English. [...] SCHOLAR can prompt the student, indicate when it does not understand him, detect misspellings, and answer the student's question using acceptable English. SCHOLAR can also generate questions and evaluate the student's answers, deciding when these are correct, wrong, or only approximately or partially correct, and then take some conditional actions. It keeps track of content and changes it on the basis of relevancy and time considerations. SCHOLAR does all this without specific and detailed directions, but rather by applying general criteria and procedures to a body of 'knowledge' about the subject being discussed." [16].

Since the early 1990s researchers brought the ideas of adaptive learning to the usage of hypermedia documents called "adaptive hypermedia". The goal was to adapt static hypermedia documents to the users needs [19].

Since early 2000 researchers started to transfer the ideas from adaptive hypermedia to an area called "3D Educational Virtual Environments (EVEs)" [18]. "[...] using interactive 3D graphics lets developers create representations of subjects or phenomena that are more informative and make it possible for users to analyze a single subject from different viewpoints. In EVEs, adaptivity can play an important role in increasing both learning-process effectiveness and interface usability." [18]. An practical approach for adaptive learning is to "[...] give users a 3D action sequence for activities they're unfamiliar with, while devoting less time and detail to well-known ones." [18]. "In both EVEs and educational hypermedia, the learning process is based on student-driven navigation and interaction within educational material. It thus makes sense to start from adaptive hypermedia techniques and explore how we might change or extend them in the EVE context." [18]. This is a very active field of study [20, 21, 22, 23]. The next step would be to extend the techniques created in the EVE context, which are based on the adaptive hypermedia approaches, and extend them to fit into the virtual reality learning environment.

## 5 Approach for Adaptive Learning in Virtual Reality

In the following an approach is presented, that demonstrates how adaptive learning in the context of virtual reality could look like.

The new approach is composed of four parts. The first part is the user model. This user model is capable of holding information about the users goals, preferences, and knowledge. Goals in form of what the user wants to learn or achieve. Preferences in form of what kind of representation or interaction he or she prefers. Knowledge in form of what the user already knows and can be build upon.

The second part is responsible for detecting the users emotions. AutoTutor, an adaptive hypermedia approach, recommended to classify the emotional states as confusion, frustration, boredom, interest, excitement, and insight [24]. Their idea was to classify the emotions based on "[...] dialogue patterns, content covered, facial expressions, body posture, mouse haptic pressure, and keyboard pressure." [24] The new approach takes the emotional classification as a starting point but the ways to detect these emotions are different. To consider dialogue patterns and the content covered could be pretty similar with the exception that a dialogue would be most likely to be spoken and not written. Detection of the facial expression is not available because half the face is covered with the HMD. But there are HMDs available that are able to detect the users eyes and thereby know where the user is looking [25]. These information can then be used to derive emotions. The information of the body posture is gained by the tracking system that is used to track the user in the room which is already available. Usually in addition to the HMD the user has two controllers, one per hand, to interact with the virtual world. The combination of the head and hand tracking is used to detect in which body posture the user is currently in and then this information is used to derive emotions like boredom or frustration from it. This detection has to be adaptive for each user to avoid misinterpretations. To improve the detection of emotions, additional sensors can be used to measure pulse, blood pressure and brainwaves of the user.

The third part is responsible to detect the users interaction with the teaching material. For one misbehavior, in the sense that the user interacts with the system in a way that was not intended, should be detected. For another, the way of interaction should be monitored as well. The interaction in virtual reality is unique because the user is neither using a mouse nor a keyboard. The above mentioned consumer products are using controllers that you are holding in your hands, one per hand, while usually standing up. With the new version of the HTC Vive Pro it is even possible to track bare hands, without controllers, with build-in cameras.

The fourth part is responsible to take the information gained by the emotion-detection and interaction-detection to optimize the representation and interaction with the teaching material and update the user model. This part has to detect how well the user is capable of interacting with the provided teaching material and support the user if necessary. Additionally these information will be supplied to the user model to be considered for later use. Figure 2 shows the interaction of the various parts and the loop of the system behavior.

Here is an example of how the different parts work together. The user wants to learn how to make pancakes. The user already knows how to navigate in virtual reality and operate the stove, this information was gained from the user model, so it is not necessary to teach him or her that again. Another information gained from the user model is that the user likes to take action right away with a minimum explanation. The optimization-component uses this information and places the user inside a kitchen with the recipe, tasks and all needed utilities visible to the user. The first task for the user is to take an egg and gently crack it into a bowl. The emotion-detection identifies interest. The user tries to finish the task but uses too much force and therefore the egg-shell gets also into the bowl. The interaction-detection identifies the misbehavior. The emotion-detection is still identifying that the user is rather interested then frustrated. The optimization-component gets these information of the failed task and the emotions and decides to set the user to the initial situation. The user tries to finish the task but uses too much force again. The misbehavior is identified by the interaction-detection, the emotion-detection identifies that the user gets frustrated. These information are supplied to the optimization-component which decides to give the user

a hint in form of a video how to crack an egg. After watching the video the optimization-component sets the user to the initial situation. Now the user is capable of finishing the task without using too much force. The interaction-detection identifies that the task was executed successfully. The emotion-detection identifies excitement. These information supplied to the optimization-component are leading to an update of the user model, first the information will be saved that giving a hint in form of a video worked well and that the user now should know how to crack an egg.

Especially detecting the users emotion and his or hers interaction with the learning material in the context of virtual reality are unique.

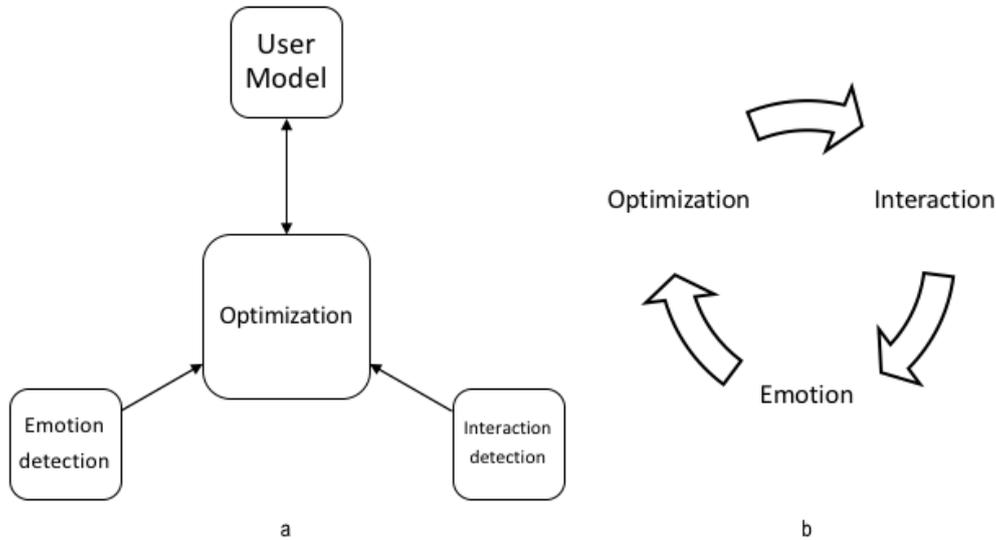


Figure 2: a) Interaction of the various parts b) Loop of system behavior

## 6 Conclusion

In this paper an approach was presented to create an adaptive learning environment in the context of virtual reality. The important part is to consider the goals, preferences and knowledge of each individual user. Additionally it is necessary to monitor the users emotions combined with the interaction. All these information are supplied into a user model which represents the user and will get more accurate over time to enable the optimization of the overall learning experience. The next step is to look at each part of the new approach individually and use, respectively create, solutions to address each problem. After that, all parts will be combined into a working prototype to evaluate the new approach.

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# OVER-THE-AIR UPDATE COMPLIANT DEVICE MANAGEMENT APPROACHES FOR AUTOMOTIVE SYSTEMS

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**Abstract:** *Powerful in-vehicle computer has the major intend of reducing the amount of Electronic Control Units while increasing computation power as well as the diversity of functionalities. At the same time, projects like APPSTACLE transfer latest trends from Internet-of-Things to the automotive domain. For enabling new features or enhancements, guaranteeing security and setting up access rights, or even providing simple bug fixes without hitting a workshop, a sophisticated solution has to be found. While car manufacturers work on their proprietary solutions, the major challenge addressed in this paper is to come up with an open-source device management solution for the automotive domain that is capable of managing in-vehicle components throughout a single private car or even a fast number of vehicles in a fleet. Therefore, this paper presents available device management solutions of different domains and identifies to what extent the solutions are completely or partially applicable to the automotive domain. In comparison to the Internet-of-Things, the automotive domain comes with specific requirements like safety, security, timing, modularity or other constraints. A corresponding requirements list is therefore identified and presented in correspondence to an appropriate device management solution. In fact, the focus is specifically on maintenance with the ability to provide Over-the-Air software updates. Consequently, this paper covers the basic but mandatory device management functionalities necessary for providing Over-the-Air software updates for in-vehicle computing systems. The authors have found no open-source implementation that addresses those challenges sufficiently. For this reason, the outcome of the discussion is used in future work for specifying an automotive grade device management that is capable of performing Over-the-Air updates.*

**Keywords:** device management, Over-the-Air update, automotive, IoT

## 1. Introduction

Today, as automotive systems become more software-intense due to advances driver assistance systems and approaches towards autonomous driving, the computing power of in-vehicle systems is increasing. In the early beginning of bringing digital technologies to cars, Electronic Control Units (ECUs) were only responsible for the mandatory functionalities. Later on, a variety of assistance and entertainment systems have been added and evolved in the recent years. Latest development trends for autonomous or highly assisted driving add even more features to vehicles. In addition, manufacturers are working on functionalities like including smartphones in the infotainment for an augmented user experience, enabling seamless navigation, vehicle tracking or emergency calls [1] [2]. Just like the hardware components of a vehicle, software components undergo strict testing, validation, and analysis processes before they are migrated. However, over time in use it may become necessary to deploy software updates. Reasons are bug-fixing, adding new functionality, re-configuration, or software improvements.

Typically, if a vehicle component is in need of an update, a car workshop is taking care of this. The workshop employees flash the according ECU and perform several tests to prove correct functionality. Over-the-Air (OTA) updates aim on simplifying the process as they make a visit at the car workshop obsolete for software updates. In case of larger callbacks of vehicles, which can be solved by updating software, this saves time and financial efforts not only for the manufacturers but also for car owners. In relation to the increase of software installed in cars, OTA updates are beneficial for deploying fast software updates.

This work is part of the ITEA3 APPSTACLE project that was released at the end of 2016 and its goal is to ease the development for in-vehicle applications in combination with cloud and IoT technologies [3]. This includes a device management for in-vehicle computing systems. A major task of the device management is to take care about updating the in-vehicle software. This is why the device management as a complete component is in this work's scope, but the main focus is on applying OTA updates.

## 2. Challenges for Over-the-Air Updates in The Automotive Domain

In terms of safety, security, and functionality, an OTA update should leave a car in the same condition or better. Since automotive software has been developed for decades, processes on handling challenges related to software development are already covered. This also applies to updating software via wired connections. We assume that update artifacts are built accordingly. The following list outlines challenges for deploying updates over wireless, unreliable connections:

- **Connectivity:** The wireless connection is not as reliable as a wired one and may fail while downloading or processing an update. In addition, typical network constraints like bandwidth, delay, packet loss, and jitter have to be considered.
- **Restrained device hardware:** Embedded devices in cars are precisely designed for a special purpose.
- **Safety:** A car has to remain as safe as possible, since errors may lead to lethal consequences. The process of updating must not decrease the level of safety. Furthermore, some updates may have a certain urgency if they relate to a safety issue.
- **Security:** All car components must be protected against manipulation. Update processes and exposed interfaces must be secured. This not only includes the whole infrastructure.
- **User convenience:** As the update system has to be adapted by the market, it has to be designed to minimize the impacts on user convenience.
- **Life cycle:** Update processes have to cover the full vehicle lifetime.
- **Stability:** The system has to perform updates with a certain degree of determinism. This means, that if updates are deployed at the cloud, their vehicle counterpart should be applied in a given time frame.
- **Robustness:** In case of malfunctions, systems must be able to reset to a stable state.
- **Scalability:** The system should be able to scale for big quantities of vehicles and updates.

## 3. Existing Device Management Technologies and Concepts

Within the automotive domain, well-known manufacturers like Tesla or Porsche are working on according update solutions. Tesla promotes over-the-air updates, received via cellular network [4]. This feature made it to the news, when a recall for Tesla cars was raised [5]. The cars had to be updated for safety issues with a charger, which could cause a fire. Here, Tesla was able to fix the issue without owners having to bring the car to a car workshop. Also, in Porsche's new electronic driven car concept, some updates are installed via wireless networks overnights [6]. Despite the efforts of the manufacturers, OTA update solutions for the automotive domain are in

an early development stage. Additionally, these technologies are developed proprietarily, redundant, and without the consideration of any necessary standards or common basis.

This situation has been found critical in current research. In [7], the authors describe a method to apply Over-the-Air updates to a vehicle's ECU. They use a smart-phone as a gateway, which receives the updates from a server. The ECU receives its update from the smart-phone via CAN bus. Therefore, the three processes pre-reprogramming, reprogramming, and post-reprogramming, are necessary. They are responsible for applying the update correctly whilst performing a variety of checks. Another paper [8] introduces a tool called "AiroDiag" which is designed to perform OTA updates and diagnostics. An ARM based computer-on-module is therefore connected via CAN or serial bus to the vehicle. It also has an UMTS module for communicating with cloud-based services. The authors mainly focus on securely diagnosing a car over an Internet connection but also introduce a method for ECU flashing. In addition, the authors in [9] address the topic of OTA security in the automotive domain. They state the importance of agile thread aware systems and describe an approach for this purpose. Overall, the present research examines device management and update systems only partially. Despite that, we were not able to find an open-source or public project, which gives access to any of the described approaches.

On the contrary, the mobile and Internet-of-Things sectors already contain approaches for device management and OTA updates for many years. For instance, Android as one of the most used mobile operating systems, includes OTA updates since its early beginning in 2008. Android provides two approaches to update its operating system components. In particular, either A/B or Non-A/B methods are used. The older Non-A/B method puts the device in a recovery mode after the user manually confirmed the update [10]. Binaries are then applied file- or block-wise. In the newer A/B system, the update is applied in the background [11]. The system uses two similar partitions; A and B. While one is active, the update is streamed to the other. With the next reboot, the system switches to the updated partition. This system provides two benefits. Firstly, the user can use the device while updating and secondly, in case of an error while booting the updated partition, the system can always switch back to the older working version.

Mender, which is an open-source Internet-of-Things project, presents another update approach in [12]. Mender is a client-server application, which accepts build artifacts from connected build systems such as the Yocto project and deploys those to a device. The management server is constantly monitoring the software inventory on the devices under control. If new artifacts are available, updates for the designated clients are prepared, scheduled, and deployed. Mender also utilizes the A/B system update because its robustness purposes. Besides this, mender also specifies a set of meta-data, which is used to deploy update artifacts according to their purpose. Unique JSON web tokens are correspondingly used for authentication and authorization. The benefit of Mender is its elaborated documentation, its integration with build systems like Yocto, and its current state of development as version 1.5. Its major drawback is its application limitation to Linux Internet-of-Things devices only.

Eclipse hawkBit is a backend framework to roll out software updates to constrained edge devices [13]. hawkBit incorporates protocols like OMA-DM and LWM2M for device management services. Devices receive their updates either via the device management federation API utilizing AMQP, or via REST APIs. For a more convenient use, hawkBit also helps managing roll out campaigns, e.g., by defining deployment groups, cascading deployments, providing emergency stops of rollouts, and monitoring OTA progresses. hawkBit is continuously under development and by the time of writing this article at version 0.3. On the positive site, hawkBit incorporates up-to-date machine-to-machine protocols. Further, it integrates well into the Eclipse Internet-of-Things landscape.

#### 4. Results and Conclusion

Recent development activities in the automotive domain show the common interest in OTA update technologies. However, just a few manufacturers provide existing concepts that are rather initial and cover only rudimental solutions that remain closed source, i.e., proprietary. No dedicated open-source project in this specific domain is currently available apart from APPSTACLE concepts.

Solutions for device management and OTA update deployment are though present in the IoT, smartphone, and Cloud domains. The A/B method for updating operation system components introduced with Android and Mender addresses the challenges of user convenience and robustness. On the downside, it is more demanding in regards of hardware and conflicts with the restrained devices. Mender brings in the integration with build systems, for an automated deployment. hawkBit also provides update scheduling and progress reports, addressing the stability and connectivity challenges. It also introduces up-to-date machine-to-machine protocols, which are more lightweight than the commonly used HTTP approaches. All systems are also designed to be scalable for large amounts of devices under control. However, the challenge on safety is not covered sufficiently. The presented open-source solutions do not perform the specific tests a car requires in a car workshop after an update. Furthermore, none of the presented approaches is able to cover all challenges completely.

In conclusion, the presented systems are not directly applicable to the automotive domain. Therefore, a domain specific adaptation is required. This development should make use of present approaches, like e.g. the A/B operating system update and machine-to-machine communication. In addition, it should provide the integration with existing systems such as software build systems. The described challenges are in major focus of the ongoing APPSTACLE project.

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# REQUIREMENTS FOR A SOFTWARE DEVELOPMENT PROCESS FOR 2D- AND 3D- MODELS IN CONSTRUCTION

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**Abstract:** *Currently, there are many software products on the market to reproduce 2D- and 3D-models of buildings, structures, plans, systems and circuits for various purposes. Construction projects are so complex that there is no one single program covering the whole complex of necessary elements for construction, therefore, in the design process, as a rule, they are used by several. Another problem associated with different CAD systems is that different software tools allow for differences in assumptions. Most often, when transferring files from one system to another, the host system loses some tolerances, resulting in a model with holes or spaces [1]. The model is often found in the form of surface data that needs to be refined, and to see if the program can sew these surfaces into a complete model.*

Keywords: Agile, software development, requirements

## 1. Introduction

Software products for construction should be pre-installed on devices and require a large amount of computing resources. Thus, with modern design systems, they cannot build a single, enriched data model that has architectural, structural and engineering elements with drawings of plans, facade sections, specifications and information, visualization, energy certification, and smart models. The expression “smart models” refers to models composed of parametric objects [2, 3, 4], that is virtual building components that are identified by modifiable parameters, such as dimensions. With the introduction of Building Information Modeling (BIM) already complex drawings become even more informative and as a result - a significant amount of investment in hardware for successful work is required. Also, many of these programs are not supported by all operating systems. They cannot meet all the requirements for the presentation of projects or works that are performed directly on the site. Therefore, the development of such software that would provide the full range of construction of 2D- and 3D-models for construction companies is an urgent task. At the same time, the task is to minimize the amount of computational resources for constructing such models. To accomplish such a task, it is necessary to choose such approaches to the development of this software, which would ensure the prompt and effective implementation of this project.

So why this software should be created? What’s the point?

There is a huge amount of knowledge built up in even the most typical Architecture, Engineering and Construction (AEC) 3D-models – geometrical and architectural relationships, BIM information, relationships between various building systems, etc. Compared to the abundance of this three-dimensionally-encoded knowledge that is being created continuously by the AEC industry, it remains relatively difficult for an author to share a thought in 3D with an audience of any size. It is easy to author 3D-models, and difficult to publish them.

AEC require to embrace 2D/3D in the browser, but everyone who wants to publish 3D-content - design architects, builders, engineers everyone – needs something a little different in terms of

user interface, or they need a database on the back end, or whatever. As an industry, we need open source solution that can be customized to suit all of respective needs. Software aims to provide just that - a solid foundation that can be built by developing new features, easy to use web viewer for AEC models.

## 2. Agile software development

Agile development, in its simplest form, offers a lightweight framework for helping teams, given a constantly evolving functional and technical landscape, maintain a focus on the rapid delivery of business value (i.e., bang for the buck). As a result of this focus, the benefits of agile software development are that organizations are capable of significantly reducing the overall risk associated with software development. Recently, the so-called flexible software development methodologies are quite popular in the world. Most of the flexible methodologies are aimed at minimizing risks, by reducing the development to a series of short cycles, called iterations, which usually last one to two weeks. Each iteration itself looks like a program project in miniature and includes all the tasks necessary to issue a minimal increase in functionality: planning, requirements analysis, design, coding, testing, and documenting. To develop a product, it is suggested to use the flexible approach of Agile, since it allows you to successfully plan and monitor, monitor changes in the project, and allocate workload [5].

Agile is based on the postulate of six qualitative goals whose achievement determines the success of the project (Fig. 1). These goals determine the model of the project team. While the team is responsible for the success of the project, each of its role clusters, defined by the model, is associated with one of the six goals and works on its achievement. The process of creating a product will include iterative development, from the transfer of basic functionality to the client in the early stages. In each portion is delivered a certain part of the functionality [6]. The unified process divides the iterations into the following phases: beginning, creating a plan, constructing and transitioning.

- The beginning determines the scale of the project, the risks and requirements (functional and non-functional) at a high level, but sufficient to assess the complexity.
- The result of the plan will be a production architecture that mitigates the most significant risks and fills non-functional requirements.
- The building gradually fills the architecture with a ready-made code, which is created through the analysis, planning, implementation and testing of functional requirements.
- The transition translates the system into the production environment.

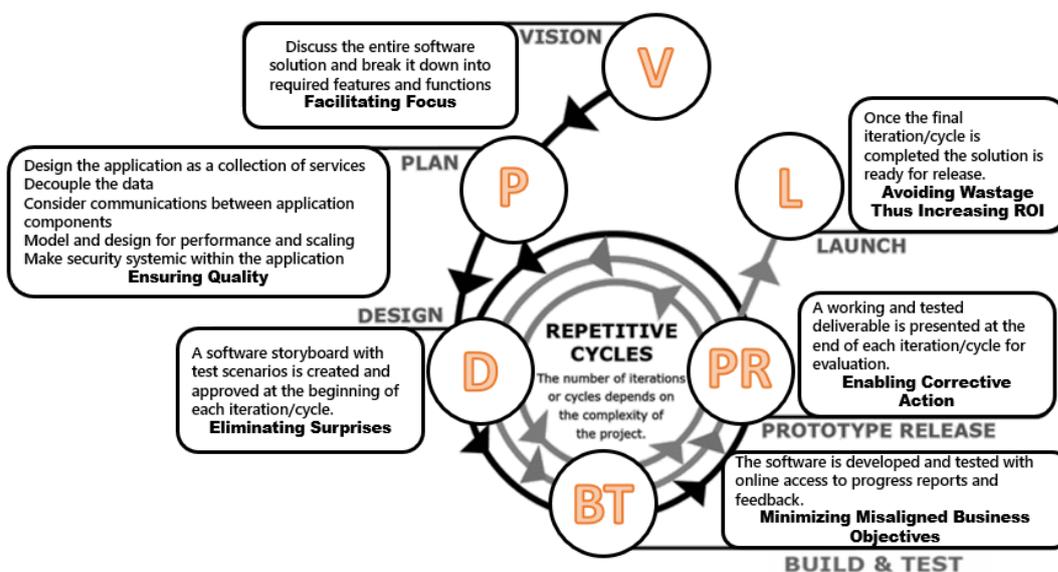


Figure 1. Steps to building a cloud software development in Agile

Each of the phases can be divided into one or more iterations, which are usually limited in time, but not in functionality. Architects and analysts will work on one iteration ahead of programmers and testers in order to keep their list of tasks complete [7].

### **3. Requirements for a software**

This task is closely related to the construction, so in the development of software must include support for BIM technology. To integrate BIM, a three-dimensional object model associated with an information database must be formed, in which each element of the model can be assigned additional attributes as well as complex processing in the process of designing all architectural, design, technological, economic and other information about the building with all its interrelationships and dependencies, when the building and all that is related to it, are considered as the only object. The peculiarity of such an approach is that the construction object is projected and considered in essence as a whole [8].

Developed software must also meet certain requirements. The first of these is cross platform. It will provide such benefits as:

1. Budget savings - the use of one technology and a set of schedules reduces the number of working hours and the budget of the project;
2. Time of development - the absence of unique interface elements and one technology platform shortens the design time;
3. Support and product upgrade - adding functionality or fixing bugs directly to all platforms;
4. Mobile version of the site - most cross-platform solutions allow you to generate a mobile version of the site from the program;
5. The only logic of the application - the logic of the application will work equally for all platforms. Written and debugged logic contains a potentially a smaller number of errors and differences in their work.

The second requirement is the use of cloud technologies. It will provide such benefits as: reliable protection of personal data; large space of space; availability on different devices; the possibility of restoring deleted data; support for various file formats; access to data online; the ability to share files with other users.

The next requirement is to support all available data formats for presentation models, which will extend the use of the product.

Open source is needed to be used and planed the future development of the system. It is proposed to use the principles of classical Agile, which include providing a client with a ready-made solution including staff training, system documentation, support and maintenance, etc.

### **4. Results and Conclusion**

It's no secret that the use of BIM, a software that allows 3D-modeling, is becoming increasingly necessary (and often under contract). But the combination of BIM with a cloud that connects a large number of computers or devices through real-time communication is something that can give firms a serious competitive advantage and push the limits of 3D-technology. Also, application of MSF for Agile flexible approach, BIM technology use, all existing data representation models' formats; cross platform, cloud technologies and software support will meet the needs of users, as a consequence, the widespread use of software, its development and collaboration with well-known companies.

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# THE VALUE OF KNOWLEDGE MANAGEMENT IN START-UPS IN THE AGE OF DIGITAL TRANSFORMATION

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**Abstract:** *Recently start-ups have become a contemporary trend considering their capacity to drive entrepreneurship and economic capabilities in Europe. To survive during the phase of development to an established company, start-ups are to overcome a series of challenges like the need for digital adaptation, high employee turnover which includes the risk of knowledge loss, and a lack of cross-team communication. The right knowledge creation, retrieval and application shaped in a Knowledge Management System (KMS) can contribute to solving these problems and can lead to long-term success of start-ups. The impact of it needs to be considered to avoid a loss of knowledge, profits, and ultimately a start-up's fail. As we are living in the age of digital transformation, the topic of digitalization and its adaption into Knowledge Management (KM) will be addressed in this paper. The result of this research shows that it is necessary to implement KM digitally into a start-up since its early stages. However, the approach to KM needs to be integrated into its strategy to guarantee that the digital system is actually used by employees. The technique 'Communities of Practice' (CoP) is introduced to highlight that, especially when looking at projects, building networks, communities and relationships is crucial for start-ups. Examples of KMSs are mentioned, which combine networking and creating and sharing knowledge digitally, which fosters cross-team communication. These solutions show that KM can be easily implemented into the everyday working life of a start-up. Thus, this paper provides a solution for start-ups on how to successfully implement KM: CoP, a KMS and the implementation into the strategy.*

**Keywords:** knowledge management, knowledge management system, start-up, digitalization, Communities of Practice

## 1. Introduction

The number of start-ups is increasing and is more and more gaining central stage in literature and investigations. This growing number and relevance are supported by the number of investments in start-ups in Europe, which has nearly doubled from the first half of 2015 till the first half of 2017 (from 857 investments to 1639 investments) [1]. The value of those investments reached also its peak in the first half of 2017 (7,593 million euros) in comparison to the half-years before [2]. Hence, start-ups are running up. A start-up can be defined by the following three characteristics: 1. 'younger than 10 years; 2. [...] feature (highly) innovative technologies and/or business models [; and] 3. [...] strive for significant employee and/or sales growth' [3, p. 15]. When taking this definition into consideration, one can compare a start-up with a project. In some way, it has got a temporary nature like a project as after a certain amount of time it is not named start-up anymore, it is unique and new to the market and develops innovative products like a project [4, p. 3]. [5] supports this by highlighting the importance and usefulness of Project Management skills in start-ups as he claims they 'bring clarity, focus and much-needed structure to the startup process'.

Furthermore, Knowledge Management (KM) is becoming considerably important and valuable for companies in general but specifically for start-ups. 'A KMS [(Knowledge Management System)] is an information system and/or a managerial practice adopted to support companies in

creating, storing, transferring, sharing or applying knowledge' [6, pp. 9-10]. Start-ups need to focus on KM as 'knowledge sharing leads to a greater understanding of the unsolved issues and the existing knowledge between team members' [7, p. 155]. Hence, KM will lead to greater success and to a better performance [7, p. 155].

However, nowadays digitalization plays a leading role and needs to be considered as well. Digitalization is claimed as the process of converting from analog to digital, that means a shift in focus from products, hardware, and mechanics towards software and services and possibly disruptive business models [8, p. 261]. But how all three emerging and important topics of start-up, KM, and digitalization can be integrated to be most successful? This paper addresses this issue and aims at bringing attention at the usage of KM in start-ups in the age of digitalization in order to be successful and profitable.

## **2. Methodology**

In this paper, conceptualization and keyword search methods were applied to gather relevant literature and information among project management periodical and related scientific publications. Then gathered literature and information sources were screened for defining relevance of literature based on certain criteria: frequency of possible synonyms of keywords searched, novelty of the publications about digitalization and digital KMSs to have more recent research findings, as well as the country where the research was conducted in played a role since the focus was put on European countries. On the following step all collected and selected sources were reviewed to analyze data retrieved beforehand and extract secondary data to define challenges start-ups face nowadays and potential solutions concerning optimal usage of digital KMS. To align research findings and to come up with comprehensive results the method of synthesizing data was used with the intention to determine possible solutions to the issue of KMS usage in start-ups in the era of digitalization.

During this methodology implementation the limitation among literature and information sources was noticed considering the benefits of a KMSs usage in start-ups, that underlines the necessity to proceed with the study of KM solutions for start-ups.

## **3. Relevant Literature Review**

### **3.1. Knowledge Management**

KM is a topic which is gaining more and more attention in literature. 'Knowledge is an important organizational resource' [9, p. 10] and existing knowledge can lead to the creation of new knowledge. [9, p. 11] defines the most important capabilities of knowledge to be renewable, reusable and able to accumulate valuable resource to the organization when applied to the production / services processes. Therefore, Knowledge Alignment plays a crucial role, as the knowledge needs to be congruent to lead to a positive and successful outcome [10, p. 592]. Knowledge Alignment is described as 'the production of comprehensive sets of knowledge' [10, p. 599]. This is the process, which mediates KM by aligning various knowledges of specialists and a shared understanding among them [10, p. 599]. KM aligns the different knowledges but also enhances the working life of knowledge workers qualitatively [11, p. 80]. According to [11, p. 80], KM improves the accomplishment of the businesses' goals and increases the businesses' values. Moreover, it gives the companies and start-ups a competitive advantage. 'KM is the process through which an organization uses its collective intelligence to accomplish its strategic objectives' [11, p. 80]. As a KMS needs to be able not just to store and share information, but also to create it, KMSs need to allow employees to interact with each other. Knowledge should therefore not only flow into one direction, but in many [12]. Fig. 1 shows the new way of knowledge creation, which will enhance employee's learning, because it is likely to be memorized easily and it is also more pleasant than the traditional method of knowledge acquirement [12].

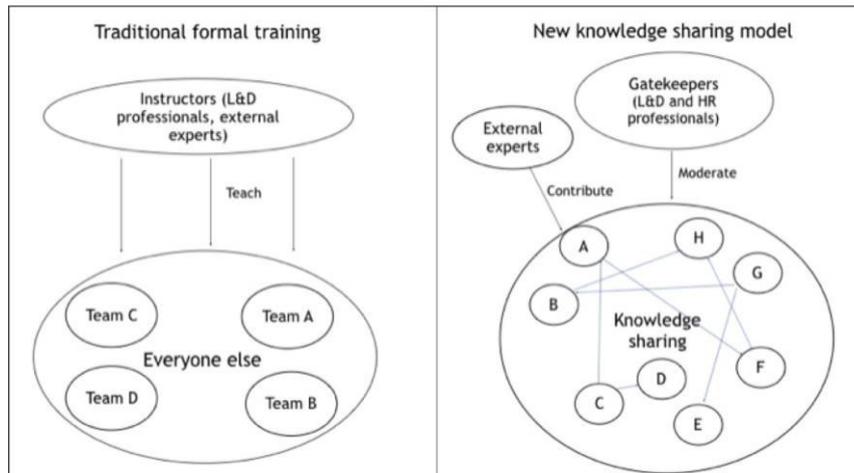


Figure 1. A new way of knowledge creation (source: [12])

When creating and sharing knowledge within a network, trust is a key factor. Several scholars ([7], [13], [14]) underline the importance of trust in building the relationship among information system's participants and in knowledge-sharing activities' support, since project interaction handles with communication with internal and external stakeholders.

### 3.2. Start-ups

At the beginning, start-ups consist of small teams which know the product or service they offer very well [15, p. 1]. However, they seek to expand and grow [3, p. 15], [15, p. 1] and this growth leads to an increasing number of employees. When the teams in start-ups expand, the coordination and communication become more complex and difficult [16]. Regarding the growth of start-ups, a 'lack of cross-team communication' [15, p. 1] is a challenge which needs to be addressed. This challenge occurs, because new hired employees need to contact their existing colleagues to find out all relevant information they need for their work. A further challenge is 'employee turnover and intellectual property loss' [15, p. 1], [17]. When a start-up is growing, there is the possibility of a high turnover of employees. In the case of employees leaving the start-up, 'valuable intellectual capital is lost with their departure' [15, p. 1]. This would be negative for a start-up as this kind of capital is one of its most important assets and gives the start-up a competitive advantage in the market [15, p. 2].

### 3.3 Digital Learning

Digitalization is becoming increasingly important in nowadays business world. However, according to a survey conducted by PwC [18, p. 11] only 33% of the respondent companies consider themselves digitalized but they are also expecting to increase their level of digitalization to 72% by 2020. This underlines the increase in digitalization. [19, p. 188] show the importance of digital technologies' capabilities as they help to quickly transfer explicit knowledge into electronic format. The 'Bring Your Own Device' (BYOD) policy becomes more and more common in companies, which consequently reinforces the need for a system on how to access information from any place at any time and from any kind of device. Knowledge needs to be immediately applicable, especially when serving customers [20].

However, 'in today's fast-paced digital environment people need to constantly up-skill but have little time to learn' [21]. In order to make learning and training of employees less time consuming, the microlearning technique has been welcomed by many companies [22, p. 38]. Microlearning can be described as 'the delivery of small doses of training material' [23], which allows employees to train on the job, rather than to get taken out work for a longer period [22, p. 38].

Implementing this technique digitally brings various advantages along, e.g. that it is available when it is needed [22, p. 38] or that it is 50% cheaper and 300% faster to develop [24, p. 46].

#### **4. Discussion and Findings**

As we see from the literature review, the value and trend of start-ups and digitalization are frequently discussed. Hereby, knowledge plays an important role in companies but especially in start-ups. The knowledge of a start-up is the basis for its success as it gives entrepreneurs a competitive advantage. Start-ups seek to grow and proceed to become an established company. In order to do this successfully they need to ensure that their knowledge is stored safely and that it is available for all employees. However, the stored knowledge needs to be congruent to make sure that it is understandable for all employees making use of this knowledge. The need of start-ups having a system for storing and sharing this knowledge is based on the growth trend of start-ups which includes an increasing number of employees. Start-ups can be seen as projects as they are only considered a start-up for a limited period of time till they are established in the market. This development from a project similar company to an established company includes in most cases a significant growth with the mentioned increasing number of employees. Those new employees need to get to know the start-up and the product or service related information, which is unique to the specific start-up, because when they enter the company they might have the professional expertise and knowledge, but they need to know everything about the product or service of the start-up to execute their work successfully. To ensure this knowledge exchange, cross-functional communication is highly important. However, according to [15, p. 1] most start-ups show a lack of such a cross-functional communication. Moreover, in start-ups the employee fluctuation tends to be rather high which leads to the danger of losing valuable and important knowledge [15, p. 1]. KM can be the solution for start-ups as it allows the creation, storage, transfer, sharing, and application of knowledge [6, pp. 9-10]. This exchange of knowledge needs to be interactive which means that it should not flow into one direction but in various directions to ensure that all employees have access to the knowledge, understand it correctly and are given the opportunity to create it together. Hence, the KM in start-ups needs to move away from the traditional approach where the knowledge only flows into one direction by teaching, to a new approach. This new approach includes the dynamic interaction between the employees as the knowledge is exchanged between the employees as well as other experts [12]. KMSs therefore would overcome the challenge of cross-functional communication as this would be facilitated by it. This shows the importance of the human aspect when integrating KM into the start-up. In the case of a key employee leaving the company, the start-up can benefit from a KMS as this employee stored all of his/her knowledge in the KMS and thus it is available to colleagues or new employees. Hence, the danger of losing crucial knowledge can be avoided by using a KMS. Next to and because of the avoidance of those challenges, KM will support start-ups in accomplishing their business goals and increasing their value [11, p. 80] as well as in ensuring the availability of the start-ups cumulative intelligence from its early stages. All companies, but especially start-ups benefit from KM as they are trying to establish a long-term business and need to protect their unique knowledge in order to be successful. To ensure the congruence of the start-up's knowledge, the start-up needs to focus on Knowledge Alignment and needs to include this into their KMSs.

As digitalization seems to be a driving trend in today's business world and as most companies are seeking to become more digital, start-ups should consider this in their approach to KM. Digitalization can enhance their KM as it integrates various technologies [25, p. 1319] which can support the easiness and quickness of the creation, storage and sharing of knowledge. Furthermore, it will support and facilitate the BYOD trend as a digitalized KMS would ensure the accessibility of the stored knowledge from various different devices. At the same time, the microlearning technique fosters this learning and sharing approach as it enables people to learn new content in small doses quickly.

## 5. Solution: CoP, Digital KMS and Integration into the Strategy

As the human aspect and the digitalization of sharing knowledge are highly important to KM, both must be considered when providing a solution for start-ups. Communities of Practice (CoP) can be recognized as a possible mechanism for knowledge sharing as well as the creation and should thus be fostered and implemented into a start-ups' culture. From the start-up's perspective, the opportunity to be in contact with other newly business founders is seen as valuable in order to learn from their experiences and to avoid potential pitfalls [26, p. 302]. However, the interaction between team members is also highly important and for this CoP is regarded as a powerful motivational driver to enhance knowledge sharing [27, p. 42]. Therefore, it is recommended to integrate CoP into a start-up's culture from its early stages. The questions, however, are: how can that be achieved? How can this knowledge be transformed digitally? And how can it be stored to make it accessible for the entire start-up?

An example for a digital KMS is the platform 'SmartUp'. It is a digital knowledge sharing and creation platform, developed by a company that is also called 'SmartUp'. This platform allows employees to easily transform their knowledge into small modules, which can then be shared with the rest of the organization [28]. The creation of such small modules is known as the microlearning technique. It is especially helpful for keeping the captured knowledge manageable. If a start-up has successfully implemented a digital KMS and knowledge alignment is maintained, the knowledge base created will grow until it is unmanageable, which can be overwhelming for someone who is looking for specific information. Therefore, SmartUp is highly valuable for the management of knowledge.

SmartUp is also compatible with any type of online device, which makes it accessible at any time and any place and it provides a way to create new knowledge directly on the platform. This knowledge creation can be done in innovative ways either individually or by interacting with others. When interacting with others, knowledge flows in many directions, which is known to be more efficient (see Fig. 1) [29]. This also represents the essence of CoP, which is sharing knowledge within a group and learning from each other [30]. SmartUp supports this mindset by providing the opportunity to create various communities within the platform, with one being the master community including all modules. Other sub-communities can then be formed and also shared with, e.g. clients or business partners. By creating such sub-communities, the user of SmartUp can regulate the amount of shared knowledge to its wishes [31]. A network of start-ups can be hereby developed, which can share their experiences with each other on the platform. This proves that SmartUp connects the idea of CoP with the digital transformation of knowledge into one KMS.

Some people might object that they are too lazy to use this platform, however SmartUp has found a creative way how to incentivize its usage. Points are accredited for interacting with the material offered, whether it is watching a video, taking a quiz or creating new content. Colleagues can hence make sharing, acquiring and creating knowledge a fun challenge [29]. The knowledge alignment is hereby given, assuming that everyone is willing to share their knowledge.

The SmartUp platform has already many users, some of them being Deloitte, Harvard Business School, and Moët Hennessy [32]. That such big and successful companies are using SmartUp should be a sign to start-ups to start using it as well. Additionally, by 2017 more than 100,000 start-up founders and teams have been using it [33]. Such a huge customer base shows that SmartUp can aid in storing, sharing and creating knowledge digitally and interactively and that value can be added by using it.

However, SmartUp is not the only digital KMS that is highly used today. Another example of a popular digital KM platform is the Confluence knowledge base software, which puts an emphasis on CoP, fast and easy tools of information exchange and knowledge retrieval. Its collaborative workspace with integrated project and data management systems has attracted 40,000 clients worldwide [34]. Another digital KMS worth mentioning is 'Theum', which is rather focused on intelligent search of needed knowledge as well as summarizing it. Sources are thus blended 'into

a single uniform environment that finds answers from the whole without forcing users to visit other systems' [35].

In order to implement such systems and practices the start-up needs to create an awareness of the need for KM. Its positive influence on start-up's performance underlines a necessity to involve a digital KMS into start-ups' strategy. [36, p. 232] highlight that the combination of technology development, marketing approach and KM helps start-up companies in the organization of their development strategy. In the frame of KM strategy, knowledge is seen as a primary driver of a company's value [9, p. 28]. To enable this strategy the organizational and behavioral culture are to be transformed as well. This cannot happen overnight and demands a continuous improvement. As an umbrella term for this a Total Quality Management (TQM) has to be considered being an effective enabler of strategic KMS implementation [37, p. 243]. Vice versa, KM can provide various opportunities empowering success of TQM strategies [37, p. 251]. As a tool improving a TQM system and establishing the organization's KM strategy, the EFQM Excellence Model should be used as a reference framework for the KM project implementation and a cultural framework fostering the KM processes' effectiveness [38, p. 1639].

## 6. Conclusion

In this paper the issues of KM and digital transformation in start-ups were considered. Table 1 shows the summary of those mentioned and possible ways to address them.

Table 1. Summary of benefits of KMS usage for start-ups

Considered issue	Influencing factor	Way to improve	Benefit
Risk of knowledge loss	Employee turnover	Integration of KMS into strategy	Knowledge captured from the very beginning
Lack of cross-team communication	Small but fast-growing team	CoP integrated into digital KMSs	An opportunity to be consulted by peers, irrespective of time / place
Need for a digital adaptation of KM	Lack of time to retrieve knowledge and learn	Digital KMS, microlearning techniques	The congruence of knowledge and its availability and accessibility irrespective of time / place

The issues discussed in this paper are not the only ones a start-up will face but are seen as the major issues by the authors and were thus emphasised. In order to ensure that start-ups can tackle these challenges, three components of one solution were identified: CoPs, a digital KMS and the integration into the start-up's strategy. A digital KMS is essential in today's business world due to its fast-changing environment in the era of digitalization. With such a system, Knowledge Alignment can be achieved and the microlearning technique can support the system in many ways. However, a successful implementation and usage of it implies that the employees are willing to share their knowledge, which might not necessarily be given. Thus, trust needs to be built. CoPs can be of avail for that, as relationships are built and fostered in a rather informal environment. It also gives the opportunity to build a network with external partners for generating a broader knowledge exchange. The digital KMS should also provide the option to integrate these networks into the system directly and to guarantee that everyone can interactively take part in the knowledge creation, sharing and retrieving at any given time or place. As the strategy is fundamental for companies and employees, KM should be integrated into the start-up's strategy in order to guarantee that every employee is aware of the importance and the benefits of KM.

As addressed above, the issues mentioned in this paper are only some of those start-ups will face. Further research should thus be conducted on e.g. the following topics: a dependence of start-ups on digitalization, a significance of digital KMSs in start-ups or how knowledge creation interactively can change KM of start-ups.

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# CONTRIBUTION OF KNOWLEDGE MANAGEMENT TO INNOVATION PROJECTS

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**Abstract:** *Around 85% of respondents have highlighted the importance of knowledge management (KM) towards the success of their company/projects according to the study conducted by Forbes and SAP [1]. Indeed, the KM strategies of organizations lead to success by creating innovation processes, and it helps to manage the knowledge in innovation projects. Another main success factor for most of the businesses is to come up with new ideas to keep operations, products, and services fresh which is known as innovation projects. However, there is a research gap about the specific model which addresses the linkage between KM and innovation projects and its contribution. Thus, the focus of this study is to analyse and compare different KM models and propose an integrated model as an organizational asset which focuses on innovation projects. Based on secondary research and by reviewing the qualitative data such as journal articles, case studies and books this paper mainly describes all the basic concepts at first and then shows the relationship, importance, and contribution of KM to innovation projects leading towards innovation culture. After reconciling of the literature review this article firstly develops the understanding of the terms: Knowledge, Project, Innovation, KM, Innovation Projects and later reviewing in detail the relationship between the KM processes or strategies adopted by organizations in innovation projects and looking at the impact of KM strategies on organizational culture in terms of innovation. Based on the conceptual and theoretical studies, the conclusion and recommendations are proposed for better KM systems in organizations explicitly focusing on innovation projects and lastly identified some areas for future research work.*

**Keywords:** innovation, projects, knowledge management, innovation projects

## 1. Introduction

KM has been acknowledged as a critical factor for both organizational performance and project success [2]. Indeed, it has been brought up with a study conducted by Forbes and SAP [1] where about 85% of the participant in the survey emphasized the importance of KM as a critical success for their company and projects. Nowadays, organizations and companies around the globe are facing a similar challenge: an enhancing need for their performance to take advantage on rapid change and to establish or achieve a competitive advantage by adopting and applying innovation into their organization [3]. Thus, innovation is a vital aspect of achieving and maintaining a competitive advantage for the organization. Therefore, it should be an emphasis on developing innovation in organizations. The KM strategies of organizations lead to creating innovation processes, and it helps to manage the knowledge in innovation projects. "Enhancing the innovative ability in organizations is one of the most important steps to increase profitability and growth in organizations" [4, p. 49]. This paper describes the concept of KM, Project KM, Innovation and innovation projects in general. Further, the linkage between knowledge and innovation and some existing KM models are elaborated. Several studies address the linkage between 'KM and innovation,' 'KM and innovation level in the organization,' 'KM and

organizational culture' and lastly, 'KM in projects.' However, there is a significant need in the existing literature regarding the collaboration of KM to innovation projects. This paper presents a KM model for innovation projects to fulfill this gap and helps the organizations to understand the usage and their relation in advance level to enhance their performance, manage the knowledge in innovation projects and achieve a sustainable competitive advantage.

## **2. Research approach**

The research approach adopted in this paper is based on qualitative data analysis; mainly reviewing the secondary research from journal articles, case studies, and books. It elaborates all the basic concepts at first and later analyses the relationship, importance, and contribution of KM in innovation projects. Based on the literature review, this paper offers an integrated KM model followed by a conclusion, acknowledgment, and further potential research area.

## **3. Literature Review**

### **3.1 Knowledge Management**

KM is the formalization of access to experience knowledge and expertise that create new capabilities, enables superior performance, enhances customer value and boosts innovation [5]. KM has a strong relation and influence on organizational goals and strategy. Also, KM involves management of knowledge which creates value for the organization [6].

### **3.2 Project knowledge management**

According to Fuentes-Ardeo, *et al.* [7], the highlighted characteristic of the project is uniqueness. However, they all have one thing in common, and that is knowledge. It has been identified that KM has a positive influence on project success. The project success is motivated by the knowledge that is considered inside the project as a critical factor. KM creates specific bodies of knowledge within a project which is essential for successfully achieving the project goals. While some of this knowledge will remain tacit, it is necessary for most of it to be transformed into explicit knowledge to be examined, shared, accessed, and used.

### **3.3 Innovation and innovation projects**

Innovation could be confused with invention term which is only the first step in innovation. Thus, innovation can be defined as "The process of translating an idea or invention into a good or service that creates value or for which customers will pay" [8]. Innovation can be delivered in different types; For instance, it could be a product, process or organizational innovation. Innovation has different ranges in scope (radical/ disruptive to incremental/evolutionary innovation) [9]. The role of KM in innovation process can vary depending on the type, scope, and complexity; While radical innovation requires new knowledge, which is created or applied from a different context and sources, for incremental innovation reuse of existing knowledge be essential [10]. Innovation projects refer to the process of converting inventions or creative ideas into a product, service or a result which could lead to the innovation of the current system, practice with advanced concepts or create value for an organization.

### **3.4 Innovation, and knowledge – an integrated system**

Though knowledge is defined differently in a different context [11], somehow it is also linked with the culture of organization or project explicitly gathering, storing and sharing of the knowledge [11]. There is no doubt about the significance of organizational structure in KM, to foster innovation practices and innovative mindset in the organizations,

hence the processes and programmes implemented must encourage the learning and knowledge sharing atmosphere [11]. It is evident that the primary objective of KM in the organizations is to improve productivity to gain an edge over the competitors sustainably and long-term [12]. However, for long-term sustainable growth, organizations must embed the KM process in the organizational culture and provide an appropriate environment where new ideas and knowledge transfer is encouraged, and communication is accessible and open for all [12].

As stated by Khedhaouria, *et al.* [13] Innovation (R&D) projects are the roots of modern organizations nowadays and they also highlighted the importance of team's ability to conduct research activities within project and the usage of shared knowledge for generating, developing and implementing the knowledge in order to generate creative solutions and innovation projects. The project itself holds characteristics such as unique and temporary with limited resources regarding cost and time [14]. This uniqueness and transient nature of projects make the knowledge transfer a critical issue for organizations, especially when dealing with R&D projects or innovation projects [15]. According to some studies, it has been clear that the employees, working on the project, generate and acquire new knowledge (both explicit and tacit), this learning in project environment becomes so important for organizations [15]. Further, most of the projects hold a considerable portion of tacit knowledge. Thus, it is even harder to transfer this knowledge into a lesson learned for future project reference. Though challenges are still there for summarising these lessons learned for future reference, and transfer of the tacit knowledge is more challenging [16] but it is also evident from the studies that the knowledge expertise gained during project influences the organization's long-term success [16] and creating the knowledge about the possible and innovative solutions for the successful completion of the project [16]. Many challenges exist for gathering, and dissemination of knowledge in projects yet the importance of KM in innovation projects is increasing every day.

### **3.5 Existing KM models**

#### **3.5.1 The "D-R-N" Process Model of KM for innovation**

As stated by Allameh & Khadem Abbas [17], the proposed model of Transfeld, *et al.* [18] shown below in Fig. 1, aims to demonstrate the capabilities of KM for enhancing innovation. The founder of this model considers innovation as a staged process which is within three phases of activity: discovery, realization, and nurture. The Discovery phase focuses on the need for researching and new findings in internal and external environments and interesting potential innovations. This phase has three stages: search, capture and articulate. The searching stage includes the scanning of potential knowledge for specific article or information, in the capturing stage the knowledge is internalized within the organization, and the articulation stage is about adding a precise definition and style. The realization phase emphasizes on the successful implementation of innovation in the organization by developing the innovation from an idea to an end product or service. This phase includes two main processes which are contextualizing and applying. The contextualizing process includes the process of adding articulated knowledge to a specific organizational context. The applying stage consists of the usage of contextualized knowledge in the organizational challenge. The last phase of activity is nurture which contains three stages: Evaluate, Support, and Re-innovate. In the evaluating stage, the competence of knowledge application is determined, the supporting stage consists in the creation of sustainability over time in knowledge application, and the re-innovating stage involves the reapplication of knowledge in a different section of an organization.

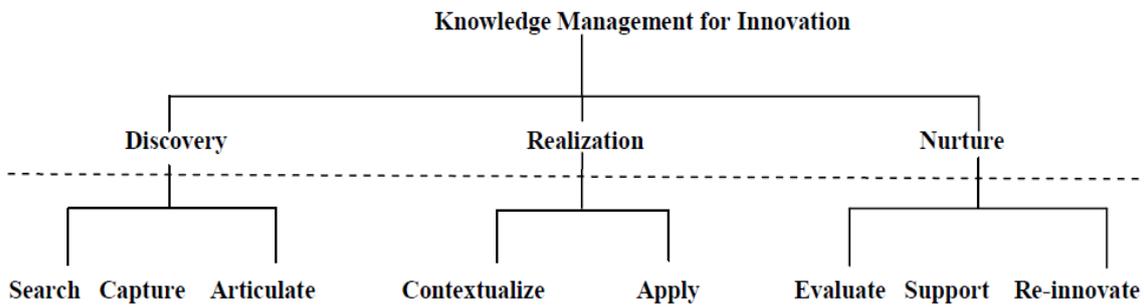


Figure 1. The “D-R-N” Process Model of Innovation [18]

### 3.5.2 Systematic Lessons Learned Knowledge Model (SYLLK) for projects

As shown in Fig. 2 and stated by Duffield and Whitty [19] the SYLLK model represents the organizational functions that drive the overall behavior of an organization. This model comprises of various elements for social and cultural learning, supporting technology, processes, and the organizational infrastructure. SYLLK model is divided mainly into two parts: People and Systems wherein people section it is focusing on social and cultural learning and sharing of knowledge. Further, in the second part it is talking about supporting elements: processes, technology, and infrastructure of organization which helps to promote this learning environment in projects for better acquisition, transformation, and dissemination of knowledge by moving in both directions [19]. Further, the model links with the concept of information sharing and knowledge integration in projects as the best way of organizational learning and for innovation [20].

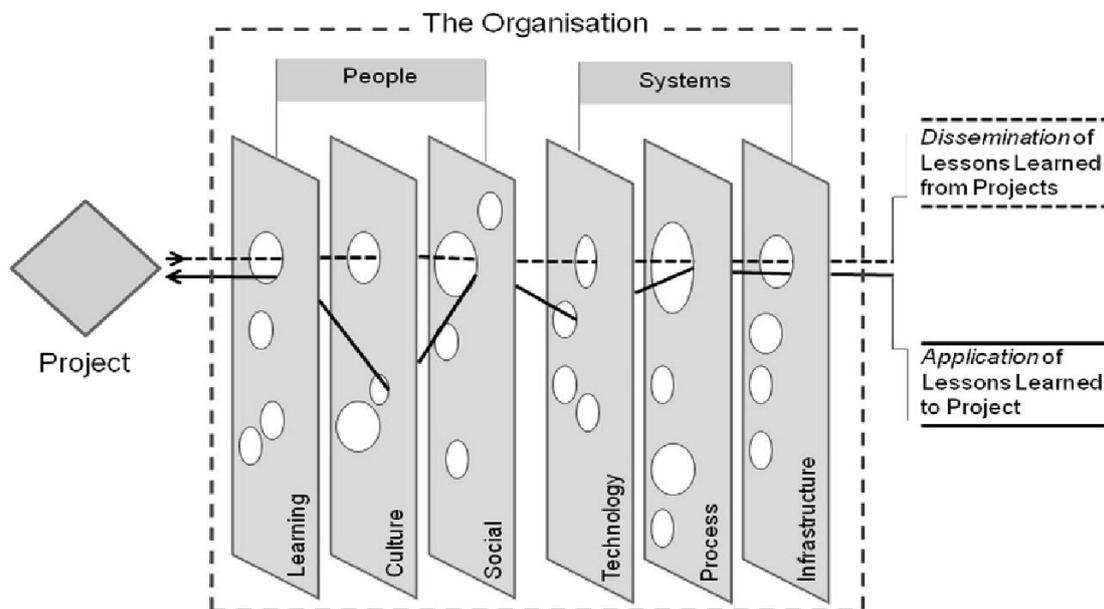


Figure 2. The Systemic Lessons Learned Knowledge Model [19]

### 3.5.3 KM Model for Innovation and Learning

A KM model for innovation and organizational learning was proposed by Maqsood and Finnegan [21]. As shown in Fig. 3 the KM initiatives of organization help them to develop active organizational learning and more importantly this learning environment transform it to be innovative comparatively. The model consists mainly of two parts one is about internal

knowledge of the organization which is revolving around People, Process and Technology which combined develops an overall culture of an organization. The second part focuses on external factors and external sources of knowledge which are integrated into the internal knowledge system for learning and innovation purpose.

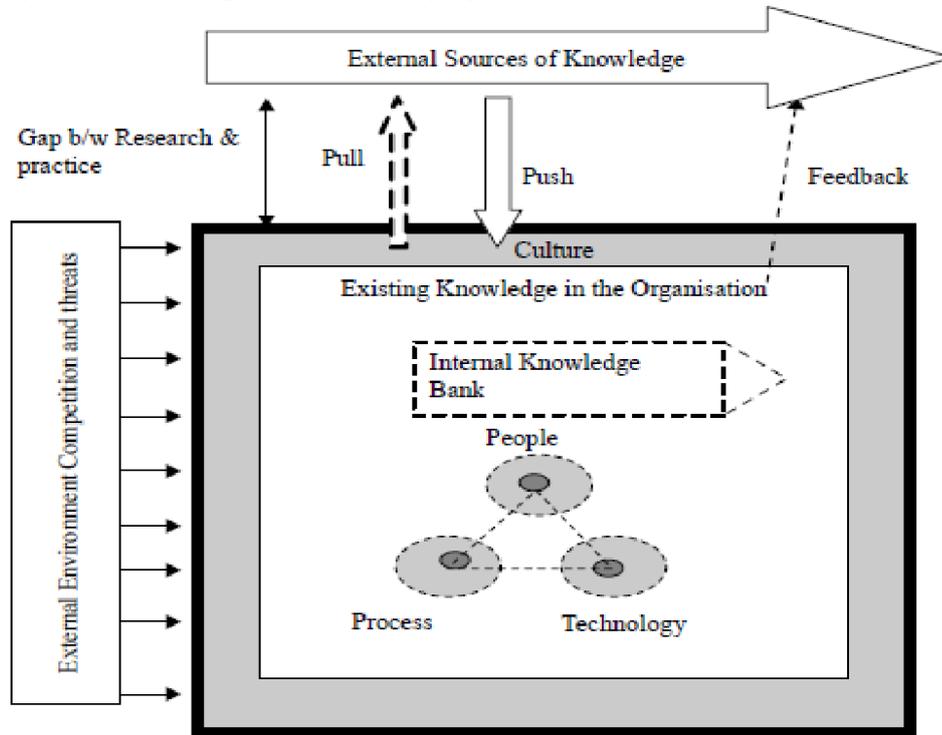


Figure 3. KM Model for Innovation and Learning [21, p.130]

#### 4. Research results and discussion

According to the previous literature review, KM is an accelerator for innovation, and a common objective of both innovation and KM is to create value for the organization. For a radical innovation, it is necessary to acquire new knowledge from the external environment; on the other hand, incremental innovation is achieved by reusing the already existing knowledge in the internal environment. Innovation can be delivered as an organizational process, or organizational innovation and KM is directly linked to the organizational culture. Knowledge is crucial for organizations because they need to develop such structure and processes which foster the knowledge sharing in its all forms. However, for long-term sustainable growth, organizations must embed the KM process in the organizational culture and provide an appropriate environment where new ideas and knowledge transfer is encouraged, and communication is accessible and open for all.

After developing the understanding of the terms and analyzing the different models in the literature review, some gaps were identified. Therefore, it is necessary the proposition of an integrated model of KM for innovation project -which is shown below in the Fig. 4 - to fulfill these gaps, to enhance the organization's performance and to achieve a sustainable competitive advantage.

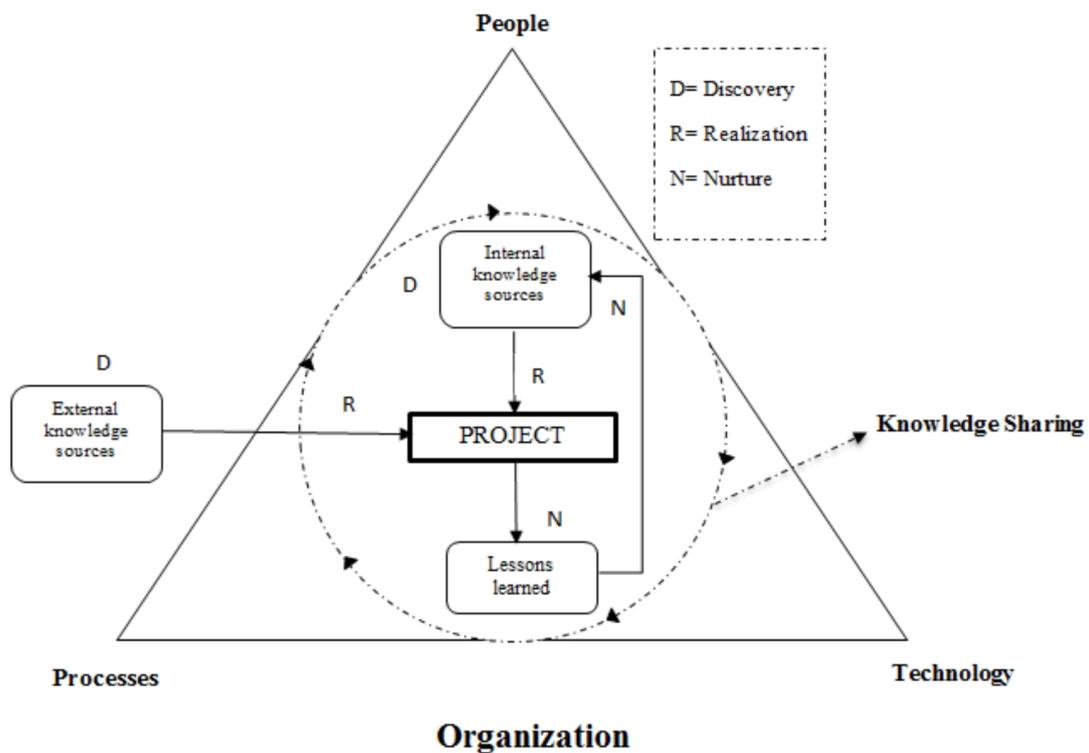


Figure 4. Integrated model of KM for innovation projects [Own creation, 2018]

The model shows the organization as a triangle where people, processes, and technology are the main actors in a knowledge sharing constant cycle. The application of the model starts with a discovery phase in which potential knowledge from external and internal sources is retrieved and later internalized within the project. In this context, the external sources are ideas from the external environment, e.g., people, previous research, organization's knowledge. The internal sources are the tacit and explicit knowledge of the organizational members, project team, and the documents stored in the lessons learned repository or database system.

In the realization phase of the project, the contextualization and application of the knowledge previously internalized is performed. In this phase, it is essential that the employees (people) working on the project, generate and acquire new knowledge (both explicit and tacit) to improve the processes through the use of different technologies, to increase the project's productivity, to be innovative and to achieve an added value for the project's success.

In the nurture phase is performed an evaluation of the knowledge application during the project, the outcome of this evaluation is represented by a lessons learned report which is directly stored as an internal knowledge source for its reapplication in different projects in the future.

All this is proposed with the objective of leading the change or transformation of the organization to a learning organization in time, in order to decrease the innovation gap of the company in relation with the external environment, to increase the organization's performance, to add value to the different projects and to achieve in this way a sustainable competitive advantage by managing knowledge.

## 5. Conclusion

As results of the research have shown, KM within an organization can be used as a technique to create innovating effects within the organization or innovation project. In the past, several models have been created to perform KM; such models are expected to provide improvements

in organizations aiming to innovate. After reviewing and analyzing the previous literature and models in the KM, a need for KM in innovation project has been discovered. Therefore, in this work, an integrated model of KM for innovation project has been developed. This new model helps the organization to manage the knowledge in innovation projects. Indeed, this model simplifies the use of KM within an organization and project. It also explains the fellow and the transformation of tacit and explicit knowledge, internal and external source of the knowledge and creation and use of innovation. The consequence of KM's contribution to innovation project for organizations is a performance enhancement, sustainable competitive advantage and more efficiency in managing knowledge in an innovation project. Since the study subject is relatively new, many challenges exist for gathering and disseminating knowledge in projects, especially innovation projects. Therefore, the importance of KM in innovation projects should be upgraded continuously.

## 6. Acknowledgment

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## 7. Future research recommendation

The authors expect that there will be further research on KM in particular by using this model to define how effective and efficient is this model to manage the knowledge, especially in innovation projects. The authors suggest future research on a model which could distinguish the innovative and innovation projects and explains the collaboration of KM to innovative projects as well.

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# KNOWLEDGE MANAGEMENT IN DISTRIBUTED AGILE PROJECTS

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**Abstract:** *Nowadays, many software organizations are focused on capturing the international and global market while trying to reduce the development cost. As a result, a significant amount of organizations is currently using agile methodologies as their development approach for achieving their strategies. Based on some statistics, agile projects are 28% more successful than traditional approaches. Hence, some companies in order to expand and become more global, are starting to implement agile projects as strategy to become a distributed company which means that different team members from different geographical areas will all work together. Consequently, agile projects, especially those in software development, are reliant on knowledge management, which is a key success enabler for software projects, and hence, for a correct development in the global market.*

*On the other hand, most of the methodologies use face-to-face communication, informal communication, and open channels as enablers for knowledge sharing in the project between team members. However, in distributed and agile projects these enablers for knowledge sharing become more challenging to have, this because of social and cultural aspects, background, norms and beliefs and the absence of face-to-face interactions between team members since they are in different geographical locations. Furthermore, there are also some knowledge sharing tools used in agile projects that are missing in the distributed agile projects and most of these tools are office based such as the whiteboard, innovation board, task board, etc.*

*Important to note out, that currently there is little research regarding the topic of distributed agile projects in connection with knowledge management sharing and processes. This paper, first of all, will use qualitative approach reviewing the existing literature and content analysis of papers and articles regarding the subject. Secondly, it will discuss the current tools and techniques used in knowledge sharing while trying pinpoints the gap in the current knowledge management processes inside agile projects and finally it will introduce some suggestions and recommendation to enhance the knowledge sharing process and engagement of team members in offshore agile projects.*

**Keywords:** knowledge management, project management, agile software development, distributed teams, virtual reality.

## 1. Introduction

Agile methodologies are very effective for projects, especially for IT. Therefore, there is an increase in the organizations using this approach to develop their projects. Nonetheless, agility is not a symbol of easiness. Conversely, agility comes with a set of challenges such as time, cost, scope and, communication among the stakeholders; this increase while working with a distributed team in which people with different backgrounds, culture and, expertise levels collaborate all together. as a fact, there are multinational organizations with more than 100,00 employees located in 100 different cities around the world. Thus, a distributed team is a reality not only for startups but for any type of organization.

Due to the popularity of agile approaches, particularly in software development using distributed teams to fulfil the project's needs, there are challenges in how to handle knowledge sharing

between team members. Empirical studies have shown that technically driven design decisions influence coordination and knowledge sharing in development teams, which can in turn decrease productivity (Herbsleb, James D.; Mockus, Audris, 2003). The exchange of knowledge in distributed teams become a challenge in the agile methodology as a result of time limitation and many other factors. There are few gaps that need to be addressed in order to implement the knowledge sharing between the team members.

Most of the work in software development is documented in repositories that help developers to access different resources, such as documents or source code, which can be reusable for future projects. Nevertheless, these approaches have lack of process to maintain up to date these resources. The Experience Factory (EF) (John Wiley & Sons, 1994) describes a framework for building repositories of reusable knowledge. However, knowledge sharing in the world of software development in the 21st century is beyond code, knowledge is about sharing experiences in problem-solving, challenges that were faced during the development, tools and techniques that most of the time cannot be reflected in the code. The mentioned approaches fail to support sharing small pieces of experience that most of the time can be collected in informal communication such as coffee break. But, how to share a coffee in distributed teams? Now with the widespread adoption of email, video conferencing, real-time chat the problems seem to be reduced. However, in some cases these technological channels are more a barrier than a support. As part of scrum cycles, there is a stage for retrospective which can be used to share activities the developers have carried out to resolve a certain bug or lessons learned on configuring a component of the project, but the main question is how retrospective can be implemented in distributed teams where limitations exists such as time, the culture, language, and even the tone of a call that could be misunderstood?

Nonetheless, there is a wide range of technology to overcome the barriers of a distributed team but there is a lack of procedures to help the teams overcome these challenges. At this point, how do we communicate complex issues across geographically dispersed teams with different languages, time zones and cultures? is not the main question? Due to technological advance, this issue was solved. while the key success factor of a distributed team is engagement, this paper aims to respond to a different question; which is how to engage distributed teams and compensate the lack of face-to-face communication.

## **2. Research methodology**

The researchers used a qualitative approach to pinpoint the gap by reviewing the current literature about agile projects, distributed teams, and knowledge management in distributed teams. In addition, reviewing the current literature regarding the current challenges and solution regarding knowledge sharing techniques and team engagement in the project and with other team members. Finally, a suggestion of the use of Virtual Reality, Augmented Reality, and Artificial Intelligence was provided as the future of knowledge management in distributed teams.

## **3. Literature review**

### **3.1 Distributed teams**

agile is a term or a word that encompasses the principles, values, methods, and teams of the respective software development philosophy (Schwaber, And Beedle,2001) The main focus of agile methodologies is delivering high quality products done by simple and easy work processes (DINGSØYR, 2010). moreover, agile focus on the individuals, communication, collaboration among the stakeholders. Thus, the team or the people who work together in different ways are important to the effectiveness of the work. But what actually the term team in agile project really means? That's why we reviewed a variety of definitions regarding the term team. Francis and young said that team are a group of people who work together and are committed to a certain goal who produce high quality results (Eckstein, J., 2010). Whereas others define teams as the group of individuals, each one of them has a specific role that is known by everyone. Salas et al, defines

the team as a unique set of two or more people who interact toward a common and valued goal (Salas et al, 2007). Different definitions of the term team are almost very similar and have the same elements but the definition of the team in agile projects are different since we have to combine the classic definition of a team with the concept of agility. Agility is the ability of a team to embrace the changes happened at any stage of a project in order to deliver working software that provide business value to the customer (Moran, A., 2014). Taking into consideration the agile principles and the concept of agility we can define agile team as a cross functional, self-organizing team that carries out software development activities in order to provide business value to the customer. (Rigby, D.K., Sutherland, J. and Takeuchi, H., 2016.). Cross functional team means that the team involve everybody in the development of the project in another word, interdisciplinary team. The team should have all the demanded skills and knowledge for the project and be willing to share with the others. Self-organizing team means that the team manages their own work activities, divide the work between each other's, and make decisions 129. This characteristic of an agile team is the most important success factor for the agile team. Moreover, when the team is highly cohesive and engaged, focuses on project success and strive to provide the value for the customer; the team will be a high-performance team (Korkala, M, 2007). Agile team proved over time their effectiveness and efficiency and proved that the way they interact with each other contribute 28% more to the project success rather than traditional projects (Pwc). Another study showed that 50% of team members are motivated by team success while 27% by the company goals, and 23% for personal goals. (Atlassian). However, many software organizations are focused on capturing the international and global market while trying to reduce the development cost and they are doing that by having teams located in different geographic areas. This need for organizations created the need of distributed teams. Linpack and stamps described in their research about virtual teams, different types of distributed teams regarding the space or the geographical location and the organization. As stated on the figure below from Linpack and Stamps, collocated team are individuals who work in the same space and time in the same organization while the collocated cross organizational team are individuals from different organizations. distributed teams are individuals working for the same organization but from different places and time zones, while the distributed cross organizational team are from different organizations.

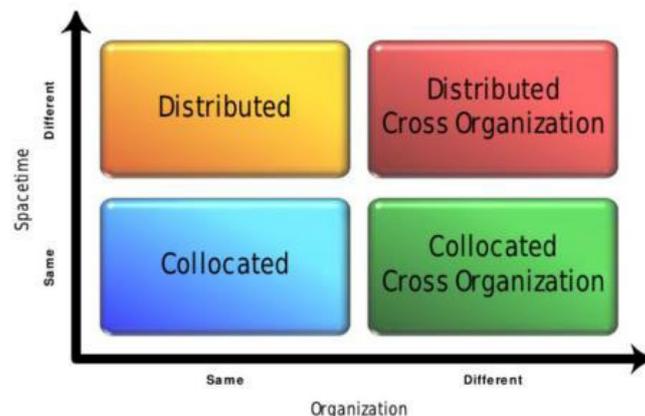


Figure 1. Virtual team (Lipnack, 1997)

In this paper, the focus and the discussion are regarding the distributed teams and distributed cross organizational teams. Thus, we define distributed team as the project team that can be from the same organization or from different organizations where at least on team member is distant from the others in different geographical location.

### 3.2 Managing knowledge in distributed teams

Benefiting from global knowledge resources was one of the main reasons for software companies to shift into distributed software development. The distributed teams need to share knowledge in

order to develop and create a valuable software within the project constraints of time, cost, and scope. Knowledge is usually created by the people involved in the project, like the project team, project customer, project manager, and other project stakeholders (Polyaninova, 2010) knowledge in the project generated from different internal and external sources (Polyaninova, 2010). Moreover, knowledge is divided into Tacit and Explicit knowledge. Tacit knowledge is the action-oriented knowledge that lead human behavior, while explicit knowledge is the know what knowledge that comes in written or verbal forms (Smith, 2001). In distributed teams the tacit knowledge is the most valuable knowledge because it is within team members in the form of experience and skills. The importance of knowledge in distributed team makes it important to have enough attention for managing this knowledge. Knowledge management is *“the process of sharing, distributing, creating, capturing, and understanding of the company knowledge”* (Al-Hawamdeh, S., 2008).

In order to gather, store, use, and share project knowledge, teams in agile projects use face-to-face interaction and continues communication between team members. in general, agile teams have to understand the process of managing knowledge in the projects regarding a variety of topics regarding the development of the software itself, the used tools, the technology in use, and many others. However, managing knowledge in distributed teams is hard due to the lack of face-to-face and continues communication that is the base of managing knowledge in regular agile projects. Thus, many challenges faced distributed teams in managing and maintaining communication between project team. On the other hand, current literature and practices came up with solutions to try to overcome these challenges.

#### **4. Current status (challenges and solutions)**

##### **4.1 Challenges**

Knowledge sharing and Knowledge creation are fundamental elements of knowledge management which play a critical role in building organizational value. Knowledge creation is the most important asset for successful companies, because it helps them to compete effectively in this current era of information and knowledge. In order to achieve a proper level of knowledge creation and innovation, both top management and support staff must be active key players. Creating knowledge is not merely matter of learning from others or obtaining knowledge from outside but knowledge must be built on its own through communication and interaction among people in the organization. In fact, it is only limited by mental and environmental constraints. This process seeks more attention to the critical role of knowledge sharing in an organization and therefore in its projects.

Most of the knowledge generated in agile software development projects is tacit, which depend heavily on the human itself rather than documents and papers. Thus, it becomes the key challenge to overcome in distributed projects. Hence, it is hard to find an efficient way to communicate between teams in distributed projects since there are differences in time zones, working hours, culture, and linguistic barriers (Ramesh,B. 2006). When projects are distributed across time, space, and culture, it is harder to obtain the same level of group cohesion expected in collocated teams (Sakthivel 2005). Moreover, the lack of face-to-face communication can negatively impact trust and increase the amount of issues and misunderstandings.

The identified main challenges arise because the project must be divided in work packages and distributed across the team members which are located in different cities. The task division and distribution can make it difficult for project participants to understand the task, its purpose (Kirkman et al. 2004; Sakthivel 2005), and their own contribution to the overall task (Ebert & De Neve 2001; Farshchian 2001; Herbsleb & Mockus 2003). Therefore, allocation of resources in every work package can be crucial for the project. Furthermore, team members in distributed agile projects complain about how they spent almost 35% of their time dealing with collaboration issues rather than focusing on the main tasks on the project (Richter, I., Raith, F. and Weber, M., 2016). The lack of infrastructure adds up some more challenges when team members waste some of their time trying to create a stable connection or online setting for the meeting. In addition, one of the

main characteristics in agile projects is to have a consensus while making the process, but that can be affected when the size of the project team members in distributed project becomes too large, as the team gets larger it will be more difficult to hear all the voices and effectively communicate between each other.

Furthermore, distributed teams do not give much attention to which will affect their understanding about the project. Pair programming where two developers set side by side to work on the same code is another challenge since distributed teams are space distanced. In addition, in regular agile projects, the process is more people oriented and informality used to control the project but in distributed teams they have to do that using formal tools and channels. Furthermore, cultural difference, team cohesion, and language are also challenges that face distributed teams doing projects.

All these challenges that rise in distributed agile project environment will create a lack of lucidity in measuring innovation, creativity, and quality which in turn will lessen the managers confidence in the team (Annosi, M.C., Magnusson, M., Martini, A. and Appio, F.P., 2016). However, some knowledge sharing techniques and tools have been already implemented trying to improve this process in agile distributed teams.

## **4.2 Solutions**

### **4.2.1 Knowledge sharing techniques and tools**

In order to overcome the previous challenges, knowledge sharing tools and techniques should be tolerized for the nature of distributed teams. Knowledge sharing in distributed teams is not about the selection of the right tool but about the right integration of all of them, each one is a bridge connecting the gaps that should be used for every member of the team, the organization and the client in order to achieve common goals.

There are very well-known bridges. For instance, under the scrum methodology, the daily scrum meeting for distributed teams is executed through Online conference and screen sharing. Additionally, tools such as Common chat room, technical forum, Discussion Forum and Electronic Board are used to add and discuss the issues, Knowledge gained, lessons learned or any project related topic which leads to knowledge storage in different platforms. The alternative option been used is the digital library (wiki) where developers can find, add and update project information. Based on the nature and needs of the project, the type of wiki might change. Moreover, using case diagrams with other user stories will enhance the understanding and in turn will enhance the collaboration between the team and enhance the documentation in the project. Issue tracker is another tool also to enhance documentation in the project. In addition, show-and-tell hour where every team member shows his work to the entire team and receives feedback will mitigate the problem of physical distance in pair programming. Different solutions are suggested in the practice regarding the different working hours like developer to developer handshakes and end of the day status notes where every team member should share with the others what he or she did during the day.

### **4.2.2 Team Engagement**

Previous studies mentioned that team cohesion is a success factor and a performance enhancer in any project (Rasnacis, A. and Berzisa, S., 2015). In order to achieve this cohesion an emphasis on bundling the team right should be undertaken. Teams should get to know each other and by that they will recognize each other, and every team member will understand the structure of the team. This in turn, will give the team members a feeling of identification with the team and the work will be directed for the success of the project. One suggested way also to help in getting the team know each other and give everyone sense of identification is to have big pictures for every team member in the project in every dispersed office, this will remind everyone that he/she is part of a wider team. Building relationships with team members will help in the engagement process. those relationships can be built by sharing personal information such as hobbies, interests, and

family background with the whole team. Moreover, the use of communication is very important in this situation for the lack of face to face interactions as mentioned before. Attending or using video conferences but for informal purposes is the best way to overcome one of the challenges that face distributed teams. Furthermore, it is very important for the team to have one vision. Regarding that, we are here emphasizing the role of the customer in the engagement of distributed teams. The customer is the one who creates the vision and by that creating the direction of the project and when the team understands the vision and the direction for the project, the team will act as one and that will enhance the engagement of distributed team members. important to note out, that the role of the manager here is really important in this context; managers need to recognize team members efforts in order to develop a sense of closeness to the team. (Takpuie, D. and Tanner, M., 2016).

Another dimension is time. Distributed teams work in different time zones resulting in delays in obtaining feedback and responses for project activities which also in turn will result in condensed productivity in one of the distributed teams. Several techniques can be used in order to overcome this barrier. Formal meetings with a preassigned date and time will give team members the opportunity to communicate and interact with each other in order to share the current status, the progress, share and discuss impediments, and discuss potential solutions. Moreover, planned unconfereces is another technique that enhance the engagement and interactions between team members. before planned meeting or maybe after, video conference call is conducted between team members in order to have casual conversations which in turn will enhance the intimacy between team members. in addition, spontaneous conversations like one on one phone calls between team members help to get rid of barriers between team members. one of the most important technique in time context is shifting work hours in order to enhance the synchronization between distributed teams and offering flexible working hours to create time overlap which helps in having real time collaboration between the teams.

In order to engage team members together and with the project to ensure a smooth effective knowledge sharing, it is recommended that the space gap between distributed teams should be closed temporary between team members. doing that can be done by inception workshops, these workshops are held in the beginning of the project where customer and team members can meet together for defining the structure of the project. Participants who attend the inception workshops were able to develop direct communication with the customer and other team members resulting in high engagement and commitment toward the project (Singh, P. and Singh, S.K., 2015). Cross-site visits where one team member or more visits the other team on the site in order to engage and spend time with other members proves to be helpful. In addition, rotation where team members of the same level, experience, and role swap locations offer team members to engage in social and face to face conversation and learning how to work with someone from different country or culture. Moreover, coach travel is very common in distributed agile projects and we emphasize about the importance of establishing solid relationships with the team and create the bond between the coach and the team.

Furthermore, cultural differences play a huge role in distributed teams and one of the biggest challenges in distributed projects. In order to enhance the engagement of team members, team members should have the awareness on the conflicting culture in order to familiarize themselves with the culture and avoid misunderstandings in the team.

moreover, sharing the same standards and practices between team members will enhance the knowledge sharing process and the engagements of team members (Stanberry, L., 2018). In addition, shared e-workspace is an effective technique to ensure that. This interconnected environment combines software development tools with the communications technology in order to collaborate on the project like using a digital task board for example. Moreover, distributed teams should learn how to share and take responsibility of mistakes, errors, and difficulties resulting from distributing teams and try to work these out as team and not blaming the other.

Lastly, by tracking the literature on how to enhance the engagement of distributed teams the idea we found that some companies are already implementing project room concept. Project room is where distributed teams from distanced location are working all the time while seeing each

other's. this technique proved to enhance trust, motivation, team cohesion, and performance within distributed teams.



Figure 2. Project room concept (Source: own creation)

## 5. The future

After reviewing the current status of distributed teams regarding knowledge sharing through communication and interaction and reviewing the current challenges and solutions. We found that there is still a gap in the current status, looking at the previous solutions, it can be seen that engagement techniques and knowledge sharing techniques relatively enhanced the knowledge sharing and different aspects in engaging distributed teams together. However, distributed teams still feel the disconnection between other team members and they miss the idea of being in one place and faces from screens are not really enough to feel the connection between teams. Thus, the question is what is next to enhance and overcome the barriers of knowledge sharing and communication in distributed teams and enhance more the engagement of teams?

We believe that Virtual Reality, Augmented Reality, and Artificial Intelligence are the next level for distributed teams. According to Information Systems Audit and Control Association survey, 64% of US consumers believe that VR and AR enhancements would benefit the workplace (ISACA). Moreover, it is believed that VR and AR will increase the visibility with clients, trainings and engagements, communication, and remote learning and development.

VR can be used by distributed team where everyone has a computer in front and a keyboard, VR headset and gloves where ones can see his hands in the virtual space. Sprints meetings can be done through VR in a virtual room where everyone can see and hear each other's. in the virtual room there will be a virtual white board, story board, and what the meeting will need. Moreover, Augmented Reality will be used where some information and notification will pop up in the virtual room. Pair programming challenges will be reduced to the best when using Virtual Reality, two employees can meet in the virtual space to do pair programming. every employee can choose the setting of the virtual space and choose what makes him more comfortable. For example, employee A may choose a garden as a setting and employee B may chose the moon as a setting for the virtual space. As part of the integration of different technologies to improve distributed teams, Artificial Intelligence can be used in distributed teams, where teams are working in different time zones, robot assistant can be the solution. Robot Assistant will have all project

information such as appointments details, knowledge base of codification issues and the tracking work of every team member which will allow to provide information when Team A is asleep in time zone A and Team B is awake in time zone B and need project specific information, they can ask the Robot Assistant. The key success factor of the Robot Assistant is the ability to change “personas” based on the person who is enquiring. If a developer is asking a technical question, it will be able to change to a developer persona or if a project manager is asking a non-technical question, it can also change to Non-technical personas. Robot Assistant uses computational intelligence as a logical approach to operate.

On the other hand, the integration of the mentioned elements Virtual Reality, Augmented Reality and Artificial Intelligence can be also used as a “room game” for the employees. They will have the ability to play different types of games among each other during their “break time”. As part of the functions of this room, every developer could access the room through the avatar and walk to see anyone who is available for a game. In addition, this is a valuable time where they could share experiences and challenges in projects. Workers are encouraged to “casually collide,” as an aim of organizations to encourage “unplanned collaborations.”

Artificial Intelligence can be used in distributed teams, where teams are working in different time zones, robot assistant can be used. Robot Assistant will have all project information and the work of every team member when Team A is asleep in time zone A and Team B in awake in time zone B and want project specific information, they can ask the Robot Assistant

This virtual approach will be the best substitute of face-to-face communication which is the most important communication mean in agile projects. thus, team engagement, building trust, overall team cohesiveness and highly effective performance will be enhanced. Other benefits for the organizations as result from using Virtual Reality technology are saving project costs for collocated teams, improve the quality of the deliverables, increase innovation with talents from other locations and countries, enhances the opportunity to work from home and overcome the challenges that faces distributed teams in knowledge sharing.

## **6. Conclusions, proposals, recommendations**

A review on the current challenges and solution was conducted. To conclude, challenges were mainly about documentation, communication, team cohesion, time and space difference, cultural differences, and pair programming and others. Moreover, the current solutions and techniques used for knowledge sharing and team engagement were also reviewed. thus, we found that it is vital to improve the communication overall by applying the aforementioned techniques and by synchronizing work hours, insure the informal communication between agile team but through formal communication channels. Furthermore, its important in improving the communication between the team to balance the coordination and retain the constant communication flow between team members. Thus, this will enhance and facilitate the knowledge sharing process. Moreover, the focus for the team should be on the understanding of the functionality rather than critical new functionality and doing short cycles rather than time boxed development. In addition, maintaining a product or/and process repository as mentioned above will facilitate the knowledge sharing process.

After reviewing the current literature and the current status, the gap was pinpointed. The gap of not fulfilling or present a substitute for the face-to-face communication. The current solutions suggested communication means through the screen where all communication will be either with the screen or with a face behind a screen. Our suggestion was using Virtual Reality, Augmented Reality, and Artificial Intelligence as communication means between distributed teams. These futuristic means will be the substitute of face-to-face communication. Virtual rooms, the use of Augmented Reality, and the use of robot assistant in distributed teams work and meetings will enhance the creativity, engagement, team cohesion, and overall performance. The future will be in the Virtual space.

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# KEY SUCCESS FACTORS IN IT PROJECT MANAGEMENT

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**Abstract.** *Project success could be considered from three perspectives: project outcomes, project management processes, and project manager competencies. IT project manager competencies are crucial for IT project success. IT project success mostly is a perception different group of stakeholders and therefore IT project manager desired skills, knowledge, and abilities should be relevant to the context. The aim of this research paper is to help IT project manager to define skill sets leading to success of a particular project, in different contextual consideration (stakeholders perceptions and project's life cycle phase) based on proposed "fixed-flexible skills mosaic" framework.*

**Keywords:** IT Project manager success, Project manager competencies, Success criteria.

## 1. Introduction

Project management is defined as "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements" according to PMBoK [1]. One of the main challenges in project management is the achievement of project success. Project is a complex undertaking in which two main flows of activities are pointed:

- Project delivery (outcomes).
- Project management (process) [2].

In project management when the success of a project is discussed, it is important to define what kind of success it means, is it project success or project management success?

According to E. Harrin, there are two types of project success criteria:

- Project deliverable success criteria (related to things delivered as a result of the project).
- Project management success criteria (related to the professional job of running the project) [2].

C. Millhollan, and M. Kaarst-Brown in their research moved further and proposed "tri-focal lens" of success – considering it from three perspectives: project outcomes, project management processes, and project manager competencies [3].

This has two implications for this research:

1. Success couldn't be strictly defined; it constantly shifts depending on perspectives and context;
2. Each of these perspectives focuses on different success factors that are most relevant.

So, project manager should be aware that project success has both objective and subjective components. It implies in practice that objective components should be measured and subjective components should be identified for successful project management.

## 2. IT Project Manager Competences

According to definition from PMBoK the project manager is "the person assigned by the performing organization to lead the team that is responsible for achieving the project objectives"

[1, p. 52]. It implies that project manager is mainly responsible for meeting project's goals and therefore for project success.

It is supposed that for IT project success IT project manager competencies are crucial (from both perspectives – project and project management). Therefore the questions should be explored: What is IT project manager success? What is special about IT project managers (those working in IT-centric environments)? What skills do IT project manager need to effectively run a project?

IT projects are characterized by a high degree of uncertainty, innovativeness, fast-changing requirements and customers vision of final products which make IT environment very stressful, challenging and dynamic. IT project managers more often than project managers from other specific domains are required to deal with users, technical workers, managers, conflicts, miscommunication and work burnout [4].

The evidence from researches show that IT project managers should combine technical skills with other skills to achieve project success [4]. The most important skills necessary for successful activity of IT project managers are: ability to communicate at multiply levels building trust and using appropriate communication mode [5]; competency to work effectively with various types of stakeholders, conflict management [4]; abilities to engage with stakeholders evaluating the outcomes [3].

So for being successful in today's challenging IT environment project manager should be competent which means possessing and using certain essential skills besides technical skills. Therefore, IT project managers have to develop a diversified range of competencies.

Competence is defined as “a combined set of an individual's knowledge, abilities, personal characteristics used to perform a specific task or activity” [4].

Project management skills researchers often divided on two groups:

1. Hard skills – skills and knowledge “outlined in the PMBoK Guide or other technical training”.
2. Soft skills – abilities “to apply effectively the project management tools and techniques” [3].

There are different approaches in defining project managers' competencies among which are PMI and IPMA approaches using as the basis for professional certifications in project management.

Main points of the research paper “fixed-flexible skills mosaic” approach to IT project manager skills:

- There is a need for applying variety of IT project manager crucial skills in order to achieve success in delivering a project.
- There is a need for different types of skills applying to different project phases and project management process groups.
- There is a problem to combine all needed skills in one project manager.
- Project team could be viewed as a skill-resources pool from which project manager could chose team-member possessing needed skill for reaching the goals, meeting objectives, and solving particular problems.
- Project team is a mosaic combined from people possessing particular skills and project manager will make temporally union with particular team-member in order to achieve high results on each project phase.
- Project integration management and project stakeholder management are crucial processes for achieving overall project success from project manager point of view (Table I).

TABLE I  
Project Manager Skill Sets/Competencies: Different Views

PMI* approach: “talent triangle”		IPMA** approach: “standard competence eye”		Research paper’s approach: “fixed-flexible skills mosaic”	
1) technical project management	the skills to effectively apply <i>project management knowledge</i> to deliver the desired outcomes for project;	1) the technical competencies	competencies related to <i>project management itself</i> such as project planning, time management;	1) fixed skills	combined project management and business (technical) <i>knowledge and ability to use</i> it effectively;
2) strategic and business management	the ability to use project manager’s <i>business knowledge</i> of the work performed in organization for making the best decisions regarding the successful project delivery;	2) the contextual competencies	competencies related strictly to <i>the context of a specific project</i> such as development and programming skills, business knowledge;	2) flexible skills (mosaic)	the most crucial skills needed for successfully running a project on its particular phase with using the <i>skills-base-pool of project team skills</i> .
3) leadership	the ability to <i>guide</i> , motivate and direct <i>a team</i> .	3) behavioral competencies	<i>personal abilities and skills</i> of the project manager such as leadership, creativity and commitment.		

\* – PMI – Project Management Institute [1, p. 56–60];

\*\* – IPMA – International Project Management Association [4].

Based on these assumptions all skills necessary for running project successfully could be divided on two groups:

1. Fixed skills – the basic requirements to project manager for particular IT project. Fixed-skills are combined project management and business (technical) knowledge and ability to use it effectively. These skills relevant to IT project manager could be defined as knowledge and abilities that practitioners can obtain through certification processes.

According to job board survey results top five of project management certifications are:

- CAPM – Certified Associate in Project Management (Project Management Institute).
- CSM – Certified Scrum Master (Scrum Alliance).
- CSSBB – Certified Six Sigma Black Belt (ASQ).
- CSSGB – Certified Six Sigma Green Belt (ASQ).
- PMP – Project Management Professional (Project Management Institute) [6].

Organization should decide which project management methodology would be better suited for its business and projects and based on this which certificates project managers need to possess.

2. Flexible skills – the crucial skills which must be in “possessing of project team members”. Flexible skills (mosaic) are the most crucial skills needed for successfully running a project on its particular phase with using the skills-base-pool of project team skills. Project integration management and project stakeholder management are considered as crucial processes for achieving overall project success. Therefore skills which help successfully manage these particular processes are critical for IT project success.

Why is project stakeholder management crucially important for successful IT project management? IT projects experience a high degree of changes which require active engagement and participation with most influenced project stakeholders. Based on PMBoK 6<sup>th</sup> edition it is defined crucial skills for IT project success on the different project phases (Tables II; III) [1].

**TABLE II**  
Check Points in Project Stakeholder Management (Tools and Techniques)

Tools and techniques	Project management processes			
	Identify stakeholders	Plan stakeholder engagement	Manage stakeholder engagement	Monitor stakeholder engagement
Expert judgment	+	+	+	
Data gathering	+	+		
Data analysis	+	+		+
Data representation	+	+		+
Meetings	+	+	+	+
Decision making		+		+
Communication skills			+	+
Interpersonal and team skills			+	+
Ground rules			+	

**TABLE III**  
Crucial Skills for IT Project Success on The Different Project Phases  
(Project Stakeholder Management)

Project phases	Project management process groups: processes	Project stakeholder management	
		check points	crucial skills
Concept	Initiating: Identify stakeholders	Data-based techniques	Data gathering: questionnaires and surveys; brainstorming. Data analysis: stakeholder analysis; document analysis. Data representation: power/interest grid; power/influence grid; impact/influence grid; stakeholder cube; salience model; direction of influence; prioritization.
Develop	Planning: Plan stakeholder engagement	Decision making	Prioritization / ranking.
Execute	Executing: Manage stakeholder engagement	Communication skills Interpersonal and team skills Ground rules	Feedback.  Conflict management; cultural awareness; negotiation; observation /conversation; political awareness.
	Monitoring and controlling: Monitor stakeholder engagement	Combination: Data analysis-representation + Decision making + Communication and team skills	Data analysis: alternative analysis; root cause analysis; stakeholder analysis. Data representation: stakeholder engagement assessment matrix. Decision making: multicriteria decision analysis; voting. Communication skills: feedback; presentation. Team skills: active listening; cultural awareness; leadership; networking; political awareness.

Crucial flexible-skills for IT project management team on the different project phases (necessary for successful project stakeholder management):

- 1) Concept phase – analytical skills and data operating effectively.
- 2) Develop phase – decision making skills.
- 3) Execute phase – communication, interpersonal, and team skills.

These skills are equally important to fixed skills and should be considered while forming project team and moving from one project phase to another, for particular IT project these skills should be detailed and concretized.

### 3. Stakeholders Perception of IT Project Success

IT project success is defined “Not only by meeting technical requirements and providing a product, service, or result but also by achieving high levels of satisfaction from the stakeholder groups” [3].

Different groups of stakeholders define project success differently [7], therefore it doesn’t exist stable definition of IT project success which IT project manager could use for achieving better results in managing project. For each project phases project managers need different sets of skills and abilities (Table IV).

**TABLE IV**  
Definition of Stakeholders’ Views on Success Criteria Based on “Tri-Focal Lens” of Success

Group of stakeholders*	Part I Project delivery (outcomes)			Part II Project management (process)		
	definition of success	success criteria**	project manager competencies	definition of success	success criteria	project manager competencies
Internal stakeholders						
External stakeholders						

\* – Stakeholders which may have significant influence on the project and its expected outcomes.

\*\* – How to document success criteria: 1) name it; 2) measurement of it (how to measure – particular indicator, how often, who is responsible for measuring).

Project success criteria are an evaluation of the project outcomes and could be defined as “the standards by which the project will be judged at the end to decide whether or not it has been successful in the eyes of the stakeholders” [2]. These standards or measures could be both qualitative and quantitative. What is important – they should be clearly defined and easily assessed.

Defining the project success criteria from stakeholders’ perspectives could be made on the concept project phase while identifying stakeholders [1]. Monitoring the meeting of these criteria is the constant process during the project life cycle development.

When defining the success criteria and relevant skills, it is useful to study the best practices to select appropriate ones:

- 1) Concept phase – “laying the foundation”;
- 2) Develop phase – “planning the project”;
- 3) Execute phase – “estimating the work; tracking your progress”;
- 4) Finish phase – ‘learning for the future” [8].

Project manager should discuss issue of defining project success with all important project stakeholders (Table IV, part I). He could develop a special procedure of doing it following these steps:

- Develop a list of possible success criteria which could help stakeholders to clear their views;
- Formulate the most important points in project success for particular stakeholder;
- Clear define the stakeholder’s definition of success;
- Write as many success criteria as possible according to stakeholder’s perception of success;
- Group all criteria on qualitative and quantitative ones and prioritize them in each group;
- Make short-list of 3-5 crucial success criteria and confirm them with stakeholder;

- Discuss and choose requirements to project manager’s competencies to achieve success criteria.

It is supposed that project management success criteria (Table IV, Part II) could be defined after finishing and clarifying procedures in first Part I. Project manager should discuss this issue mainly with top-management of organization and project team.

The result of these actions would be clear defining what success looks like, so stakeholders and project managers know when they have achieved it.

#### 4. Results and Conclusions

IT project managers have to understand various stakeholders perceptions of success; formulate success criteria both for project success (outcomes) and project management success (process, methodologies); and apply a combination of desired skills relevant to particular phase of IT project development (Table V).

**TABLE V**  
**IT Project Manager Desired Skill Sets in Different Contextual Consideration**

Group of stakeholders / Defining Success Criteria and Skills		Stakeholders A		Stakeholders B	
		Success criteria*	Flexible skills**	Success criteria*	Flexible skills**
IT project phases (PM process groups)	Concept phase (Initiating)				
	Develop phase (Planning)				
	Execute phase (Executing, monitoring, and controlling)				
	Finish phase (Closing)				

Based on combined data from Tables III; IV.

\* – success criteria from stakeholder perspective and at this particular IT project phase (project success criteria, outcomes).

\*\* – list of IT project manager’s flexible skills relevant to this particular context.

Since project is a unique undertaking by its nature, and defining project success depends on context (stakeholders perceptions and project’s life cycle phase), that there is not a standard set of success criteria and constant set of fixed-flexible skills needed for it. For particular project to be successful IT project manager should define desired skill sets in different contextual consideration based on proposed “fixed-flexible skills mosaic” framework.

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# IMMUNE MECHANISMS OF PROJECTS MANAGEMENT IN THE CONTEXT OF THE "BEHAVIOR ECONOMY"

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**Abstract:** *The transition from a "rational economy" to a "behavioral economics", which is a global trend, requires additional research on the effectiveness of applying existing methodologies, knowledge systems, mechanisms of immunity (protection) of projects and programs, and the competence of project managers. The basis for changing the behavior of stakeholders is the change in the paradigm of decision-making in the management of a rational to an irrational paradigm. The modern approaches to creation of protective immune mechanisms of project management under the conditions of "behavioral economics" are explored, and from the point of view of decision-making processes in project management and anomalies that influence these processes. The content model of the diagnostics of the use of immune mechanisms, models and methods of project management in the "behavioral economics" is presented. The project managers' behavior profiles were studied when creating a project product and managing projects. Such profiles allowed the author to identify threats and bottlenecks in the application of immune mechanisms of project management methodologies under the conditions of "behavioral economics".*

**Keywords:** behavioral economy, project, competence, behavior profile, project manager

## **1. Target setting**

The global trend of the transition to a new "behavioral economics" from the traditional "rational economy" substantially changes the profiles of managers' behavior in applying modern methodologies for project, program and portfolio management. At the same time, the global trend of economies convergence and key directions of development continue to persist. The basis for convergence (approximation) is a rational and behavioral economy along with economies digitization, the information societies development, the knowledge bases application and innovations. These trends affect the global development of societies, public administration and development projects in the real economy.

Using "rational economy" approach, a person makes a choice, based on the possible optimal result. That is why, when projects are being chosen, the manager will make a choice impartially, acquiring only the best of what that can allow, based on rational expectations.

Intuitive creativity is a logical consequence of a significant preparatory work of the mind, a tense substantiation of the problem, idea, and plan. This type of creativity is characterized by integrity, completeness of its results, solid and realistic level of forecasts, which gives to the intuitive creativity of a natural nature.

"Behavioral Economics" uses conditional minimization. In this case, the choice in project management takes place with a limited budget, implementation time and alternatives of the decisions.

The considering problem is related to the construction of protective (immune) mechanisms in project management systems and profiles of project managers' behavior in the development of "behavioral economics".

Building of models, methods and mechanisms of modern project management methodologies in the context of the transition to a "behavioral economics" is the paper's purpose.

## **2. Studies and publications analyzed**

Today it becomes clear that the transition to a "behavioral economics" essentially depends on the project managers' competence, teams and organizations adapted to irrational decisions regarding the project implementation. Modern organizations face the important task: to develop the specialists' competence potential in all parts. It is extremely important for the adoption of right management decisions and the conduct of reliable expertise in the frame of the project implementation [1,2]. It should be kept in mind that for each employee who develops their careers in an organization, this development is, on the one hand, a motivating factor, on the other hand, a threat to the organization that has not formed the mechanisms for the retention of such employees. At the same time, it is expected from each employee that he/she has learnt to manage their own competencies and will be develop them at the neuronal and immune levels.

A neuroeconomics appearance is as a result of the attempts to improve the behavioral economics. The neuroeconomics is interdisciplinary direction in science and it lays at the intersection of economic theory, neurobiology and psychology. The neuroeconomics [3] is studying the decision-making process in the frame of the alternatives choosing in the allocation of risks and rewards. Therefore, the state-of-the-art research direction is studying of the project managers' behavior profiles in the management of development programs.

If earlier competence management was seen as a desirable component of the management system of an organization, now it has become absolutely necessary. The competent approach development is associated with the application of the studying idea of the project manager's and organization's "field of competence" [4]. The field of competence is the space of competencies in the project management areas and product creation. The appropriate management system should be created for realization of the "field of competence" idea. This system should be based on the following principles:

- competences should be clearly demarcated (principle of components independence of an effective model);
- all competencies of the field related to the organization's activities should be included into the management system (principle of completeness);
- the powers of employees should be clearly defined, periodically be up for review and take into account the actual challenges of the organization (the principle of realism);
- all competencies of the field must be detailed to the desired level (the principle of differentiation);
- indicators should be developed for all competences of the field. These indicators should allow to evaluate of the employees competence (the principle of dimensionality).

Studying of the formation of the field of competence in project management and product creation showed slight fluctuations in the staff competence who managed the project and created an IT product using the Agile methodology.

The two groups of anomalies were studied in the "behavioral economics". These anomalies models the managers' behavior in the processes of preparation and decision-making.

The anomalies in the behavioral of the person are:

- the effect of benefits;
- ownership;
- rejection of injustice;
- mutual benefit;
- intermediate consumption;
- advantage of current consumption;
- impulse investment;
- greed and fear;

- flock behavior;
- trap of drowned expenses.

The anomalies in the behavioral of the market are:

- a riddle of profitability of shares;
- hypothesis of effective level of remuneration;
- tightening of prices;
- the limit on arbitration operations;
- a trap of dividends;
- propensity to extremes;
- calendar effect.

The first stage of work on creating an effective corporate system for project and program management is diagnosis of project-oriented organizations and businesses from the point of view of identifying organizational anomalies of the rational application of the "behavioral economics" principles. The purpose of organizational diagnostics is to identify the main problems, their interrelations, and to propose appropriate methods for making the necessary decisions on successful development in the new management paradigm. Methods of diagnosing organizational anomalies are aimed at defining the incompleteness / redundancy of organizational structures and methodology of business organization, their non-compliance with the requirements of business processes of the enterprise, inconsistency with strategic goal-setting and end of purposes identifying organizational and methodological ruptures and collisions. The next methods are used for diagnosis, in the practice of the implementation of organizational development projects:

- analysis of the products' life-cycle and security components of production technologies, management processes of operational activities, development and business implementation;
- analysis of organizational structure and managerial mistakes in terms of projects and programs safety;
- work with organizational anomalies at the levels of applied methodologies and their implementation in project models, programs and portfolios;
- self-assessment of the organization's representatives by the method 360<sup>0</sup>;
- diagnostic interviews on security issues;
- building graphs of problems, challenges and solutions.

In the process of diagnosis, the organization determines the symptoms of potential anomalies, a system of indicators for their determination, and so on. During the preparation of these events, interconnected project chains are formed along the defined vision horizons. At the same time, the clarification of the vision of the projects and their synchronization in time and organizational methods are been at each step.

Project managers who work in industries with high communicative capability may lose interest and motivation in work after a while. It leads to lowering personal efficiency and productivity. High communicative ability is a strong stress factor, especially if the person's work is associated with a highly competitive environment and high client expectations.

### **3. The constructing principles of project and programme management of development of organizations**

The main study hypothesis is what the key factor in the programs success of development of organizations is the active knowledge use based on the formation of a protective mechanisms system, best practices and lessons in management processes. The constructing principles of the immune (protective) systems of projects and programs will be considered below.

The main principle of the immune systems constructing of projects and programs is the *Ashby principle* (The Law of Requisite Variety) [5]. In our case, the goal of project management is to reduce entropy as a measure of uncertainty. The Law of Requisite Variety states that the diversity (entropy) of the project implementation can be reduced to no more than the amount of

information about the project in the control system, which is equal to the diversity (entropy) management for less loss of information from ambiguous management. In other words, management is better, the greater the diversity of the controlling influence and the less the loss from the ambiguity of management.

*The principle of coherence* of immune mechanisms is determined by the system reaction on the threats in real-time that is concerning of the project safety. Delayed actions, like as the immune response, lead to project security issues.

*The principle of "convergence, integration and harmonization"* of immune mechanisms is related to the creation of an effective immune system for project protection from internal and external negative influences. At the same time, various mechanisms are about to a single immune system, integrate and further harmonize in terms of possible gaps and intersections.

*The principle of result oriented and product* is traditional for project management. This principle supplements the previous ones in order to form an integrated mechanism of achievement.

#### **4. Sorts and functional areas of immunity of the projects**

Let's consider the types of immunity presented in the following structure:

- Natural
- Inborn
- Acquired
- Artificial
- Active
- Passive.

The natural immunity of the project is related to the immunity of the organization or the project implementing team. This immunity can be inborn, determined by the project managers' competence or acquired through the transfer of lessons and best practices in the organization [7].

Artificial immunity is formed in an organization based on lessons from previous projects and best practices. It can be passive, when the managers team learns lessons and best practices, and be active, when the team uses its expertise.

The considered immunity types are used by the managers team in the context of the functional areas. The following functional areas of the immune mechanisms are considered:

- information security;
- staff;
- organization;
- mechanisms and technology.

Each functional area has its own building technology of the immune mechanisms that protect the project from penetration of malicious resources.

The state of functional activity of the immune system is life-critical mean for the body and is designated by the term "immune status". Immune status is a quantitative and qualitative characteristic of the state of functional activity of the immune system's organs.

Immune response is a processes set taking place in the immune system in response to the introduction of a foreign resource (antigen). The mechanisms involved in the immune response are called immunocompetent. A full immune response determines the response of the organization to penetrating threats. On the base of this definition it follows that the immune response is reactive. The formation of the full immune response of the organism (organization) consists in the fact that from the selected scenarios of its movement between the points where there may be other threats - points of bifurcation - it is necessary to form a project of the program realization management. This approach transforms the management style by the programs of organizational development into a proactive. The program will be formed on the base of the projects that create the full immune response. Herewith it is necessary to know:

- the content of each script;

- parameters of the endpoint of following, including probability, size, aftereffect;
- to formulate a step-by-step scheme of the immune response. It indicates that the movements in the project should be in such a way as to work out all threats.

### **5. Immunological memory of projects and immune mechanisms**

Immunological memory is the ability of the immune system of the organism to respond to specific reactions to the repeated introduction of an alien resource, manifested by acceleration or amplification of the response to the antigen. There are short-term, long-term and lifelong immune memory.

Consider the following types of immune memory of the project manager:

- working memory;
- episodic memory;
- semantic memory;
- procedural memory;
- memory of rewards and punishments;
- cognitive memory.

These types of memory include intuitively or based on drivers that determine the possible schemes for migrating knowledge and experience of project managers. The cognitive memory is integrate all other types of memory. It allows generating immune response scenarios and triggering them through immune mechanisms.

There are various mechanisms of exposure to the immune system that are designed to bring its activities to the norm, such as: immunorehabilitation, immunostimulation, immunosuppression, and immunocorrection.

Immunorehabilitation is a mechanism for influencing the immune system. The purpose of immunorehabilitation is to restore to normal values of functional and quantitative indices of the immune system. Immunostimulation is a mechanism for influencing the immune system to improve the immunological processes that occur in the body, as well as increasing the responsiveness of the immune system response to internal stimuli. Immunosuppression (immunosuppression) is the suppression of immunity for one reason or another.

Immunocorrection is the restoration of the immune system. Immunocorrection is carried out for preventive purposes in order to increase the resistance of the organism during periods of activation of threats, to improve recovery of the body as a result of implementation of anti-crisis programs.

### **6. Anomalies of projects management in the conditions of the "behavior economics"**

Under the profile of the project manager's behavior [6] will be understand the model of application of behavioral competencies in management processes. A model of competence groups in the format "Leadership-Intelligence-Emotions" is being offered.

The two groups of anomalies are noted in the "behavioral economics" from the position of the creation and development processes of organizations:

- inborn at the time of the organization creation and its management system;
- acquired in the process of the life cycle (creation, development and aging).

There are four types of organizational anomalies from the point of view of the organization [7,8].

#### *Anomalies in the organization creation*

1. the domination of the structure over functions (the creation of new units to solve problems instead of the constructive use of available assets);
2. separation of units due to the desire of individual leaders to be independent;
3. the incompatibility of the person with the function (more often it relates to managers and occurs when the actions of the manager come into conflict with the organizational order);
4. bureaucracy (excessive number of procedures).

Anomalies in the founding an organization cover the entire structure of the enterprise from the top-management to the subordinate units. The consequence is a violation of the links

between divisions, centers and departments, slowing down the implementation of decisions, the failure of the functioning of the organization as a whole. Anomalies of this type are usually characteristic of large organizations and correspond to the level of technological maturity and competence. Incompatibility of a person with a function is a special kind of anomaly that can occur in any organization. In this case, the main role plays the personality of the leader or the employee. In identifying anomalies of this type the structural analysis is used in the practice of project management. The definition of the structure as a relatively stable set of relations, the recognition of the methodological primacy of relations over elements in the system, partial distraction from the development of objects are lied in the base of the analysis. The basic notion of structural analysis is a structural element (object). The Structural element is an element that performs one of the elementary functions associated with the simulated object, process or phenomenon.

Structural analysis supposes the system studying by using its graphical modelling representation, which begins with a general overview and then is detailed, gaining a hierarchical structure with an increasing number of levels.

The purpose of structural analysis is to transform the general vague knowledge about the original domain into precise models that describe the various subsystems of the modeled organization.

In general, there are a lot of different models are used for the system modeling and for the purposes of the structural analysis. These models reflect:

- the functions that the system must perform;
- processes ensuring the fulfillment of these functions;
- data that are necessary for the performance of functions and the relationship between these data;
- organizational structures that ensure the functions execution;
- material and information flows that arise during the functions performance.

In general, four characteristics are specific for the model of the organization:

- reduced scale (size) of the model, to be precise, its complexity, the degree of which is always less than the original. The simplification is introduced deliberately under the model construction;
- preservation of key relationships between different parts;
- performance of the model, that is, the ability to work, in principle;
- adequacy of the model to the actual properties of the original (degree of reliability).

It is also important to indicate that any model reflects the point of view of a project or program stakeholders group. Each model has its own goals and objectives, and therefore the business object, which is a complex, integrated organism, as a rule, is described by some set of models that collectively forming the general model of this business system.

*Anomalies in administrative functions and decision-making system (functional anomalies):*

- pendulum system of preparation and decision making (measures and countermeasures);
- duplication of organizational order (obligatory norms that are duplicated instructions, etc.);
- ignoring organizational order (violation of accepted norms);
- the gap between the decision and the tasks implementation (difficulties of the accepted decision implementation from behind unaccounted factors or the impossibility of its implementation);
- stagnation (inability to change, inability to implement them);
- suppression of the development by the excessive functioning;
- demotivative leadership style (prevalence of negative evaluation of employees' actions, lack of incentives);
- inversion (the result of managerial influence turns out to be opposite to the goal).

The wrong decisions of the governing bodies and the formed anomalies in the departmentation are the reasons of the anomalies appearing. These anomalies also lead to a violation of the work process, causing recession in the organization's activities.

The pendulum solutions may be an example. This pathology occurs due to absent of a clear decision-making system and plan, and in the end the result of one action is neutralized by others. Sometimes it manifests itself in its pure form: an adopted measure introduces a countermeasure, and the accepted decision is canceled. For example, the establishment of a center of competence for the management of development programs and its further abolition, justifying the importance of introducing new technology and returning to the old way of production, etc. Situational approach, lack of action program, can be very dangerous, because the result of the organization's activities in this the case is reduced to zero. The company does not develop and loses its competitiveness.

Anomalies in organizational relationships (organizational pathologies):

- conflict (division of organization on conflicting sides, complication of cooperation);
- uncontrollability (force loss of the governing body over the subordinate);
- without subjective influence (a situation where nothing depends on employees or they are passive, non-initiative);
- predominance of personal over work relationships;
- scattering of goals;
- occurrence of a click (use of resources of the organization by the top-management group for personal purposes).

Anomalies in organizational relationships often occur against the background of managerial mistakes. For example, the de-motivation style of leadership conduces the appearance of a non-subjective style of management. Naturally, if the motivation is absent, employees become less active and do not seek to put forward new ideas.

A typical example of anomalies in organizational relationships is the scattering of goals. Each organization has its main goal, but its achievement is possible only by dividing the overall goal into smaller goals and objectives. As a result, of constant fragmentation, the totality of sub-targets will not fully meet the strategic goal of the organization, and the result will be a partial accomplishment of the purpose or its non-fulfillment. Among the reasons are mainly subjective factors: inaccurate transmission of information, especially the perception, personal goals of employees. Sub-targets become the main goals of units that no longer seek to accomplish a common task and do not take into account the goals of other units.

This phenomenon is to some extent characteristic of all organizations, but it is most strongly manifested in large firms with a large number of units and in companies with low motivation of staff. Because of this anomaly, the degree of organization manageability can be evaluated: the stronger the dispersal of the goals, the lower the manageability.

## **7. The competency-based approach to project management taking into account anomalies**

A generalized model of assessment of available and required (potential) competencies regarding the organization's developmental mechanisms, taking into account anomalies, will be considered. The next factors for estimating anomalies are defined: the problem of defining the purpose, the problem of goals achievement, the problem of organizational competence, the problem of organizational behavior. The Fig.1 shows that existing potential of competencies have very large gaps in management and operational levels, including the development of staff competence. These gaps form anomalies in project management and organization development programs.

The Competency Model IPMA ICB 4.0 [9, 10] is used for identifying key competencies that affect the tasks and functions of projects and programs management under creating a project product and its result (Table 1.- Table 3).

The Fig. 2 shows the results of the "Strategic competencies" (Perspective) evaluation on the 10-point scale for the development project on which was undertaken the study. 16 experts were involved during the study. The results of modeling by groups of competences allowed identifying weaknesses in the managers' (sponsors) preparation of projects and programs. These

managers need to improve their competencies in order to ensure the success of financial institution development projects.

The result of the simulation demonstrates one competence "Compliance, standards and regulations" where the project's sponsor has sufficient competence in relation to the requirements for this competence. Others are needed development.

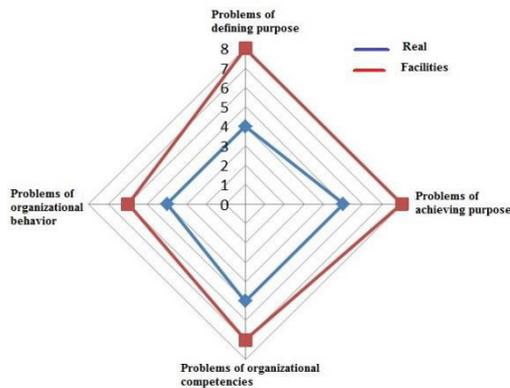


Fig. 1. Factors for estimating the anomalies of the mechanisms of projects management of organizational development

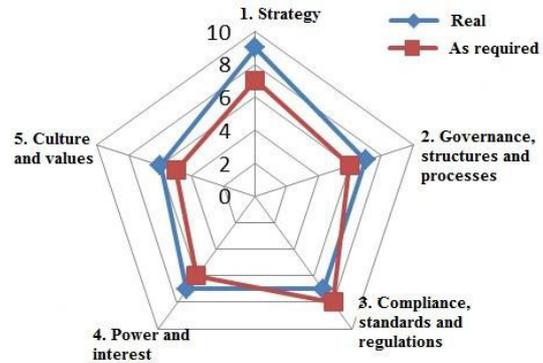


Fig. 2. Results of simulation for the group "Strategic competences"

Table 1

**Strategic competencies (the management level)**

Strategic competencies	The influence level for goals achievements	
	Real	As required
1. Strategy	9	7
2. Governance, structures and processes	7	6
3. Compliance, standards and regulations	7	8
4. Power and interest	7	6
5. Culture and values	6	5

Table 2

**Behavioral competencies (the project management level)**

Behavioral competencies	The influence level for goals achievements	
	Real	As required
1. Self-reflection and self-management	6	7
2. Personal integrity and reliability	5	7
3. Personal communication	6	7
4. Relationships and engagement	5	7
5. Leadership	6	8
6. Teamwork	4	7
7. Conflict and crisis	5	7
8. Resourcefulness	4	7
9. Negotiation	5	7
10. Results orientation	5	7

Graphic model of the influence of behavioral competencies on the achievement of project goals is shown in Fig. 3

The results of the behavioral competencies (People) assessment indicate the need for the development of virtually all behavioral competencies for achieving the project objectives. The

biggest gaps are observed in the competencies of "Resourcefulness" and "Teamwork". The special training and business games in the team building and creative technologies are required.

The simulation of technical competencies is considered for achieving the projects and programs goals. Table 3 defines the degree of real and required technical competencies to achieve project goals successfully.

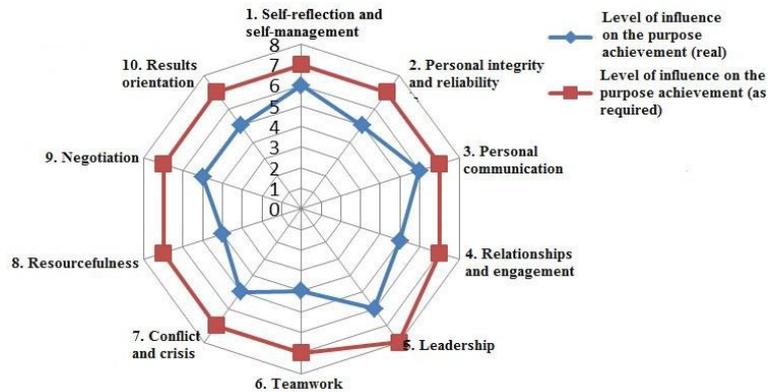


Fig. 3. Results of modeling for the group "Behavioral competences"

Table 3

**Technical competencies (the organization's operative business level)**

Technical competencies	The influence level for goals achievements	
	Real	Real
1. Project design	7	8
2. Requirements and Objectives	6	8
3. Scope	7	7
4. Time	6	8
5. Organization and Information	6	8
6. Quality	5	7
7. Finance	6	8
8. Resources	6	8
9. Procurement	5	8
10. Plan and Control	6	8
11. Risk and Opportunity	5	8
12. Stakeholders	6	8
13. Change and Transformation	5	7

A graphic model of the influence of technical competencies on the achievement of project goals is shown in Fig. 4.



Fig. 4. Results of modeling for the group "Technical competencies"

In this case (Figure 4), the project manager doesn't have enough competence level in the competencies "Finance" and "Risks and Opportunity". According to the simulation results, it was decided to conduct additional training of the project team in these competencies.

## 8. Conclusion

1. As a result of the study, the behavioral economics principles and the anomalies expected in the transition from a rational to a behavioral economy were identified and analyzed.
2. The principles of constructing of project management immune systems are formulated. These principles take into account anomalies and the protective (immune) mechanisms formation that ensure projects and programs success of organizations development.

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# MANAGING STAKEHOLDERS IN THE PROJECT IMPLEMENTATION PROCESS IN THE CONTEXT OF AN INTEGRATED UNDERSTANDING OF PROJECT PROCESSES

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**Abstract:** *One of the successful project's criteria is an integrated understanding of terms and concepts in project implementation between the project manager and stakeholders. The lack of such understanding leads to conflicts and the project closure. The terminological and conceptual bases of project management are extensive. The stakeholders do not necessarily need the complete/full knowledge. The article considers conceptual approaches to determining the size of the conceptual and terminological bases of project management needed by stakeholders in order to have an integrated understanding of the project approaches used by the project managers. The ways of delivery of the conceptual and terminological base to the stakeholders are considered. Approaches to managing stakeholders, allowing for effective management of the conceptual and terminological databases, are described.*

**Keywords:** project management, stakeholders, concept, term, integrated understanding

## 1. Introduction

Each project has its own peculiarity and specificity, its customer and product, own team and movable context, budget and implementation time. A project manager should be able to manage all of these. Stakeholders and the movable context are paid under special attention by the project manager. Their influence, support, values, interest, amount of education can both contribute to the project, and "kill" the project.

Practice shows, that the lack of knowledge of the conceptual and terminological bases of the project management is one of the reasons for rejecting the project approach and its introduction to into the organization together with misunderstanding or miscommunication of the main approaches and methods of project management. The integrated understanding of terms and concepts is one of the main rules for providing the logic of project management. The rule violation misinforms those to whom the documents are addressed [1]. The differences and nonintegrated understanding can begin with the term "project". Some questions are arising: what is the project? What are the differences between the project and non-project activity? The term "project" is defined as the term "product", and the project's lifecycle is defined as the product's lifecycle. Such an incorrect understanding of the terminology base leads to a misunderstanding between the project manager and the stakeholders. The result of this misunderstanding may lead to the increase of time for project implementation or, even, the project closure. In addition, the documents prepared by the project manager can be read incorrectly, which causes misunderstanding (or even irritation) among stakeholders. A misunderstanding leads to conflicts, which lead to the project closure and, as the result, the project approach rejection and its positive and effective results.

In the view of the foregoing, the problem of management of stakeholders in the context of an integrated understanding of the project management conceptual and terminological bases is relevant.

There are differences between the conceptual and terminological bases. The next definitions will be presented for correct understanding:

- "a base is a fundamental principle or groundwork; foundation; basis" [2];
- "a concept is an idea of something formed by mentally combining all its characteristics or particulars; a construct" [3];

- “a term is a word or phrase used to describe a thing or to express a concept, especially in a particular kind of language or branch of study” [4].

The next concepts will be defined on the base of the defined terms that are presented above:

- a conceptual base is a set of generalized essential features of the object of reality. In other words, the conceptual base reflects only a certain level of knowledge of objective reality;
- a terminology base is the basis of the something existence, which consists of words and phrases, which means clearly defined concepts of the subject area. In other words, the terminology base is a list of key terms that relate to the subject area.

At first glance, the last two definitions are similar. However, there is a difference between them. The terminology base includes terms and their definitions, and the conceptual base consists of the terminological base and related concepts. For example, the terminology base will include the terms "project", "program", "project management", "work", "work package". The conceptual base will be expanded concepts of "Work Breakdown Structure", "Matrix of Responsibilities", "Critical Path Technique", "PERT method", etc. All conceptual base's elements are related to each other by direct and indirect links. The terminological base's elements are a set of terms that may not be related (but they are related to the subject area).

It is necessary that the stakeholders understand not only the terminology base but also the conceptual base during the project implementation. Understanding the subject matter makes the communication easier and removes the misunderstanding barriers better than clear knowledge of definitions and without understanding the entire concept of the subject area.

The project management conceptual and terminological bases are extensive. There are glossaries of Project Management Terms [5, 6]. Nevertheless, the glossaries are the list of the terms and concepts without connection with the project life-cycle. The research questions are: do stakeholders need to know them in full? What size is the minimum necessary one for successful project implementation? How can a project manager manage these bases so that, from the one hand, stakeholders have integrated understanding with the project manager, and, from the other hand, they would not be overloaded by terms and concepts?

Answers to these questions can be given through the solution for the following tasks:

1. to classify the project's stakeholders from the position perspective of knowledge of the conceptual and terminological bases, to analyze the scope and understanding of these elements on the basis of the carried out classification;
2. to form the basis of the most used concepts and project management terms for stakeholders;
3. to determine the size of the conceptual and terminological base of project management for stakeholders;
4. to determine the ways of delivery of the conceptual and terminological bases to stakeholders;
5. to find approaches to the management of stakeholders, by allowing effective management of the conceptual and terminological bases.

The offer of the approaches for the solution of these tasks will be the main topic of this article.

## **2. Classification of stakeholders and analysis of their conceptual and terminological bases understanding**

Stakeholders of the project, according to PMBOK [7], are the individuals, group or organizations that may influence or be influenced, or feeling being influenced of the decisions, activities or results of the project.

There are different criteria of classification that can be used in the process of classification of stakeholders. The criterion of classification "participation in project implementation" was used for the case when stakeholders, which already was involved in the implementation of the project, may take part for the first time in such activities or took part, but not systematically (rarely) (fig. 1).

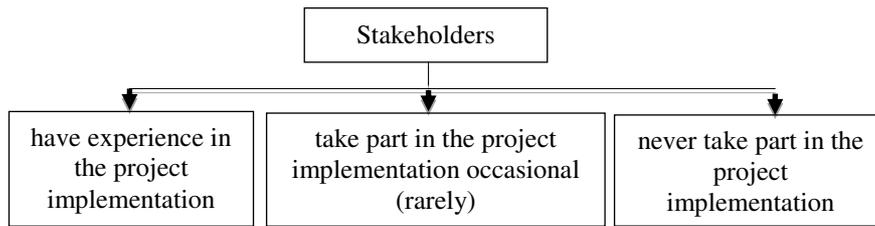


Fig. 1. The classification of stakeholders on the base of their experience of participation in the project implementation (own source)

This criterion of classification is important in the evaluation of the conceptual and terminological bases of stakeholders. It can be argued that the conceptual and terminological bases are known for those who take part permanently and have experience in project implementation. Those stakeholders, who do not systematically take part in the project implementation, own certain elements of these bases. Those stakeholders who have never taken part in the project implementation know nothing.

The IPMA DELTA certificate [8] in the implementing organization can indicate that the stakeholders understand and know the conceptual and terminological bases. The class of certificate identifies the knowledge level. The higher the class of certificate, the greater and wider the possession and understanding of the elements of the bases.

The absence of the certificate may point at two things: (1) the organization rarely or accidentally implements projects; (2) the organization implements projects continuously but does not consider necessary to pass certification. The first situation points at ignorance or lack of awareness of stakeholders in the framework of conceptual and terminological bases. The second situation requires an evaluation that can be obtained either in the frame of the first negotiations or based on information about the organization's activities.

The project manager's understanding of the size and knowledge of the stakeholders' conceptual and terminological bases of project management is based on the following information:

1. An experience of projects implementation of the organization/stakeholders;
2. The presence of the IPMA DELTA certificate of the organization;
3. Number of certified project managers in the organization;
4. The result of the initial negotiations with stakeholders.

Based on the received information, the project manager can draw conclusions about the size and awareness of the elements of the relevant bases and decide the solution for the stakeholders about the places occupied by these bases. The project manager should understand the level of immersion of stakeholders in a project management and the need of measures to create conditions for the integrated understanding of the conceptual and terminological bases by all participants of the project process. The project manager's actions can be presented in the form of the algorithm (Fig. 2).

### 3. The conceptual and terminological base formation for stakeholders

The evaluation of the understanding of the project management's conceptual and technological bases by stakeholders is the illustration of the level of understanding of these bases by the stakeholders for the project manager. If the organization has the certificates by the class S/M/O (according to the IPMA DELTA) or the projects are implemented regularly the stakeholders know the concepts and terms of the project management. In this situation, it can be declared the stakeholders have an integrated understanding and the project manager should not take any action to organize the integrated understanding.

The integrated understanding creation is needed if the projects in the organization are implemented occasional/rarely or for the first time. It is necessary to understand that the presentation of the full scope of the conceptual and terminological bases should not be at the initiation phase. It can irritate the stakeholders and cause a reaction of "rejection" of the project implementation. A large amount of information cannot be learned immediately and correctly. This can also cause irritation

during discussions (stakeholders will have to check their understanding of concepts and terms all the time. That will delay the project implementation).

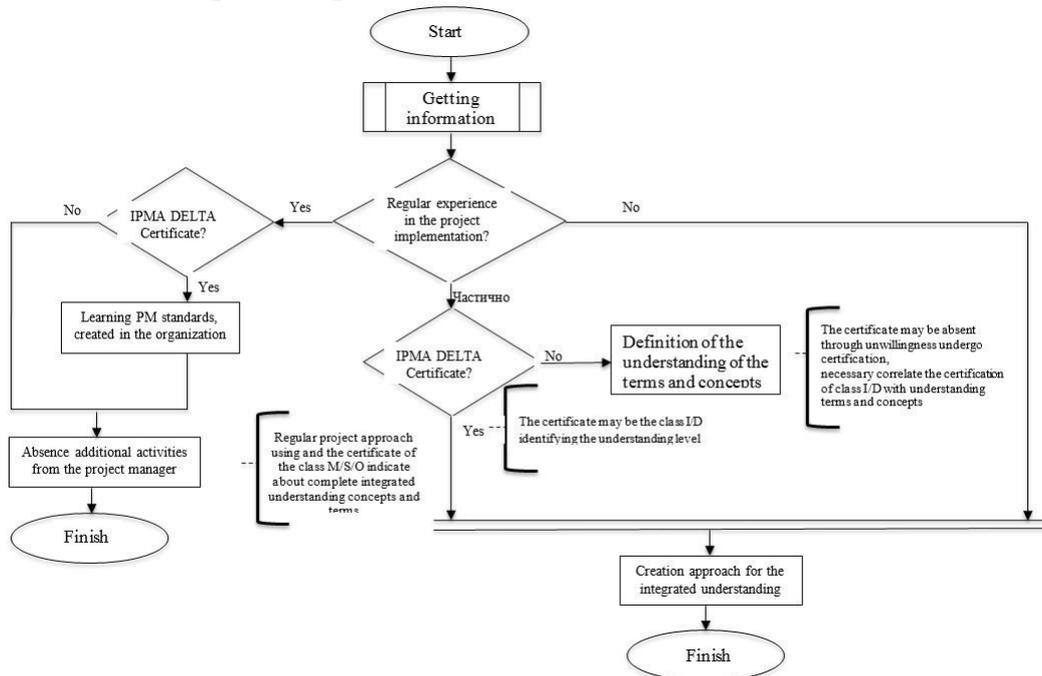


Fig. 2. The algorithm of the making decisions by the project manager concerning activities of the integrated understanding of the project management's terms and concepts (own source)

The one-at-a-time provision of the necessary concepts and terms in small portions is the best approach for forming the integrated understanding. Such an approach facilitates their faster memorization.

Some steps should be done by using this approach:

Step 1. *Create a complete base of concepts and terms that are used in project management.* The concepts and terms from other subject areas are used often in the project management (total management, IT, finance, quality, etc.). These concepts and terms are not professional terminologies of project management. For stated case, the conceptual and terminological bases will be created only from the concepts and terms related to the project management.

Step 2. *Relate concepts and terms to the project phases.* At each project phase, some terms appear for the first time and some come from another phase. The same situation happens with concepts. For example, the concept "WBS" appears in the planning phase and constantly used in the execution phase. All concepts and terms will be grouped according to their first appearance. For instance, the term "Project" appears at the initiation phase and it is used in all other phases. Therefore, this term should be referred to the initiation phase. The concept "Tender procedure" appears in the planning phase and it is used in the implementation phase, so the concept should be referred to the planning phase.

Step 3. *Formation of the base of the most used concepts and terms of project management for stakeholders.* In the process of the project implementation, there are terms and concepts that are used systematically and/or often, and those that are used rarely or only in the narrow professional environment of project managers. Stakeholders should receive only essential terms and concepts without the interaction with stakeholders, otherwise, it will be ineffective. Stakeholders do not need to dip completely into terminological and conceptual bases. The goal is to create a mental space with the integrated understanding of project processes for the successful project implementation.

A frequency dictionary (frequency list) can be considered as an approach for the formation of the most used concepts and terms. The approach is used in the compilation of lexical dictionaries. This approach allows a creation of a set of words (phrases) together with information about the frequency

of their occurrence. The dictionary can be sorted by frequency, alphabetically, by word groups, by the type. Usually, the frequency dictionaries are based on the corpus of texts: “taking the set of texts, which is a representative of the language in general for some subject area or a given author, and word forms, lemmas and parts of speech are extracted from it” [9].

Using the frequency dictionary approach, a frequency dictionary of terms and concepts for each project’s phase can be created. This frequency dictionary will be put into the base of a mental space created for the integrated understanding of the project management terms and concepts for stakeholders.

Step 4. *Create terms and concepts network*. All terms are related to concepts. All concepts can be put into one network, connecting them with each other and with terms. Such network allows to review the entire conceptual and terminological base of project management, showing its scope and interrelations within the network. Using the results of step 3 and the theory of graphs with Boolean algebra, the terms and concepts network can be created. In this network, using the frequency dictionary, the terms and concepts can be grouped according to their frequency usage: the most frequently used, often used, less used and rarely used.

#### **4. Evaluation of the size of the conceptual and terminological basesize for stakeholders**

The conceptual and terminological bases size for stakeholders should be determined by the knowledge level of the stakeholder in project management. Documentary evidence of the knowledge level may be:

- the degree in project management and/or the certification of a person (specialist);
- the certificate obtained under a certain certification system, for example, IPMA DELTA, for a legal entity (organization).

The documentary evidence is an evidence of his/her personal knowledge, practices and skills of a person and a systematic approach to the introduction and use of the project approach in the organization, as well as the staff potential for the legal entity.

In some situations, a person or a legal entity may have sufficient knowledge in project management (extensive project practice), but any documentary evidence does not have it (the reasons for this may vary. For example, the lack of the necessary funding to pay for training or certification). In this case, knowledge can be assessed through testing or within the framework of interviews (negotiations). Based on the evaluation results, there are several solutions:

*The solution 1.* The additional training is not needed if the documentary evidence exists (for example, the certificate of class S/M/O according to the IPMA DELTA, and the certificate of the level A/B according to the IPMA ICB 4.0).

*The solution 2.* The additional training should be provided if the project approach is applied rare or the documentary evidence exists (for example, the certificate of class D according to the IPMA DELTA, and the certificate of the level C/D according to the IPMA ICB 4.0). This training is required in order to expand the project management conceptual and the terminology bases.

*The solution 3.* The training for the creation of the project management conceptual and terminological bases is strongly needed if the project approach is used for the first time and the documentary evidence exists (for example, the certificate of class I according to the IPMA DELTA).

The results of step 4 (see section above) can be accepted as the bases size calculation. The frequency dictionary has frequencies of usage of terms and concepts. The sequence of creation of the conceptual and terminological bases for the stakeholders is presented in table 1 (own source).

#### **5. Determination of the ways of delivery of the conceptual and terminological base to stakeholders**

The formed base of the most used concepts and terms of project management must be delivered to stakeholders. Delivery ways can be different. Each of the delivery ways is aimed at a specific category of stakeholders and achievement of specific goals. This has advantages and disadvantages. Some of the existing approaches are presented in table 2 (own source). The choice of approach depends on the target audience, goals, financial capabilities and motivation.

Table 1

**The sequence of creation of the conceptual and terminological bases for the stakeholders**

Number of solution	Necessity	Sequence
1	Optional	(Optional): the learning of the rarely using terms and concepts may be conducted
2	As required	Step 1: the learning of the terms and concepts that are used often; Step 2: the learning of the terms and concepts that are used less. (Optional): the learning of the terms and concepts that are used rarely.
3	Make sure	Step 1: the learning of the terms and concepts that are used the most often; Step 2: the learning of the terms and concepts that are used often. (Optional): the learning of the terms and concepts that are used less.

Table 2

**The ways of delivery of the conceptual and terminological base to stakeholders**

#	The way of delivery	The project phase	Target audience	Target	Advantage	Disadvantage
1	During the project discussion and/or the project planning	Initiation	Top-management	<ul style="list-style-type: none"> <li>The integrated understanding of project processes and project results</li> </ul>	<ul style="list-style-type: none"> <li>Not necessary in the special training conducting</li> </ul>	<ul style="list-style-type: none"> <li>Lack of the systems approach;</li> <li>The absence guarantee that all moments will be learned and understood;</li> <li>The absence of motivation</li> </ul>
2	Seminars in the organization (hired lecturer)	Planning and/or Implementation	Middle management, employees	<ul style="list-style-type: none"> <li>The integrated understanding of project processes and project results;</li> <li>Understanding of the project approaches, methods, practices used for project</li> </ul>	<ul style="list-style-type: none"> <li>Systems approach;</li> <li>Learning and understanding guarantee;</li> <li>Selecting learning program</li> </ul>	<ul style="list-style-type: none"> <li>High cost for the organization ;</li> <li>Learners' low motivation</li> </ul>

				implementation; <ul style="list-style-type: none"> <li>• Right information prepared for the project;</li> <li>• Project management understanding</li> </ul>		
3	Obtaining a higher education in the project management	Before starting the project implementation or Initiation phase	Middle management, employees	<ul style="list-style-type: none"> <li>• Getting complete information about project management ;</li> <li>• Knowledge of the approaches and technics concerning of the project management ;</li> <li>• Getting skills and practices of the project implementation</li> </ul>	<ul style="list-style-type: none"> <li>• Systems approach;</li> <li>• Complete learning of the terms and concepts;</li> <li>• A guarantee understanding of the project management in all aspects;</li> <li>• Getting additional preference in the labor market</li> </ul>	<ul style="list-style-type: none"> <li>• Longer terms (1,5 – 2 years);</li> <li>• Cost;</li> <li>• Motivation;</li> </ul>
4	Certification	Initiation, Planning, Implementation	Top-management, middle management, employees	<ul style="list-style-type: none"> <li>• Confirmation of the project manager's qualification. It confirms knowledge and integrated understanding of all project processes, terms, and concepts</li> </ul>	<ul style="list-style-type: none"> <li>• A confirmation of the professional level</li> </ul>	<ul style="list-style-type: none"> <li>• High cost for the organization /specialist;</li> <li>• The necessity in taking part in additional short-term courses (additional cost for the certification)</li> </ul>
5	Training within the organization	Permanently	Middle management, employees; maybe top-management	<ul style="list-style-type: none"> <li>• The integrated understanding of project processes and project</li> </ul>	<ul style="list-style-type: none"> <li>• Low cost;</li> <li>• A guarantee getting knowledge and integrated</li> </ul>	<ul style="list-style-type: none"> <li>• Extra work for employees who will conduct the training;</li> </ul>

				<ul style="list-style-type: none"> <li>results;</li> <li>• Understanding of the project approaches, methods, practices used for project implementation;</li> <li>• Right information prepared for the project;</li> <li>• Project management understanding;</li> <li>• Inner preparation of the project managers staff</li> </ul>	<ul style="list-style-type: none"> <li>in-company understanding formation;</li> <li>• Evaluation of the specialists in the context of the further moving in the project management</li> </ul>	<ul style="list-style-type: none"> <li>• Learners and teachers' low motivation</li> </ul>
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**6. Finding approaches for the stakeholders' management, allowing the effective management of the conceptual and terminological bases**

Time in the project is a limited resource. Often there is not enough time and financial resources to conduct large-scale training. The lack of integrated understanding leads to a delay in the project (or its closure). A problem of finding an effective approach for managing stakeholder awareness has appeared. Information management can be implemented through the task of information management: that should be the information impact (from the project manager's point of view) in order to obtain the required behavior from the stakeholders.

If the stakeholders are presented as a social network the task can have a solution. The social network is a social structure consisted of a multitude of agents (individual or collective subjects). A set of relations is defined on it (a set of relations between agents, for example, cooperation). The next concepts can be described as the network structure: community (a set of agents that are not influenced by agents outside the network), a group (community of agents in which any two agents directly or indirectly influence each other) and a satellite (a community of agents that has no influence on any of the groups). If in each group at least one agent at all somehow trusts his/her opinion, then the satellites' opinions are determined by the groups' opinion, and within the groups, the opinions of the agents converge and are equal. Thus, the distribution of the conceptual and terminological bases should be aimed at the groups, first of all, and further in the communities. The satellites, in this case, may not be considered, because they do not have a significant impact on the project process.

The tasks of the informational management can be considered as the network (changes in the opinions, reputation and/or trust of a small number of key agents in the network as a result of spreading the change of opinions, the required opinions of the participants of the whole network or a part of it are formed).

The three components (opinion, trust, and reputation) can be identified in the network. The management has an impact on the management system in order to ensure its required behavior, then

the agents' opinions, their reputation, and trust to each other. This can be the subject of management in the social network [10].

The above control can be realized by using the Markov chain and the linear programming. The detailed application of such approaches is the goal of further research by the author.

## 7. Conclusion

The integrated understanding of the concepts and terms of project management of all participants of the project process is one of the most important factors for the project success. Most often the misunderstanding arises between the project manager and the stakeholders. One of the tasks of the project manager is finding ways to manage stakeholders in the context of the single blended mental space formation for understanding the project process. Using formalized and non-formalized approaches can be applied to decisions of this task.

Non-formalized approaches are based on the use of models of communication influence and knowledge about the psychology of the individual. The use of formalized approaches allows obtaining more generalized solutions. The author proposes to use the Markov chains, the linear programming problems, the Boolean algebra, the graph theory for management of stakeholders in the context of the formation of integrated conceptual and terminological bases of project management and the learning process optimization. Now, the research is aimed at describing the application of the above mathematical tools in practice.

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# BEHAVIOR MODELS OF PROJECT MANAGER

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**Abstract:** *In 2017, R. Tyler received the Nobel Prize in Economics for his research in the field of behavioral economics. The results of his research say that people often make decisions not on the basis of the rational approach that is the basis of the existing economic theory, but on the basis of the influence of independent and random factors. At the same time, the spectrum of factors is inherent in every person individually and has an impact in the professional sphere. In the process of implementing the project, the project manager constantly makes managerial decisions. Some of them are based on an intuitive ("behavioral") component. At the same time, not always successful project managers who make the right decisions when implementing projects in one subject area will also be successful in implementing projects from another subject area. What influences the "failures" in making the right decisions by project managers in the presence of professional certification standards. The article will be devoted to the analysis of the impact of the project domain on the requirements for the personal qualities of the project manager and comparing them with the required competencies described in ICB4.0.*

**Keywords:** project management, ICB4, leadership, teamwork, project manager, behavior

## 1. Introduction

Involvement of the right project manager is an important task for organizations. According to A Guide to the Project Management Body of Knowledge [1], the project manager is the person responsible for accomplishing project objectives. The project manager manages the project through identifying project requirements; establishing clear and achievable objectives; balancing the competing demands for quality, scope, time and cost; adapting plans and approaches to the different concerns and expectations of the various stakeholders; and managing projects in response to uncertainty. The project manager's role is one of the most challenging jobs in any organization, because it requires a broad understanding of the various areas that must be coordinated and requires strong interpersonal skills. It is widely acknowledged that the final outcome of the project depends mainly on the project manager; therefore, the selection of the project manager is one of the two or three most important decisions concerning the project [2].

The project manager is the decision maker who works in the limited resources, terms, budget, most often in a turbulent environment. Knowledge, skills and competence of the project manager are defined in ICB 4.0, on the basis of which their certification is carried out.

The competencies described in ICB 4.0 cover the full range of knowledge, practices, and abilities that the project manager must possess and which should apply. Certification under this standard is carried out without regard to the specifics of the project subject area. But each project is unique. For each project (program, portfolio of projects), it often needs its set of knowledge, practices and skills that is the best. Identifying such sets (patterns) and their classification according to the projects would allow the selection of project managers and design teams that would be better targeted at the implementation of certain projects. Such patterns would allow to identify the "weaknesses" of existing project teams and level them out by conducting focused trainings.

However, the task of creating subject platforms for each subject area is complex and requires detailed analysis and study of the peculiarities of project implementation and evaluation of project managers.

## **2. Literature review**

Digitization, which forms the backbone of the Industrial Revolution 4.0, requires the development of appropriate software that gives a new impetus to the development of IT companies. New software is created through programs and projects. As statistics [3] show, only 16,2% (in the period from 2000 to 2017) of IT projects are successful. Among the reasons leading to the failure of a project or program, one can note the adoption of the influence of managerial decisions. In our time, there are a lot of IT companies. It is these companies that are increasingly in demand in recent times. Such companies are facing problems. They may be different in nature, but the most common problem in an IT company is a situation in which communication between people within the company is disturbed. Someone from interlocutors may not understand another interlocutor (his opponent), and then an incorrectly completed assignment may call into question a project, or even a company name. Therefore, communication is one of the important parts.

However, for communication to be correct, you need to get the right team, find the perfect model for each position in the company, especially for company executives, project team leaders, project teams, team managers and operational activities.

For better understanding these problems you need to have experience or research in this area.

One such recent study was performed by Keil, Lee, and Deng [4]. In this article author identified 19 skills an IT project manager should have. In this publication consider software projects a subset of IT projects. In addition, they also require more detailed research on what is needed for a good project manager, and assert that new perspectives need to be taken into account in new research than just project managers.

## **3. Applying Research Approach**

An article was considered where was used a purposive sample [5] that consisted of 15 project team members from the software development section at Sony Mobile in Sweden. This sample size follows the recommendation of Tan and Hunter [6] for having a range of 15–25 interviews. All the participants, 14 men and 1 woman between the ages of 27 and 46, were active as project team members on several projects. The average length of tenure in the company was 38 months, which according to HR department information, is typical for the software development parts of the company.

The data collection tool was a structured interview. To both capture and initially analyze the data, the “Enquire Within” software package was used.

Such categories were considered: Handling and Understanding People, Technical Subject Matter Knowledge and Experience, Communication and Information Handling, Structuring and Organizing the Work, Allowing Participation and Collaborating, Calm Versus Stressful Behavior, Handling External Demands and Internal/External Communication, Feedback and Appreciation, Flexibility and Openness to Change, Taking Active Responsibility, Presence and Confidence in the Role, Availability/Visibility, Follow Up, Reliability, Genuineness/Sincerity, Positive and Constructive Leadership, Conflict Handling, Miscellaneous.

The result of this research was shown in Figures. There you can find the answer on the questions: What characteristics software development project team members associate with the project manager role and which of these characteristics are seen by software development project team members as associated with good project management by the project members [7].

#### 4. Some results of the research of needed and existing competencies in IT projects (Ukrainian example)

Nowadays there are many companies from different spheres. But recently technologies have started to develop. And this led to the fact that companies began to appear in the IT sphere. Analyzing the companies of Ukraine, was considered companies that carry out IT projects. After studying the results, they were interpreted on the basis of Individual Competence Baseline for project, programme and portfolio management 4th version. The most frequently mentioned competencies in which individuals do not have the necessary qualifications are singled out. They are presented in the form of a "spider" diagram that is demonstrated at Fig. 1 Strategic competencies, which has the chief, the project team and the stakeholders.

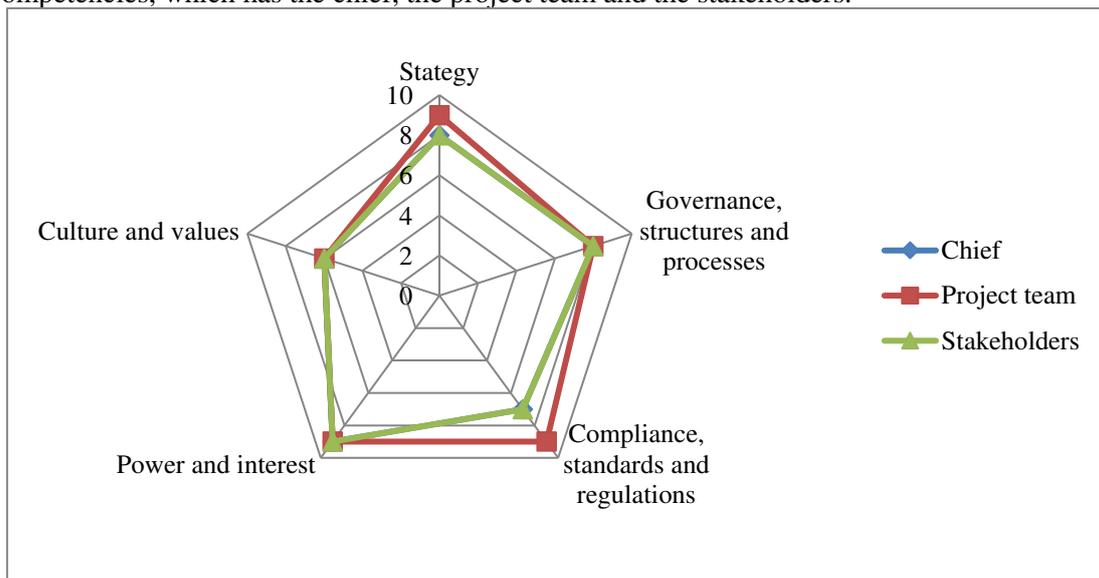


Figure 1. Strategic competencies

In addition to the competencies mentioned above, there are gaps in others in Behavioral competencies which have the chief, project team and stakeholders, which are indicated in Fig. 2.

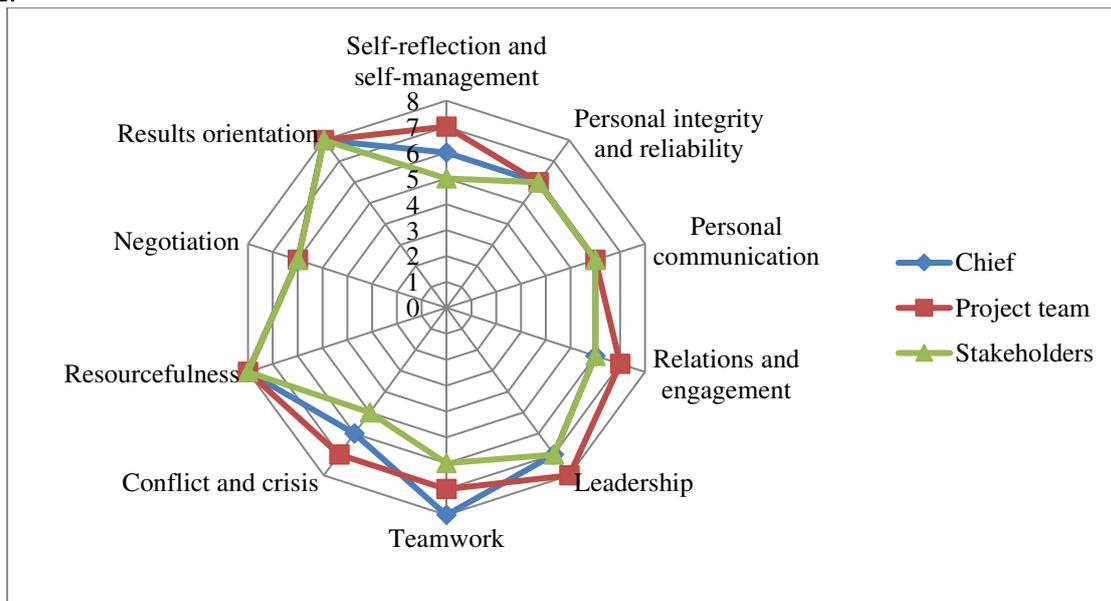


Figure 2. Behavioral competencies

Any IT project cannot be imagined without the knowledge of the basics in technology, but also in the technical competencies there are gaps that can be seen in Fig.3.

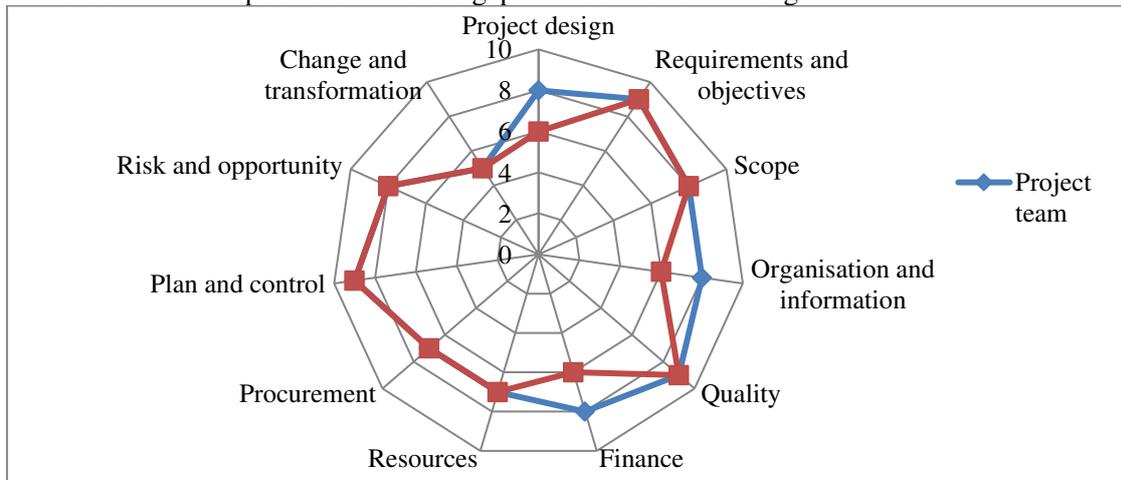


Figure 3. Technical competencies

After analyzing these diagrams, one can see that there are no perfect compasses and each company has its own disadvantages. But in order for the project to take place, without additional funds and money, and to get the final product, it is necessary to approach the ideal.

To eliminate these gaps, we offer training, but this applies not only to the project team, but also to the bosses and even the stakeholders. Training can be conducted in the form of trainings for a short (1-3 days) or long (7 days - a month) time. After this study was conducted (which revealed the ulcers), it is necessary to take all possible measures to eliminate these disagreements. For deciding what problems exist in your company may be sufficient to conduct a survey and, sometimes, a personal interview. After such actions, it is possible to identify gaps and begin to act. After all, such a study showed that such gaps exist on such projects, it can be assumed that they can exist on other projects. Verification of the latest statements will be the basis for further research.

## 5. Results and Conclusion

The analysis of the literature showed that the "project" component influences the project implementation. The standards for assessing individual competencies make it possible to identify broad bullets of the necessary knowledge, skills and practices required by the project manager, but they do not take into account the individual component of both the project product and the identity of the project manager.

Possibilities of compiling individual competency models of the project manager on the basis of a unified model based on ICB 4.0 would give an opportunity to select project teams for each project taking into account the specificity of the subject area presented through the personal qualities of the manager.

The study and creation of competence models of the project manager, taking into account the subject area, is the field of further scientific research of the author.

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# A REVIEW OF PEOPLE PERSPECTIVE ON PROJECT MANAGEMENT

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**Abstract:** *The paper aims to review the human perspective underlined in project management literature concerning project team competencies, personnel requirements, and management tools. The literature reviewed will not include the Individual Competence Baseline by International Project Management Association to have more extended view on people perspective in project management literature. Furthermore, the multiple intelligences model will be covered as an umbrella term for personal skills and competencies. This review serves a basis for research agenda in multiple intelligences measurement and modeling the project management competencies.*

**Keywords:** project management, people perspective, human resources, competencies, multiple intelligences

## 1. Introduction

Since no project in a business environment can be managed without people it is interesting to discuss about the people view on project management (further PM). By ‘people’ in projects can be understood all internal and external project stakeholders or stakeholder groups with different roles and levels of authority. Critical stakeholder groups defined by [1] are divided in seven groups: owners/sponsors, consumers, operators/end users, project executives, lead contractors, other contractors/suppliers, and finally, public stakeholders.

The project is not considered to be successful or completed if project stakeholders are not satisfied with its output. With this in mind, identifying and analyzing stakeholders, and managing stakeholder expectations are critical to the success of the project [2]. On the other hand, the project’s success is measured by managing the project within the triple constraints of scope, time, and cost. For this reason, the project manager and project team members as lead contractors are responsible not only for conducting stakeholder analysis and managing stakeholders’ expectations but also for executing the project itself. Under those circumstances it is equally important to focus on communication, relationships, team organization & development, and what skills, knowledge and competencies the project team should have to succeed the project.

While the project manager is responsible for managing the project he directly becomes the guilty person for its failure or success. Hence the recruitment of the “right” project manager means almost everything to the project. However, according to cost or time limitations, senior management has to assign to project available human resources who are at least familiar with PM. In this case, the manager’s role is underestimated by the organization and the project manager can lose the authority he needs to influence management processes. At the same time, project managers with the focus on professional contributions tend to lose their control of management tasks [3]. In reality, the more complex project is, the more important to pay attention on project manager’s professional and management skills, and competencies.

## 2. Core PM competencies

PMI [2] defined the three key competencies the project manager ought to have: knowledge, performance and personal competencies. Knowledge competence means what the project

manager should know to apply processes, tools, and techniques for project activities [4]. It is important to mention that the requirements for knowledge skills and their depth are industry-specific and vary from one field to another. Performance competence can be defined as performance of PM knowledge or how the project manager applies knowledge to meet project outcomes. Personal competence refers to project managers' behavior when performing PM activities, their attitude, personality characteristics, and leadership that allows to lead the project team. From the people perspective, the personal competence may be considered the most important while it refers to social, communication and management skills. For the most part, the mentioned skills are essential to deal with internal (e.g. project executives, lead contractors) as well as external stakeholders (e.g. other contractors, public stakeholders) while the project manager needs an agreeable and well-groomed appearance to communicate a positive external image for the project [3].

Further it will be discussed in more details what competences team members should have since the project team is identically counted as the basis of efficient PM. Generally speaking, project team members should have the same personal skills and traits, and especially a social competency as the project manager has. Therefore, the question is if it is enough for efficient team. From the human resources management perspective, it is necessary to build, develop and manage the competent project team to meet all the project requirements and to motivate the team to work together on further projects. Besides universally used Belbin's model, team management systems and recommendations for teamwork, a multiple intelligences (MI) model was developed that helps to increase the productivity of the team (Fig. 1). Intelligence is defined as "the capacity to apprehend facts and propositions, and their relations, and to reason about them" [5]. The model uses linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, and natural intelligences and suggests that people learn information and perform their skills in different ways. In its turn, project personnel are hired according to their skills and preferences that are correlating with the MI being the strongest sides of individual. The MI model can be used to determine the competencies, skills and abilities the project team members should have.

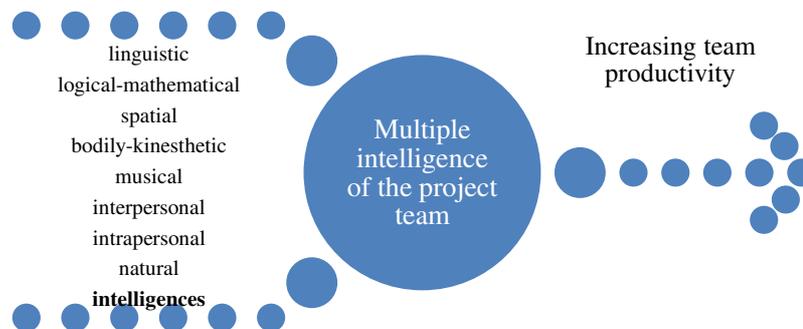


Fig. 1: Multiple intelligence model (own creation)

A team member possesses some intelligence as a strength, and complementing intelligences of other team members, the MI of the project team is being evolved. Another question arises how to implement this model. Every MI should be measured beforehand (self-assessment with the help of questionnaires or third-party evaluation as intelligence quotient tester) and then team member is to be assigned to the project role. As mentioned in [5] a person can possess several intelligences as strengths that makes this assessment and model implementation quite difficult.

In addition to the PMI's key manager's competencies, [6] defines primary skills an effective project manager needs to have: knowledge of the business, risk management and integration. Risk management marked as a critical skill that needs for performing significant business knowledge. From the people perspective, during the planning phase project resource risk must be equally

identified. [7] divided people risks into five categories: permanent and temporary loss of staff, queuing problem, late start and motivation issues. Permanent loss of staff has the main impact while the reasons for it include resignation, reassignment, promotion, and health issues. [8] speaks about people and behavioral risks that are related to the changes that people need to make executing their daily activities, and to their behavior. The author also gives the examples of personal risks such as weight and health, old age and pension, workplace stress, and personal finance. These risks are long-term in nature conflicting with our short-term life approach. Eventually, precise planning and reliable scheduling of the project work tend to detect the most serious probable phenomena regarding people.

### **3. Personnel requirements**

Important to realize that while planning, besides evaluating personal risks, it is necessary to conduct the analysis of available and required personnel; this will answer next questions: how many of which type of staff are required to execute the project. So, quantitative and qualitative personnel requirements should be determined and planned. The information for the requirements can be derived from work and resource breakdown structure, time schedule, work package descriptions, requirements profiles, personnel developments plans and job descriptions [3]. It is interesting to mention, that from the people perspective work breakdown structure is also considered to be a communication tool between the project manager and project stakeholders while it helps to understand the current state of the project regarding completion criteria for the project deliverables [6]. When planning, the project manager also needs to take into consideration how the project team members perform, how much time they need to switch on the next task or activity and what appropriate personality needs to be hired to accomplish the team. With this intention, it is crucially important to avoid employees who can play destructive roles on a project team (aggressor, dominator, devil's advocate, topic jumper, recognition seeker, withdrawer, blocker) and vice versa to assign to implementation teams' people with supportive roles (information seekers and givers, encourages, clarifiers, harmonizers, consensus takers, gate keepers, initiators). At the same time, the project manager always can ask himself if he plays destructive or supportive role to his team.

### **4. Controlling management function**

Another key point is controlling management function. [6] divides it into three steps such as measuring, evaluating, and correcting and has also underlined the importance of having strong interpersonal skills during controlling the project. This function refers to formal and informal authority since that helps the manager to ensure that the project progresses [3]. From the people view project controlling focuses on personnel controls including human resources practices such as selection and training to regulate knowledge, skills, abilities, values and motives of employees [9]. So, it is important to clarify about team's and manager's personal objectives at the very beginning to aware what abilities should be improved. The tool for this can serve an analysis of strengths and weaknesses. For minimizing time required for team building on further projects and increasing an effective team performance it is worth to implement motivation training. In this case team building as an ongoing process and team learning by the manager are considered a project investment in future. Furthermore, conflicts appeared during team building and development phases differ in nature, they can be functional or dysfunctional. Dysfunctional conflicts lead to the team's demise, but functional conflicts help to develop creativity, problem solving techniques, and critical thinking skills that leads to productive and successful project team performance [5].

Finally, to see the team performance progress, different evaluation tools can be implemented such as questionnaire, surveys, checklists, and self- and team assessment techniques. Some of these techniques are also crucially important for the development of the project manager's skills. Besides the motivation or other weak sides, managers should train their leadership skills.

Leadership is defined by Kerzner [6] as the complex of the three key elements: the person leading, the people being led and the situation, hence, the PM leadership is considered a conflict between individual and organizational values. This phenomenon is also referred to the leadership perspective on PM.

## 5. Conclusion

As a matter of fact, the most projects fail since less attention is paid to the people aspect. In terms of internal stakeholders (lead contractors), this issue can be addressed if the project manager will consider the MI model and know the strengths and weaknesses of his team.

In the final analysis, an awareness of influence of people behavior on project environment cannot happen overnight as soon as the same can be applied to the entire PM dimension. Since every project and PM aspect involves people and if there is an intention to cover the human view on PM, there is a need to cover every PM concept and domain.

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# PROJECT MANAGEMENT UNDER THE INFLUENCE OF PSYCHOLOGICAL PHENOMENA AND EMPIRICAL LAWS

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**Abstract:** *Project management is a process in which the human factor plays a very important role. The paper describes various psychological and mathematical laws and principles that explain the behavior of project team members under certain circumstances. The authors have also proposed a few ways to reduce or remove some of them.*

**Keywords:** project performance, psychological phenomena, empirical law, team-based approach.

## 1. Introduction

Human factor plays the main role in the development of the product, so the relationships inside of the team and the behaviors of each individual member affect project performance. In a team-based approach, it is necessary for the project manager to be familiar with psychological phenomena and empirical laws that affect a team member's productivity.

Understanding the psychology behind the way human brain tick might help to tick even better [1] – which makes it mandatory for project managers to be familiar with psychology and ways of reducing an impact of phenomena on team members working capacity.

The relevance of the topic: project performance would be identical to the project plan only in an ideal world. In real life, different psychological phenomena affect people on a daily basis and some occur in project execution, which leads to deviations from the plan, so it is necessary to research the topic in order to find ways to improve team working experience and project execution to a higher level.

The objective of this work is to search methods of managing projects under the conditions of psychological phenomena and empirical laws and to reduce their impact on team members.

## 2. State of art

The examples of psychological phenomena and empirical laws are presented below.

Pareto's Principle (principle 20/80) – the empirical rule is most formulated as "20% of the effort gives 80% of the result, and the remaining 80% of the effort is only 20% of the result" [2]. The way to reduce the influence of this rule, according to Richard Koch, is to choose 20% of the most important tasks and solve them in the first place [3].

Ed Murphy in a popular rule states that: "If something can be done in several ways and one of them does not work, then there will definitely be someone who will succeed in this way" [4]. To prevent Murphy's Law from entry into force it is expediently to implement "protection from a fool" technique [5]. Even though Murphy's Law was discovered a long time ago and many solutions were proposed, none of them are perfect and the problem of Murphy's Law effect is still number 8 in top 10 project management problems according to Project Management Institute [6].

The principle of Peter says: in the hierarchical system each individual tends to rise to the level of his incompetence. The solution was proposed by 37signals in 2010. Jason Fried wrote in a column: "Usually companies tend to develop "vertical" ambitions in employees, that is a desire to move up the career ladder. And in 37signals try to take those who are close to "horizontal" ambitions" [7]. In 2018 a similar principle was proposed by John Reh in his abstract [8]. It is normal for the human brain to want a reward after hard work. For most of the employees' such reward is a pay raise and moving up a carrier ladder and the 37signal way is not the best, because not everyone can accept it in the modern society.

Another important issue is the student syndrome. Student's syndrome is a form of procrastination when a person who has been given a task begins to constantly postpone it. The syndrome tends to follow a person in adult life which leads to delaying the tasks until the night before the deadline. In terms of project work, even if work was managed to be accomplished in time, reduces the quality of the result.

As a good practice to prevent student syndrome from occurrence in a team, additional checkpoints during the project that could be implemented. Also, for project managers, it is a good thing to provide a day-to-day list of tasks for team members and check its performance [9]. Gregory Ciotti in his abstract "Six Scientifically Supported Ways to Crush Procrastination" advised to set macro goals and micro quotas and always hit the ground running [10]. However, this does not guarantee that employee uses working time efficiently and it is mostly oriented on beating syndrome by the employee himself, so the project manager does not really control that process. Project managers have much more phenomena of human psychological confusion to deal with the escalation of commitment, one percent rule, statistical variation among dependent events, etc. [11].

### **3. Method to reduce the influence of psychological phenomena.**

It is common that companies use time trackers to know how many time employees spend on each task, but the right time tracking tool can help to achieve so much more and gain more control. Hubstaff company integrates with many project management solutions so team leader can see exactly what team is working on and how much time they spend on each task [12].

During this research, it was found that software could be used to monitor the activity of employee by making screenshots in some periods of time (2-15 minutes) and if the user doesn't move the mouse or use the keyboard for 15-20 minutes Hubstaff turns off. Knowing that team member is monitored, it is assumed he is going to fight his student syndrome and make work tasks step by step, but at the same time, the process can be monitored by the project manager.

The experiment to confirm the theory of beating student syndrome by an employee using time tracking tool took place at the small IT-company named 7prism (Kiev, Ukraine). The working process of 10 employees was monitored for one week. Conditionally experiment was divided into two parts: the first part continued 2 working days and second part 3 working days.

At the first part of experiment employees didn't know they were monitored and at the second part project manager announced that a new program is established in a company. General behavior pattern was following: during the first part of the experiment student syndrome appeared in some employees' behavior and during the second part they started to fight it over. More detailed information is described below on an example of two selected employees with the strictest student syndrome display.

The results of the first days of work of selected employees are presented in Fig. 1 and Fig. 2. It is clearly visible that some entertainment sites like Youtube and Lifehacker are viewed by employees at some periods of work.

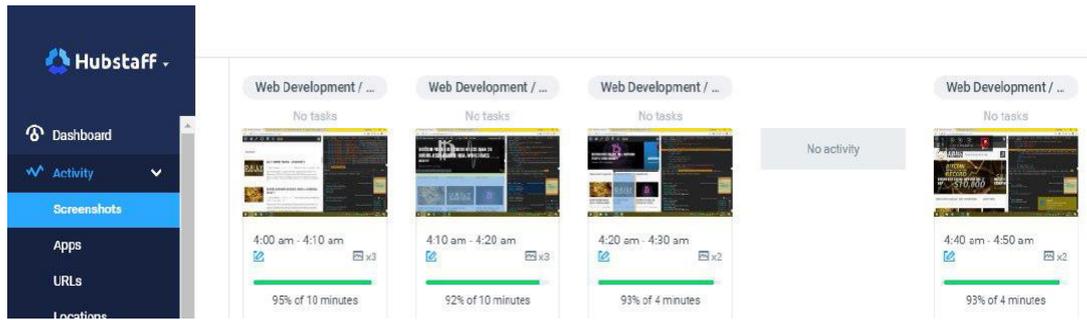


Figure 1. Results of work of employee A in the first part of the experiment [12]

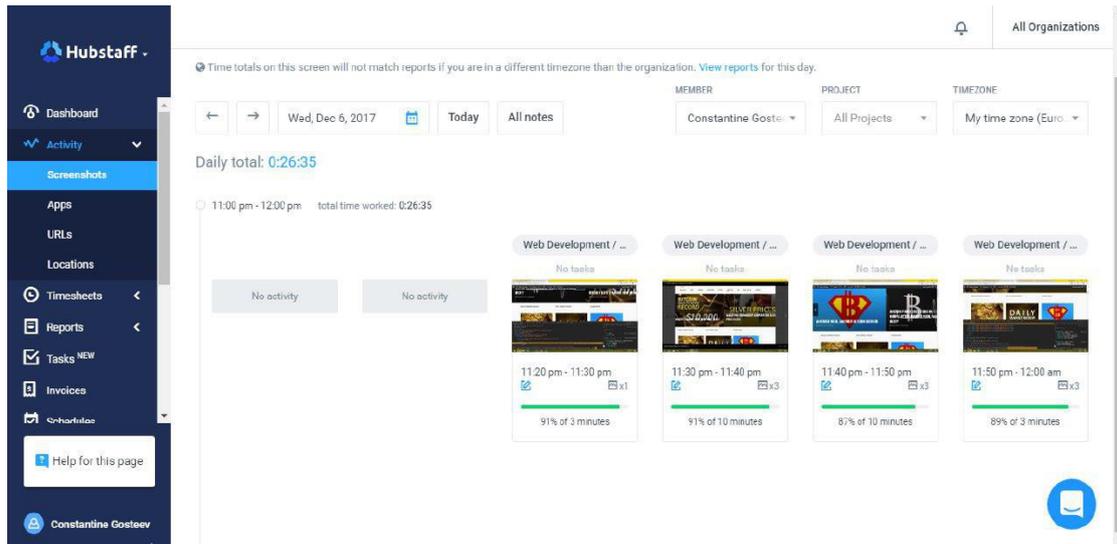


Figure 2. Results of work of employee A in the first part of the experiment [12]

In the second part of the experiment, the results of work started to improve in the organization. The picture changed to the more productive working process as shown in Fig. 3 and Fig. 4.



Figure 3. The results of the work of employee A in the second part of the experiment [12]

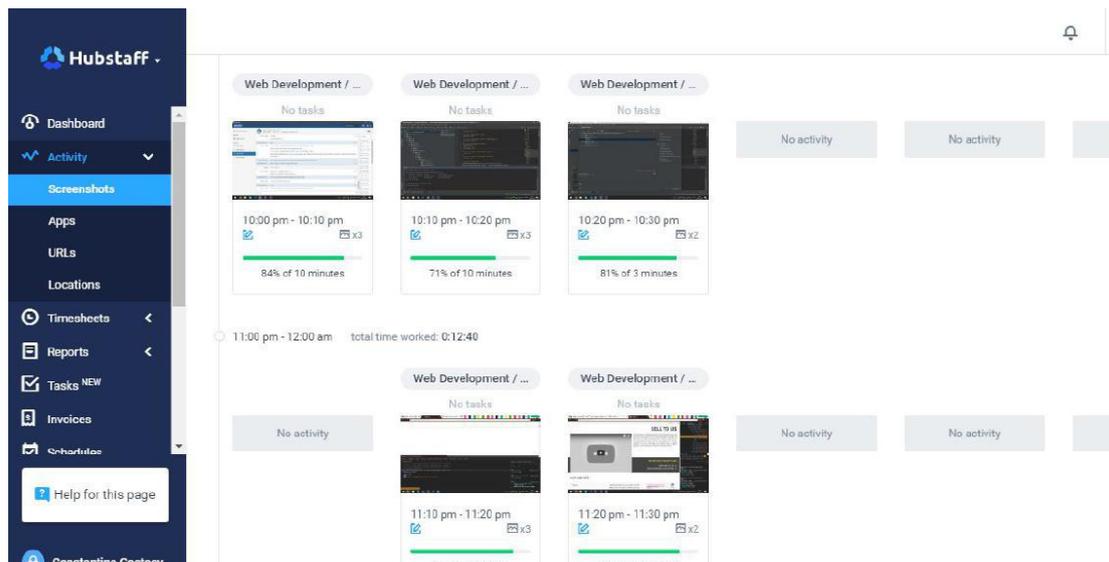


Figure 4. The results of the work of employee B in the second part of the experiment [12]

For a certain amount of people, it is impossible to fight procrastination on their own and that people require an additional push from supervisor to start working over. Such supervisor control model helps to say no to unnecessary entertainments at the working place.

The experiment showed that the proposed way is working, and it is planned to make such an experiment on a few other companies with more employees to see if the method is applicable and useful in bigger target groups.

#### 4. Results and conclusions

The human brain is constantly tricking its owner, impairing perception of reality and affecting work in a team. The effective project manager is expected to deal with such phenomena and empirical laws that occur in project team life.

The team-based approach is the best way to focus on human resources in a project to maintain maximum performance from a team. There is no universal way to reduce the impact of empirical laws and psychological phenomena on team members yet and the topic requires further investigation. It is possible to catch and remove every impact by using individual ways to each case, which is not always productive way of handling things.

Project managers must use the situations and factors that naturally contribute to the development of the team and find the opportunity to cope with the situations and factors that interfere with it. They have to demonstrate an extremely interactive management style that serves as an example of teamwork.

In future researches, the presented method will be implemented to exclude the influence of other psychological phenomena and empirical laws described above and the results of the work will be monitored.

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# TRENDS IN MODELING AND SIMULATION OF SENSORS

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**Abstract:** *Significance and importance of sensors in the modern world, highly relying on high-tech solutions, cannot be overemphasized, so, in a great number of cases the high-tech solutions are associated with different types of embedded systems where sensors play the key role in the sensing of an environment. The tendency to delegate more and more complex and critical functions on embedded systems has been growing during last decades and it will continue to grow for many years to come.*

*The authors of this article aim to explore the current trends in the area of sensor simulation and application. The article is analytical in nature and it is structured in a way to go evenly through the concepts of Hardware-In-the-Loop technique, basis of the modeling and simulation, the modern trends in the sensors' modeling and simulation, the further research activities.*

**Keywords:** sensor, sensor application, modeling, simulation

## 1. Introduction

During the last decades, the modern world has been invariably influenced by new emerging technologies. Thus, due to the new technologies, more various duties, which used to be the privilege of humans alone, have been being delegated to the machines. New technologies not only allow machines to take over the duties, but also empower human beings. Often, the new technologies are accompanied with or thought of as the embedded system solutions where sensors play the role of the sensory organs.

The embedded systems are often characterized as the soft- or hard-real-time systems, with high requirements for safety and intensively interacting with the real physical world. Such nature of the embedded systems makes them dependable in a high degree on sensors, and thereby, on the sensors' design methodologies. Today's design methodologies allow us to study sensors' behavior carefully and characterize them at a very early design stage with the help of modeling and simulation techniques. Therefore, the insight into the concepts underlying these techniques and into their application scenarios is of high practical significance.

An academic project committed to development of a Flight Control Computer (FCC) functional prototype at FH-Dortmund [1] is a good example where sensors' modeling, and simulation play one of the key roles along with the core functionality. The project is based on the Hardware-In-the-Loop concept and it is pursuing not solely design and development aims, but also facilitates educational and research activities. Implementation of the project, the current and further support of educational and research activities would not be possible without sensor modeling and simulation techniques. The sensor modeling, and simulation, both, let the academic staff and students be involved in the development of the technique, and in the future in many other various processes which are not feasible or too expensive to be conducted on a real physical equipment.

## 2. Low-budget HIL implementation using simulated sensors

Educating by means of case studies is essential for master courses at University of Applied Sciences and Arts Dortmund. We decided on creating a case study on avionics computers to support subjects like control theory, software engineering, HW/SW Co-Design or mechatronic systems engineering. The case study should give students the opportunity to implement and verify their solutions on an avionics computer prototype. Designing software and hardware for this avionics computer includes consideration of real-time and safety requirements. To make this scenario as realistic as possible, the avionics computer prototype will be embedded into a Hardware-in-the-Loop system (HIL). Core component of this HIL system is the commercially available flight simulator X-Plane [2] which will run on a PC. A full featured avionics computer in the loop additionally would require sensors and actuators to be part of the loop. Ideally these components shall be original airborne equipment. Due to limited budget it is not possible to fulfill these requirements completely. Instead sensors and actuators will be simulated to a certain extent that allows to observe their signals.



Figure 1. Basic concept of the HIL system

Fig. 1 shows the basic concept of our HIL system. X-Plane flight simulator runs on a PC either under Windows or Linux, to simulate a plane and its environment. X-Plane can be configured to provide a selection of its actual state variables via UDP on the Ethernet. An embedded computer receives this data and performs what we call SAS (sensor and actuator simulation). As a result, the SAS Computer transforms the actual state of the plane into simulated sensor signals. The FCC (flight control computer) prototype continuously reads the sensors' data and performs control, navigation and autopilot algorithms. To control the plane the FCC generates signals for actuators whose behavior is simulated in the SAS. The SAS-computer then translates actuator signals to according commands for X-Plane to control the plane.

## 3. Modeling and simulation basis

Modeling and simulation are one of the long-standing and widely used methodologies in science and engineering. It's high effectiveness of use has been numerous times proven and validated across different application domains. Clear understanding of the modeling and simulation concepts and correlated techniques facilitates effective usage of this methodology.

### 3.1 Modeling

Christian Köhler, in his work [3], gives the following definition for the idea behind the model notion:

“A model is a mapping of a system or a process to another conceptual or representational system, which is created by using known principles, an identification and assumption. The model has to present the system or the process sufficiently accurately with respect to the question at hand”.

Considering carefully the definition, we conclude that the requirement “*to present the system or the process sufficiently accurately*” dictates us to reach the clarity on the types of models. There

exist many various classification criteria to systematize the types of models, and these include application domain, modeling language, determinism, model time notion, information known about the model referent, implementation technique of the model, realization medium, type of the experiments which will be conducted on the model and other specific to the objective of the model aspects.

In this work, we pay attention to the continuous and discrete models which are classified as the mathematical type of models. Our current interest in this type of models is motivated by the wide usage of models in the research, design and development processes at the very early stages and later during the referent's life cycle. On the other hand, the mathematical models form the basis for the computer-based simulation and they are becoming more and more competitive and applicable nowadays due to their ability to be adopted to different tasks and significant computing power of the modern computing machines.

*Mathematical model* is an abstraction of a system in the terms of mathematical formalism. The mathematical model can be composed of a set of variables, functional or logical relationships between these variables and expressions. Often, a mathematical model is presented as a set of simultaneous equations of different types [4]. Both, static and dynamic behavior can be represented with mathematical models - dynamic model contains a notion of time and evolves with respect to time, otherwise the model is static.

*Continuous model* represents behavior of a system in a continuous (smooth) manner when infinite number of the changes in the state are possible. Therefore, the changes in the system state, can be (theoretically) observed at any possible point in time and with infinitely small increment in time. Continuous models belong to the class of analytical models and represented by a set of algebraic or differential equations.

*Discrete model* mimics behavior of a system an abruptly manner when system state changes only at a countable number of distinct points in time. These distinct points are characterized by the occurrence of events, the stimuli, which may cause the system to change its state. Mathematically, discrete models can be represented in terms of difference equations. Due to their nature, the discrete models are not capable of observing the system state at any point in time. It should also be noted, that the class of discrete models includes *discrete-time* and *discrete-event* model types.

### 3.2 Formalism of the models

More formally, mathematical models are clearly defined in [5]. With respect to the dynamic mathematical models, the changes  $h$  in time  $t$  and system state  $s(t)$  are considered as specified by a clock  $c$  and transition function  $f$  correspondingly:

$$h = c(s(t), t) \quad (1)$$

$$s(t + h) - s(t) = f(s(t), t)g(h) \quad (2)$$

The clock function  $c$  determines increment in model time  $h$ , the transition function  $f$  and the time influence function  $g$  determine the change in the state of system  $s(t)$ .

The time influence function  $g(h)$  is set up to  $g(h) = h$  time units for the continuous models and as  $g(h) = h = 1$  time unit for discrete models.

*Continuous models* are characterized by a time continuum, it means that the next instant of time  $t + h$  is infinitesimally beyond the current time  $t$ . Thus, taking into account the assumption that

$g(h) = h$  time units and consider the limit while  $h$  tends to 0 (4) representing continuous-time model is obtained from (2):

$$\lim_{h \rightarrow 0} \frac{s(t+h) - s(t)}{h} = f(s(t), t) \quad (3)$$

$$\frac{d}{dt} s(t) = f(s(t), t) \quad (4)$$

The transition function  $f$  in (4) mimics the rate (derivative) of system state change. The trajectory (solution) of the system state over time is derived by solving the equation.

*Discrete models*, unlike continuous models, cannot be characterized by a time continuum. In other words, discrete models are not capable to handle an infinite number of infinitesimally changes in time. Here, the state changes in time at the distinct points with regular intervals between two consequent time points. Thus, with assumption that the time influence function is defined as  $g(h) = h = 1$  time unit, (5) representing discrete model is derived from (2):

$$s(t+h) - s(t) = f(s(t), t) \quad (5)$$

Equation (5) is a difference equation, which is discrete analogy to a differential equation, and represents discrete-time model. In such types of models, the state may change every fixed step (increment)  $h$  of time units. The increment,  $h$ , can be scaled with the time influence function  $g(h)$ .

For both, continuous-time models and discrete-time models, the clock function  $c$  takes two arguments the current state of system and current model time, as defined by (1) and the time step (increment)  $h$  can only be fixed, which is not the case for discrete-event models.

For the discrete-event models, since the causality is owing to events, it is proposed to think about the clock function  $c$  and the transition function  $f$  as working together in order to advance the model in time to the next state, based on the type of event  $e$  that occurs. Thereby, (1) and (2) are transformed into the form:

$$t+h = c(s(t), t; e) + t \quad (6)$$

$$s(t+h) = f(s(t), t; e) + s(t) \quad (7)$$

Equations (6) and (7) constitute the discrete-event model and differ in meaning from the equations (1) and (4), (5) respectively. As we can see, (1) species increment in time, while (6) determines a time point  $t+h$  of the next event occurrence. And similar difference is found in the interpretation of (7) and (4), (5). Equation (4) and (5) determine the rate of state change and (7) species the next state at time point  $t+h$ .

This difference between continuous-time and discrete-time models is well discerned in the classification of solvers (programs implementing methods to solve model) given by MathWorks® [6]:

“Continuous solvers use numerical integration to compute continuous states of a model at the current time step based on the states at previous time steps and the state derivatives. Continuous solvers rely on individual blocks to compute the values of the discrete states of the model at each time step.”

“Discrete solvers are primarily for solving purely discrete models. They compute only the next simulation time step for a model. When they perform this computation, they rely on each block in the model to update its individual discrete state. They do not compute continuous states.”

It is obvious, that the type of a model, continuous or discrete, to be used to mimic a particular system shall be chosen taking into account the nature of the system, purpose (type) of simulation, required fidelity and accuracy and the level of computational cost accepted.

### 3.3 Simulation

In the current work, we are guided by two definitions for the simulation concept which in our opinion complement each other and differ only in the level of abstraction they can be applied at: “Simulation is the imitation of the operation of a real-world process or system over time [7].” “The execution of a model over time is understood as simulation [4].”

Simulation is aggregation of different concepts, among those, the model concept is the core element. The simulation performance, accuracy and validity depend on these elements. These elements are *data*, *model*, *method*, *implementation* and *realization*. These constituent elements have to be carefully taken into account during a model and simulation design processes. The detailed description of these components is beyond the scope of this article and can be found in [4].

Unlike the previous elements, the types of simulation are of closer interest for us in this work. Within the scope of our focus, depending on the purpose of simulation and model designed, the computer-based simulation we consider the *Continuous simulation*, *Discrete-event simulation* and *Combined discrete-continuous* types of simulation [8].

*Continuous simulation* operates a continuous model in order to continuously (smoothly) track system behavior trajectory. The change in the system state, can be (theoretically) observed at any possible point in time. In fact, computer-based continuous simulation is performed on digital computers, which are inherently discrete-time computing machines capable of creating the illusion of continuous operation for the given conditions.

*Combined discrete-continuous simulation*. Due to the fact, that far from all real systems are only continuous or discrete inherently, the majority of the systems will be required to be analyzed against both continuous and discrete behavior criteria. For such kind of systems, it may be required to design and run two types of interrelated models - continuous and discrete in order to obtain sufficient fidelity of the system simulation. An approach to combine two types of simulation forms lead to a new type called Combined discrete-continuous simulation. There are basically three types of the interaction that can occur between continuously and discretely changing system behavior trajectories [8] [10]:

- A discrete event may cause a discrete change in the value of a continuous state variable.
- A discrete event may cause the relationship governing a continuous state variable to change at a particular time.
- A continuous state variable achieving a threshold value may cause a discrete event to occur or to be scheduled.

In practice, the approach, when a continuous model being performed under control a discrete - event model is used, called Hybrid simulation [9].

Also, two general criteria can be applied in order to refine types of simulation mentioned above. The first criterion specifies type of simulation with respect to the real-world time. Based on the ability of the simulation to run a model in real-time or non-real-time manner, the simulation can fall into corresponding eponymous groups. MathWorks® [11] defines real-time simulation in the following way:

“Real-time simulation and testing extend beyond simulation by verifying algorithmic design behavior while running models at required speeds, respecting precise timing requirements.”

The key phrases in this definition are “*required speeds*” and “*respecting precise timing requirements*”, meaning that neither a faster either a slower simulation is acceptable to be classified as real-time simulation. The real-time simulation runs model at the same time rate in a timely manner as the real-world referent of the model does, otherwise the simulation is non-real-time. The second criterion refines types of simulation on the basis of the number of computational nodes (processors / cores) required to run the model adequately. For its part, the number of computational nodes is determined in accordance with the need for computational power, deployment of the model and simulation resources or inherit characteristics of the referent. Simulation is called distributed if the model is carried out with a hardware made up of more than one computational node, otherwise the simulation is local.

Now, when we have reviewed the theoretical basis on modeling and simulation, with the focus on the mathematical continuous and discrete types of models, our attention is directed to explore how these concepts and the general idea behind the modeling and simulation are applied on practice.

#### **4. Sensor modeling and simulation practices**

Many areas of natural sciences and engineering benefit from the sensor modeling and simulation concept employed by analysis in such activities as research, development, design, optimization, testing, operation and control. Each particular application scenario of sensor simulation sets up its unique requirements and scenarios which differ in sophistication and complexity. Despite a great variety of possible applications, the results of the research conducted make us to lean to the conclusion that there exist two general directions in the application of sensor simulation. The first direction can be characterized by the specific, that sensor models are used for data generation and the second is the one which is deeply focused on sensors as the main object of modeling and simulation.

##### **4.1 Sensor models as data generators**

This application direction employs sensor data modeling and simulation with no or little focus given on the first principles underlying the sensors involved in a simulation scenario. Sensors, themselves, are not the object of studies in this case. Mel Siegel, in his work [12], characterizes this approach as:

“more oriented toward abstraction of real sensor outputs into the hypothetical output of an imagined sensor than toward complete bottom-up simulation of an unavailable sensor.”

Application scenarios of sensor simulation like that aim to serve as an auxiliary functionality (data generation) in simulations designed for analyzing systems of a higher level and larger scope and allow to facilitate them. Within this approach there exist different methods and techniques varying in complexity and scale used to simulate sensor data. In those cases, where no focus given to sensor operational specific features at all, the readings may be modeled in the simplest way as set of data in terms of time or other parameter. In other cases, when more realistic scenarios of sensor simulation are concerned, such parameters as noise, sensor fault conditions and others can be modeled. A summary on a few examples of such an application is given further:

- [13] presents an idea of sensor fusion within a virtual reality environment in order to develop a simulator capable of integrating a multi-sensor robot simulation.
- [14] describes research activities conducted with the focus on the data generated by the Wireless Sensor Networks (WSN) simulator and how these data are made available for the user applications.
- [15] gives a focus on a work related to the modeling and simulation of an air data computer. The sensor simulation is only considered as a data source implemented in a simple way in a form of voltage range by means of DC power sources and potentiometers.
- [16] addresses the process of creation of a sensor data generation system in order to test the storage engine of the Digital Environmental Home Energy Management System (DEHEMS) project.
- [17] presents a methodology to test a sensor data validation module with the help of sensor generated data.

Unlike this direction in the application of sensor simulation, the second one focuses on sensors themselves, as on the object of studies.

#### **4.2 Sensors as object of modeling and simulation**

Within this approach, sensors are the main object of studies simulation is intended to facilitate, thus different activities with regards to studying and analyzing of sensor models take place here; the questions of modeling, fidelity, accuracy, performance optimization, implementation, deployment, and many others are addressed. The approach is challenged by hard-to-simulate first principles underlying functionality of sensor system components. Depending on the level of details and fidelity required, a simulation can be nearing the emulation of the model referent, especially it becomes possible with reconfigurable hardware. Hereafter, a short recap on a few papers concerned with sensors as objects of modeling is provided:

- [18] presents an approach how the FPGA based methodologies can be used for sensor simulation to create more deterministic and more adaptable test systems.
- [19] addresses research and development process of a virtual sensor for the angle of-attack signal, starting from the design requirements and going through the first principles, modeling and simulation.
- [20] describes a methodology developed to dynamically simulate airborne Forward-Looking Infrared Sensor (FLIR).
- [21] introduces methods of simulation for optical sensor such as cameras, Time-of-Flight (TOF) cameras, laser range scanners and sensor simulation framework.
- [22] give a description of a modeling technique for the entire Micro Electro-Mechanical Systems (MEMS) acceleration sensor with auxiliary control circuits by the means of software / hardware co-simulation.

#### **4.3 Common requirement to the both directions**

Although, these both directions in sensor simulation have little in common, they can efficiently complement each other at different level of abstraction of sensor modeling and simulation. The decision on which of the forms of sensor modeling and simulation to follow, first of all, depends on the aim of the simulation and has to lead to a valid model of the sensor. We found, that the description of a valid sensor model given in [23] is applicable for both directions:

“In any goal-directed sensory system, a virtual sensor is a (conceptual) device whose output can be modeled in terms of the relevant characterizing parameters, and the outputs of other virtual sensors. The virtual sensor modules should be chosen at the highest level of abstraction that

enables a sufficiently accurate characterization of the total system behavior, but at which the interactions between various virtual sensor modules are (relatively) simple, both in their statistical (in)dependence and in the causal relationships. In a simulated system, we have the additional demand that the virtual sensor models should be amenable to being validated.”

In the context of this definition, a valid sensor cannot be distinguished from the referent sensor during data acquiring session [23], provided that simulation produces adequate and convincing results, meaning that a valid sensor model has to possess the satisfactory level of fidelity.

Wide diversity in the scenarios of sensor simulation also implies a variety of platforms used to realize simulation. In the next section we go through the hardware technologies employed for sensor simulation.

## **5. Platforms employed to implement simulation**

In this particular case, we are paying our attention to hardware platforms utilized in sensor simulation. In general, our research has identified three groups of hardware technologies used for simulation nowadays: the conventional computers based on the von Neumann architecture, the computer machines based on the parallel computing architectures and the systems based on Field Programmable Gate Arrays (FPGA).

### **5.1 Conventional and parallel architectures**

Historically, the machines of conventional type are the most widely used today and capable of solving many problems, but nevertheless they may not be applicable for solving some computationally intensive problems in an adequate manner. This is particularly true for some modeling and simulation applications, where huge amount of data and complex mathematical algorithms are to be processed.

When big amount of data is being processed, the central processing unit (CPU) on a von Neumann architecture machine is not effectively used during the read and write operations performed on the memory. In order to run complex models which, use memory intensively, the parallel computing technology is applied. Parallel computing based on shared memory architecture does not decrease the time required to perform the memory read and write operations but improves overall efficiency of a computing system by increasing the range of data to be processed. It is also worth noting, that parallel computing allows to fit hardware architecture better for specific application tasks dividing the whole problem in sub-problems and deploy them on several specifically oriented computations nodes.

Peter Pacheco, in his book “Parallel programming with MPI” [24] cites a very indicative example demonstrating the need for more computational power to simulate complex models. The example implies development of an abstract conventional machine with von Neumann architecture capable of performing one trillion of addition operations,  $1 \times 10^{12}$ , each second, as a part of weather forecast prediction across the United States and Canada for the atmosphere from the sea level to the altitude of 20 kilometers for the duration of two days. The example clearly shows the scale of simulation when the parallel computing is required and can be efficiently used.

However, the parallel computing is far not always the solution which can be employed to simulate any model since not every problem can be solved by employing the parallel computing paradigm and due to the fact that the advantages of parallel computing introduce intrinsic challenges which have to be considered and overcome. These challenges will include decisions on the following [24]:

- Interconnection network between processors and memory units.

- System software capable of parallel computing.
- Data structures to represent problems in a form suitable for the parallel computing.
- Algorithms for solving problems by means of parallel computing.
- Division of the algorithms and data structures up to the level of sub-problems.
- Communication types that will have to be established between the sub-problems.
- Deployment of the sub-problems to processors and memory units.

As a consequence, the cost of ownership of such simulation environment is also one of disadvantages for this type of systems. Considerable overhead, complexity and cost prevent parallel computing from being an alternative solution to conventional sequential computing for solving the whole range of problems. Thus, an accurate estimate of activities to organize a parallel computing including development and implementation time shall be conducted before making a decision on the employment of parallel computing, since it might be an overcapacity solution.

## 5.2 FPGA's in sensor simulation

As it can be concluded from the previous section, the hardware architecture and correlated software are the subjects to changes in order to overcome hardware limitations to meet simulation performance requirements. And, in this respect, performance of computing system does not always mean higher computational capacity, it rather means suitability of the system for a particular simulation scenario. However, the process of changing of any hardware architecture is not a trivial one, it takes human, financial and also time resources what is unacceptable in most of the cases. In other words, it is highly desirable, if simulation environment would be based on technology which make it possible to reconfigure and customize the architecture to be able to follow changing simulation scenario in fast and efficient way.

FPGAs are developed to be the “*soft hardware*” in mind what makes them fit well the changing simulation requirements. FPGAs are becoming very powerful too due to the fact that they also include specific hardware parts such as processor cores, memory blocks, digital signal processing multiplication units, analog to digital converters, becoming Systems on Chip in this way. Due to their nature reach in flexibility and functionality, it becomes feasible to adopt hardware for simulation scenario and perform a set of various operation on a single chip in truly parallel manner.

National Instruments ® [25] credits FPGAs as ideal platforms for sensor simulation primarily because they can adapt to different sensor types with precise timing requirements which is of importance for HIL and they provide *NI LabVIEW FPGA module* [26] - a high level synthesises solution with a graphical programming interface that facilitates development of hardware descriptions. Similar approach is also followed by MathWorks ® which offers *HDL Coder™* [27] tool to generate HDL code. Both of the solutions propose direct shift from the model designed in a modeling environment to HDL code oriented on target chip.

The Sensors magazine [28] published the “Sensor Systems Based on FPGAs and Their Applications:

A Survey” article in 2012, which presents a survey on designs and implementations of research sensor nodes which are developed based on the FPGA technology, either standalone platform or as combination of a microcontroller and FPGA with the focus on Wireless Sensor Networks (WSN). The article presents analytical material obtained on the results from the implementation and operation of smart sensors transducer, sensor data acquisition boards, sensor data compression circuits and WSNs simulation. The authors note, that optimized computationally-low-power FPGAs are able to enhance the computation of several types of algorithms in terms of speed and power consumption in comparison to microcontrollers of commercial sensor nodes.

In our opinion, FPGAs are the powerful and beneficial technology for simulation and it can be applied in both sensor simulation directions - sensors as data generators and sensors as subject of modeling and simulation, especially when high level of time determinism, adopted to problem architectures, reconfiguration and prototyping are required. The relative novelty of the technology and required good understanding of principles of operation of hardware will speed up adaptation of this technique during some period of time.

## **6. Future research prospects**

Without the data on computational load and time requirements to perform simulation of a particular type, it is quite hard and maybe meaningless to estimate which of the architectures, the classical von Neumann, the parallel computing or a solution based on the FPGA technology meets the particular simulation requirements better. At global view, with no specific details, we can only discuss it in general sense; for relatively simple models, with a small number of data to be processed or small number of iterations, a conventional machine can show a satisfactory result, while for more complex models it may be not capable of adequate simulation and more power, but also more complex solutions may be required.

When it comes to a separate sensor modeling and simulation, the questions pertaining to fidelity, determinism, real-time performance, linearity, noise, errors, drift, temperature instability, etc. are becoming more meaningful and the correlated parameters can be characterized and quantified. With the established characteristics of the model and simulation it becomes possible to evaluate performance of the model and simulation on different simulation platforms and compare the derived results.

Our area of the research interest is to ascertain the performance characteristics for a set of models developed for different sensors and simulated on various simulation platforms. In order to accomplish that, we plan to use different hardware platforms built on the principles of the conventional von Neumann and parallel architectures and on FPGA based technology. While the answers on these questions might be obvious in general sense, we are interested in more specific details, for example, in such as a level of determinism of a sensor simulation at the required model fidelity level.

Simulation of sensors is our starting point where from we will proceed into different directions. To complete the outlined above HIL system simulation of actuators becomes necessary. Similar principles will apply to this. But there are other applications around which can profit from low-budget simulation of sensors and actuators. One field we currently are working on is design of low-cost test systems for ASICs (Application Specific Integrated Circuits) and PCBs (Printed Circuit Boards) [29]. PCBs in the embedded systems domain like Internet of Things (IoT) become more and more complex in their functionalities. Pure electrical tests of such PCBs are no longer adequate. There is a demand to verify these boards completely including their software. Typically, PCBs in Embedded Systems are connected to a variety of sensors and actuators. Having a test system which implements simulated sensors and simulated actuators can help to verify embedded systems' components on a low-cost level.

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# COMPARISON OF THE PRODUCT STRUCTURE OF THE CONVENTIONAL AND DIGITALISED CAR

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**Abstract:** *The ongoing digitalisation effects the product structure of the car as components change, will be added or become obsolete in future. It is presumed that the change in the product structure will have an impact on the logistics processes of automobile manufacturers and suppliers. A literature research has been conducted to extract the changes of the digitalised car. Further, the differences between the product structure of the conventional and digitalised car have been compared. As the effect on the logistics is not clear today, this research is an essential starting point for further research.*

**Keywords:** product structure, future car, digitalisation, automotive logistics

## 1. Challenges of the Automotive Industry

The automotive industry has to face the challenge of profound adjustment processes in the near future. The drivers of these adaptation processes are the technology-driven trends: diverse mobility, autonomous driving, electrification and connectivity [1]. Moreover, future business models will be focused on the creation of mobility solutions, the provision of infrastructure for connectivity and the development of software (SW) [2]. Forecasts support these trends by predicting that 50% of passenger cars sold will be highly autonomous and further 15% of passenger cars sold will be fully autonomous in 2030 [1].

Compared to conventional cars, today's cars are increasingly being digitalised by the application of new technologies. For instance, driver assistance systems, object recognition systems, voice control systems, multimedia systems and connectivity between cars are integrated [3]. Among other fields, the current state of the art includes advanced driver assistance systems (ADAS): automatic distance control, lane keeping assistant, electronic stability control and vision improvement systems [4]. Nowadays, ADAS are implemented to support the driver. In future, the assistance systems will take over an increasing number of tasks for the driver, up to autonomous control of the car. Therefore, the digitalised car requires for instance: sensors for environment

detection, control units, navigation SW, decision-making algorithms and Car-to-X (C2X) communication [3][5].

The digitalisation of the car introduces technical and logistical challenges that will change the product structure of the car. In general, the product structure defines the elements of a product and the relationship between the elements in a structured way [6][7]. The rising demand for connectivity, reliability and availability and thus the integration of additional electrical components into the car increases the complexity of the product structure [8]. In future, variants of a car will be created for different customers by adapting the SW [8]. As a result, ensuring the compatibility of different components and SW variants is another challenge.

This contribution provides an overview of research on the automotive product structure, followed by an examination of the product structure of the conventional car and the digitalised car. The main part of this contribution represents a detailed comparison of the conventional and digitalised car to extract their differences. At the end, the insights of this research are summarised and an outlook on future work is given.

## 2. State of the Art of the Automotive Product Structure

An examination of scientific papers, monographs, dissertations, journal articles and other sources (e.g. websites and conference proceedings) has been conducted within this contribution. The research has been performed in the English- and German-speaking area using the digital databases of ScienceDirect, Google Scholar and Springer. The description of the product structure of the conventional and the digitalised car is based on divisions as well as their electrical and non-electrical components. Furthermore, relevant SW components have been considered.

First, the terms product structure, conventional car and digitalised car will be introduced. The explanations form the basis for the presentation of the product structure of the conventional and digitalised car as well as for the following comparison. The product structure describes the divisions of a product as well as the interrelations of the divisions and thus represents the physical and hierarchical structure of a product [6][9].

This contribution refers to a combination of the classifications determined by Schäuffele & Zurawka [8] and Schindler [10] as this combination allows a detailed description of the effects of digitalising the car. The resulting automotive product structure is divided into the following divisions: *body & exterior*, *chassis*, *propulsion* and *electrics/electronics* (see Figure 1 – information based on [11][12]).

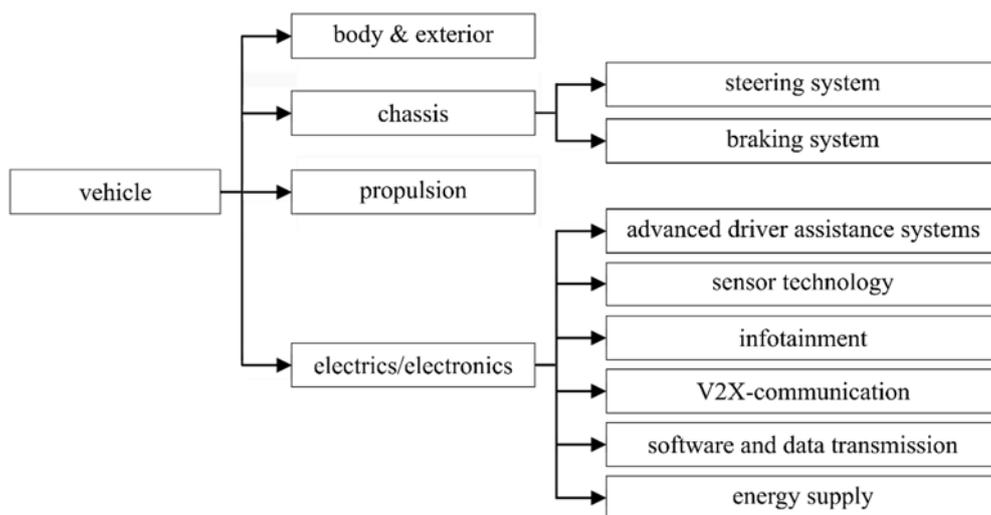


Figure 1: Product structure of a car

Before the classification shown will be applied, the terms conventional and digitalised car will be defined. The differentiation between conventional and digitalised cars is based on the technologies used. The conventional car is classified as a car dominated by mechanical components, including systems such as the anti-lock braking system (ABS) or the electronic stability program (ESP). Although the change from conventional to digitalised cars is an ongoing process, the conventional car is defined as produced before the year 2000 (see Figure 2 – information based on [13][14][15][16][17]). The year 2000 marks the boundary between conventional and digitalised cars within this contribution, as the frequency of technological novelties in the car has increased significantly since then (see Figure 2 and Figure 3 – information based on [3][13][14][16][17][18]). This trend is driven primarily by the development of electrical components using information technology.

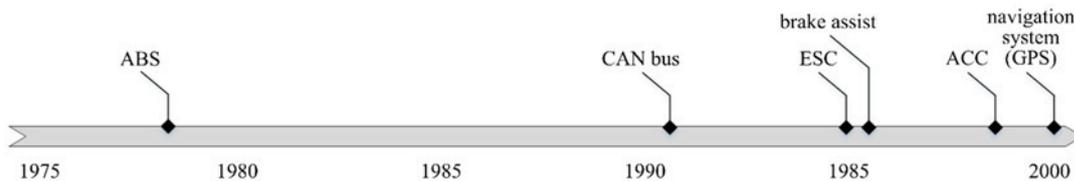


Figure 2: Technological development of conventional cars

The integration of GPS-supported navigation devices into the on-board network is defined as the beginning of the digitalised car. From 2000 onwards, an increasing integration of electrical systems and driver assistance systems, such as the lane keeping and lane change assistant, into the car can be observed [19]. The technologies shown in Figure 3 are based on the rising use of sensors for environment detection and integration of control units [20]. The latest and for the future predicted technological developments are primarily determined by the use of SW and car connectivity [21]. Overall, the growing substitution of mechanical components by electrical ones, as well as the use of information technology is called the "digital revolution of the car" [20]. In the long term, digitalising the car is intended to enable autonomous driving [22].

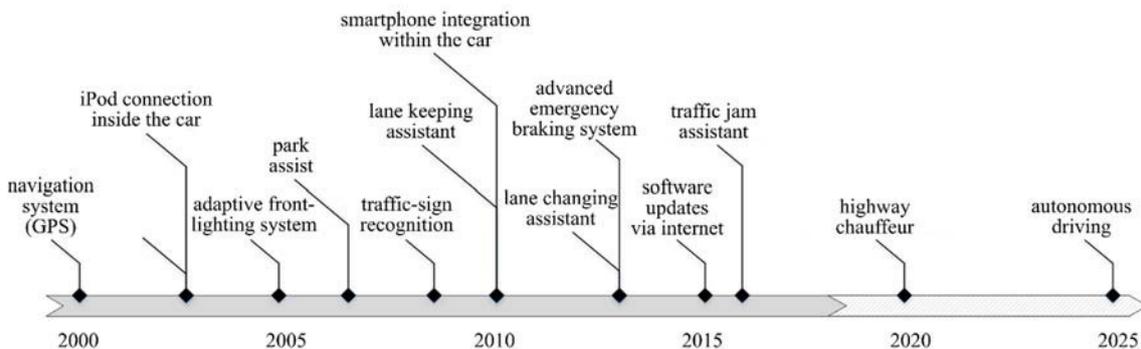


Figure 3: Technological development of digitalised cars

### Product Structure of the Conventional Car

This section outlines the product structure of the conventional car focusing on the divisions that change or are added in the context of digitalisation. Unless otherwise stated, the specifications refer to the car model Volkswagen (VW) Golf III. Although depicted in the product structure, the *propulsion* is not considered in more detail within this contribution, as this paper focuses on the digitalisation of the car as well as its effects on the product structure, whereby most digitalisation processes (e.g. integration of ADAS) are identical for cars of all propulsion types.

*Body and exterior* form the physical basis of the car as well as locking system, windshield wipers, lighting and exterior mirrors [10][23]. Locking and unlocking is done either by turning the key in

the door lock or by radio remote control. Moreover, the conventional car is equipped with a central locking system. Windscreen wipers and lighting are switched on by the driver as required. As optional extras, electric windows and heated door mirrors can be selected.

In the *chassis division*, the conventional car has a hydraulic rack-and-pinion steering system consisting of steering valve, steering cylinder, rack with piston, steering pump, oil tank and oil hoses [14]. The conventional braking system, consisting of brake pedal, brake cylinder, brake discs, brake calliper and hydraulic lines, uses hydraulic, pneumatic and mechanical energy transmission [12][24].

Based on *electrics/electronics*, driver assistance systems support the driver in perception, handling, car guidance and car stabilisation [14]. Systems of the conventional car which fulfil these driver support tasks are: anti-lock braking system (ABS) to ensure maximum manoeuvrability even with full braking, traction control system (TCS) and electronic stability control (ESC) to prevent loss of traction, e.g. on slippery roads [18], adaptive cruise control (ACC) for automatic speed adjustment to maintain the safety distance to the car in front [25] and brake assist (BA) to increase the brake force in dangerous situations [10].

For proper operation, these driver assistance systems require data on systems such as engine control and environment recognition. This data is provided by sensor technology. The ACC of conventional cars, for example, uses a radar distance sensor to determine the distance to other objects [25][26]. Infotainment mainly comprises the four segments information, communication, entertainment and assistance [27].

Information about the car is provided to the driver analogously, e.g. via speedometer or rev counter. Communication with other connected systems inside or outside the car is not intended. For passenger entertainment, the conventional car is equipped with radio and CD/cassette player. Early navigation systems enable route guidance based on GPS positioning and stored maps [28][29].

The interaction of the car with objects in its environment is termed C2X communication. However, the conventional car does not have systems that meet the specifications of C2X communication [20].

Above mentioned driver assistance systems and less complex mechanisms such as electric windows require electronic control units (ECUs), whereby the ECUs of the conventional car each serve a specific function and operate independently of each other [30]. Therefore, the ECUs are not directly connected to each other and there is a clear assignment of functions and control units. The ECUs are controlled via a central gateway, whereby communication takes place via bus systems such as the CAN bus developed by Bosch [15][21]. As the SW interfaces of ECUs provided by various suppliers are not standardised, integration must take place at the Original Equipment Manufacturers (OEM) [13][31].

The energy supply for the electrical components of the conventional car is usually provided by a 12V on-board power supply system consisting of generator, battery, cables, plugs and fuses [10].

#### *Product Structure of the Digitalised Car*

The fundamental goal of digitalising the car is to increase safety, eco-friendliness and comfort, e.g. by enabling autonomous driving which describes the possibility for a car to reach a certain destination on its own without the driver intervening [4][32]. The Society of Automotive Engineers (SAE) and the National Highway Traffic Safety Administration (NHTSA) have defined six automation levels that map the responsibilities of driver and car. The conventional car can be related to the first two levels containing no automation but early driver assistance, while the digitalised car is assigned the following levels (levels 2 - 5). As with the conventional car, the description of the divisions is based on general information in literature and exemplary configuration variants of special car models. Unless otherwise stated, these specifications refer to the car model VW Golf VII.

Regarding *body and exterior*, technologies such as “Keyless Go” allow the driver to open, close and start the car without actively pressing the key or even replace the key with the mobile phone [33][34]. Moreover, the digitalised car is equipped with a rain sensor for automatic operation of the windscreen wipers, high beam assistant for automatic headlight adjustment and blind spot sensor to ensure safer turns and lane changes [35][36][37].

Within the *chassis division*, former hydraulic systems evolve into electrical or electromechanical systems. Current steering and braking systems of digitalised cars are electromechanical systems, i.e. a mechanical connection between steering wheel and steering gear respectively brake pedal and wheel brake guarantees control of the car in case of electrical system failure. However, the share of electrics in the steering and braking system is increasing steadily and allows not only the elimination of hydraulic components such as hydraulic hoses but also simple adaptations to a large number of different cars via SW [14].

Especially, *electrics/electronics* play a key role in the context of digitalisation as approximately 90% of all car innovations can be attributed to electronics and SW [19] and the value proportion of electric/electronic components in the car has exceeded 50% since 2010 [38].

In terms of driver assistance, the digitalised car is characterised by an extended use of ADAS. The intersection assistant supports the driver, for instance, by detecting road signs, traffic light positions, other cars and pedestrians and by initiating braking in hazardous situations. In addition, the parking assistant is capable of scanning slots and parking the car either transversely or longitudinally if sufficient space is available [39]. Moreover, the driving task, including accelerating and braking as well as maintaining speed and safety distance, can be taken over by the “Highway Chauffeur” for a certain period of time and under certain conditions [40]. By combining ADAS with artificial intelligence (AI), the car will be able to perform the driving task without intervention of the driver in future [14][21][41].

The numerous sensors for environment detection provide the basis for above mentioned ADAS. Equipped with (infrared) cameras, radar, lidar and/or ultrasonic, the digitalised car is able to detect other road users, road markings, road conditions, traffic signs and traffic lights and can determine the distance to other objects [14].

In terms of infotainment, the driver gets information about the traffic situation and the optimal route to the target destination by navigation systems which integrate real-time data on traffic delays and information from cars ahead. Communication is enabled by connecting the smartphone to the car whereby further music can be played via streaming services and digital radios [33][37]. In order to enhance driver convenience, the infotainment system can be operated via touch screens as well as gesture, eye and voice control [21][42].

The integration of C2X communication is an essential prerequisite for autonomous driving. C2X communication not only allows the digitalised car to exchange data on traffic or hazardous sites with other cars, but also enables communication with parking garages, petrol stations and traffic management systems, thus offers the basis for optimising the flow of traffic [20][43]. Information is exchanged via long-term-evolution (LTE), local networks such as wireless local area networks (WLAN) or dedicated short-range communications (DSRC). Consequently, the digitalised car requires LTE, WLAN and DSRC interfaces as well as the ability to transmit and process information [21].

Although the number of ECUs in a digitalised car has risen considerably until around 2010, it has remained relatively constant since then due to the limited space available [44]. However, as the number of functions grows, the ECUs are becoming more and more powerful. In contrast to conventional car’s ECUs, the digitalised car’s ECUs are connected, communicate with each other and are updateable which is extending their life cycle [8][15]. In order to process the large volumes of data generated by ADAS and C2X communication in real time, the ECUs communicate not only via bus systems, but also increasingly via Ethernet as Ethernet provides higher data rates, bandwidths and flexibility [30][45][46]. To integrate SW modules from different suppliers into one ECU, approaches for SW standardisation such as Automotive Open

System Architecture (AUTOSAR) have been developed. The AUTOSAR standard aims to standardise interfaces, decouple hardware (HW) and SW and make SW scalable for different car variants [47][48].

The energy consumption of the digitalised car is higher compared to that of the conventional car due to the increase of electrical consumers such as ADAS and electric actuators. However, the energy consumption does not rise linearly as the components become more energy-saving and intelligent [44]. Nevertheless, OEMs begin to focus on a 48V on-board power supply system as the higher voltage leads to a smaller cable cross-section which transmits the same power and thus the weight of the cable harness can be reduced [19].

### 3. Comparison of the Conventional and Digitalised Car

The comparison between conventional and digitalised cars is based on the divisions described in the previous chapter. These are evaluated regarding the criteria HW and SW, whereby the criterion HW is subdivided into quantity and complexity. While the quantity analysis focuses on the change in the number of components, the complexity analysis comprises aspects of structural complexity, scope of functions and integration capability. The rating (summed up in Table 2) on how the product structure has changed due to the digitalisation of the car is applied as follows:

- + : criterion more pronounced
- 0 : criterion similar pronounced
- - : criterion less pronounced

#### *Body & Exterior*

The HW components of the conventional car have been extended by sensors such as blind spot sensor, rain sensor and light sensor. Since this only represents an addition to the existing components, the HW quantity is rated "0/+". The complexity of the components has increased with the digitalisation of the car, as the added sensors must be integrated into the components and the electrical infrastructure (rating "+"). Moreover, the numerous features require SW, e.g. for controlling the wipers or indicating cars in the blind spot based on sensor data (rating "+").

#### *Chassis*

The main change in the steering system is the shift from hydraulic to electrical systems. Due to the legal requirement for redundancy, the change is not yet completed, so that in current cars both systems coexist (rating "0/+"). Since the hydraulic system merely serves to safeguard the electrical system in the digitalised car, the hydraulics turn out to be less complex. However, this reduction in complexity is compensated by the addition of the electrical systems (rating "0"). With a pure electric steer-by-wire system, the HW quantity and complexity would be evaluated "-" due to the elimination of hydraulic components. The components of an electric steering system are connected and controlled via SW. Furthermore, the ECUs of the digitalised car's steering system communicate with a large number of adjacent assistance systems such as parking assistant or lane departure warning assistant (rating "+").

As the development of the braking system is comparable to the development of the steering system and the legal requirement for redundancy applies as well, the HW quantity is rated analogously with "0/+". The complexity of the HW components is reduced in the electro-hydraulic braking system of the digitalised car, since the individual parts are fine adjusted using SW. In addition, connections, which had to be mechanically or hydraulically matched in conventional cars, have been replaced by less complex cable plug connections. Therefore, the HW complexity of the braking system is rated "-". With the shift to electromechanical braking systems, the brake pedal is no longer hydraulically connected to the brake calliper and brake disc, but the intensity of the brake pedal actuation is converted into a corresponding braking force by SW. Moreover, the braking system of the digitalised car is connected to various ADAS, such as

traffic jam assistant, parking assistant or the collision avoidance system, thus leading to the rating “+” for the SW criterion.

#### *Electrics/Electronics*

A multitude of new sensors (e.g. camera, lidar, infrared) and upgraded existing sensors (e.g. radar) are the result of the added ADAS. Since each ADAS comes with an ECU for data processing and exchanges data with other ECUs via cables, the HW quantity is rated “+”. Due to the effort involved in connecting the ADAS and integrating them into the car system, the HW complexity is assessed "+". Moreover, SW is required to make the high volumes of sensor data comprehensible to the driver and the actuators in real time. Consequently, the relevance of SW has increased due to both the higher number of ADAS and the higher quality of the data to be processed (rating “+”).

Since the ADAS are based on sensor technology, the digitalised car is analogously equipped with an increased number of sensors for environment recognition, thus leading to the rating “+” for HW quantity. As the new sensors must be integrated into both the body and the car infrastructure, the HW complexity is evaluated with "+" as well. However, the sensors themselves do not include any SW (rating “0”).

While additional HW components are necessary for gesture, eye and voice control or head-up displays, the fusion of the individual systems such as the radio, CD player and navigation system into one central head unit generally tends to reduce the total HW quantity required in the digitalised car (rating “-/0”). Since the head unit combines all the functions of infotainment, integration in the car interior turns out to be less complex than the previously necessary integration of all individual systems. Consequently, HW complexity has decreased in the course of digitalisation (rating “-“). In contrast, the importance of SW in infotainment is growing significantly as information, communication and entertainment are realised via Apps (rating “+”).

The digitalised car can communicate with other road users, traffic lights, traffic guidance systems, etc. and is therefore equipped with HW components for sending, receiving and processing information from other objects. Since these components do not exist in the conventional car, the HW quantity is rated "+". In addition, the interconnection of the components required for C2X communication with a multitude of other components and objects such as sensors implies a high level of HW complexity (rating “+”). Moreover, SW is required to decide which information are sent and how received information are processed (rating “+”). For the future, it is conceivable that this SW will be subject to continuous updates and that AI will be used, as the decision about the processing of received information improves the more empirical values are available from other cars.

Mainly due to ADAS, the digitalised car is equipped with an increased number of ECUs. These ECUs are connected via various bus systems and/or Ethernet, thus leading to the rating “+” for the HW quantity and complexity criteria. The processing of data in the digitalised car is performed by a multitude of software programs and versions. Due to the challenges of standardising SW interfaces and making SW updateable, the tasks and requirements for SW in the digitalised car are higher than in the conventional car (rating “+”).

In order to provide sufficient energy for all electrical consumers, the digitalised car is equipped with a 48V on-board power supply system in addition to the already existing 12V on-board power supply system. As the introduction of this additional voltage level demands extra components such as a generator and a voltage converter, the HW quantity increases (rating “+”). The HW complexity does not change however, since the components of the 48V on-board power supply system are comparable to those of the 12V system, but are merely scaled differently (rating “0”).

SW components are not relevant for the power supply of electrical components and thus do not vary from conventional to digitalised cars (rating “0”).

Table 1: Analysis of the product structure of the digitalised car

Components Product Structure	HW		SW
	Quantity	Complexity	
Body & Exterior	0/+	+	+
Chassis			
Steering System	0/+	0	+
Braking System	0/+	-	+
Electrics/Electronics			
ADAS	+	+	+
Sensor Technology	+	+	0
Infotainment	-/0	-	+
C2X Communication	+	+	+
Software and Data Transmission	+	+	+
Energy Supply	+	0	0

#### 4. Key Insights and Outlook

As a result of the digitalisation of the car, the number and complexity of sensors and ECUs as well as the amount of data to be transmitted have increased significantly. These large data volumes are processed by SWs which have standardised interfaces (AUTOSAR) and must be updateable as well as App- and AI-ready. The number and complexity (for logistics) of infotainment as well as steering and braking system components have decreased due to the integration of several functions into generalised electrical control units respectively due to plug connections and adjustment via SW. This trend is supported by developments such as steer-by-wire and brake-by-wire.

It can be assumed that the modification of the product structure will lead to a change in the logistics processes (e.g. procurement logistics) of automotive OEMs and suppliers. Changes in logistics are expected, for example, in the number of suppliers, the degree of supplier integration and the different innovation cycles of HW and SW.

Therefore, this research is an important starting point, as it shows the differences between the product structure of the conventional and digitalised car. The effect on the logistics is not clear today, which indicates the necessity of research in this field.

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# MANAGING THE MULTIDISCIPLINARY ENGINEERING PROJECTS IN THE DIGITAL TRANSFORMATION ERA

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**Abstract:** *In this paper we want to describe some initiatives to motivate young people (pupils and students) to be innovative and more entrepreneurial. This is done in all cases by stimulating project work. For this the groups of pupils and students needs some tools: easy, open source, free, flexible and mobile. Authors looked for and recommend a number of tools which proof to be useful to them.*

**Keywords:** management, collaborative work, sustainable education

## 1. Introduction

Amongst the new trends in all fields of study, digital transformation takes a prominent place whether we think about e-Health, connected cars, internet of things, cyber physical systems, advanced robotics, digital engineering, 3d printing, mobile applications.

The educational approaches are also influenced by digital changes – new ICT tools, e-learning systems, remote laboratories, personal learning spaces, MOOL/MOOC and etc.

Labor market requirements towards ideal graduates also change and we see a lot of common skills and competences emerge for young professional engineers:

- They have broad (rather than deep) knowledge;
- They have strong ICT- and programming skills;
- They are aware of processes in the applied field;
- They are multidisciplinary and can interact with engineers from different fields;
- They gained practical experience during their studies

We can conclude that it's actual to switch university curricula into more interdisciplinary approach.

Also, outside of traditional study curricula, initiatives are taken which promote these methods in all kinds of multidisciplinary projects promoting innovation and entrepreneurship. In comparison to students in regular studies, who are coached by their teachers and can rely on some resources (software and organizational) of the schools or universities, participants in the less conventional tracks have limited resources and could lose a lot of effort in finding appropriate tools and support. With some cases as an example we search for supporting tools which is available to all and show how it helped participating youth in manage their projects.

## 2. Multidisciplinary engineering projects

Let's consider existing international extra-curricular multidisciplinary projects in which authors was involved at different levels.

## 2.1 Technovation challenge

Technovation Challenge is an educational program for girls from all over the world, which aims to develop leadership qualities of girls and motivate girls to change the community around them [1]. The assignment for the Technovation challenge is that the teams set up and develop a mobile application that is useful for society. To do this the teams need to look for an idea, a need in society, an experienced problem which they can solve or bring under the attention of the general public with a mobile application.

For the Technovation project there are detailed online curricula with templates, guidelines, mentors' and students' guidelines, video lessons and organized webinars.

In 2017 the Z\_teens-team developed the application AirNear. The goal was to bring under the attention of the public the problem of air pollution by industry in Zaporizhzhia, an ecological problem with consequences to health. The application informs in real-time about the actual state of harmful elements in the air of different regions of the city and alarm if it exceeded the critical value. The app gets its information from the open source data measurement from the city of Zaporizhzhia and represents it in table of map form on the smartphone, so representing the actual values near the measuring points in the city. As such the user gets and evaluation of the air quality near his location.

In 2018 this team developed application aimed to solve the problem of poverty, which can give possibility for the students of high schools, colleges and university to find one time job. Other applications suggested by girls in Ukraine were dealing with healthcare problems, homeless gods, quality of the water and many other.

In the program are involved different groups of stakeholders:

- Students – teams from 1 to 5 girls aged from 10-18. Teams are divided into junior (aged 10-14 years) and senior (15-18);
- Mentors – professional who are helping girls to develop leadership qualities and help them to fulfill the curricula;
- Ambassadors – the regional leaders who helps to promote the program and increase the Technovation community;
- Judges;
- Parents.

Experience of participation in the Technovation Challenge in 2017 and 2018 allow us to make following conclusions:

- Girls improve language and communicative skills in high degree (making video pitch and real pitches, developing business plan and using learning material);
- Girls improve leadership qualities as they got confirmation that they can make the society around them better;
- Girls become more social active;
- Girls become more aware of modern technologies, developing mobile application and investigation of the problems allow them to get system thinking and a multidisciplinary approach connecting marketing, business and IT.
- For Ukraine this year success level is near 33%: 30 teams from 90 successfully finished their applications.

Doing a project and managing this kind of project requires the use of (many) tools. By the developers of the program there are provided their online LMS system which is combined with project management tools and suggested to use MIT App Inventor as open source platform for mobile applications.

Of course, participants of similar contests and projects are not limited by it and can use any development tool they like. But all above mentioned tools are free, useable and understandable for common users, so that they do not require unachievable levels of knowledge.

## 2.2 Best competition

Best competition – the Board of European Students of Technology, in which 4 Ukrainian universities including ZNTU are participating, each year organize an engineering competition (EBEC) [3,4]. The EBEC Challenge is a 2-phased, team-based competition in 2 categories: Team Design and Case Study. Both categories are based on interdisciplinary tasks developed for students of technology. Each student that comes from a technical university where a Local BEST Group is operating has the right to take part in EBEC Challenge. This competition doesn't have a curriculum for the students, but its requirements are very similar to the previous project. Students do not have any constraints in the selection of the tools they can use. Mostly they are using open sources and free software as project management tool and development tool.

As this is a competition for (engineering) students, they have the same needs and could benefit from the same tools. As the projects is often supported by university and run from within the university, tools available there can be the obvious choice. For challenges outside of university three tools is indispensable:

- Open source software development tool for front-end and back-end applications [5,6].
- A project management tool to structure and log the follow-up of the project [7].
- LMS: learning management tool. To order and manage learning outcomes, presentations, webinars, courses. MOODLE as an open source tool is of interest here.

## 3. Multidisciplinary projects as basis and part of sustainable education

Besides extra-curricular projects it is the task of education to integrate these same methodologies in the regular studies.

A path way to multidisciplinary project education has been established by the CDIO consortium. The CDIO framework provides students with an education stressing engineering fundamentals set in the context of Conceiving - Designing - Implementing - Operating (CDIO) real-world systems and products [8].

The four stages of CDIO are:

- Conceive: Defining customer needs; considering technology, enterprise strategy, and regulations; developing concepts, techniques and business plans.
- Design: Creating the design; the plans, drawings, and algorithms which describe what will be implemented.
- Implement: The transformation of the design into the product, including manufacturing, coding, testing and validation.
- Operate: Using the implemented product to deliver the intended value, including maintaining, evolving and retiring the system.

Some examples following this approach can be found in different engineering faculties.

### 3.1 Basic Engineering school (BEST)

Basic Engineering School – an innovative concept of teaching and learning involved in Ilmenau University of Technology for the students of the first academic year [9]. Within semester students should make an interdisciplinary project – e.g. an autonomous miniature transporter. Additionally to the basic curricula the project involves Mechanical Engineering (Drawing, CAD, Construction, Mechanics), Electrical Engineering (Basics Circuits Electronics), Computer Science (Algorithms and programming, Computer engineering). The results are assessed individually by the responsible specialist supervisors and results are recognized as academic achievements.

### 3.2 Project based digital learning tools

An efficient tool for project-oriented learning which can be easily introduced in a digital environment is the remote laboratory [10]. Implementation of remotely controlled experiments into study allows teachers not only to give students the possibility to have access to the unique equipment 24/7 but allows students to self-study and (re)experiment different aspects without much time-limits. On top, the equipment is used more effectively (longer time) without much personnel, as such cutting costs. Involvement of students for the development implements project based teaching approach and increase multidisciplinary knowledge. Also, it is very effective tool for inclusive education [11].

Development of remote labs as student projects was done in a project-oriented approach at ZNTU. Students, under the supervision of ZNTU staff, designed and built several remote labs covering a bunch of experiments on embedded systems (ISRT) [12].

## 4. Results and Conclusion

The implementation of new and rapidly emerging technologies requires from engineering education a more digital approach, or an approach more involving the digitalization of technology.

Project oriented learning can motivate students to be more innovative. Therefore it is very important that the projects which are done by students not only have digital components but they should be very practical – it should improve or community in they live, or infrastructure around them or solve concrete engineering tasks.

To help finding tools and not to be lost in the variety of different applications a short list of useable tools is plus in project oriented learning. As technology and tools are in constant evolution, a static list is not preferable but it can be a good indicator.

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# IMPACTS ON AUTOMOTIVE SUPPLY CHAIN DUE TO FUEL CELL ELECTRIC VEHICLES

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**Abstract:** *Due to increasing environmental protection requirements, alternatives to conventional vehicles (ICEVs – internal combustion engine vehicles) are necessary. Alternatives to ICEVs are, among others, battery electric vehicles (BEVs) or fuel cell electric vehicles (FCEVs). This contribution analyzes the product structures of ICEVs as well as of FCEVs to identify changes. In particular, the analysis considers if car parts are obsolete, must be added or modified. The changes in product structures affect the automotive supply chain management as well as the relation between OEMs (Original Equipment Manufacturers) and suppliers. In this context, it is examined if core competencies of OEMs and suppliers are changing. Moreover, this contribution is an important starting point regarding the analysis of impacts on supply chain complexity.*

**Keywords:** car architecture, product structure, internal combustion engine vehicle, fuel cell electric vehicle, automotive supply chain, automotive logistics

## 1. Introduction

The advancing globalization and digitization combined with an increase of sustainable products and services lead to a reconsideration of structures and concepts in the automotive industry – Germany’s most important industrial sector [1]. The transition from conventional cars (internal combustion engine vehicles - ICEVs) to cars with alternative concepts, e.g. battery electric vehicles (BEVs) or fuel cell electric vehicles (FCEVs), has been pushed forward in the last years. Especially because of two major reasons, this process accelerated in Germany - the so-called “diesel gate” and media reports on cartel agreements between OEMs (Original Equipment Manufacturers). In the “diesel gate”, several OEMs had manipulated their exhaust systems to realize significantly lower emission values on the test benches compared to reality. As a result, the companies circumvented legal requirements for environmental protection. [2] According to Spiegel [3], cartel agreements between the OEMs Volkswagen, Audi, Porsche, BMW, and Daimler shall have taken place and agreements on technology, costs, suppliers as well as the exhaust systems have been made for diesel vehicles. Thus, the reputation of the German automotive sector is compromised and companies and politics are forced to find new solutions to protect the sector against major problems. Other reasons for the transition are the growing demand and higher prices for fossil fuels as well as the increasing importance of environmental protection in private and legislative areas [4].

FCEVs, as possible alternatives to ICEVs, represent a subcategory of BEVs. Here, in contrast to BEVs, the electric energy is generated by a fuel cell from hydrogen instead of applying a traction battery. These alternative concepts focusing on more environmental-friendly drive technologies

radically influence the product structure of vehicles, the competencies of manufacturers and suppliers as well as the associated logistics processes. [5]

In this context, due to the high complexity of vehicles, the decomposition in form of a product structure is necessary to analyze the vehicles. In general, a product structure is described by Deng et al. [6] as product knowledge decomposed into elementary components and the description of relations between a product, its components, and relevant tasks for assembling. A widespread form of such a product structure is the bill of materials (BOM). The radical changes in the car architectures regarding the trend of e-mobility also impact on logistics processes of OEMs.

Changes in car architecture are characterized for example by larger and heavier batteries, eliminated exhaust systems, or modified powertrains. Here, the powertrain of BEVs represents one of the radical changes. Among others, the manual transmission is obsolete, which is caused by the torque characteristic of electric motors. In particular, the full torque can be applied from standstill [7]. Moreover, in BEVs a single- or multi-speed transmission can be used [8]. The trends of green energy and vehicles lead to new challenges, including new technologies, changes in the legal framework, and necessary adaptation of tasks of OEMs and suppliers. For the mentioned reasons, an investigation and analysis of the current situation in the OEM and supplier landscape is necessary.

The contribution is structured as follows: in chapter 2 and 3 relevant fundamentals in the context of ICEVs and FCEVs are described. The changes of the product structures as well as the core competencies of OEMs and suppliers are analyzed in chapter 4 and 5. This is followed by an analysis of supply chain management structures of ICEVs and FCEVs presented in chapter 6. Chapter 7 summarizes the results as a conclusion and a perspective of future research is given.

## **2. Three-Stage Strategy for Fuels**

Vehicles with conventional powertrain contain an internal combustion engine, whereby the internal combustion engines can be distinguished into petrol and diesel engines. The chemical energy bound in the fuel is converted into kinetic energy, which causes the propulsion of the vehicle. Petrol fueled vehicles need a spark plug for external ignition of the air-gas mixture, while diesel fueled vehicles do not need it as the mixture ignites itself [9]. There are three basic arrangements of the propulsion: front, center, and rear engine arrangement. These engines can drive the front wheels, rear wheels, or both (four-wheel drive). [10] Despite decades of research and mature drive technologies, the efficiency of ICEVs is not comparable to that of electric vehicles. Thermal losses of cooling (27-37%), exhaust gases (30-35%), friction (8-10%), and auxiliary components (2-4%) can be described as the major efficiency problems of ICEVs. Due to these high losses in the powertrain, only a relatively small part of the fuel (36% for petrol and 46% for diesel engines) can be used effectively. [11] In addition to legal requirements for environmental protection and rising fuel prices, these losses have led to the further development of ICEVs as well as research and development (R&D) in the field of e-mobility. In 2009, the Verband der Automobilindustrie e.V. (German association of the Automotive Industry) [12] described a three-stage strategy for fuels regarding the worldwide scarcity of oil resources: saving, supplementing, and replacing. The aspect of saving includes lightweight design and powertrain optimizations. Supplementing aspects are composed of flex-fuel vehicles, gas-powered vehicles, and biofuels. The last step, in particular replacement, is dominated by the areas of electric driving as well as the fuel cell technology. Regarding this strategy, there is a long-term perspective of switching from conventional engines to alternative propulsion systems in the German automotive industry. One of these alternative drive systems is represented by fuel cell technology, which is explained in the next paragraph.

### 3. The Fuel Cell Electric Vehicle

In the automotive industry, fuel cell technology is one of two ways to use hydrogen. The first possibility offers the opportunity of direct use of hydrogen as fuel in an ICEV, while within the second alternative electric power is generated by fuel cell technology. This is realized by combining hydrogen and oxygen in a fuel cell and using the energy to power an electric motor or to recharge an additional battery. Thus, the second possibility is the most widespread form of using fuel cell technology in cars, it represents the focus in this contribution. The fuel cell is also referred as an electrochemical converter, which consists of two electrodes that are separated by an electrolyte. Then, the hydrogen and oxygen are converted to water by a so-called cold combustion. [13] Fuel cells work without mechanical friction, are quiet, and emit no exhaust gases. There are various types of fuel cells, whereby the Polymer Membrane Fuel Cell or Proton Exchange Membrane Fuel Cell (PEMFC) is most commonly used to generate traction power. Its features include a flexible operating behavior, short start and stop phases, and high dynamics of the power range [14].

Fuel cell technology is being implemented in the automotive industry by three different types of FCEVs. The first represents a pure FCEV with direct usage of hydrogen as energy source and without storing in a battery. A second variant, which is also referred to as a booster system, has an additional battery. In this case, it is a lower performance battery to cover power peaks. The excess power is stored in such a battery. The third type of FCEV is the so-called battery charger FCEV, which contains a more powerful battery. The fuel cell is just responsible for the base load and the battery charge, therefore the electric motor receives its energy from the battery and not the fuel cell. [15] An analysis of the three leading manufacturers in the field of FCEVs shows that most FCEVs represent booster with less powerful batteries (see Table 1). Therefore, this contribution will be focused on the analysis of the booster FCEV.

Table 1: The three best-selling FCEVs worldwide in 2016 [16]

OEM	model	comment
Honda	Clarity	<i>A small onboard battery stores energy recovered during deceleration and braking (...) [17]</i>
Toyota	Mirai	<i>The battery allows regenerative braking and also assists during high-power demands like accelerating (...) [18]</i>
Hyundai	ix35 FCEV	<i>Electricity stored in the battery, along with electricity generated by the stack, is used to give the vehicle an extra boost (...) [19]</i>

Advantages of FCEVs are high efficiency, high dynamics combined with low noise generation, and the possibility of using recuperation while braking. Recuperation works by electronically switching an electric motor into generator mode during the braking process. Thus, this allows to recharge the battery [7]. However, these benefits are offset by some disadvantages, such as the high purchase price and the cost of hydrogen production. The required hydrogen must be generated electrolytically, which converts electrical energy into chemical energy. Because of this process, hydrogen represents a secondary energy source that causes high losses. According to Bossel [20], only 25% of the primary electrical energy can be used at the end, which is very inefficient. Another disadvantage is the poor infrastructure of hydrogen stations. Even though Germany had 45 stations at the end of 2017 - the second most stations in the world after Japan. Compared to the 14,500 existing petrol and diesel stations in Germany, the hydrogen station network is limited [21, 22].

#### 4. Car Architecture Changes due to FCEV

In order to be able to compare the product structures of ICEVs and FCEVs, a categorization of the car into systems will be defined, whereby the particularities of both vehicle types are considered. Here, referring to Klug [23] and Schramm et al. [24], the following seven systems are applied as car decomposition: *suspension and wheels*, *powertrain*, *exhaust system*, *body structure*, *exterior*, *electrics and electronics*, and *interior*.

Especially the modules of *powertrain*, *exhaust system*, and *electrics and electronics* are significantly affected by changes, therefore they are examined in detail in this paper. The vehicle parts associated with the respective modules of ICEVs and FCEVs are described and changes are indicated.

The *powertrain* of ICEVs consists of the engine with cooling and auxiliary units, the oil filter system, transmission and clutch, as well as the drive and cardan shaft, and axle drives. The combustion engine is replaced by an efficient electric engine, typically using one to four motors, depending on the chosen configuration [25]. The three most widely used FCEVs (see Table 1) are powered by electric motors with a power between 136 hp and 174 hp. These are designed as asynchronous motors (Toyota Mirai and Hyundai ix35 FCEV) or synchronous motors (Honda Clarity), which are characterized by a compact design, good power/weight ratio, and cost advantages compared to other electric motors [9]. As well as combustion engines, electric motors must be cooled. The belonging process is defined and described in DIN EN 60034-6 (VDE 0530-6). Auxiliary units, such as oil pump, oil filter, turbocharger, or alternator, become obsolete. Since electric motors can reach very high rotational speeds up to 20,000 rpm, gear systems are not necessary anymore, but can still be used for efficiency reasons [26]. Therefore, also a clutch is no longer necessary and can be omitted. The eVchain.NRW [27] study defines two different development stages for BEVs, on the one hand a conventional vehicle architecture (“Conversion Design”) and on the other hand an adapted and optimized BEV vehicle architecture (“Purpose Design”). Vehicles of the second development stage are independent of the construction methods of ICEVs (e.g. the bodywork) and thus represent completely new developments, whereby the drive shafts and differentials can be omitted when using wheel hub motors, for example.

The *exhaust system* includes the exhaust manifold, a diesel particulate filter required for diesel vehicles, the catalytic converter, and the silencer with tailpipe. Due to the described change in the powertrain and the use of environmentally-friendly electric motors, a FCEV does not produce any exhaust gases during operation, only pure water. This results in an obsolete exhaust system and reduces both pollutant and noise emissions. Though, there are considerations to increase the low-noise level of the BEVs with the help of sound modules in order to improve the perceptibility of the vehicles [28].

The *electrics and electronics* are responsible for powering the interior and external systems, such as lighting or wiping systems. In addition, the communication and entertainment system is supplied with the necessary electricity. Moreover, the engine management and chassis/drive electronics are ensured. The vehicle functionalities have been expanded considerably in recent years due to the rising requirements in the areas of safety, environmental protection, and comfort [9]. This development can be observed independently of the change to BEVs. The increased number of infotainment and assistance systems results in a significantly higher energy demand, which leads to electronic energy management systems to control the energy balance. The shift towards e-mobility causes changes, especially in the areas of electric drive control, batteries, and charging infrastructures. This is evident in the increased proportionate manufacturing costs of electronic systems compared to the vehicle manufacturing costs in total. The proportion currently amounts ca. 25% and is expected to rise. [9] The mentioned FCEV version of booster has a lower performance battery, which – due to the extreme temperature fluctuations in winter and summer in passenger cars – must be equipped with cooling and heating systems in order to keep it in an operating range that is optimal for efficiency [13]. Furthermore, components for controlling the power electronics become necessary and the chassis/drive electronics must be adapted. Due to

the complexity of the interaction between fuel cell, battery system, and electric engine, an additional engine management system is required, which is implemented on an electronic control unit [27].

## 5. Core Competencies of OEMs and Suppliers in the Automotive Industry

In this chapter, the core competencies of OEMs and suppliers in the context of the considered car systems are described and analyzed. Therefore, the three systems *powertrain*, *exhaust system* as well as *electrics and electronics* are examined in more detail.

The automotive suppliers' proportion of value added to worldwide automobile manufacture is constantly increasing, which is changing the competencies of suppliers as well as OEMs. For example, the value-added share of automotive suppliers was around 56% in 1985. It has extended over the years and is nowadays ca. 80% [29]. Based on these developments, an analysis of the changes in core competencies due to the change to FCEV is of scientific relevance, in order to be able to derive conclusions on a possible change in the supply chain management of OEMs and suppliers.

As described before, the *powertrain* system causes significant changes in the product structure. Here, motor technology plays a decisive role, as electric motors feature differentiated technology and significantly higher efficiencies. Due to their complexity, conventional engines have always been one of the core competencies of OEMs [30]. Here, changes can result from new electric motor concepts, since the technology is less complex compared to internal combustion engines [7]. This creates opportunities for suppliers to take over the development and production of electric motors. Various cooling concepts for electric motors exist, which are manufactured and offered by suppliers. According to DIN EN 60034-6, these cooling concepts are divided into indirect and direct systems. As already described in the previous chapter, gear systems are not necessary, but can still be used for efficiency reasons. Both, OEMs and suppliers, have competencies in this area. In addition, there are some suppliers being pure transmission specialists with specific knowledge, e.g. the German company Tandler. The same applies to the drive shafts and axle drives. The cardan shaft, which is only used for four-wheel drive and vehicles with front motor and rear-wheel drive, can still be used in FCEVs, but it is not necessary in a vehicle containing the technology of wheel hub motors. OEMs and suppliers are currently researching both variants - with and without cardan shaft - which is why the competencies in this area can also be attributed to both. [31]

The development of an obsolete *exhaust system* affects the supplier industry in particular, as they have core competencies in this area and manufacture a large proportion of vehicle parts for this system. The additional equipment with sound modules can be provided by suppliers, but does not have high specific demands on the production [28].

*Electrics and electronics* are currently dominated by the supplier industry. Not only big suppliers, such as Bosch or ZF Friedrichshafen, are major players in this sector, but also small and medium-sized companies with a high degree of specialization in the field of electrical engineering exist [32]. The engine management system is developed by OEMs because it must be specifically adapted to the respective engine. The chassis and drive electronics as well as the control units and on-board network are also manufactured by both, suppliers and OEMs. This is caused by the necessary specific knowledge and the compatibility of the individual vehicle parts. [27]

As a summary, Table 2 presents the results of chapter 4 and 5. The applied evaluation is: eliminated (-), unchanged (0), change necessary (+), new part (++), applicable (X) and applicable for obsolete parts (Y). As indicated in the table, comprehensive changes to the car architecture are necessary due to FCEV. Few parts can be adopted without modification, creating new challenges for OEMs and suppliers and underlining the importance of R&D. Most of the parts are already manufactured by suppliers. This is in line with the above given statistics, which show the shift in the share of value added in the automotive industry to suppliers.

Table 2: Changes in car architecture and associated core competencies

	systems	changes of car architecture	manufacturer	
			OEM	supplier
powertrain	motor	++	X	X
	motor cooling	+		X
	auxiliary unit	-		Y
	oil filter	-		Y
	gear	-/+	X	X
	clutch	-		Y
	drive shaft and axle drives	+	X	X
	cardan shaft	-/+	X	X
exhaust system	exhaust manifold	-		Y
	diesel particulate filter	-		Y
	catalyst	-		Y
	silencer	-		Y
	sound module	++		X
electrics and electronics	power supply	+		X
	communication system	0		X
	engine management	+	X	X
	chassis and drive electronics	+	X	X
	comfort electronics	0		X
	fuse	+		X
	control units	+	X	X

## 6. Impacts on Automotive Supply Chain Management

The transformation from ICEVs to FCEVs and the associated changes in product structure and core competencies have an impact on the logistics of OEMs and suppliers. This chapter introduces the supply chain structures in the automotive industry and examines a possible change in OEM-supplier relationships.

According to Garcia et al. [33], a reduction in value-added share of OEMs can be observed in automotive logistics, as well as increased cooperation and networking between OEMs and suppliers and the modularization of components and related bundling of transports. The OEM-supplier relationship is organized as a pyramid. The OEM is at the top, followed by the system suppliers (1<sup>st</sup>-tier), module suppliers (2<sup>nd</sup>-tier), and component suppliers (3<sup>rd</sup>-tier), which are connected to each other. [34] In this context, consolidation of suppliers can be observed, leading to larger and more powerful system suppliers (e.g. Bosch, Continental or ZF Friedrichshafen). This shifts the negotiating positions from OEMs to suppliers. [35] Due to the complexity of the logistics network in the automotive industry, a well-structured supply chain management (SCM) is necessary. Reasons for the growing importance of SCM include the ongoing cost pressure in the industry, the reduction of vertical integration of OEMs, and the very high quality-requirements. The cross-company exchange of information, the transfer of additional information from OEMs to suppliers, and the transfer of quality requirements to subordinate levels are important in the automotive industry. To ensure these measures, a Collaborative Planning, Forecasting and Replenishment (CPFR) can be installed, which simplifies cross-company planning and coordination of future order quantities. [30]

Due to the transformation of ICEVs to FCEVs, the complexity of the entire logistics is increasing. As a reason, the product structures of FCEVs differ from those of ICEVs and therefore new production and supplier networks must be set up. In particular, the new parts can be supplied by highly specialized suppliers or through joint ventures and procured from OEMs. In certain cases, this can cause difficulties if these companies have never produced for the automotive industry before. Therefore, extensive qualification measures are necessary. [35] Parts procurement has to be more global, as a large number of electrical and electronic components require raw materials whose availability is limited or characterized by high demand. The limited availability is supplemented by the bundling of raw materials in just a few countries and accordingly few companies selling them. [30] This means that not only the procurement of raw materials is a complex task itself, but negotiations with the few suppliers are also becoming more difficult. This global procurement of raw materials in turn influences the life cycle assessment of FCEVs, as long transport routes and lower ecological standards in the suppliers' countries of origin have a negative impact [36].

The components that are obsolete for an FCEV can cause difficulties for those suppliers who do not diversify in time and offer alternative vehicle parts or systems. Investment in R&D is necessary to remain competitive in the market. These R&D activities are cost-intensive and can often only be carried out by large companies, so that problems can arise for small and medium-sized enterprises.

The transition to FCEV requires a smaller number of vehicle parts, simplifying procurement and production for OEMs and suppliers. This is partly due to the easier design of the electric motors and the significantly lower number of parts in the electric powertrain [37]. In addition to the well-known suppliers, the change also offers opportunities for smaller or new companies that concentrate on specific components and offer these to OEMs, such as BASF or Panasonic (see battery technology) [38].

The supplier market can be described as diverse and is undergoing changes. New suppliers are pushing into the market, system suppliers try to strengthen and further expand their market positions, and small and medium-sized enterprises who fail to switch are being displaced. The market for electric mobility and especially the FCEV offers suppliers new opportunities to enter into cooperation. These areas are associated with high investments for OEMs due to the uncertain future situation (e.g. which technologies will prevail, when is the right time for series production of BEVs or FCEVs, etc.), which are easier to implement through cooperation. Otherwise, procurement processes are becoming more complex, since the increase in electrical and electronic parts means that rare raw materials have to be used and procured accordingly. The cooperation with suppliers to exploit synergy effects can have a negative effect on OEMs, as the suppliers could gain specific know-how and offer this to competitors.

The next chapter summarizes the results of this paper and provides an outlook on the future development of mobility towards FCEV and related changes in the product structure and the necessary supply chain.

## **7. Results and Conclusion**

Due to increasing environmental protection requirements and the crisis in the German automotive industry, alternatives to ICEVs are necessary. Vehicles with different concepts, such as the BEVs or FCEVs, represent alternatives to conventional vehicles. Here, the subject of FCEV has been researched and described. The change to FCEV has an impact on the product structure of the vehicles (see Table 2). The systems of the *powertrain*, the *exhaust system* as well as the *electrics and electronics* are of particular importance. This changed product structure has a decisive influence on the production of both – OEMs and suppliers. Certain rare raw materials can only be imported from a few countries. This has a negative impact on procurement and places requirements on OEMs and suppliers. Furthermore, the change towards BEV allows new OEMs (e.g. Tesla) and suppliers to arise and displace existing suppliers who miss the switch to modern

technology solutions. Companies of other industries can also become suppliers of the automotive industry, e.g. Panasonic and BASF in the field of battery technology.

Moreover, logistics in the automotive industry is changing and becoming even more global. A decisive competitive advantage is a well-structured and organized network management, in which all participants are provided with sufficient information to cover requirements and to be able to solve arising problems together in short time. To ensure these measures, a CPFR system can be installed.

This work has shown that the change to FCEV and the resulting changes in product structures require action among both OEMs and suppliers. The core competencies of OEMs and suppliers are changing and thus influencing the balance of power between both parties in favor of the 1<sup>st</sup>-tier suppliers. In the area of SCM, a further investigation of procurement strategies should be carried out in order to understand the influence of the changed car architecture on OEMs and suppliers better. Here, concepts such as Just in Time or Just in Sequence are widespread and should therefore be examined for changes in future studies.

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# QUALITY MANAGEMENT AND STANDARDS COMPLIANCE FOR AGILE DEVELOPMENT OF AUTOMOTIVE SOFTWARE

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**Abstract:** *Developing automotive mechatronic systems constitutes a huge challenge in practice due to the interaction of involved components such as electronics/electrics, automotive software and mechanics. Intensive mechanical functions are being replaced by software functions that facilitate innovation, fast delivery through reuse, and potential differentiation of new products. All these trends demand for such situation in which the software has become a key factor in embedded systems and play an important role in bringing innovation and competition in marketplace. Following this trend, the automotive industry is also moving from an intensive mechanical to an intensive software industry in which the majority of innovation and competition rely on the competence of software. Automotive systems and mobility systems become software defined products, meaning software is the main driver for value creation but also key factor for development and maintenance efforts.*

**Keywords:** automotive software, agile development, innovation, standard compliance, quality management

## **1. Introduction**

Developing automotive mechatronic systems constitutes a huge challenge in practice due to the interaction of involved components such as electronics/electrics, automotive software and mechanics. Intensive mechanical functions are being replaced by software functions that facilitate innovation, fast delivery through reuse, and potential differentiation of new products. All these trends demand for such situation in which the software has become a key factor in embedded systems and play an important role in bringing innovation and competition in marketplace. Following this trend, the automotive industry is also moving from an intensive mechanical to an intensive software industry in which the majority of innovation and competition rely on the competence of software. Automotive systems and mobility systems become software defined products, meaning software is the main driver for value creation but also key factor for development and maintenance efforts. Software development processes are organized in phases where the focus is on a specific part of software development. The phases are often done in parallel as modern software development paradigms postulate that it is best to design, implement and test software iteratively. However the prevalent software development model in automotive industry is the so called V-model. This model is prescribed by international industry standards for development of safety critical systems i.e. ISO 26262. As the software development is audited and need to be done according to certain standards. For example, ISO/TS 16949 is the globally recognized quality management standard for the automotive industry. Regarding automotive software's, major drivers are innovation speed, complexity and flexibility that are difficult to be addressed by incorporating heavy weight process i.e. V model. To address this gap, there is a need to develop processes which are fast, agile with user involvement and which still fulfill the requirements/standards of automotive industry. In order to go for such processes in automotive industry; technically, model driven development would allow the implementation of agile development. Agile is time boxed, iterative approach to software delivery that builds software

incrementally from the start of project, instead of trying to deliver it all at once near the end. It enables: Individuals and interactions over Processes and tools, Customer involvement over Contract negotiations, working software's over Comprehensive documentation, responding to change over following a plan.

Agile software development methods have changed the way software is developed in many domains; better ability to cope with changing requirements, shorter time to market, and faster release cycles. The main reason for adopting Agile is that traditional software development methods are not flexible enough.

## **2. Challenges**

Development of automotive software's often face challenges, in order to integrate efficiency, innovation, complexity, flexibility/agility, user involvement etc. in software development; it's not only the case that by implementing agile processes we can get rid of all challenges being faced during automotive software life cycle. There are challenges which have been reported throughout the phases of agile development e.g. change resistance, lack of investment, coordination challenges in multi team environment, different approaches merge in a multi team environment, Hierarchical management and organizational boundaries, requirement engineering challenges, quality assurance challenges, integrating non development functions, challenges faced in the integration of software and hardware (K. Dikert et al. 2016). The increasing complexity of automotive systems leads to higher risk of possible malfunctions of mechanical, electrical, computational and control subsystems, which can be classified as hardware and software failures. These faults must be detected and prevented as soon as possible by enhanced development processes to avoid failure occurrence. Effective quality management states that an important task in automotive software development is to avoid failed or failure in customer use. To reach this target, possible malfunctions have to be detected and avoided from early development phases on, which requires effective and efficient analysis methods. For this purpose, efficient quality management, standard compliance and enhanced development processes have to be realized by introducing Key process/Performance Indicators (KPIs) to enable objective quality evaluations as soon as possible during automotive software development process.

## **3. Using KPIs for Automotive Software Development**

The application of analysis methods in the development of automotive software is centered on measurement and evaluation of certain properties of the software to gain qualitative information of development progress and quality. Efficient quality management is supported by quantitative data gathered from indicators. Measuring the performance can be done by three parameter types. (Erlachner S, Ernst M, Hirz M, Fabian J., Wotawa F - 2015).

Key Result Indicators (KRIs): Deliver information how it is done in a perspective.

Performance Indicators (PIs): Deliver information about what to do.

Key Performance Indicators (KPIs): Deliver information about what to do to increase performance.

KPIs are metrics to evaluate, to measure and to compare performance. They are the indicators to handle the CSFs and support organization to check the progress of objectives and performance trends. In comparison to CSFs, which are requirements to reach a business target, KPIs are quantitative measures for the achievement of long-term targets (Kazmi A. 2015). Quality improvement in automotive software development needs new analysis methods by using KPIs. During software development different questions and perspectives occur because of various involved parties, e.g. quality assurance, project leader and general management. New analysis methods based on objective quality evaluations and specific metrics have to consider all these perspectives (Ernst, M. et. al. 2016). The potential of KPIs in automotive software development is very variegated. It supports decisions about the introduction of further measures as well as new development methods and processes. Each analysis method delivers different KPIs, which

enables various possibilities for quality management optimization. Quality management in automotive software development starts with a continuous monitoring of status and progress of relevant development items (Markus E 2016). He described about potential KPIs in automotive software quality management that in the development process of automotive software various stakeholders are involved, such as general management (GM), project management (PM) or quality assurance (QA). The presented analysis methods using KPIs support the answering of their different questions and viewpoints. In another study regarding quality management KPIs conducted by M. Staron, W. Meding, K. Niesel and A. Abran in 2016, they proposed KPI quality model in which they organized quality dimensions in sub categories to form KPI quality model.

**Research Questions:**

- What are the key performance indicators that needed to identify, implement, monitor and evaluate in quality management and standard compliances within the agile development and how can these KPIs reflect the goals of automotive software's?
- Given the specific (heavy duty) nature of automotive software's how agility can be incorporated without compromising on quality and standard compliances?

#### **4. Proposed Solution**

To cope with challenges (Quality management, standard compliance and process stability measurements etc.), it is important to identify indicators which can assess the project complexity and efforts in early stages of software development and to control progress and quality in the later phases. It is important to monitor properly and identify the key issues that affect the ability of QM to deliver quality products, and to plan, design, implement and control change in an effective and timely manner, within the whole automotive supply chain. QM and standard compliance for agile development of automotive software is a key requirement to ensure a competent automotive software for supplier network, aiming for customer satisfaction, lean processes, and defect free products.

In particular research, we will address the research gap that there is need to develop processes which are fast, agile, with user involvement and still fulfill the standards of the automotive industry. For this purpose key performance indicators are required to address the challenges i.e. quality management and standard compliance for agile development of automotive software's. The identified KPI's will be helpful to define and design such processes that enable auditable and certifiable results in automotive software.

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# INCREASING ABSORPTIVE CAPACITY IN PROJECT MANAGEMENT: PROCESS IMPROVEMENT THROUGH THE APPLICATION OF LEAN MANAGEMENT

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**Abstract:** *The ability to absorb knowledge has a large impact on organization's success, which raises the importance of companies' focus on increasing the responsiveness to external knowledge (e.g. the customers' need for innovative products) and accumulated lessons learned in previous projects in order to become competitive on the globalized markets. Unfortunately, productive process of gathering applicable knowledge from end-consumers and suppliers becomes a significant problem for many companies. By Absorptive Capacity (hereinafter AC) we consider a sufficient view on knowledge processing activities, however today's understanding of how companies' application of this ability improves performance indicators in different industries and why some companies seem to explicitly cultivate it while other companies do not remain unclear. This article considers the lean management system, which was penetrated to other industries from Toyota Production System, as one of the well-known examples of organizational improvement culture. We selected the lean methodology that has been applied to companies' processes in order to improve their performance and also to increase customer satisfaction. In literature there is much said about lean approach as a way to increase efficiency of processes, but little is written about how it influences a company's AC. Specifically, we are investigating how lean management/leadership principles impact on projects of organizations. Going further, we would like to shed light on how lean thinking philosophy can influence on the AC and project management (hereinafter PM) of an organization.*

**Keywords:** project management, absorptive capacity, lean management, organizational culture, learning environment.

## 1. Introduction

An increasing number of organizations are implementing their business operations through projects [1]. By definition, project is a temporary endeavour undertaken to create a unique product, service, or result [2]. Due to a temporary nature of project, AC of knowledge and experience become necessary. Thus, learning in project environment is so important for the organization that even the success of a project is determined through two dimensions: project performance and project learning [3]. Continuous learning and development are considered to be the highest level an organization can reach in terms of PM maturity [4]. Based on the crossing idea, which is continuous improvement in project-oriented organizations and in lean management, this paper investigates a link between AC and PM from the framework of lean thinking organization. In order to support the idea that project-oriented organizations which are based on lean thinking philosophy and open enough to absorb knowledge to be innovative, the diverse literature has been examined. We also follow the systematic approach, which considers all the aspects of the raised questions, its interconnections and entirety. In the next sections we provide the overview on the understanding of AC and its types, PM and its processes as well as lean leadership principles.

## **2. Research methodology**

In this paper we investigate what has been written about the observed topic, thus we conducted a literature review considering 30 articles for the first iteration and an additional 12 articles for the second iteration. Our method was based on inclusion and exclusion criteria - relevance to our theme and the selection and examination of primarily recent articles. In order to identify the connection of mentioned topics, we went through the relevant literature, having the following steps:

1. In our first iteration we identified key words relevant to our topic;
2. Selected and examined articles related to AC;
3. Selected and examined articles concerning the topic of PM;
4. Identified a linkage between organizational environment and AC, compared existing organizational models which focus on the increase of knowledge transfer and AC in companies and organizations and considered the lean methodology as the organizational culture model that can increase AC in a project-oriented company;
5. As a result, we did a second iteration of literature review considering articles related to lean thinking and lean management and using keywords;
6. We searched for and selected articles related to the lean management with application to PM and increase in AC;
7. As a final step of our research we have developed an improvement process framework for project-oriented companies, via the application of lean management, which highlights the identified link between AC and PM in project process improvement.

In conclusion, we disclosed that in the discovered literature there is a limited amount of research on how AC might be related with PM, advantages and disadvantages of this relation from the perspective of organisational value. Thus, this article raises two main questions: How to increase AC in PM and what environment must be created in order to improve the organizational project processes.

## **3. Literature review**

The scope of the literature review is contained in what is already known about AC, PM and Lean management. We considered these fields aiming to discover interconnections related to our topic.

### **3.1 Absorptive capacity**

[5] state that AC is the capacity to identify, assimilate, and apply external knowledge for innovation. The innovation literature highlights the importance of external knowledge for solving technical problems within a firm. Innovation management frequently involves the integration of knowledge from market demand and scientific and technological developments [6]. This means that companies need as much as possible external knowledge. However, knowledge encounters various internal organizational, technical and human barriers in order to be assimilated and enhance organizational competitive advantages. The capacity of a firm to evaluate and acquire external knowledge is called potential absorptive capacity (hereinafter PAC), whereas realized absorptive capacity (hereinafter RAC) reflects the firm's capacity to leverage absorbed knowledge and exploit it into innovation [7]-[10]. Innovation occurs when unmet customer needs encounter with knowledge about technological solution. Both knowledge types are often located outside the firm and need to be absorbed in order the innovation to occur [11]. So, PAC is considered to be a process of combining capabilities. It is a determinant of strategic innovation and an antecedent of organizational learning [12], [13]. Knowledge acquired by exploration activities could sustain R&D actions and allow new competences to be developed [14]. RAC is effective in using the resources and competences incorporated into a firm in the short-term, but firms cannot exploit knowledge that has not previously been

assimilated [15]. Exploitation activities are related to organizational learning [16] because acquired knowledge is a resource that is ready to be used inside the firm. However, each dimension of AC is related to innovation outputs in a different way, and therefore project teams may experience difficulties in managing the levels of PAC and RAC [9].

### **3.2 Project management**

From the organizational perspective projects are means to achieve strategic plan of the organization. Strategic considerations such as market demand, customer request, business need, technological advance and legal requirements give rise to the projects [17].

In today's fast-paced business world, the need for successful project has become a necessity rather than a luxury. Many tend to think of it as a new venture for growth and development. However, PM has been around for thousands of years and was involved in the planning, coordination, and construction of the Ancient Wonders of the World [18].

According to [2] PM is the application of knowledge, skills, tools and techniques to project activities for meeting the project requirements. This is possible through the application and integration of the PM processes. All these factors are interrelated to a great extent and can affect one another. [19] state about how processes are implemented depend on the organization's corporate culture and leadership style.

### **3.3 Reflecting on the idea of learning environment**

In order to have an efficient knowledge management in an organization it is important to have openness for new ideas and improvements, thus there is a need for the establishment of a learning environment. For instance, [20] mention that companies which have a flexible and open knowledge context could have a beyond-expectations increase in the success of future projects. This is possible with the help and experience of the project manager through collecting lessons-learned and by creating good practices for PM. The authors also highlight that in project-based organizations the influence of organizational culture is required for an effective process of knowledge transfer and conclude, "High-intensive knowledge environments provide firms with higher levels of absorptive capacity". Moreover, [21] suggest that projects are more than sender/receiver islands and due to organizational setting, through tools, norms and the project team members' experiences they are connected.

Other authors point out or develop different models for increasing the knowledge transfer within a company or institution. For instance, Duffield & Whitty [22] developed the systemic lessons learned knowledge (hereinafter Syllk) model based on the successful model for safety and systemic failures named Swiss cheese model. The Syllk model has been created for managing projects. Its aim is to enable the collection of lessons learned from projects in order to improve the organization's future project performance. The authors note that both Swiss cheese and Syllk models highlight that "naturally evolving complex adaptive systems incrementally modify their behaviour over time to optimally fit their environment". In other words, an effective model developed in an organization has the capacity to prepare it to the changes in the environment, thus it can increase its AC. The same authors in their work, referring to the application of the Syllk model [23], highlight that it is important to understand which are the facilitators and barriers of knowledge transfer in an organization and which are the knowledge management practices applied in order to identify and understand the elements that influence the learning lessons process and the overall organizational learning.

Other authors [24] present an alliance as model for building AC. The alliance facilitated the organizational change from a single-loop learning environment (correcting actions to solve/avoid mistakes) to a double-loop learning environment (correcting the underlying causes of occurring problems) and established a learning climate where, through formal and informal settings, managed to maximize its AC.

Furthermore, [25] developed the triple-loop learning framework. The concept proposes a blending of knowledge management and organizational learning and consider as a core process within the PM activity. The authors present the single-, double- and triple-loop processes, the third loop including the organization's cultural values and goals in the context of learning organization. They note that a learning organization enables the creation of a culture for continuous improvement and development concerning people, products and services and has effect on all levels in a company.

### 3.4 Lean management

Lean means a systematic approach to identifying and eliminating "muda" (waste) through continuous improvement. It seems that the famous Henry Ford had been using parts of lean as early as the 1920's. But, the Toyota Production System (hereinafter TPS) was the fundamental basis for the "lean". Lean manufacturing makes obvious what adds value, by reducing everything else. This management philosophy is derived mostly from TPS and identified as "lean" only in the 1990s. TPS is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this success [26]. It seems that Toyota has been also applying lessons learned method while creating its TPS. Step by step, the lean movement has penetrated other industries, like retailing, construction, and even management.

As already mentioned, the lean model has been applied to several fields and industries, although the implementation of the lean management has not been successful in all cases. Studies [27] show that the organizational culture can have a significant effect on the success of lean implementation. The authors revealed that high level of institutional collectivism, future and human orientation and low level of assertiveness could be the characteristics of the organization culture that show positive lean implementation and focus, beside Lean Management technicalities, on soft lean management practices (concerning people). A similar idea was presented by T. Mielke [28]. The author notes that the process related to waste elimination is usually adopted by companies, while the "invisible" parts of lean, which refer to philosophy, people and partner, and problem solving are not addressed. This also contributes to the short-term success of lean implementation, as for long-term success the implementation of proper lean management is needed which is possible through the continuous improvement process. As described by U. Dombrowski and T. Mielke [29] the fundamental principles of lean leadership are:

1	<b>Improvement culture</b>	<ul style="list-style-type: none"> <li>• Striving for perfection</li> <li>• Failure is a possibility to improve</li> </ul>
2	<b>Self- development</b>	<ul style="list-style-type: none"> <li>• Lean leaders are role models</li> <li>• New leadership skills are necessary</li> </ul>
3	<b>Qualification</b>	<ul style="list-style-type: none"> <li>• Long-term development of employees</li> <li>• Continuous learning</li> </ul>
4	<b>Gemba</b>	<ul style="list-style-type: none"> <li>• Shop floor management</li> <li>• Decision based on first-hand knowledge</li> </ul>
5	<b>Hoshin Kanri</b>	<ul style="list-style-type: none"> <li>• Customer focus</li> <li>• Aligned goals on all levels</li> </ul>

Table 1. Fundamental principles of lean leadership (Source: retrieved from [29])

## 4. Discussion

In this part we reveal our findings for connecting the elements studied in the literature review and develop our process improvement framework. In addition, we sustain our framework

through the application of Lean management/leadership for the improvement of AC in a project-oriented organization.

#### **4.1 Interconnections of AC and PM from the framework of lean thinking organization**

As it is mentioned previously, a project is aimed to achieve results within temporary time constraint. In the pursuit of the project result, organizations involve the best human capital and technologies with a high level of knowledge. And most often project-oriented companies setting a temporary vector to the project, aim to monetize the result and further invest it into the future business growth.

When it comes to investing, project-oriented organizations put priority to the innovation and development of processes. Issues arise, on one hand, when processes are not reviewed, changed or improved in time and, on the other hand, employees do not understand the reasons behind the processes and cannot contribute through suggesting improvements or changes to them. In order this not to happen, it is necessary that the organizations to be open to initiatives coming from employees, moreover to promote and reward such proposals. Thus, an organization culture, where knowledge transfer is promoted, is imperative for increasing AC in a company or organization. In this regard, there are three conditions we identified:

1. The company must have a learning organizational culture, where employees and project team members are trained to identify opportunities and risks both coming from outside of the organization or from within;
2. Processes must be revised and improved continuously;
3. Project team members/employees at all levels should feel confident to suggest improvements and changes to processes.

Furthermore, in project-oriented companies a complementary focus should be put on the temporary aspect, where the retention of employees and their continuous development should be considered.

Lean leadership as described by [29], [30] focuses on the development and improvement of processes through the implication of employees from all levels of hierarchy. Although project-oriented companies differ from productions systems, we consider that several elements are applicable also to projects, thus can improve the project-management processes within a project. Moreover, by increasing the AC of the organization, it can also improve the processes from one project to the next.

Indeed, by improving the process through lean management, right resources are used at the right time, and companies decrease costs and increase the quality of the product or service produced. Thus, they achieve such strategic goals as a quick response to the market demand and customer satisfaction.

#### **4.2 Idea development**

In projects it is very easy to lose gained knowledge or use a generic approach without a continuous improvement. The framework (Fig. 1), created as a result of our research, shows the whole process of project improvement, including the effective use of certain PM knowledge areas through the application of lean leadership to the project environment.

The first step for any successful project organization is to recognize the market request at an early stage. To do this, it is appropriate to use PAC, which is aimed for acquisition of information and then its assimilation in the project. In our framework we have considered two projects in a project-oriented company.

When the acquired information (i.e. PAC) is assimilated within the first project, and applied in the context, it transforms into the knowledge. At the stage of transformation, this knowledge acquires strength and value, and for further application of this knowledge it is important to preserve the entirety and quickly transfer it to the second project.

How to do it quickly and holistically, without a negative impact to our process? Here, we introduce lean management/leadership part of our framework, which improves the process by building an organizational culture and develops the learning process. Its main principles consist of: improvement culture, self-development, qualification, Gemba, and Hoshin Kanri, which we would discuss further.

Upon completion of the second project, the organization generates a determined successful result, with improved indicators for the application of Resource Management, Stakeholder Management, Quality Management and Communication Management. Thus, the organization applies its RAC and provides a quick response (in the form of a product or service) to a market request.

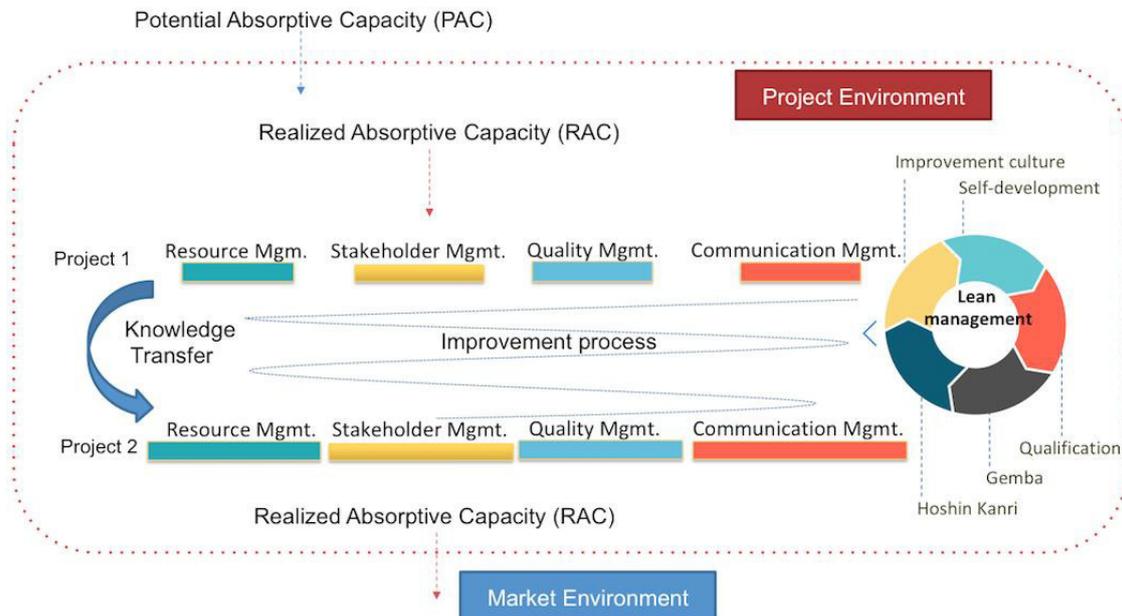


Figure 1. The project process improvement framework (Source: own creation)

Now let's take a closer look to the improvement process presented in the framework and consider it from the perspective of lean. Based on the principles of lean leadership and previous sources, we wish to shed light on the relation between lean leadership and increase of AC in PM.

We already saw in our literature review the direct relation between the organizational culture of a company and its AC; furthermore, we highlighted the importance of a learning environment for proper knowledge transfer. As lean leadership, described by [29], [30], has a great focus on continuous learning and process improvement, we consider it as a way for increasing knowledge transfer in the company and it also contributes to the development of AC in PM.

**Improvement culture** is the first principle of lean leadership and focuses on the continuous striving to perfection and the understanding of failure as an opportunity for improvement [29]. This aspect is a must for a learning organization, as the first condition for improving AC. We consider that, in PM it can be applied as follows:

1. Recognition from top management of the importance of applying proper PM, as a condition for successful projects and accordingly support project managers and their teams;
2. Focus on the retention of project managers as the involved parties who can most effectively bridge knowledge from one project to another;
3. Increase the problem-solving capabilities of project team members;
4. Promote the culture in projects that focuses not only on the problems that occur, but also motivates project team members to seek for the causes that lead to the problem and eventually improve the processes.

**Self-development** is another principle of lean leadership defined by [29], [30] and refers to the abilities of leaders to develop themselves through self-reflection. Furthermore, it is important for leaders to deeply understand and know the processes in order to act as coaches for others. Lastly, they need to understand the customer's view for properly defining and structuring goals. In our opinion, these abilities can also be considered for PM in the perspective of increasing AC, as follows:

1. Project managers should seek improvement in their abilities and consider training if necessary. This is even more applicable if they are dealing with projects in different domains of activity, or the complexity of projects is increasing;
2. Project managers should become coaches to project team members, so besides managing projects they must become also the leaders for their teams;
3. Project managers should develop the ability to understand and focus on the customers' needs and be able to transfer the knowledge to the project team in order to consider them;
4. Long-term development of executives is an aspect of lean leadership. Developing career opportunities for project managers is a way to compensate on the temporary characteristics of projects and reduce insecurity for project managers, thus they become more motivated to improve their knowledge and become an asset for the company on the long-term;

**Qualification**, as the third principle of lean leadership refers to continuous learning and long-term development of employees [29]. For the purpose of our framework, qualification in project-oriented companies can also take place formally (e.g. trainings), but also working in projects. The long-term development aspect is again harder to implement, due to the fact that project team members may work on different types of projects. Still, the learning process can be improved, and AC increased by:

1. Continuous feedback for project team members through the project life-cycle;
2. Increase motivation of team members and promote autonomous learning;
3. Run lessons learned workshops.

**Gemba** in lean leadership, as described by [29], [30] refers to shop floor management and decisions made on first-hand knowledge. From our perspective, its applicability in PM can be considered as follows:

1. Project managers should work close together with the project team members and should know their problems, concerns with regard to how the project is evolving. This way, dealing with occurring issues or problems can be made fast and effective;
2. Project teams should be kept small, so that the development and coaching of team members can take place individually.

**Hoshin Kanri**, as the last lean leadership principle refers to customer focus and aligned goals on all levels [29]. This principle focuses more on organizational strategy. From our perspective, PM can be improved through this principle on two levels:

1. On organization level, clear definition of company strategy can lead to the proper selection and development of projects that are truly contributing to company growth. Moreover, standards in PM can be introduced to efficiently managing projects. Furthermore, development of project team members should be considered as part of company strategy;
2. On PM level, project teams should be aware of their contribution to the strategy of the organization and should consider the long-term goals of projects, rather than quickly dealing with short-term goals which may not contribute to the overall success of projects. Thus, decentralization of goals in projects is important, both for reducing the complexity of projects and for a better understanding of the long-term goals.

In conclusion, lean management/leadership focuses both on cultural development and the improvement of employees. Applying its principles to PM can increase the overall success of developing projects. Moreover, it increases motivation and reduces uncertainty for the team members, as it has a long-term application for organizations.

The elements of lean leadership, like promoting an improvement culture, focus on self-development and qualification, furthermore promoting the importance of knowing and improving the processes also contributes to the AC of the project-oriented organization.

## 5. Conclusion

In the beginning of our research we raised two questions: How to increase AC in PM and what environment must be created in order to improve the organizational project processes. We discovered that AC in PM has not been recognized as a part of the project processes and partly was mentioned as an organizational ability to work with the external requests; however, the importance of absorbing information is crucial for many companies, although the level of necessity might magnitude from one specific field to another. Regarding the relationship between AC in PM we did not find a direct link as the processes lie in different paradigms. Thus, AC is more the element of organizational structure where the soft skills play a significant role, as well as a maturity of the organization. On the other hand, PM processes are organized as a flow of hard skills' processes and standards with a focus on implementing the project and also taking into account all the constraints and the satisfaction of stakeholders. Yet, the importance of AC has been increasing during recent years, especially in companies where innovation is one of the important elements. Following our research and identifying increasing request on AC we decided to explore our second question referring to what environment must be created in order to increase AC in PM. As a result, we came up with this process improvement framework comprised of four elements such as AC, PM, Lean management and learning environment, where lean approach serves as a bonding element which helps to create a better circulation of an organizational life. We showed that in a lean thinking environment the capacity of absorbing knowledge, assimilate it and, the most important thing, to apply it from one project to other leads to a permanent improvement of the learning process in the project environment. Also, it is worth mentioning that according to the lean leadership principles a request for the improvement it is not a single action, it is a philosophy where every further project must be improved regarding all essential elements. Finally, the implementation of our framework contributes to the market and supports the position of the company among key business competitors.

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# KNOWLEDGE MANAGEMENT CONCERNING THE FACTORS OF PROJECT SUCCESS

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**Abstract:** *The barriers of understanding in correlation to the application of Knowledge management, aimed at project success have been a subject with high regards in the aspects of: integration, processes, technologies, structure, people, cultures, potential, as well as inter-organizational policies, not excluding environmental factors. This paper reviews the evidence and studies of diverse Knowledge Management and Project Success Factors, in order to identify their interdependencies with one another. With this cross-relational information, what should be prevalent is a clear intersection between Knowledge Management and Project Success. Bringing the two aspects mentioned above to the same plane can provide an insight concerning the common points of the two elements. In order to do so, a secondary data collection method was utilized and mostly gathered from the International Journal of Project Management, including theoretical and practical studies, related to the main dimensions of Knowledge Management and Project Management publications, such as: general models that include frameworks, constructs, capabilities, competencies, mind maps and graphs. Finally, the findings are presented in an integrated model, which summarizes the main success factors which are related to Knowledge Management and Projects, offering an ideal alignment within an organization for project success.*

**Keywords:** knowledge management, success factors, project management, people.

## 1. Introduction

"Knowledge Management [(further KM)]", has intensified in recent years because knowledge is considered one of the most important assets among organizations in the twenty-first century" [1]. In consideration, companies attempt not only to organize KM but do it successfully, gaining maximum benefits. Ideally, to obtain a competitive advantage while executing projects based upon the possibility to achieve unique success factors. Furthermore, it is essential to know 'what' knowledge is acquired by the organization, where it is allocated and how to use it properly. Recent studies show that managers have begun to align KM and projects to meet the necessity of providing business value to the company. Moreover, it is essential to identify and analyze the factors that facilitate successful KM within organizations as well as elements that influence project performance in a successful way. An additional objective is to emphasize the correlation between all elements of development in the adopted model showing the common alignment to business values from both sides.

The remainder of the paper has been structured in Four parts. First, the description of KM in general and identification of its success factors. Second, the essence of project success within an organization and its influential factors. Third, the developed model of project-based KM is investigated with a discussion covering the subsequent results. Finally, a discussion will cover plausible influential aspects not covered in depth here, followed by the conclusion.

## 2. Research Approach

Regarding the research method, a scientific approach was followed, gathering publications of the most relevant journals of Project Management, taking into account previous studies not older than 2013 and their respective sources. In this process, with the use of keywords as "Project Management," "Knowledge Management," "Success," "Factors" and "Indicators," including some of their variations, 36 different papers were pre-selected. Next, the main criteria of selection were considered on whether or not they provided direct evidence and conclusions related to Critical Success Factors of KM and/or Project Management while performing a thorough revision of the abstracts and main figures, classifying materials into "must" papers and "optional", that could provide supportive information.

The "must" material was classified in four different categories "General models", "Capabilities-competencies", "Lessons Learned" and "Knowledge sharing", with the main findings of each paper collected in a thematic map, in order to finally design and develop an overall model that relates within one table, while at the same time, indicating the most relevant Knowledge and Project success factors, essentially to single out those with the most impact according to the literature, plus the incorporation of one transversal important finding of the "General models" defined as the Knowledge Alignment Impact. The overall resultant approach is described as qualitative.

## 3. Critical Success Factors of Knowledge Management

By Critical Success Factors, it is understood in this paper to be the main areas that are mandatory to exist and that have to be completed with the highest regards towards quality, reaching a set goal.

### 3.1 Essence of the Knowledge Management Structure

KM structure or processes means the life cycle of knowledge that evolves simultaneously with different steps, starting from conceptualization, and throughout the moment of being applied to the next operation or project. However, the processes themselves, do not lead to the overall success of KM and plan success, being that the fundamental understanding of these processes' effectiveness coupled with a sound methodology, leads to a more grounded approach. The cycles among KM are divided into four main groups describing essential activities done within the KM domain: acquisition, storage, dissemination and application [2].

- *Acquisition process*

Knowledge acquisition process in the organization is oriented towards gaining knowledge. Besides that, the priority process that might be named as a sub-process is knowledge audit. That means that the company must know which knowledge it obtains within one or another form [2]. Furthermore, there should be a clear understanding on whether it is a collaboration between people that gather their own experience and background or engagement in alliances with partner organizations when for both parties it is more favorable to exchange the collected knowledge, maximizing the outcome.

- *Storage process*

Once the information is collected, it should be recorded accurately and stored in 'easy-to-access-for-all' databases or with the help of other techniques (for instance, private portal of organization). To bring this storage into existence an organization should have a "common dialogue of knowledge" by creating a unique framework containing organizational and structural rules [3]. For example, after each project stage accurately documenting all relevant lessons learned.

- *Dissemination Process*

Dissemination or sharing process is used to distribute explicit and implicit knowledge within the organization with the help of various tools such as web portals, as well as intranet, etc. The essential part of this process is to create such corporate behavior, as to turn the dissemination process into a daily routine.

- *Application Process*

The application process is a series of activities to implement the retrieved knowledge into the future operation or project. Knowledge itself does not have value until it impacts the organization's performance through implementations in the form of lessons learned.

### 3.2 Critical Success Factors

According to Akhavan and Zahedi [4], there are several levels of critical success factors in KM. Further, these levels will be described. Additionally, the element "People" (that was not introduced in the article of Akhavan and Zahedi) was included into the group of factors, because without people it is hard to imagine any other factor. All factors are compiled in Fig. 1.

People	Knowledge Structure				
	Knowledge Recognition	Knowledge Strategy	Knowledge Sharing	Knowledge Storing	
	Familiarity	Educational Scheme	Personal Outcomes	IT	
	Transparency	Senior Mgmt Support	Organization Wide-Culture	Rewards	Trust

Figure 1. Critical Success Factors of Knowledge Management (based on the Akhavan and Zahedi [4], with own interpretation)

**Knowledge Structure** is a core element of KM in every single organization that defines the direction of its business model. It can be described as "a set of guidelines, standards, and logic that engineers the KM processes" [4].

**Knowledge Strategy** helps the company reach the success in the KM. Knowledge Strategy should be aligned with the Company's strategy to create business value [4].

**Knowledge Sharing** is an essential factor that influences the KM process. This factor is based on all kinds of communication (oral, written forms), observation (necessary to share, "tacit" knowledge [5]), artifacts (e.g., prototypes), and HR activities (e.g., educational events) [6]. Besides the events that can be organized within company workshop events or meetings, a database can be established and be available to project teams with all information from the past (project reports, lessons learned, etc.). Furthermore, adding inclusiveness as company/employees can participate in "communities of practice" as mentioned by Lee, Reinicke, Sarkar and Anderson [7], who have highlighted that the opportunity for project managers to learn and communicate with some companies are limited. Retrospectively, the best way to get new knowledge and share existing is through a community of practice.

**Knowledge Recognition and Knowledge Storage** factors reflect the way in which knowledge is gathered, categorized and stored. Efficient methods and technologies should be used to have easy access [4].

The middle or second level according to Akhavan and Zahedi [4] includes **Familiarity, Educational Scheme, Personal outcomes** and **IT**. All of the factors are supportive to the above mentioned main factors of success, for instance, Personal Outcomes can play a significant role in Knowledge Sharing. The third level includes factors such as: **Transparency, Senior Management Support, Organization-Wide Culture, Trust, and Rewards**. These factors are supportive and interdependent of all of the previous ones that are included in the two above levels. As an example, without the support of the Senior Management, it will be challenging to organize practical Knowledge Storing with the help of modern IT solutions.

**People.** This Factor is in conjunction with all of the factors as mentioned earlier, notably intersecting at all levels of the KM / CSF, and Project Success Factors. Metaphorically speaking, people, in this case, are similar to the foundation of a house. Additionally, studies have shown that 85% of people working on a project obtain new knowledge through experience. Those as mentioned above, further support, the need to implement a knowledge sharing culture, which would align learning with business value [8]. Management styles vary and are thought to move knowledge from inclusive to exclusive via motivation, contributing to the underlying factors that may stimulate a team's motivation from intrinsic to extrinsic sources. More successful organizations have in recent years put a focus on the individual employees, as organizations seek to exploit the benefits of identifying employee motivation [9]. Additional implications highlight the importance for companies to assess the passion related characteristics of staff, as well as the level of skills [10].

Further research postulates that people, along with processes and technical factors, also support people as a critical element of project success. In fact, among the research results, it was found to show that people are more than a quarter of critical success factors (27%), when considering 'software projects' in conjunction with 26 critical success factors. It is essential to note that among software projects, this research concludes 27%, however considering that the majority of failures among projects aren't directly related to technical difficulties, but non-technical influences would indicate a permeable relationship with humanistic factors and project success. Interestingly enough, the skilled and sufficient staff is listed as another important element that supports KM. The research doesn't excuse the element of effective project management, due to the fact that a competent, skilled and realistic project manager will be far more effective [11].

## **4. Critical Success Factors of Projects**

### **4.1 Essence of Project Success**

According to PMBOK, a project is a unique performance to deliver products or services that has been defined from the beginning to the very end [12]. As a result, this performance can be successful or can fail depending on the indicators of project success that have been developed over the years. As previously stated, initially, the only success indicator was the 'iron triangle' meaning; time, cost, and quality. Put into other words, "if the project was done according to the schedule, under the planned budget and met all specified quality measures, then it was considered a successful endeavor". With the increasing complexity of projects, it is interpreted that the triangle cannot be perceived as an adequate indicator of project success alone. Also, the components of project success were not solely concentrated upon the aspects concerning team development and softs skills, but also on the external environment such as organizational strategy, as well as the interests of all related parties [13]. Nowadays, the most important measurement of project success is the earned business value by the customer or organization [14]. It means that if the organization (customer) does not increase the net monetary or non-monetary benefit through sponsoring the project, that project should not be even managed. Furthermore, this impact could be gained not only during the project implementation or right after it, but in the long-lasting perspective [15].

## 4.2 Project Success Factors

To the measures mentioned above, the success factors should be identified and communicated to the project's stakeholders. Different projects and industries determine their specific factors to succeed during the performance. However, based on the Turner's study [16] were suggested the most common elements among industries that could be divided into three categories:

- Factors that may be **observed today** and add business value immediately after the project's implementation - they are related to the 'iron triangle' and project team itself, they eliminate the divergence of the final results from the customers' concept and ensure the basic measurements;
- Factors that may be observed in **the nearest future** (up to two months) - they concentrate beyond the project and focus particularly on the customers or sponsoring organization, they facilitate building the trust and common understanding between related parties;
- Factors that may be observed in the **long-lasting perspective** - they direct the new capabilities that could be encountered by the organization while facing future business challenges and changing environment.

May be observed today	May be observed in the nearest future	May be observed in the long-lasting perspective
<ul style="list-style-type: none"> <li>• Clearly defined Scope</li> <li>• Compliance with planned Time, Budget, Criteria</li> <li>• Team Member Growth/Satisfaction</li> <li>• Communications</li> <li>• IT Utilization</li> </ul>	<ul style="list-style-type: none"> <li>• Clients Acceptance</li> <li>• Customer Satisfaction/Loyalty</li> </ul>	<ul style="list-style-type: none"> <li>• New Technology</li> <li>• New Organizational Capabilities</li> <li>• Profits</li> </ul>

Figure 2. Project Success Factors (based on Turner [16] with newly developed interpretation)

## 5. Model of Project Based Knowledge Management

As previously listed, and according to the study of Horner et al. [14], the most variable element that proves a success element among a project is Knowledge Alignment; however, KM elements are not independent of one another. Likewise, there is a distinction between Project Management Performance and Project Performance, while understanding that, the typically agreed, "Project success" only includes achieving the triple constraint (Time, Quality and Costs), but excludes the concept of Business Value, that needs to be incorporated, (understood finally as the "Project Performance" for the Organization, instead of project management exclusively), given that the achievement of schedule and budget targets, does not necessarily relate to the achievement of business value, which will come from proper communication with the sponsors and clients to understand, "what success looks like" beyond the right project execution [14].

For this, it is important to considered KM as the combination of three essential elements: Enabling Environment, Knowledge Practices, and Knowledge Stock understood as the tools, the processes of interaction and the expertise with regards to the explicit knowledge that a project and or organization has. As a consequence of these elements, Project Based Knowledge in the Technical, Organizational and Business area is generated, with all six variables studied as

contributors to Project Success. Conclusively, none of the six variables have a direct impact, but all of them are tied to Knowledge Alignment, that will explain 38% of the variance in the Business Value, implying that the most critical domains of a Project are: Technology, Organizational Change, and Business Value. With overcoming the development of each of them, can prove to bring value to an organization [14].

The aforementioned, further implies that the specific CSF and KPIs of each stage of a project, should not only point to optimize the fields but to understand what the counterparts will do and need for finally creating Business Value, on each Life Cycle stage of the project.

## 6. Results

As it can be seen in Table 1, the result of the models and studied critical success factors, as well as mitigations due to the lack of mechanisms is for the expedient retrieval of previous relevant information within a temporary organization. As stated by Lindner and Wald [17], it is suggested for the aforementioned purpose to target the critical aspects of project success, in correlation with KM success factors. Subsequently, the following table combines both KM Success and Project Success Factors, in alignment with the previous definitions with improvements.

		Project Success Factors									
		Today					Nearest future		Long lasting perspective		
		Clearly defined Scope	Compliance with planned Budget, Time, Criteria	Team member growth/satisfaction	Communication	IT Utilization	Clients Acceptance	Customer satisfaction/loyalty	New technology	Profits	New organizational capabilities
KM Success Factors	People (skills, competence, intrinsic motivation)	•	•	•	•	•	•	•	•	•	•
	Knowledge Structure	•	•				•		•		•
	Knowledge Strategy	•	•				•		•	•	•
	Knowledge Sharing	•		•	•	•		•			•
	Knowledge Storing	•				•					
	Knowledge Recognition	•	•				•	•	•	•	•
	Familiarity	•			•			•	•	•	•
	Education Scheme				•				•		•
	Personal Outcomes	•					•			•	
	IT	•		•	•	•			•	•	•
	Transparency	•			•			•			•
	Senior Management Support				•						•
	Organization Wide-Culture			•	•	•					•
	Trust				•		•	•			•
Rewards			•								

Table 1. Alignment of Critical Success Factors (Developed During Research)

To develop the table, the KM Success factors were placed on the left side according to prioritization from the most important elements, throughout the supportive ones forming the horizontal lines of the table. The Project Success Factors shaped the columns regarding the 'time' categories. Then, all KM elements were aligned with the Project Success Factors in order to investigate the corresponding influence between them. The intersections with the most significant interconnections were highlighted with a special indicator. For a better understanding of the created table, the example of the logic behind it is demonstrated in the following case. With the help of a clearly defined Knowledge Structure, the project team is able to find applicable knowledge more precisely, which would help to define the Scope of the project, causally fostering Compliance with planned budget and time. Furthermore, with the help of Structured knowledge, the team is able to provide the client with the best solution, which will lead to Client Satisfaction. Well-structured knowledge in perspective will be a solid base to create New technologies and New organizational capabilities.

As can be seen from Table 1, the left variables (KM Factors) in conjunction with the top variables (Project Success Factors), are found to have a massive influence among one another, when both meet on the same plane or intersecting line of KM Success Factors and Project Success Factors, with a correlation to the CSF. In alignment with the factors indicating the most impact, the key focus for an organization's understanding is that the KM factors related to People, Knowledge Structure, Knowledge Strategy, and Knowledge Sharing, conjoined with Knowledge Recognition, and focusing on alignment, will influence in a feasible manner the future or even long-lasting indicators of any project such as; Client acceptance, possible New technologies and New organizational capabilities, not excluding the overall Profit and Customer satisfaction. Pointedly this will foster the most influential factors towards Business Value for an organization. Meanwhile, the supporting KM success factors such as Familiarity, Education Scheme, Personal Outcomes, IT, Transparency, Senior Management Support, Organizational-wide Culture, Trust, and Rewards should be concurrently relevant for the successful KM implementation, and have a material impact in project success factors, that could be detected right after the project implementation or even during, putting a focus on Team Member growth/satisfaction, Communication and IT Utilization.

Furthermore, it can be stated that, 'People' (as the most valuable resource) has a substantial influence among KM success factors, and it must be duly noted that from the top left quadrant, stretching among both upper quadrants, people have been found to influence every aspect of project success, starting from the implementation period until the distant future of the organization. Viewing this from a PM perspective would highlight a requirement to focus on supporting the people among any project to promote knowledge alignment in combination with coaching during the KM processes. Based on the aforementioned, it is key for managers to identify among their infrastructures the relational dynamics of people and project success. If managers are to adapt the aforementioned framework, then this, in theory, should provide them with sufficient footing for the applicable groundwork, leading to KM and project success.

## **7. Discussion**

Although the methods covered are feasible in approach, consideration must be taken in regards to the unforeseen outliers that could produce negative results, contributing to an unsuccessful project. With this, what must be realized is that there are some elements that may not be able to be controlled systematically, such as; managerial conflicts, latent, or insufficient technology, lack of motivation, intercultural conflicts, etc. The above, further provokes a necessity for further development and improvement of the model with refined correlations between Critical Success Factors of KM in Projects, as well as a vaster number of practical cases must be reviewed. For example, considering Complex Projects that were out of the scope of the current

paper, and since these cases are unique, and consisting of a diverse range in the definition of Project Success, postulate the need for further research and implementation.

Other research, in relation to positive psychology among people participating in a project, has been indicative of adding value to overall project success factors. According to Welling PPM Intelligence [18], team members who display markers of well-being and good intentions, are more likely to engage in open and friendly conversations. Likewise, this can promote a knowledge sharing culture, pushing for a more than likely outcome towards project success, via knowledge sharing. Similarly, an adept project manager may find it far easier to relate to team members and stakeholders by utilizing a positive attitude. This is to further express that more research must be devolved on how to create a positive environment, via the utilization of psychology and sociology to promote Project Success.

## 8. Conclusion

Literature supports the existence of proven factors that influence Project Success when considering KM elements, such as People (skills, competencies, among others), Knowledge Structure that will be the basis for the Strategy to be followed, Knowledge Sharing and Storage (in a simple and systematic way), and Knowledge Recognition, to understand whether an element is relevant to the organization's knowledge or not. The most critical factor from the KM perspective will be related to Knowledge Alignment among the mentioned CSF, where all of them should point to generate Business Value, to foster the Project Performance and as a better indicator of Project Success. It is also relevant that this summary of the conclusion of previous studies allows to synthesize information that belongs to different domains (such as Project Management and Knowledge Management) under a common Framework, prioritizing at the same time the most relevant factors and incorporating supportive conclusions as the concept of Knowledge Alignment, impacting in the reduction of knowledge disparities among research areas.

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# IMPLEMENTAION OF AGRICULTURE INFORMATION MANAGEMENT (AIM) IN PALESTINE

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**Abstract:** *The agricultural sector is characterized by uncertainty. However, in Palestine it is slightly different from the rest of other countries. It is still under occupation; more than 70% of its agricultural lands are under the control of the other side, in addition to the multiplicity of governmental and non-governmental bodies in this sector. There has been a marked decline in the sector as a result of the lack of resources and lack of awareness in the management of this sector. One of the most important objectives of the applying information management in the agricultural sector is to reduce the decline in production quantities resulting from technical and scientific conditions in order to reach the food security of the Palestinian citizen. Therefore, we expect the implementation of information management to lead us to achieve this in case of applying the proper application and its adoption by the responsible authorities.*

**Keywords:** Palestine, agriculture, information management, Information Technology, sustainable development.

## 1. Introduction

The agriculture sector has become a source of concern for both the decision makers and economists, as well as farmers who are directly involved, with rabidly increasing of numbers of people and the emergence of modern consumption patterns and poverty in many developing countries, so that the need for data to help workers in this sectors is becoming increasingly urgent, while there are declining in quantities of natural resources of land and water [1].

With the environmental changes of the past two decades, such as climate change and the emergence of new diseases and pests, all of which have led to decline in the agriculture sector, making it necessary to resort to information and knowledge management as solution [2], addition change such in the seasonal loop of agriculture crops also its led to decline in quantities as a result, all the above and more has placed a burden on agriculture sector in supplying the required quantities and meet the needs especially in those countries that suffer from lacked and poor distribution [3].

As mentioned above, resource constraints for agricultural production have become more stringent than in the past while growth of yields is slowing down. This is a primary reason why people express fears that there are growing risks that world food production may not be enough to feed a growing population and ensure food security for all [4].

Agriculture is no longer a craft as it is known but it has become an industry and has been applied to many modern industrial tools [5], also many industries and experts from various fields are working to serve this sector, agriculture sector become a huge platform for R&D and also for IT's [3], all this stems from the importance of this sector and its sensitivity.

The agriculture process is characterized by a large number of parties operating as the operations from the provision of the basic supplier to the final product in the hands of consumers [6].

This paper should focus on benefits of Information Management in agriculture sector especially in Palestine, in our case; Palestine lacks the application of information management in the

management of the agricultural sector, so that we like to go through the other developing countries experiments of applying information management on agriculture.

The objective of applying information management is to help us to reach the benefit of farmers and thus achieve efficiency that leads to reducing production costs, which will benefit the whole agricultural chain and achieve sustainability of this sector, all through the conservation of basic resources (land, water) in addition to appropriate practices They provide us with information management by giving the necessary advices and data in a timely manner such as [7];

- (i) Appropriate agriculture, according to the quality of the available soil and its available soil.
- (ii) Suitable crops, according to available water quantities.
- (iii) Information on pests and diseases spread and methods of prevention and treatment.
- (iv) Providing economic data as production costs and expected profitability, according to the type of activity.
- (v) Provide climate information for temperature, cold and rainfall.
- (vi) Providing data related to the market and the wishes of citizens.
- (vii) This is in addition to the provision of technical support and agricultural extension within a well thought out long-term plan for the prosperity of this sector.

## **2. Research Methodology**

The research method used is to refer to previous literature and research in addition to the scientific and practical experience. However, we found that there are a few previous studies in this field related to the country of study, so we tried to conclude from the various studies that concern in this field as much as possible with our study.

## **3. Information Management**

Agriculture Information Management "Agricultural information management (AIM) is concerned with all activities and resources necessary for acquisition, storage, updating, and making agricultural information and data of all kinds and formats – scientific research reports, growers' testimonies, market information, details of practical crop production technologies, machinery, weather forecasts, sources of credit, production, education and training and other instructional manuals, 'grey zone' literature – accessible to agricultural stakeholders at all levels [8].

The application of information management in the Palestinian case makes us able to manage this sector properly and meet the needs of the community in addition to the application of this tool contributes to reduce the prices of products and reduce the burden on the citizen as it operates according to the mechanisms studied and according to a scientific approach under the available data.

In addition, it reinstates the sector's vitality and re-attracts investments to work in this important sector. Therefore, it will benefit the society in the first place and its employees, as a large part of the distrust that characterizes this sector will disappear when the necessary data are available.

We find that there are certain mechanisms and more than the level of data handling [9], government-led, market driven, and community self-support.

There are many models in the world for dissemination among stakeholders at the level of the Palestinian situation, and it is not difficult to harmonize with the conditions of the Palestinian situation. Many of the problems facing the global agriculture sector are similar, and many are applied. Information systems based on ICT, Information and Communication Technology (ICT) In light of the widespread availability of modern digital devices, it is now possible to access and transmit information via the Internet, in addition to the use of sensors, which can transmit data such as temperature, humidity and a lot of field readings and send them to the Information Processing Center [10].

#### 4. Literature Reviews

When we talk about the application of the information technology in the agricultural sector, we consider that agricultural practices are recurrent projects and every time there are different circumstances such as budget and operational tools and the type of activity itself, farms move between more than one activity in the agricultural cycle and the surrounding circumstances, whether natural conditions such as climate or Soil or even the ages of animals that he intends to cultivate or were technical conditions such as the availability of tools and appropriate experience according to the activity practiced and all variables and we also know that the agricultural activity is characterized by uncertainty.

Here we want to drive some articles that address the project from more than one side;

In this study for Marnewick (2017), the objective of the study was to determine the level of capability regarding sustainability. Determining sustainability project management capability provides insight into how project managers as well as organizations are incorporating sustainability. The analysis indicates that the focus is on the economic dimension of sustainability. The results also highlight the complete lack of integrating social and environmental sustainability into project management. The research highlights that sustainability in business or IS projects is not being considered. The second contribution is more of a philosophical nature. Exploratory factor analysis indicates that there should be five dimensions when it comes to IS project management instead of the usual three [11].

This article Sanchez et al (2017) they talk about the benefits of applying IS on cost and time for projects" Successful development of Information Systems (IS) Projects has been a source of competitive advantage for many organizations. This paper proposes the Cost and Time Project Management Success – CTPMS, an essential measure in this context because projects must dynamically address cost and time success under an agreed scope. The goal of the paper is to identify the project management practices through which an organization can optimize the CTPMS of IS development projects. Because multiple factors can influence project management success, we analyze a real-world sample of 899 IS projects of a leading bank, using hierarchical models to account for the effects of predictors at four levels of analysis: portfolio network, project, project manager, and team. In addition to proposing and discussing a new measure of project management success for information systems development projects, we identified that project size, duration, postponement, and project manager formal power showed positive effects, whereas team size and team allocation dispersion presented negative effects. The results suggest guidance for factors such as team member allocation and prioritization, among others [12].

Wolfert et al (2017) say" Smart Farming is a development that emphasizes the use of information and communication technology in the Cyber-physical farm management cycle. New technologies such as the Internet of Things and Cloud Computing are expected to leverage this development and introduce more robots and artificial intelligence in farming. This is encompassed by the phenomenon of Big Data, massive volumes of data with a wide variety that can be captured, analyzed and used for decision-making. This review aims to gain insight into the state-of-the-art of Big Data applications in Smart Farming and identify the related socio-economic challenges to be addressed. Following a structured approach, a conceptual framework for analysis was developed that can also be used for future studies on this topic. The review shows that the scope of Big Data applications in Smart Farming goes beyond primary production; it is influencing the entire food supply chain. Big data are being used to provide predictive insights in farming operations, drive real-time operational decisions, and redesign business processes for game-changing business models. Several authors therefore suggest that Big Data will cause major shifts in roles and power relations among different players in current food supply chain networks. The landscape of stakeholders exhibits an interesting game between powerful tech companies, venture capitalists and often small startups and new entrants. At the same time there are several public institutions that publish open data, under the condition that the privacy of persons must be guaranteed. The future of Smart Farming may unravel in a continuum of two extreme scenarios: 1) closed, proprietary systems in which the farmer is part of a highly integrated food supply chain

or 2) open, collaborative systems in which the farmer and every other stakeholder in the chain network is flexible in choosing business partners as well for the technology as for the food production side. The further development of data and application infrastructures (platforms and standards) and their institutional embedment will play a crucial role in the battle between these scenarios. From a socio-economic perspective, the authors propose to give research priority to organizational issues concerning governance issues and suitable business models for data sharing in different supply chain scenarios [13].

It is clear to us that the problems facing the agricultural sector, especially in the developing world are similar with the difference in some circumstances for each country, we find that the problems limited in the following [14].

- (i) Increase population growth and achieve food security for citizens.
- (ii) Limited resources and unfair use.
- (iii) Climate change and its changes in temperature, rainfall and fluctuation in agricultural seasons.
- (iv) High input prices.
- (v) Changing consumer demands.

#### **4.1 Palestinian Situation**

When we talk about Palestinian situation in the agricultural sector, we are not far away from our counterparts in the developing world except in some particulars that come from the Israeli control over many of the axes of this activity. At the same time, we have certain privacy in the following [15].

- (i) Problems and obstacles caused by the Israeli occupation;
- (ii) Problems related to natural and environmental resources;
- (iii) Technical problems and obstacles;
- (iv) Problems and obstacles of a social and economic nature;
- (v) Institutional and Legislative Problems and Constraints;

##### **Problems and obstacles caused by the Israeli occupation:**

The problems caused by the Israeli occupation, including the confiscation of land, the restrictions on farmers and the sources of grazing, and the areas available for fishing, also control the water supply and the Palestinians are not allowed access to water sources, in addition of the signed agreements and the attempt of the other side to flood the Palestinian market with agricultural products.

##### **Problems related to natural and environmental resources:**

- (i) Limited land and water and competition of other sectors on these two suppliers.
- (ii) Soil erosion and deterioration of its properties.
- (iii) Improper use of chemicals, particularly pesticides.
- (iv) Degradation of water quality in irrigation due to over-pumping, degradation of vegetation and habitats of plant and animal habitats due to overgrazing.
- (v) Urban and random expansion of construction at the expense of agricultural land.

##### **Technical problems and obstacles:**

The lack of potential and lack of interest in research and development as the budget of the Ministry of Agriculture amounted to 1% for 2014 of the total budget of the Palestinian National Authority [16], The lack of resources and lack of interest in R&D, as the budget of the Ministry of Agriculture amounted to 1% in 2014 of the total budget of the Palestinian National Authority has led to a weakness in the potential of the human and technical staff of the ministry, we find few in the potential of the Department of Agricultural Extension and Marketing, as well as the limited availability of veterinary services, more importantly, the focus of our research is that there is a paucity of data and information available on agriculture and sometimes conflicting. Hence the

necessary need for the use of information management and knowledge management so that we can solve all these problems, which is ultimately the result of the weakness of the necessary data on time.

**Problems and obstacles of a social and economic nature:**

- (i) Small and fragmented properties, which reduced the economic efficiency.
- (ii) Lack of financial return, which led to the reluctance of many farmers.
- (iii) Weakness of the concept of collective action and lack of work through cooperatives.

**Institutional and Legislative Problems and Constraints:**

- (i) Weak legal construction and legislation regulating the agricultural sector.
- (ii) Conflicts and duplication between the relevant institutions in the agricultural sector, and weak capacity.

All of these problems have led to the reluctance of many farmers to exercise this activity according to the statistics issued by the Palestinian Central Bureau of Statistics for the year 2016 where the participation rate was 7.4% compared to the base year 1995 where the rate was 12.8% and thus led to the emergence of other problems such as increasing the unemployment rate [17].

The objective of this paper;

The objective of this study is to shed light on the agricultural situation in Palestine and to try to apply the concepts of information management in order to find durable and sustainable solutions for this important sector for the Palestinian citizen, in addition the Palestinian citizen has a different relationship with the land, which is considered a source of existence and survival.

**5. Discussion**

It is clear from the above that the agricultural sector activity like other economic activities is based on data collection in order to reach the best results and agricultural activity is a recurrent project has a beginning and end and each time is planning the activity to be practiced and monitors a new budget and being a sector that touches the needs of citizens Daily in terms of providing basic needs for them came the importance of an information management system based on data collection and analysis according to the mechanisms studied and technological development and modern means of research are possible and available at any time and place.

However, in the Palestinian case, we found that there is no department in the structure of the Ministry of Agriculture to sponsor the activity of this sector, which is concerned with data or information management, which would provide such data to various departments in order to study the state of the sector and the necessary procedure of providing services, whether technical or marketing, There should have been a database to be stored and returned to it constantly and to give the appropriate information to the beneficiary parties on a continuous basis in order to achieve real and sustainable development in the agriculture sector in Palestine [18].

In Palestine, there is more than one government agency that has a direct or indirect relationship with the agriculture sector such as the Ministry of Local Government, the Ministry of Economy, the Ministry of Finance, the Water Authority and the Water Sector Council, Such as The Agricultural Development Association (PARC), ARIJ Research Center, the Development Center MAAN, the Agricultural Work Union, and many other foreign institutions, such as Oxfam foundation, CARE foundation , this sector is large in that it deals with a wide range of Palestinian society. This greatness is a source of strength and weakness at the same time. Therefore, we highlighted in this paper the importance of having an information department covering all these activities and ensuring the availability of accurate information through databases and the ability to Analyze and publish them at appropriate times.

One of the greatest tools of information management application is to reduce the cost of production, which means increasing the profitability of farmers and encouraging the continuation and expansion of its agricultural activity, thus access to a viable sector, reducing production costs

will have an indirect and significant impact on consumers, reducing production costs will inevitably lead to fair market access for agricultural products and thus a measure of consumer welfare. This is another positive factor for the implementation of information management in this important sector.

## **6. Conclusion (Recommendations)**

In the end, the agriculture sector is the ancestral craft and the source of survival. The interest is derived from the doctrine of survival and continuity [19]. Therefore, it is necessary to work on transferring the experiences of others and the latest in global research in the use of information management in the agricultural sector in order to provide food security for the Palestinian citizen. Which will provide tools to address environmental changes, whether environmental such as climate change and the spread of pests and diseases or economically, such as open markets and global competition.

We recommend making a survey for collecting data from all agriculture parties through the agriculture chain and make a steering committee to manage the agriculture practice led by the Ministry of Agriculture, in parallel work on establishing an information department to handle all the data collected.

The elements of the success of such a step in Palestine are high because they have technical cadres and expertise that lack guidance only and provide a supportive environment for that, whether laws, legislation or community incubator.

The basis of success and survival is the knowledge and knowledge is based only on the existence of accurate information and information comes only with a comprehensive accurate database.

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# ASSESSING PROJECT MANAGEMENT MATURITY AND ITS RELATION WITH PROJECT SUCCESS: A CASE STUDY IN A GERMAN AUTOMOTIVE COMPANY

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**Abstract:** *In the contemporary world, Project management is playing a key role in the advancement and development of organizations. With the passage of time, organizations, to a greater extent, are becoming project oriented. The assessment of maturity in terms of project management is of critical importance to assess the current state of maturity, to develop confidence and improve the project management processes further in the organization. This paper provides an application of the project management maturity model on a German automotive company and establishes a relationship of project management maturity with project success. The author also gives an overview of Project Management Maturity Models, comparison of the stages of various models, and measurement of project management maturity of an organization using the Model from PM Solutions. The project success rate in the same company has also been measured. The project management maturity of the company is evaluated in terms of Project Management Knowledge Areas and Project Management Process groups. The author, based on the study, concludes that project management maturity is strongly related with project success.*

**Keywords:** project management maturity, project management maturity model, project management, project success

## **1. Introduction**

In the modern corporate world more and more organizations are following project management approach. In order to do projects effectively and efficiently organization always need to optimize their project management processes. In order to assess the current situation project management maturity models play an important role. It has been stated in a study held on projectification of western economies, such as Iceland, Germany and Norway, that in 2013, 34.7% of total working hours in Germany were project work, in 2014, 32.6 % of work in Norway was project work and in Iceland it was 27.7%, which indicates that projectification is a reality [1, pp. 72-74]. As the organizations are becoming more and more complex, it is of utmost importance that project management maturity of organization should also increase in order to do the project successfully and avoid failures. The authors in this paper have conducted a study, to assess the project management maturity of a Multinational Automotive Company, headquartered in Germany. The study has been conducted using a questionnaire and circulated to the locations of the Automotive Company in Germany. Based on the case study, the author has also proposed and established a correlation between project management maturity and project success.

## **2. Project Management Maturity in an Organization**

Project Management Maturity is the state in which a company assesses itself, regarding the project management processes. In this way the organizations can quantify the ability of the company to manage projects successfully. Maturity generally means fully developed or

perfected. It is in either meaning (1) “fully developed” or (2) “perfected” that the word is used in the term “maturity models” [2, p. 1232].

According to Crawford in his book “Project Management Maturity Model” [3, p. 10], it is defined as, a continuous development of an enterprise wide project management approach, methodology, strategy, and decision-making process. He further explains that the maturity level will vary for each company, depending on its particular targets, strategies, resource capabilities scope and requirements. The project management literature is deeply focused on the idea of maturity models [4, p. 151] [5, p. 6] [6, p. 41]. The maturity models are very important because a maturity model helps an organization to analyze its own practices and employees, the best. This can help an organization to follow a structured way to improve itself [5, p. 7]. One of the most famous maturity models is “Capability Maturity Model (CMM)”, which was coined by the Software Engineering institute. This model was then replaced by its advanced version called, “Capability Maturity Model Integration (CMMI)” [7].

## **2.1. Maturity Models for Project Management**

There is no clear definition of how a mature organization will look like however, there are 30 project management maturity models [2, p. 211]. According to TJ Man [8, p. 10], Maturity models in PM are used to assess the degree to which an organization is following project management practices, in comparison to the best practices. These models help in describing what can be done in order to improve the project management maturity in an organization.

In this paper the author presents 5 most commonly used project management maturity models. One of the models will be used to assess the project management maturity in the desired sample.

1. Organizational Project Management Maturity Model (OPM3) by Project Management Institute
2. Capability Maturity Model Integration (CMMI)
3. Maturity Increment in Controlled Environments by MINCE2
4. Project Management Maturity Model- PM solutions
5. Project Management Maturity Model- Kerzner

### **2.1.1. Organizational Project Management Maturity Model**

Organizational Project Management Maturity Model (OPM3) was first launched in the 1998 [9]. OPM3 is a framework that gives an organizational view of project management, program management and portfolio management to support best practices within these areas. OPM3 digs deep into integration [9, p. 3] of the following;

1. Knowledge (of portfolio, program and project processes)
2. Organization Strategy (mission, vision, objectives and goals)
3. People (having competent resources)
4. Processes (the application of the stages of process improvements)

The word organization could also relate to business unit or department. OPM3 is based on the idea that organization should follow a list of best practices, perform a feasibility and prioritization plan, develop a plan consisting of best series of improvement actions in order to improve maturity [10, p. 94].

#### **OPM3 Maturity Levels**

OPM3 has defined 5 maturity levels.

Level 1: None – No existing practice

Level 2: Standardize – A process for doing projects has been defined, documented and communicated, however, it is not being used in a small number of projects.

Level 3: Measure – Standardized processes are followed by all projects and processes are measured to assess effectiveness for organization.

Level 4: Control - Measured process is improved for poor application of the standardized practice. Boundary limits are established.

Level 5: Improve – Continuous improvement of process develops to a practice for outcome of best practice standard.

### 2.1.2. Capability Maturity Model for Integration (CMMI)

CMMI models are the most comprehensive process improvement models available for product and service development and maintenance [7].

CMMI was created for two basic purposes [11]:

1. To help process improvements efforts in software development organizations
2. To help identify skilled/qualified organizations in order to do software development

The CMM defines five levels of the maturity process for software development projects [12, p. 8]. The five levels of software maturity are show in the Fig. 1 below.

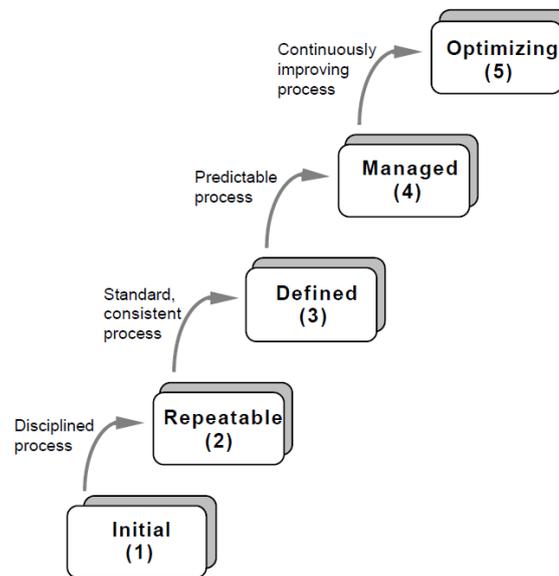


Figure 1: Five levels of software process maturity [12, p. 8]

**Initial** – The processes are ad-hoc. Success is dependent on the individual efforts with a few defined processes.

**Repeatable** – The fundamental project management processes are in place to track cost, schedule and functionality. The processes are disciplined for project with similar applications.

**Defined** – The software processes for both management and engineering activities are documented and integrated with the software process for the organization.

**Managed** – Software process is quantitatively measured and understood.

**Optimizing** – Continuous process improvement is enabled from the quantitative feedback.

In CMMI management of processes is the central focus. It emphasizes on the work to be done as per process, which enables transparency. Measurement is part of the process and product management, which helps in provision of the information needed to make decisions that guide the product development [13, p. 11].

### 2.1.3. Maturity Increments in controlled environments

MINCE was launched by MINCE2 foundation in 2007. The MINCE idea of maturity centers on the ability of an organization to follow market changes and environmental changes [14, p. 1]. MINCE aims for the whole organization to operate in a project oriented environment by enabling individual and group transformations. A controlled environment is mandatory in order

to be able to make optimal use of MINCE [14, p. 2]. MINCE developers agree and propose that the smartest way to realize adaptations is by means of projects or programs to be undertaken [14, p. 3]:

- In predefined time frame
- With predetermined goals
- With predetermined quality requirements
- Using a budget made available for the purpose
- Using a temporary organization

MINCE provide following benefits to the management [14, p. 4]:

- Maturity of the organization
- Skill set of the employees
- Increasing effectiveness of the organizations projects
- Ability of utilization of lessons learned
- Skill of change management

There are three measurement approaches to follow in MINCE; the Bronze, the Silver and the Gold, in the order of easiest to hardest. The Bronze is the easiest and fastest among the three [14, p. 45].

MINCE has the following five levels:

1. Activities
2. Processes
3. Systems
4. Supply Chain
5. Quality

**Level 1 – *Activities***; an organization operating at this level is happy when the result is achieved. It is hard to predict if the activities intended will produce the desired result or not [14, p. 39].

**Level 2 – *Processes***; an organization operating at this level is aware of processes leading to completed products [14, p. 40].

**Level 3 – *Systems***; an organization operating at this level has activities and processes developed and on top of that has established a set of standards [14, p. 41].

**Level 4 – *Supply Chain***; an organization at this level interacts with suppliers and customers in the chain [14, p. 41].

**Level 5 – *Quality***; an organization at this level is the trend setter. Other organizations follow such organizations [14, p. 42].

#### **2.1.4. Project Management Maturity Model- PM Solutions**

The Project Management Maturity model is based on the 10 Knowledge areas of PMBOK edition 5 and Software Engineering Institutes type measurement of maturity [3, p. 4]. The model has five levels of project management maturity.

##### **Levels of Project Management Maturity**

###### **Level 1: Initial Process**

The ad hoc processes are in place and management is aware [3, p. 4].

###### **Level 2: Structure Process and Standards**

The basic processes are available and used only for big and highly visible projects. The schedules and estimates are based on expert knowledge and generic tools [3, p. 4].

###### **Level 3: Organizational Standard and Institutionalized Process**

All the processes are applicable and used in the organization wide projects. Estimates and schedules can be created on industrial standards and organizational particulars. An informal analysis of project performance is carried out [3, p. 5].

#### Level 4: Managed Process

These processes are integrated with the corporate processes. All sorts of estimates are based on particulars of the organization. A strong analysis of performance is done and the management uses this data to make the best decisions [3, p. 6].

#### Level 5: Optimizing Process

These are used to analyze the effectiveness and efficiency of a project. Continuous improvement is the central focus of the management [3, p. 6].

In addition to that, PM solutions, pay special importance to the additional components and propose that the project management office, management oversight and professional development play vital role in maturity [3, p. 8].

### 2.1.5. Project Management Maturity Model – Kerzner

This model was put forward by Harold Kerzner in his book “Strategic Planning for Project Management” [6]. According to Kerzner, the foundation of excellence in project management can be best explained by a project management maturity model [6, p. 41]. KPMMM consist of 5 levels which are being shown in the Fig. 2 below.

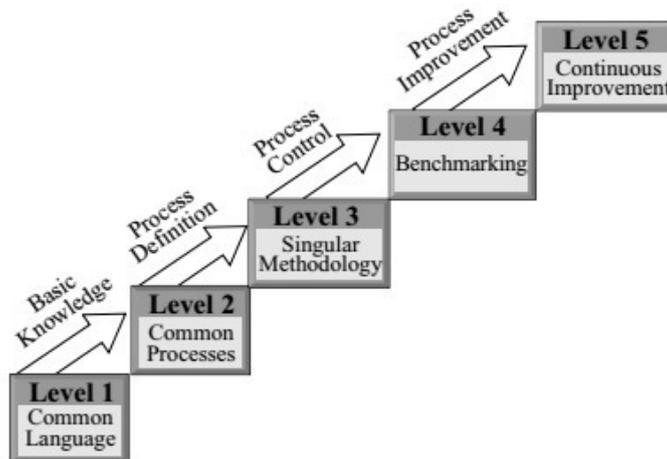


Figure 2: Five levels of PM Maturity [6, p. 42]

**Level 1 – Common Language;** the organization understands the significance of project management and necessity for project management knowledge and common terminologies.

**Level 2 – Common Processes;** organization at this stage is aware of the fact that common process must be defined so that it could be applied to all the projects to gain maximum advantage.

**Level 3 – Singular Methodology;** at this level the organization focuses on building synergies of all the methodologies which leads to a singular methodology.

**Level 4 – Benchmarking;** the organization at this stage recognizes that continuous improvement is vital to maintain the competitive advantage.

**Level 5 – Continuous Improvement;** the organization then analyses the benchmarking information and makes the decision which helps to improve the singular methodology.

### 3. Comparison of Maturity Models and Selection of Model for Research

The Author has developed a comparison of various levels of maturity models It is shown in the Table 1 below.

Levels	<i>Maturity Models</i>				
	OPM3	CMMI	MINCE	PMMM - PM Solutions	PMMM-Kerzner
Level 1	None – No existing practice	Initial	Activities	Initial Process	Common Language
Level 2	Standardize	Repeatable	Processes	Structure Process and Standards	Common Processes
Level 3	Measure	Defined	Systems	Organizational Standard and Institutionalized Process	Singular Methodology
Level 4	Control	Managed	Supply Chain	Managed Process	Benchmarking
Level 5	Improve	Optimizing	Quality	Optimizing Process	Continuous Improvement

Table 1: Comparison of Project Management Maturity Models (Author)

After comparison of the various models, the author has selected “Project Management Maturity Model” for the analysis of the project management maturity.

#### 4. Rationale of Selecting PMMM-PM Solutions

The author has selected the PMMM from PM solutions because of the following reasons.

1. The Project Management Maturity Models relates to all the processes in PMBOK.
2. The Project management maturity is grouped by level within a Knowledge area.
3. PMMM helps to analyze deeper, the maturity at the sub process level.
4. It is developed by PM solutions.
5. The model is generic and can be applied to any type of industry.
6. The data collection through this model is easy.
7. The model provides a self-assessment method.
8. It is the most modern maturity model available.

#### 5. Objective of Case Study

The objectives of this case study are

1. Application of Project Management Maturity Model on a Multinational Automotive Company
2. Assessing and Analysis of Project Management Maturity Level in the company
3. Assessing and Analysis of correlation between Project Management Maturity and Project Success in the Company

The author used questionnaire based on Project Management Maturity Model from PM solutions to collect the maturity level of project management processes. The project success was calculated based on the successful, challenged and failed projects in the organization.

## 6. Methodology of research

The current research has been carried out in the locations of Germany. The research was done through a questionnaire (attached as annex) circulated among 35 participants. The designation of the participants involved were:

- Project Steering Members
- Project Managers
- Head of Departments.

The response was received from 20 participants. The author held personal meetings and Telco with the respondents to clarify the questionnaire.

## 7. Analyses and Results

The analysis and results are presented below.

### 7.1. Project Management Maturity by Knowledge Areas

The company has an average maturity level of 3.53, as depicted in figure 3 below, which places it between level 3 (organizational standards and institutionalized processes) and level 4 (Managed Process) of project management maturity model.

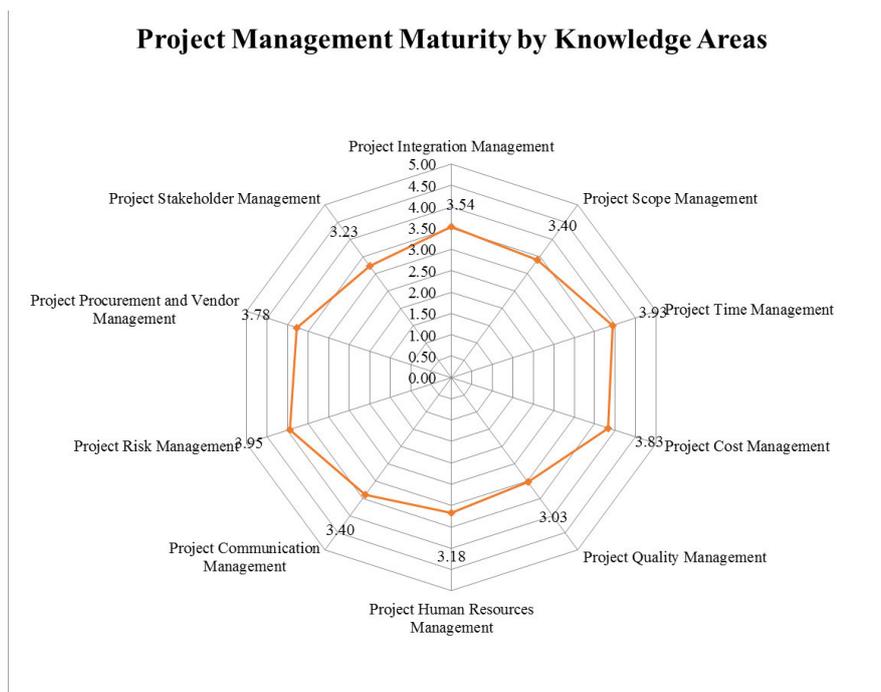


Figure 3: Project Management Maturity by Knowledge Areas (Source: Survey)

Project Integration Management lies at maturity level 3.54, which illustrates that project integration efforts are institutionalized through processes and standards. Management provides help and is actively involved in projects [3, p. 30]. The project Scope management average maturity level is 3.40, which show that company is maintaining standardized project management process within the organization. The clients are involved and core team members develop requirements, scope and other project elements [3, p. 48]. The overall project time management maturity is 3.93, which elucidate that time management processes are used and documented by majority of projects [3, p. 63]. The overall project cost management maturity is 3.83, which specify that cost processes acts as companywide standards and are used by majority of projects. The processes are repeatable and specifically the cost estimating process includes

alternative analysis and performance measurement procedures are more than just variance analysis [3, p. 78]. The overall project quality maturity lies at level 3.03, which shows that quality processes are recognized and used as the organizational standards. Management keeps eyes on quality of projects and most importantly quality has a program focus [3, p. 90]. The overall maturity level of project human resource management is at level 3.18, which shows that most of the projects are following the company wide resource management processes. The professional development path of company includes project management as a career path [3, pp. 104-105].

The overall maturity of project communication management is at level 3.40, which shows that communication management is established in the company and plans are expected from most projects. The related management is participating in approving all the changes that influence triple constraints [3, p. 117]. The overall maturity of project risk management is at level 3.95, which shows that risk managements processes are the organization standards and used for most projects. Risks are managed on program level [3, p. 129].

The overall maturity of project procurement and vendor management is at level 3.78, which indicates that the procurement processes are institutionalized, and the management considers other projects and products before making procurement decisions [3, p. 143].

Project Stakeholder Management is at level 3.23, of maturity which shows that in majority of the projects, formal project stakeholder management plans are established and implemented [3, p. 153].

## 7.2. Project Success and Project Maturity

In Oxford Advance Learners dictionary, “Success” is defined as “to achieve what was intended” [15]. According to Nicholas and Steyn, all the criteria of project success includes that project is completed on time, budget and meets the quality requirements [16, p. 50]. A project can be called as a successful endeavor if the desired goal has been achieved.

The survey results in figure 4 show that 67% projects at the company are successful projects and completed within required quality, scope, time, and budget. It also shows that 30% of the project are challenged and are either out of scope, exceeds budget, takes longer than planned or does not meet the quality requirements. A very small 3% projects are never completed or cancelled.

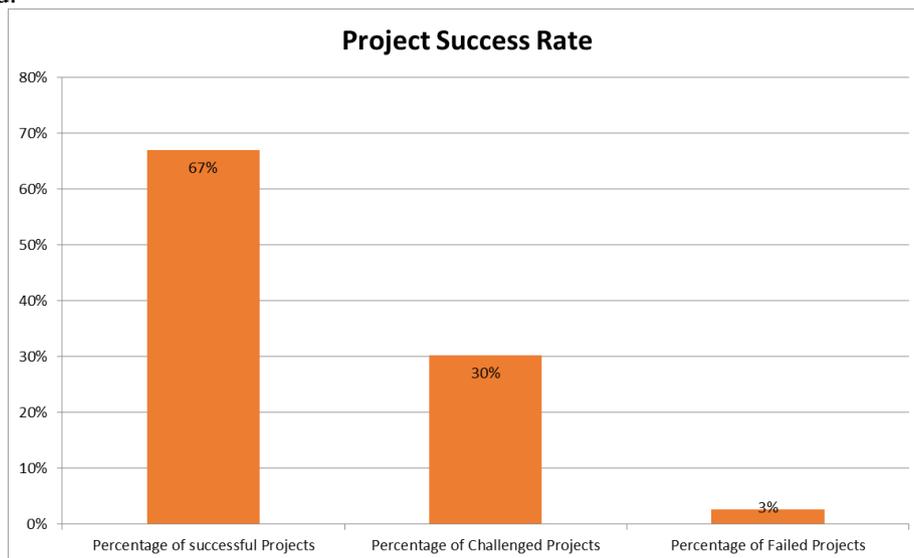


Figure 4: Project Success Rate (Source: Survey)

The project success and maturity have a very complex relationship. According to [17, p. 9], there is no correlation between project management maturity and outcome of the project. However these results are based on the construction industry of South Africa. Contrary to that,

[17, p. 10], the knowledge areas Integration management, Scope management, Time management, Cost management and Human resource management are positively correlated with the project outcome. However there is no significant correlation between Project outcome and Quality management, Communication management, Risk management and Procurement management.

According to Mullaly and Thomas there is relationship between maturity and performance but this no exiting statistical correlation [18, p. 8]. The degree of organizational maturity increases project performance [19, p. 9].

The results from the survey agree with a few of the authors mentioned above. The figure 5 below shows that maturity percentage and successful project percentage are significantly correlated.

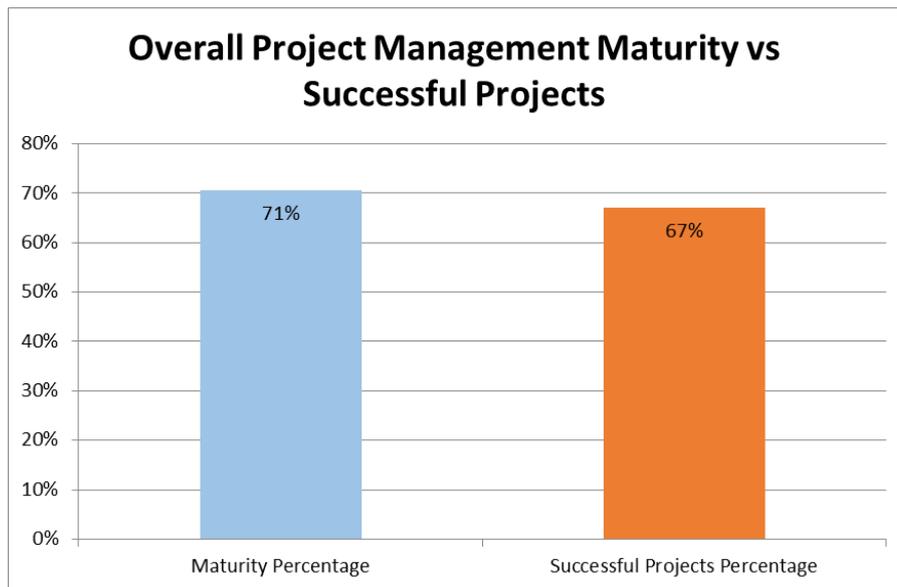


Figure 5: Maturity vs Project Success (Source: Survey)

### 7.3. Maturity Level by Process Groups

The table below indicates that the company lies at above 3 maturity level in all the process groups of project management. The company in question has the highest maturity level at project initiation and planning which is 3.65 that indicates that it has standard process in place for initiation and planning and being utilized in most of the cases.

The maturity level by process groups are shown in the Table 2 below:

	Initiation	Planning	Executing	Monitoring and Controlling	Closing
Project Integration Management	3.70	3.90	3.50	3.38	3.40
Project Scope Management		3.53		3.20	
Project Time Management		4.10		3.40	
Project Cost Management		3.87		3.70	
Project Quality Management		3.10	2.90	3.10	

Project Human Resources Management		3.10	3.20		
Project Communication Management		3.50	3.50	3.20	
Project Risk Management		4.20		3.70	
Project Procurement and Vendor Management		3.80	3.70	3.80	3.80
Project Stakeholder Management	3.60	3.35	3.30	2.90	
Average	3.65	3.65	3.35	3.38	3.60

Table 2: Project Management Maturity by Process Group (Source: Survey)

## 8. Conclusion and Further Research

The paper provided an overview of the project management maturity models. The author developed a comprehensive chart to show the comparison of project management maturity model. Based on the advantages offered by Project Management Maturity model from PM Solutions, author used this method on the organization under question. The author assessed the project management maturity of the company. The project maturity was assessed in the 10 Knowledge areas as well as in the project management process groups. The overall project management maturity of the company is at level 3.53 out of 5, which places the company in between maturity level 3 and 4 of the PMMM of PM Solutions.

This indicates that [3, pp. 5-6]:

“Level 3: Organizational Standards and Institutionalized process

All Processes standard for all projects and repeatable

Management has institutionalized processes

Summary and detailed information

Baseline and informal collection of actual data

Estimates and schedules may be based on industry standards and organizational specifics

Organizational focus

Informal analysis of project performance”

According to the author, the results are in agreement with the company’s project management landscape. The author also came to the conclusion that project management maturity is strongly related to the project success which has been shown in the results in previous section. The rate of successful projects is 67 percent, which is close to the maturity percentage of 71 percent. These results are also in line with studies of Mullaly and Thomas [18, p. 8] and Nieto Rodriguez and Evrard [19, p. 9].

The author believes that the result of the study is based on the company being studied and provides an assessment and analysis of the locations of the company, only based in Germany. The results cannot be applied to other companies operating in different as well as same sectors. The author recommends research of similar nature in other companies and different parts of the world to validate the relationship of project management maturity and project success.

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# KNOWLEDGE MANAGEMENT AS A BASIS OF ORGANIZATION COMPETENCE

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**Abstract:** *The article shows that the organization's competence influences its behavior in market conditions. It is noted that the competence of the organization depends not only on the competence of the personnel involved in the performance of functional duties. Competence, and hence the behavior of the organization, depends on how the knowledge is acquired, transmitted, disseminated and used in an organization. There is a gap in the definition of competence in standards at the levels of an organization - the performers. It is proposed to determine competence through the use of knowledge management in the organization. The conceptual model the organization competence structure formation is presented. The problems of knowledge management at different levels of the organization are presented. The organizational knowledge management environment and organizational competence management system are described.*

**Keywords:** knowledge, competence, knowledge management, organizational competence.

## 1. Introduction

Recent research shows that the analysis of the organization's activities from the point of view of the competence approach offers some advantages. The development and formation of a structure or set of competencies contribute to the progress of an organization in a competitive environment [1,2]. The ability of both, man and organization to react to changes in the competitive environment, to formulate a strategy for development and to achieve the goals set by their respective competence.

In the author's opinion, knowledge and processes related to their management at all levels of the organization are a key factor in the formation of competence. On the other hand, for the organization, it is necessary to determine the list of competencies that will allow it to occupy a leading position in a competitive environment. The purpose of this article is to identify models that will allow the organization in the future:

- to form a model of competences;
- to determine the processes of knowledge management and their role in the formation of the structure of competencies;
- develop a model of organizational competence management.

Before proceeding to the main text, it is necessary to conduct a short analysis of the concepts of competence and knowledge.

## 2. Literature review

The vast majority of existing standards consider competence as a specific goal to be achieved both by organizations and by its employees. Each competence has the so-called indicators, by means of which it is possible to determine its presence for the person. For example, Organization for Economic Co-operation and Development (OECD) competency framework [3], describe competence "Negotiating" like "the ability to work towards win-win outcomes" and the indicator is "Listens to differing points of view and promotes mutual understanding". At present, competence standards are divided into two levels: organizational and level of performers. At the

organizational level, as a rule, consider the elements of competence that allow delivering the organizational strategic objectives, in accordance with the organization's mission, vision, and strategy through program and portfolio management [4]. Individual competence standards consider staff competencies to achieve goals in project execution. However, according to the author, existing standards cannot provide a clear understanding of the structure or list of competencies that organizations must possess.

How to answer the questions: How competent are you? Does the organization recognize your competence and does it support your development? Let's take a look at International project management organization's Individual competence baseline (IPMA ICBv4) competence named "Personal integrity and reliability" which has key competence indicators like: "Acknowledge and apply ethical values to all decisions and actions" and "Promote the sustainability of outputs and outcomes" [5, p.67]. If the person answers these questions (indicators) "yes", such information will not be useful for the project, program or organization as a whole. Obviously, a system should be developed to ensure the collection, analysis, evaluation, dissemination, and use of knowledge in the field of organizational competence.

According to Peter Drucker's definition, knowledge is "information that changes something or somebody – either by becoming grounds for an action or by making an individual or an institution capable of different and more effective action." [6]. Knowledge in the organization is stored and distributed through a variety of sources, such as - policies, documents, best practices, etc. Knowledge management relates to a single mechanism of people working in the organization and relevant information technology. This mechanism should ensure the formation of the competence of the organization and its development.

There are differences in views on the interpretation of where knowledge is concentrated. For example, Aristotle argued that no one can know or possess all available knowledge - knowledge is dispersed among people in society [7]. On the other hand, Grant [8] argues that the creation of knowledge is an individual activity, and therefore organizational knowledge cannot exist as an isolated phenomenon. Indeed, knowledge in organization encoded in documents, instructions, software etc. There are some difficulties in how a person can use this knowledge in his professional activity. Since the documents, files, developed models in the software, etc. only store data is, people, develop their reaction through the interpretation of data based on personal experience. The organization or top managers should evaluate the use of knowledge by a person, for example, best practices in current projects. An organization may develop or update instructions, regulations or other documents for the maintenance and development of the system of competencies based on the results of the assessment of knowledge use.

By analogy with other models (hierarchical structures) that are used in project management, the organization must develop and approve the structure of competencies. Such an approach will allow further monitoring and control of changes in the competence of the organization and knowledge management. A conceptual model for the formation of such a structure is proposed in Section 3. The surroundings of the future knowledge management system and processes are proposed in Section 4.

### **3. Competence Breakdown Structure of the organization**

Taking into account the above, the following tasks can be distinguished for the formation of organizational competence:

- development and formation of the organization competency structure;
- development of organizational knowledge structure;
- development of organizational knowledge management system;
- development of models and methods for assessing organizational knowledge management;
- development of a mechanism for supporting the competence of the organization on the knowledge management basis.

Consider the selected tasks.

Development and formation of the organization competency structure. This article will not describe the types and types of organizational structures. It is clear that the structure of the organization's competences will depend on the type of organizational structure. It should be noted that it is optimal to apply this approach to project-oriented organizations that have standards of operation and management structure and are interconnected with it. It is appropriate, in the author's opinion, to develop and apply a competency breakdown structure (CBS) that is divided into three domains or levels:

- Strategic level (programs).
- Tactical level (portfolios).
- Project level (projects).

The following levels of structure are based on the industry, in which the organization works, its internal corporate standards, expert opinions of external stakeholders, etc. The conceptual model for developing the organizational competency is shown in Figure 1. In accordance with this model, it is first necessary to form a set of organization key competencies based on both external and internal stakeholders, as well as standard requirements – industry-specific, corporate, project management, etc. It is also necessary to take into account the current requirements of the market or industry in which the organization operates.

In the next step, based on the feedback and discussion results, a detailed breakdown structure is developed that includes indicators for the achievement of each element of competence.

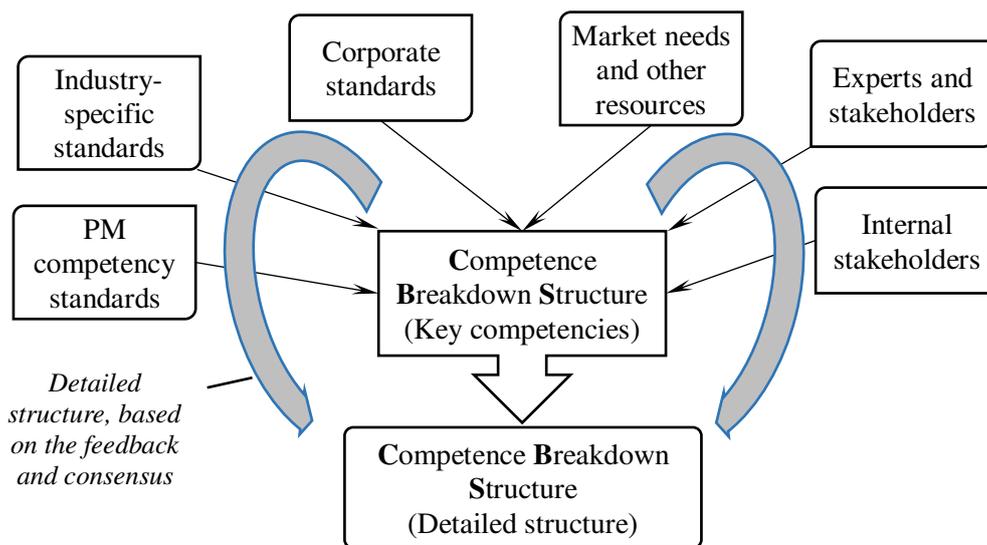


Figure 1. A conceptual model for developing the organization's competencies (own source)

This approach should be used when reviewing or updating the competence breakdown structure of the organization.

After determining the structure of organizational competence, in the author's opinion, it is necessary to develop a knowledge management system for the organization. Such a system should be built into CBS. This will give the organization a clear vision of how to manage competence through knowledge management.

#### 4. Organization Knowledge Management System

Development and formation of organizational knowledge structure. Such a task is quite complex and requires a detailed study. Let's focus only on the main aspects and problems of its solution. Dave and Meenu [9] describe such organizational aspects in reference to knowledge: organizational culture & environment; organizational knowledge base; the edifice of the

organization; organizational guidelines. Each aspect is detailed on certain elements that can be used to assess their achievement by a person or organization in the course of their activities. Some aspects can be used to answer such important issues as organizational knowledge management:

- Where knowledge is created in an organization.
- How knowledge is discovered, processed and stored.
- What information technologies provide services for processing, modeling and storing knowledge.
- How the knowledge is used in future activities.
- How knowledge is integrated and disseminated within the organization.
- How organizational knowledge affects the organization's strategy.
- Are organizational knowledge used in management decision support systems?
- How to evaluate knowledge and manage them to assess the organization's competence?

There are following problems from the standpoint of knowledge management in an organization:

- At the strategic level. The role of knowledge management in shaping the organization's development strategy is underestimated.
- At the level of project managers. Key competencies and knowledge are not related to the implementation of the organization's strategy.
- At the level of management systems. Management systems are designed for operational control and related to budgeting, not strategy and knowledge.
- At the level of information systems, Customer Relationship Management (CRM), Enterprise Resource Planning (ERP) systems, etc. They relate to the simulation of technological and information processes activities. There is no link between knowledge management and the organization's strategy.

To formalize the structure of organizational knowledge, you can use the conceptual model of knowledge in the organizational context offered by Nordhaug. He offers the following types of organizational knowledge [10]:

- Meta-knowledge. General background knowledge can be used in the performance of a range of organizational activities.
- Industry knowledge. A general type of knowledge, widely available to individuals in their role related to organizational activities, across both firms and industry.
- Intra-organizational knowledge. Industry-specific but is not specific to organizational activities or tasks.
- Standard technical knowledge. Involves a wide range of technical, operationally oriented knowledge that is generally available to all workers.
- Technical trade knowledge. Task-specific, industry-specific, and is generally available among firms in an industry.
- Unique knowledge. Specific across all dimensions and applies to self-knowledge and skills-based knowledge of unique organizational routines, business processes, and IT infrastructures etc.

This model allows standardizing categories of knowledge in an organization.

Development of organizational knowledge management system. Organizational Knowledge Management System is an enabling system for knowledge management through the whole organization. The main goal of such a system should be to transfer knowledge from past projects into current and future. The knowledge management system provides organizational competence and must take into account the specifics of the organizational context, information systems, management systems and the peculiarities of the work of the personnel of the organization. An environment of knowledge management system described in figure 2.

The architecture of a knowledge management system should include a central server that integrates organizational knowledge. In addition, in the system, according to the author, should consist of the following services:

- User access and authentication services.
- Services that allow the individual to organize the system work by categories: industry knowledge, intra-organizational knowledge, standard technical knowledge, technical trade knowledge and unique knowledge.
- Services to accumulate, transmit and reuse knowledge in the organization by the selected categories.
- Services to receive data from information systems, management systems, document management systems, and others in an organization.
- Services that allow monitoring and evaluation of the acquired knowledge in the process of the organization's activities and to transfer the knowledge gained to the appropriate base.
- Services that allow making operational changes in the activities of the organization and its systems based on the results of the assessment of organizational knowledge management.

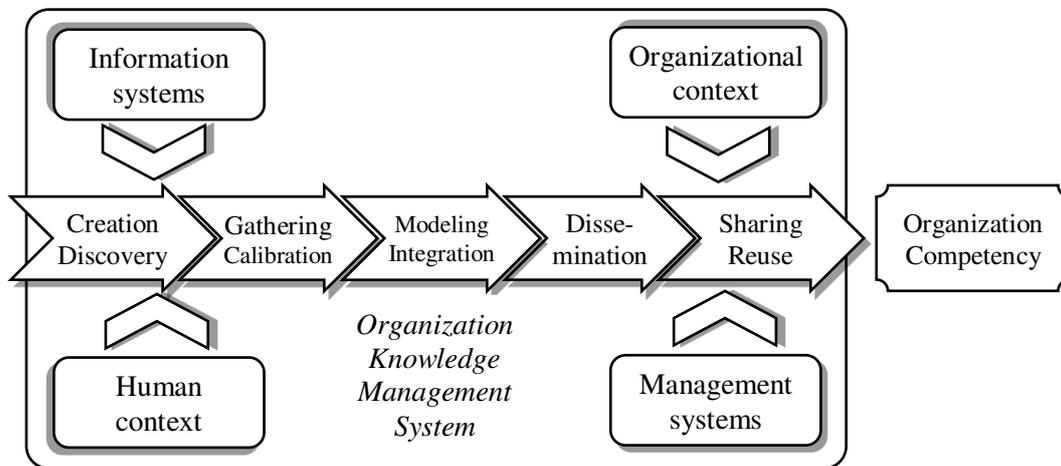


Figure 2. An environment of knowledge management system (own source)

In addition, the system should provide the opportunity to work with innovative processes and use different creative technologies to support the generation of new organizational knowledge.

The last two tasks: "Development of models and methods for evaluating organizational knowledge management" and "Development of a mechanism for supporting and developing competencies of the organization based on knowledge management" is beyond the scope of this article, as they will be the subject of further research. The implementation of these tasks depends on the formalization and results of the previous ones. It should be noted that in the system of management of organizational knowledge it is necessary to develop some criteria for success. In accordance with these criteria and the nature of the organization's knowledge management system's environment, it is possible to analyze and apply appropriate mathematical models to assess the effectiveness of its work.

## 5. Organization Competence Management System

Knowledge management system and competence of the organization do not work alone. They complement each other. When developing the mechanism for supporting and developing the competence of the organization on the basis of knowledge management, it is necessary to provide a two-way link between these systems. In general, a couple of "organization's competence structure" and "organizational knowledge management system" form a single meta-system that

determines the organization and their behavior in a competitive environment. We will call it a system of organizational competence management (OCM). Figure 3 depicts the conceptual structure of such a system.

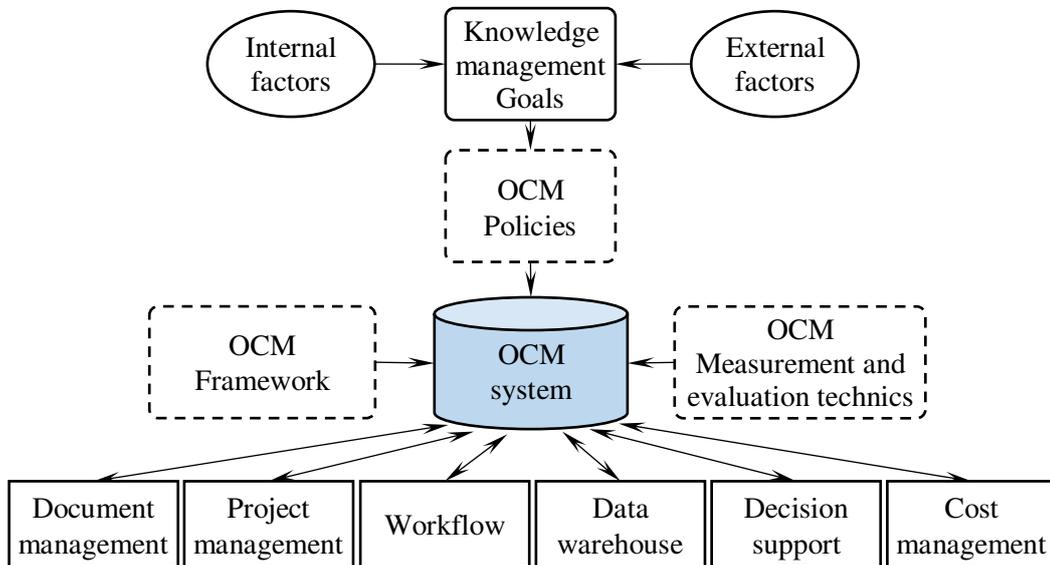


Figure 3. An environment of the organization competence management system (own source)

Components of a system include the structure of the organization competence breakdown structure and organizational knowledge management system that is clearly interlinked. The essential elements of the OCM system are: framework, policies, and measurement \ evaluation technics.

An element called "Knowledge Management Goals" is identified, which defines the scenarios for development or adaptation of organizational competence, depending on the environment.

## 6. Results and Conclusion

The role of knowledge and management in an organizational context cannot be overestimated. The existing standards for defining the competence of the individuals do not adequately describe the organizational competencies. On the other hand, in the definitions of organizational competence, an emphasis is placed on the implementation of the strategy. Managing knowledge across the organization will allow linking of individual competencies and organizational. This approach allows to come up with a study of the sources for the data management system. \

The article presents an approach to managing organizational competence through knowledge management. The author of the article proposed to develop a hierarchical structure of the competence of the organization (CBS), which will be the framework for the functioning of the knowledge management system. The environment of such a system is described. All knowledge management processes should encompass a hierarchical structure of competence. The architecture of the knowledge management system is proposed.

Using organizational knowledge management systems and organizational competence will enable to formulate, evaluate, adapt and develop a successful organization's strategy in a competitive environment.

Further research will be devoted to the development of a detailed hierarchical structure of the organization's competence in accordance with world standards. It will also be necessary to show the relationship between the project management processes and the organization's knowledge management system and its impact on the organization's competence structure.

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# MODEL OF ORGANIZATIONAL DEVELOPMENT BASED ON THE THREE COMPONENTS OF SUCCESS

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**Abstract:** *The purpose of this article is to highlight the issues of knowledge management organization based on a competent approach in the value-oriented project management and programs. In their development, the author has united in one model such important components as knowledge, values and competencies.*

*Today, for the successful functioning and creation of competitive advantages organizations need to pay much attention to the management of human capital. After all, it forms the basis of the best knowledge and practice. Targeting a value-based approach allows you to be in line with current trends, to meet the needs of stakeholders, reduce the risks to the organization. The achievement of high performance in the management of the organization and human resources is impossible without the use of a competent approach, which allows to identify the best resources and use them to build a powerful competitiveness.*

*The proposed model allows us to trace how these important components of success combine, how they interact in the framework of projects and programs, which processes take place in the management system.*

**Keywords:** competence; project; value; model; innovation; management

## 1. Introduction

Today, the progressive global trends are the transition to a knowledge economy, the global nature of the economic systems functioning and the strengthening of their social orientation. The knowledge economy formation in the present world is one of the most important directions for the economy development of the world developed countries. The new growth theory considers knowledge to be a decisive engine of economic growth. More precisely, knowledge is not used solely to the benefit of its originator, but generates positive side effects also for others, provided they have the capability to understand the transferred knowledge potential. Knowledge generation has also welfare implications for a country or a region. On a macroeconomic level, the implication of knowledge diffusion for growth seems straightforward, whereas on the microeconomic level the effect of knowledge diffusion seems more complex.

The current economy development condition is characterized by significant changes in approaches to management, technological process and social norms. The rapid development of technologies requires organizations to achieve high efficiency and increase their competitiveness. Employees are the bearers of innovations, and their combined competence forms the source of organizational competitive advantages. In current conditions considerable attention is paid to the formation and practical use of the personnel competence.

## 2. Competent approach, value-oriented management and knowledge management as components of successful organizational development

Considering the market economy conditions, for any industry and sphere of activity, the main factor of success is competitiveness. This is a very complex concept, which covers not only the qualitative, economic, aesthetic, technical characteristics of the provided service or the

manufactured product, but also those processes that occur in parallel with the company's core business.

A comparative review of organizational competitiveness factors determining approaches revealed that management and personnel components are allocated among such internal factors as vibrational, financial, scientific and technical and marketing potential. Organizational personnel and management potential are reflected in such a concept as the personnel management system. The effectiveness of personnel management is one of the most important parameters that determine the competitiveness of the organization [4]. To work in this highly competitive environment, companies need to change their business and management philosophy, approaches and models of work. They need to create business opportunities: new markets, new innovative products, higher customer value, human potential development, and improved organizational learning with increased speed and flexibility. The best way in such conditions for a company, is to use a competent approach. A competent approach becomes the basis for developing a system that combines business requirements and human resources management. The essence of a competent approach is to develop and apply in practice models of competence of employees, their selection, evaluation and training in accordance with these models.

Today, knowledge and their active use is the only source of increasing prosperity in organizations and societies [5]. Investments in natural and human resources can lead to increased incomes only by coordinating and integrating with investments in knowledge. Knowledge, information, personal qualities, specialization and qualification requirements are necessary tools for achieving material growth, and those societies that lack such tools are considered poor.

Nowadays, the organizational potential directly depends on knowledge, the creative thinking using makes it possible to advance and develop [1]. Organizations and companies realized that in a global competitive environment, no other investment would benefit them much more than investing in knowledge [3]. That is why over all these factors the personnel of the organization (which is the source of knowledge) is considered the largest investment in the organization. Accordingly, knowledge management, as a tool through which useful knowledge can be collected, classified and divided into organizations, has acquired particular importance.

The advantage of value-oriented management is that it allows to maximize the creation of value, increases corporate transparency, helps the organization to respond to globalized and deregulated capital markets, aligns the interests of managers, shareholders and other stakeholders of the project, facilitates communication with investors, analysts and interested parties; improves internal communication on strategy; prevents underestimation of shares; establishes clear priorities in management; contributes to better decision-making; helps to balance short, medium and long-term trade-offs; encourages investments that create value; improves the allocation of resources; optimizes planning and budgeting; establishes effective targets for compensation; facilitates the use of shares for transactions; helps to effectively manage increased complexity, greater uncertainty and risks.

### **3. Combination of development components in the cycle model**

The cycles management model of organizational innovative development is presented on the basis of knowledge, values and competencies. Methods of system design are used as a technology for constructing a conceptual model. They make it possible to consider the model in the form of a system, that is, a set of interrelated internal elements with a certain structure, a wide range of properties, and a variety of internal and external relationships.

The model creation is carried out on the basis of the project or program design process, taking into account the interactions of knowledge, team competence and values that migrate in space and time. These components are interrelated and all affect the outcome.

The management cycle model allows to develop different project program architectures. The model consists of the system of the organization's goals within the framework of the innovative development program, as well as from the system for assessing the knowledge value (at this stage,

the knowledge existing in the organization is assessed), on the basis of which the main cycle of program projects initiation is formed. The project monitoring cycle includes an analysis of the necessary knowledge availability to start the program projects and a forecast the values from these projects implementation. The cycle, which is carried out during the projects implementation, provides coordinated, in relation to the indicators of value, the obtained knowledge and changes in the team competence, change management in the innovative development of the organization projects [2].

The organization's innovative development program contains a number of interrelated projects or project portfolios, the implementation of which ensures achievement of the goal and allows for the use of best practices and lessons from previous projects. In turn, knowledge and lessons learned during the program implementation accumulate in the best practices knowledge base and the project lessons basis.

The distinct area of the organizational value development is based on knowledge and values that come from the general mental space, includes values that are acquired in the process of the organization's development and transition from a schematic model of work to a service one, and also uses the best practices and lessons learned in cognitive cycles during projects implementation.

The model program life cycle consists of three models: schematic, system and service. In accordance with the way in which the program passes from one model to another, the directions of its activity change, certain knowledge is acquired and the value of knowledge changes. Part of the knowledge that was relevant for working on one of the models, can lose its significance in the transition to another model. Therefore, when moving from one cluster to another, an evaluation of the acquired knowledge is conducted - valuable knowledge enters the active knowledge base, and those that lose their value are stored in the knowledge archive.

When the program executing according to the schematic model, the concept knowledge generates, the system model generates knowledge about the project and its implementation, and the service model about the program product activity.

By tracking the value changing process of certain knowledge throughout the program life cycle, we can determine the critical points in which it is necessary to pay attention to a certain knowledge type, their structuring and use.

The foundation of the model is the organizational mental space. It is formed from a variety of stakeholders, the parent organization and professional groups. Pursuing their interests, they form a common area, interaction in which allows improving the overall result. The main task of creating an effective mental space is the knowledge accumulation and the competitive advantages creation. The knowledge embodied in the projects or programs products allows the active use of innovations in projects and the organization of teamwork, as well as ensuring the program mission achievement and the stakeholders satisfaction.

Mental space is designed to maximize the projects and programs value, ensure their innovative focus, and implement effective communications on a common language for all stakeholders.

A field of complimentary knowledge arises as a result of the interaction between project stakeholders and processes that embrace their common knowledge.

In this model, knowledge is related, depends and influences the competence of the project team. From the team structure, its experience and skills depends on how effectively it will use the knowledge base, how quickly and accurately exchange knowledge and create new knowledge in the face of project complexity, uncertainty, dynamics of the environment. It is necessary to assess and take into account the level of team competence, so that it is sufficient to overcome all challenges and successfully manage the project or program.

The project or program value is determined by the benefits that the project product provides when it reaches the project mission.

The project value is guaranteed by two conditions: the ability of the project team to implement the project in accordance with the approved plan and harmonious achievement of the project value for all stakeholders, which is realized in the quality of the project product. It is also necessary to take into account that each participant has his own specific goal and understanding of the value

that he expects to receive. Therefore, it is necessary to check that the value of the program or project meets the expectations of all participants. It is important to understand that in the process of implementing the program, the properties of the value may change, and therefore it is necessary to take into account the interests of all participants, taking into account the primary vision of value and clearly coordinating the actions of the parties concerned.

#### **4. Results and Conclusion**

The article analyzes publications on the topic of knowledge management, competency approach and value-oriented management. On the basis of the processed material and own research, the authors present the model of management cycles of innovative development of the organization based on knowledge, competencies and values. This model covers all the important components for managing the organization in current environment. It is determined that value-oriented management is becoming more widespread today, the global economy goes into the knowledge economy, and effective management of knowledge of the organization is impossible without understanding and using the competence approach. The model combines all these important components; shows how they change throughout the life cycle of a project or program. Knowledge, values and competencies, their interaction have a serious impact on the outcome of the project and program implementation. Understanding what is going on with these components at one or the other moment, the project manager can predict positive or negative situations, predict the best ways to build a strong management structure, which in turn will contribute to increasing the competitiveness of the organization.

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# MANAGING A PROJECT OF REAL-TIME FACE RECOGNITION SYSTEM DEVELOPMENT USING THE AGILE METHODOLOGY

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**Abstract:** *The work describes the development of real-time human detection system in video streams using Agile principles and techniques with emphasis on Kanban Method as a project's framework. The basis of core values and instructions defining the processes and interactions grounds on PMBOK® Guide – Sixth Edition and PMI Agile Practice Guide.*

**Keywords:** Flow-Based Agile, Kanban, video analytics software, variability, uncertainty, WIP, tailoring, Scrumban

## 1. Introduction

Video analytics is a widely popular domain of technology that uses computer vision techniques to collect various information based on the sequence of frames received from video cameras in real time or from video recordings [1]. Integration of video surveillance with digital systems has opened the possibility to automatically receive and process various data for a wide range of applications [1]. A grossing market that uses it encompasses video content analysis, security systems, restricted access systems, pay systems, criminal identification, advertising, etc [1].

One of the tasks solved by video analytics is the recognition of faces in video streams [2-6]. The solution of this problem primarily has a direct application in aforementioned access control and identification systems. The goal of the project is to develop a reliable and precise facial detection system capable of working on hardware with low processing capabilities.

T. Dingsøyr et al. state that the formation of the Agile Manifesto has led to significant changes in the field of software development [7]. The transformation brought about by the manifesto is very remarkable, a great variety of many software methods, tools, methods and advanced methods have appeared [7]. While many practitioners readily accepted this unprecedented growth, much remains to be done to ensure consistency with the current discourse on flexibility [7]. After much discussion about the features of many of the proposed methods, the conversation shifted to the relative merits of planned and flexible practices and the need to have a balanced approach in which each of them would be more appropriate for different types of projects [7]. Recently, attention has been focused on issues related to management, actual planning, monitoring and evaluation of projects, optimization of stream stories (for example, Kanban), the use of six-sigma, etc [7]. Most of these ideas gave rise to a number of practices that are asserted as effective, but empirical evidence for such assertions is lacking [7].

Matharu et al. conducted a comparative analysis of the three agile-methodologies, namely Scrum, XP, and Kanban [8]. The study concludes that although the Agile family consists of several approaches to software development that use the same set of principles, they differ in different parameters [8]. Among all agile methods, Scrum has the highest application, while Extreme Programming is gaining momentum and software developers are increasingly starting to use it, and Kanban's approach to software development is being studied primarily as an addition to existing agile software development methodologies [8].

To compare the effectiveness of Kanban and Scrum on software projects, Howard Lei et al. developed a survey to include various questions about the company, software projects, project management methodology, implementation and feedback from projects [9]. The mean, standard deviation, and correlation data was calculated to compare the effects that Scrum and Kanban exert on the studied characteristics [9]. Although the numbers suggest that there is no statistically significant difference between Kanban and Scrum, they show that Kanban works better than Scrum regarding project schedule management [9]. The results indicate that projects using Kanban's methodology may have greater coherence concerning project management factors [9]. The results also demonstrate that, in general, both Scrum and Kanban lead to successful software projects were, on average, the respondents answered "I agree" with questions regarding the quality factor [9]. Companies should be aware of the differences in the practical implementation of these methodologies and choose one or the other based on the context, functional needs, and resources of the project [9].

Trends in publications researched by M. Ovais et al. indicate that Kanban is gaining popularity in the field of technical engineering [10]. A high percentage of primary research is the experience reports (47%), and most of the studies included experimental or small-scale projects or recent transitions to the Kanban approach [10]. On this basis, there seems to be a need for more extensive and rigorous scientific research on Kanban in the field of software development [10]. M. Ikonen in his study concludes that there is not much empirical research about Kanban as a method of software development [11]. Although Kanban is well known in manufacturing areas, it has not yet been extensively researched in software development processes [11]. Moreover, the influence of the process model on the work of the software project itself has been little studied [11].

Given the high demand for the research of the agile principles and their derivatives in an ever-changing field of software development, this paper will take into account current agile development trends with the focus on Kanban methodology, devise a modified version of the framework considering specifics of the project and explore the feasibility of the approach.

## 2. Proposed approach

Various assessment models help to evaluate the needs of the project and understand what project management framework is most suitable. Based on previously existing renowned measurement models, *PMBOK*® offers its version of the assessment [12]. It is a synthesis of fitness characteristics that help project managers evaluate whether projects should be implemented using predictive, hybrid or agile approaches. Characteristics are assessed in three main categories: Culture, Team, and Project [12]. The team needs to answer questions provided in the *Agile Practice Guide* for each of the categories, and the results are then marked in the diagram [13]. The value field in the circle of the center of the chart indicates good suitability for agile approaches [13]. Results outside the circle indicate that a predictive approach may be more appropriate [13]. Mean values (between flexible and predictive) suggest that a hybrid approach may be more appropriate for project implementation [13]. The diagram of the project is presented in Fig. 1.

The tailored Kanban methodology was used as a project management framework considering high degree of uncertainty regarding limitations and functionality of the system, taking into account team size, experience, decision-making, criticality and delivery demands. Some of the fitting techniques and knowledge area processes traditionally practiced in predictive or hybrid approaches were integrated into the developed management system. The Kanban method as a core developmental framework is the integral basis for gradual, evolutionary processes and changes in projects. Unlike Scrum, Kanban is not considered iterative, but a flow-based process methodology [14]. In such a flexible task-oriented approach, the team extracts functions from the backlog, based on the ability to run the job, rather than on a scheduled graph based on the iteration [14]. Project manager defines a workflow with columns in the taskbar and manages the current work for each column. It may take a different amount of time to complete each function. The team keeps the work in progress (WIP) small to better identify problems at an early stage and shortens the revision if changes are required [15]. Without iterations to determine planning and review points, team and involved participants determine the most appropriate planning, product reviews, and retrospectives. The Kanban board (see Fig. 2) helps the team further enhance its efficiency by visualizing the workflow [15], making it see obstacles and allowing flow control by adjusting the work within the work-in-progress limits.

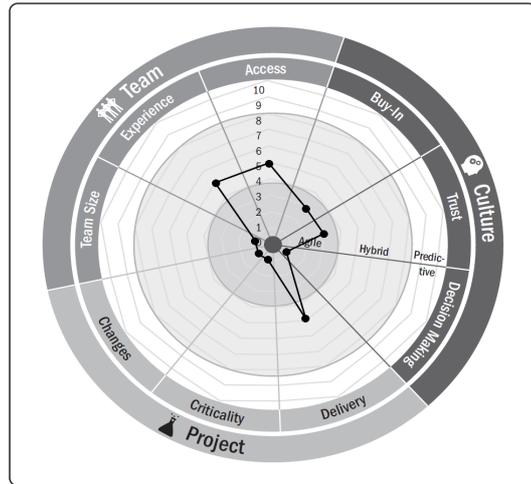


Figure 1: Suitability diagram of the project [13]

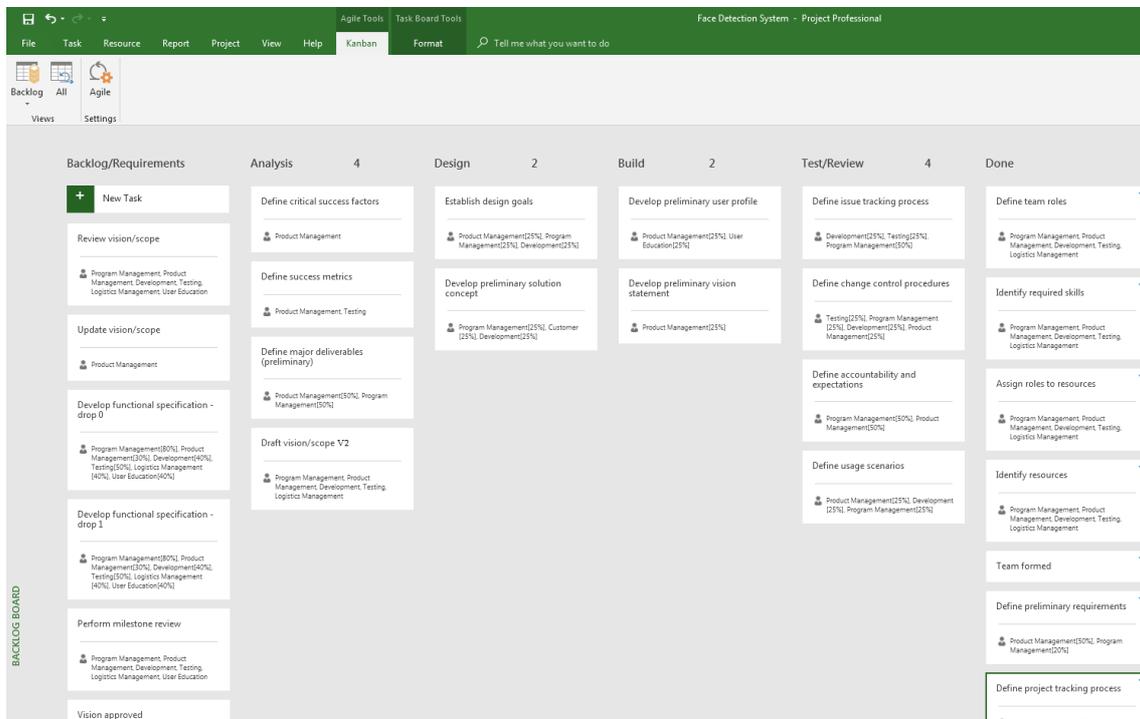


Figure 2: Project's Kanban board implemented in MS Project

### 3. Case study

Team members are determining the order of integration of plans and components. Control over detailed product planning and delivery are delegated to the team. As a result of tailoring, the project manager is part of a team and also focuses on creating an overall decision-making environment, and provides the team's ability to respond to change. With a high degree of uncertainty at the initial stage of the project, its content remains unclear and evolves as it progresses. At an early phase of the project, when using flexible methods for determining and coordinating the content, less time is deliberately allocated for the organization of the process and specification of requirements. Hence, the definition and clarification of the content occur throughout the project; requirements are forming backlog.

Schedule on-demand is the approach of the Kanban system [16] that is based on the concept of scheduling in the framework of constraint theory and demand-based lean manufacturing to limit the amount of current work of the team to balance the demand for its productivity. A tailored version of this approach is based on the schedule that is compiled earlier but considers work from a backlog or a list of priority works that are to be executed first, acquiring the hybrid features of predictive approach. To accommodate for the scope of the project, lightweight assessment methods [17] were used to obtain a rapid high-level forecast of labor costs for a project, which can then be easily adjusted to reflect changes that occur. However, this project, being small in scope, is not limited to severe cost-related limitations and requirements. Significant attention is paid to small packages of works to create favorable conditions for periodic deliveries of program components when applying flow-based methodology. Kanban's small packet system approach [17] used in the project was adapted to identify inconsistencies and quality problems in the early stages of the project life cycle when the total cost of the changes is lower. Environments with high variability, by definition, are distinguished by a higher level of uncertainty and risk. Risks are considered every time at a selection of the content for each cycle. The risks concerning this project include time delays and a low rate of successful recognition. As part of adaptation process, the Scrumban [18] reviews and retrospectives were added in-between completed phases [18]. Accordingly, analysis, identification, and management of risks are performed during each evaluation point. The exchange of information between the supervisor and the team takes place as part of a dynamic, collaborative process that allows for greater involvement and satisfaction of the stakeholders.

Essentially, the project's framework resulted in a modified version of Kanban similar to that of Scrumban, since Kanban Method is structured more as a set of techniques to promote continuous change but lacks a definitive ground of other Agile methodologies [19] to pose as an independent project management framework [20]. As A. Reddy stresses: "Scrumban is not about using just a few elements of both Scrum and Kanban to create a software development process. Rather, it emphasizes applying Kanban systems within a Scrum context, and layering the Kanban Method alongside Scrum as a vehicle for evolutionary change [20]." The "Scrumban transformation" of the project can be characterized by several key features:

- Retaining cross-functionality of the team while developing a shared vision of the current workflows and policies; adapting roles that perform well for a given phase at a certain time
- Formal events of project outlining, revision and review are occasionally adjusted or omitted
- Just-in-time [21] prioritised process control implies more informative management of backlog entities with different values and risks
- Prioritization and undertaking of the specific task is not bounded to the start of a sprint; by using visualisation tools and metrics indicating the delay, it is possible to diminish the subjectivity while evaluating the requirements

- Kanban board shifting the centre of attention away from obstacles toward opportunities for supervision and adaptation due to strict process policies
- Improving project's quality and decreasing the probability of unjustifiable and untimely advancement of the system by incorporating multiple control points and evaluations of "finished" throughout every valuable step
- Priority of the empirical data analysis (and yielding more data for measurement) which makes the process of implementation more efficient

In addition to traditional Kanban methodology metrics such as WIP (the number of tasks over which the team can work at the moment) [22], Cycle time measurements (the time at which the task from the backlog moves on to the completed work section) [22], Takt time (average Cycle time divided by the average WIP value) [22]. Project team implemented Blockers / Queues (an mechanism of control which detects processes that interrupt the ongoing development process or delay the execution, which are then analyzed and corrected by the project manager) [22]. To track metrics, graphical methods, such as diagrams (CFD, scattered) and stacked charts [22] (see Fig. 3) were used.

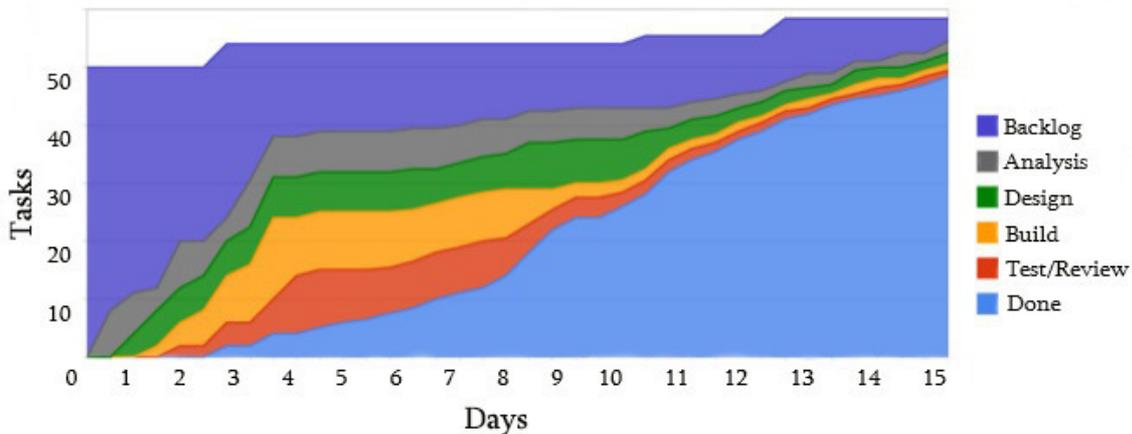


Figure 3: 15th day Cumulative Flow Diagram

Limitations:

- Only monotonous change of illumination is admissible
- The training and test sample should be taken under the same or similar lighting conditions
- Frontal or close to frontal face positions must be used
- Neutral expression of faces in images
- Individuals must not overlap with other objects significantly

Functionality:

- Processing of a video stream with the camera connected to the computer in real time
- Ability to customize the work parameters used to detect and recognize algorithms
- Output of information about the identifiable person, including the measure of association with a certain class, graphic display of the histogram and LBP representation of the face
- The ability to learn and add classes of people using the camera through the application interface (only one person in the cameraview) or via photo/video upload (see Fig. 5)

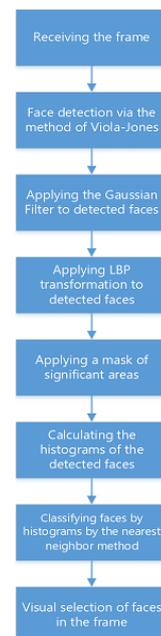


Figure 4: Processing stages

The processing of the video stream frames by the developed system includes two main phases:

- Detection of faces by the Viola-Jones method
- Recognition of the detected faces with the help of histograms of local binary templates and the method of the nearest neighbor

In addition to the detection and recognition stages, it is reasonable to use the following additional intermediate stages (see Fig. 4) of processing:

- Processing of detected faces by Gaussian filter
- Applying a mask of significant areas
- Calculating the histograms of the detected faces

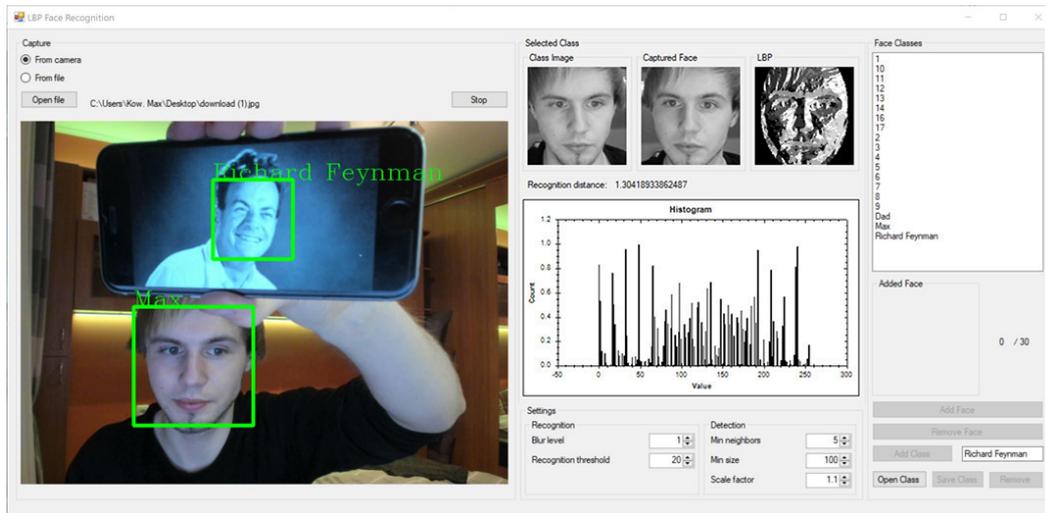


Figure 5: Developed system in work

In terms of performance, the center-symmetric local binary patterns are the ideal choice for classification criteria in the development of a real-time recognition system [23]. Nevertheless, it makes sense to make sure that it does not lose much to the slower LBP variations [23] in the accuracy of the classification. For testing, it was decided to use the data sets from Cambridge [24] and Yale [25] universities. As a training and test sample, 5 images per face were used. The test and training sample did not have any intersections, however, to obtain results on a larger data set, the test and training samples were swapped and the testing was repeated. Before processing, the images are scaled to 128x128 pixels. Respectively, about 700 images were classified in total. Optimal for the ratio of accuracy and cost of memory partitioning the image into sub-regions when using CS-LBP is a 4x4 partition, which is used in the developed system. This partition provides a consistently high percentage of correct classifications with not very large memory costs as shown in *Table 1*.

Table 1. Datasets' average accuracy

Methods \ Blocks' division	Blocks' division							
	1x1	2x2	3x3	4x4	5x5	6x6	7x7	8x8
LBP	62.1%	81.3%	91.1%	93.6%	93.3%	93.2%	94.1%	92.7%
Uniform LBP	61.1%	84.5%	94.4%	93.1%	92.4%	92%	93.5%	91.8%
CS-LBP	44%	76.8%	89.7%	92%	91.7%	92.4%	91.4%	92.1%

Speed test was carried out with a different number of histograms of individuals in the database. The processing speed of the video stream was estimated by the number of frames processed per second when one person was recognized in the frame. As was expected, CSLBP operator demonstrated significantly better outcomes, as can be seen in *Table 2* (Hardware specifications: Intel Core i5 3.2 GHz, 8Gb, video resolution 640x480).

Table 2. Processing speed

Number of histograms \ Method	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
LBP	23	18	15	13	12	10	9	8	8	7
Uniform LBP	30	30	30	29	28	25	23	21	20	19
CS-LBP	30	30	30	30	30	30	30	30	30	30

#### 4. Conclusion

The developed version of software development framework proved itself to be a viable solution for developers resulting in a reliable and precise system with precision scores ranging in about 90% correct recognition rate. For further advancements of Kanban methodology in more complex and long-term software-related projects, a team may adopt and incorporate a combination of predictive or/and hybrid approaches in order to achieve better big-scope control capabilities. The main direction of the further development of the program may be the improvement of the faces classifier. For this, more sophisticated classification algorithms may be used, for example, methods such as random forests or neural networks. The developed system can be used for solving the various tasks of video analytics, system requirements of which make it possible to use in systems with low-end hardware. It is also worth noting that the architecture of the developed application makes it easy to replace individual modules, which opens up opportunities for the further growth and enhancement of the system.

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## METHOD OF SPATIAL DISPLAYING THE GRAPHIC INFORMATION

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**Abstract:** *The purpose of the work is to develop a method of spatial display of graphic information, as well as a basic hardware version for demonstrating the working method of the developed method, based on the analysis of known methods for displaying graphical information, from open and public sources of information, both surface and spatial, determination of the most optimal solutions from the already known. Also, an assessment of the effectiveness of the developed method, in terms of human perception and use of energy and technical resources. The developed method of spatial display of information, and its hardware, provides simultaneous transmission of information to several users in the field of view of which is the device.*

**Keywords:** space model, matrix of lighting elements, 3d-displaying, dynamic indication, cylinder system coordinate

### 1. Introduction

Nowadays, the most popular and most up-to-date method for displaying graphic information is displaying in three-dimensional space (3D). To this end, many devices have been developed, including: VR devices that actually create a new virtual world with which the user can interact, complemented reality devices that make artificial elements in real world perception, complementing it, and so on. But information displayed by such devices can only be perceived by one person. They require high-tech equipment and significant computing power. For example, a device from Google (Fig. 1) [1] and similar are using smartphones with sufficient computing power and equipped with the necessary sensors. This approach allows you to save money on equipment by buying only the helmet itself. But it requires a smartphone that meets certain technical requirements.



Fig. 1. Google Cardboard

Also known are devices that display information volumetricly using 3D-cubes from light-emitting elements (Fig. 2), which can be viewed by several observers [2]. But such devices are complex. For example, a device [2] is a cube of 8x8x8 elements that can display a very primitive image. However, it requires 512 LEDs and the same keys for them. The use of dynamic displays, multiplexers and decoders reduces the complexity of hardware due to the complexity of the software. But there remains the problem of shading some of the light-emitting elements of others and the conductors of their power supply. A part of the problem is solved by the use of LEDs with transparent lenses, but they are the most intense emitting light flux only in a certain direction, and there remains the problem of shading and overlapping of some light-emitting elements by others, especially with a large number of elements (depth of the layer). This causes an inconvenience for an observer who wants to view the device from different angles.

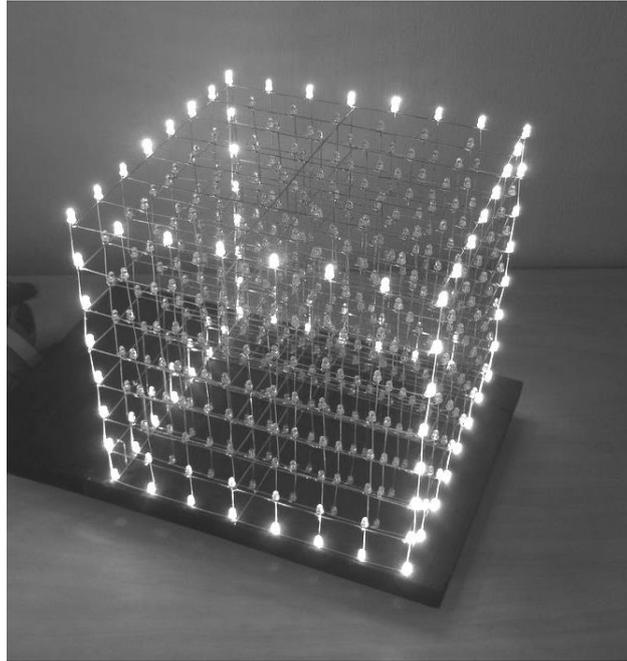


Fig. 2. View of 8x8x8 cube with LEDs

Therefore, given the complexity and high cost of known devices for 3D display of graphical information, the development of new, simpler methods for 3D display of graphic information is an urgent task.

Significantly simple, by design, devices [3] (Fig. 3, 4). They use moving light-emitting elements that light up at an appropriate time. However, such devices can only display flat images, in addition, they have a relatively low pixel density of the resulting image.

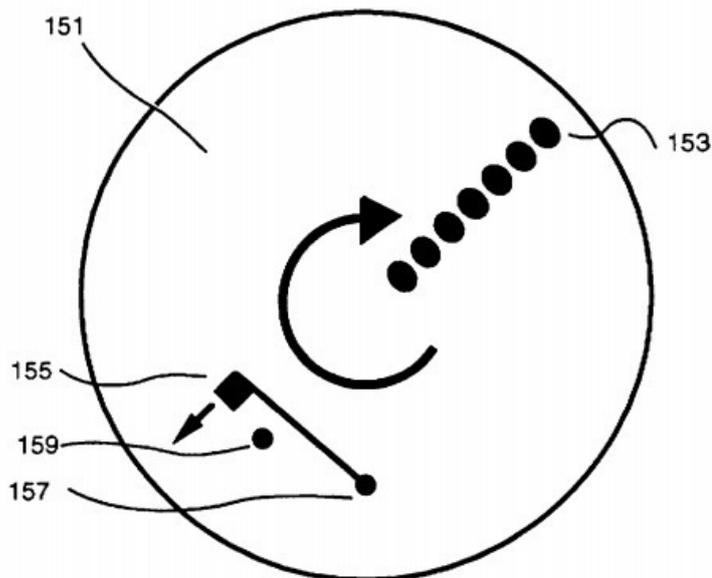


Fig. 3. Schematic representation of the design of the device [3]

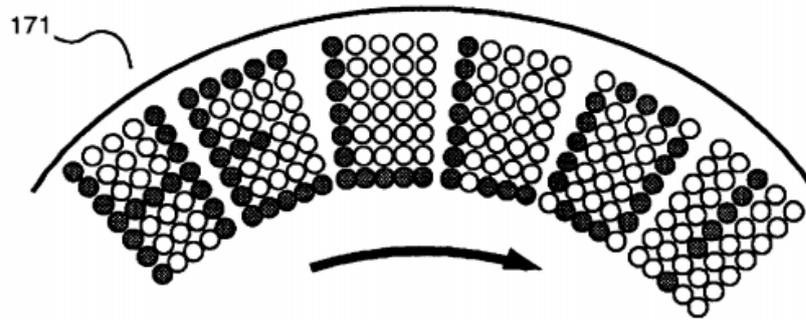


Fig. 4. Schematic image of the device [3]

The purpose of the work is to develop a new method for spatial display of graphical information (3D view), which can be viewed by several observers at the same time.

## 2. Hardware and Software of the proposed method

To test the work of the proposed method, a layout was created, the structure of which is presented in Fig. 5, and a photograph on Fig. 6.

The layout includes the following nodes:

- Movable and stationary platforms to which all the elements are attached (used elements of the hard drive / HDD);
- a matrix of LEDs located on a moving platform and generating an image;
- a microcontroller that manages a LED array;
- sets of transistor keys that control the X and Y coordinates of the matrix of LEDs;
- battery power of the mobile platform;
- two power controllers: microcontroller power supply and LED matrix;
- electric motor for rotation of a mobile platform and its controller.

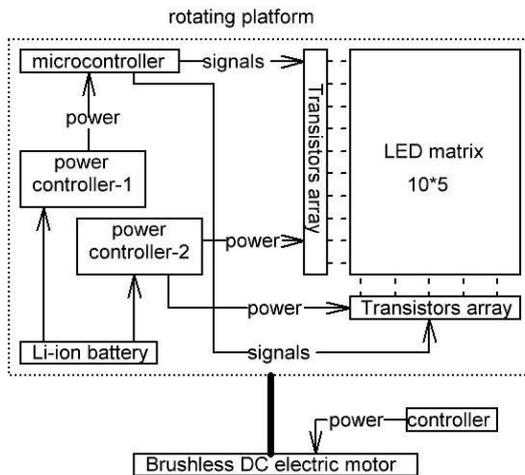


Fig. 5. Layout block diagram

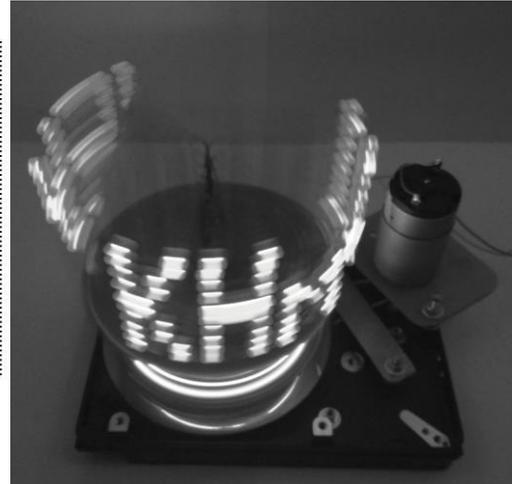


Fig. 6. Layout view

The microcontroller, after turning on the power, works on timer interruptions (in real time). It is in order (on timer signals), reads data from the program memory and manages transistor sets that include the corresponding LEDs. Such a microcontroller algorithm is chosen because of the use of a simple microcontroller such as Arduino nano V3.0 (ATmega 328P) [4], whose RAM is not enough to store the set of code needed to create a complete 3D Image. Thus, the memory of the microcontroller stores information about the state of the finished LED indicators for the management of these LEDs. And also the algorithm for creating a model. And the data is loaded in accordance with the number of frames of the image required for one revolution of the platform. Because of this, the layout displays only simple 3D images and is not able to reproduce 3D images, complex, moving objects.

Synchronization of image cropping on the matrix of LEDs can be realized in several ways:

- using only hardware (a pair of LEDs and a photodiode and an aperture on a disk, which is accompanied by a matrix of LEDs corresponding to each image matrix)
- using hardware and software (a pair of LEDs and a photodiode, one diaphragm on a disk, to split the period of rotation, and the output of frames is performed programmatically)
- using only software (the breakdown of the period of rotation on the frames is carried out programmatically, the speed of the matrix is regulated by the operator).

In the layout, for the sake of simplicity, the last method was used. For rotation of the matrix of LEDs, a collector motor and a flexible transmission (wedge strap) are used. This is possible, by introducing a non-synchronicity when changing the voltage on the engine, obtaining the rotation of the image relative to the vertical axis.

Main factors of complexity of hardware creation:

- the number of elements of the matrix and the density of their placement;
- Reducing the possibility of shading the elements of the matrix;
- balancing of the rotating platform;
- the speed of the microcontroller and the amount of its memory;
- the amount of microcontroller RAM to create a moving image;

- matrix filling speed;
- power consumed by the electric motor on the rotating platform;
- capacity of the battery of the rotating platform, or transmission of electricity to it.

But these complexity factors are not fundamental. Methods of their solution are known, their choice depends on the task that the graphic information display faces before the device.

In general, for the device display graphic information necessary software that implements personnel management supply LED matrix according sync pulses and intermediate processing of the frame to change the image according to the specified requirements. Thus, to implement arbitrary moving graphics required remote reprogramming microcontroller that controls the LED matrix, for example, by the method given in [5].

The layout uses a simpler technical solution. New image (or sequence) is loaded into the microcontroller that controls the LED matrix along with the program of work during a stop rotating platform. At the same time, the battery is recharged by charging it.

To write a program for a microcontroller using the Arduino IDE environment (Fig. 5), which is used as a programming language using C / C ++. Additional libraries were not used to create a layout program. The program code consists of one file, no external libraries.

The implemented matrix filling algorithm is executed in the form of a program function that displays only one frame of a 2D matrix per call. The layout is 64 frames per rotating matrix. To effectively display a 3D image, it is necessary for the matrix filling algorithm to provide as long as possible the continuous glow of LEDs. That is, the larger matrix of LEDs included in one command completion, the faster you can fill the matrix, the more time you can devote to glow LEDs in a single frame. The template uses a matrix that has 5 columns of 10 LEDs in each. Therefore, the fastest matrix is filled in columns (you can completely fill in 5 cycles).

A generalized block diagram of the algorithm of the function of data output (filling) on the matrix is presented in Fig. 7.

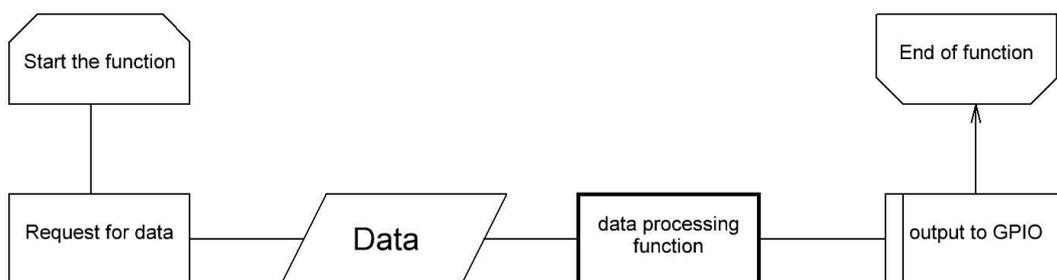


Fig. 7 - A general block diagram of the matrix filling algorithm is generalized

As shown in Figure 7, the algorithm receives data from a source that can act as a memory and a data object in memory, which is formed by software (dynamic generation of images for display). Further, the data inside the function is divided into blocks and fed to the outputs of the ports of input / output. The information in the block, which comes to the input of the function, is a description of the port states (according to the

hardware implementation), at discrete time intervals. Moreover, for a single function call, only the output of a single 2D frame (one fill of the matrix) is executed. This solution is explained by the flexibility of setting the amount of 2D frames to rotate and changing the number of matrix elements, which allows you to scale the hardware model without changing the main program code.

### **3. The proposed method of spatial displaying the graphic information**

The proposed method, like similar methods, is based on the inertia of human vision and its memory. For the formation of the image, not a tape of light-emitting elements (LEDs) is used, but their rotating two-dimensional array. It forms a cylindrical space within which a 3D displaying model or information. The density of elementary points (pixels) in this method depends on the pixel density of the base 2D matrix and the angular resolution of the control, that is, the number of possible light-emitting diodes for one rotating matrix (one revolving should be considered as one 3D image frame). You can increase the density of pixels using a few matrices, evenly arranged in a cylinder, which creates a 3D image. And using a matrix of different colors, you can create color images.

The algorithm for 3D image formation consists in alternating ignition of corresponding LEDs according to the control algorithm (and features of hardware realization). Thus, the microcontroller generates an image in real time.

### **4. Results and Conclusion**

The proposed method of spatial displaying the graphical information using a 2D rotating matrix of light-emitting elements - LEDs has a low software complexity for its implementation, as well as, relatively, low requirements for hardware support. The method can be used to reproduce both stationary and moving 3D objects.

The developed layout allowed to demonstrate the performance of the method and set up software that enabled the display of stationary and dynamic (variable frames) graphic information.

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