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THEORETICAL FINDINGS ON INTERNATIONAL STANDARD ADAPTATIONS IN ORGANISATIONAL MANAGEMENT SYSTEMS

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Abstract: *The purpose of this paper is to give an overview on the theoretical findings surrounding the adaptation of the international standards in modern organisational management systems. This will include the literature review on international standards such as ISO/IEC/IEEE 15.288:2015, and a series of examples in which standards have been adapted in modern literature to meet the needs of organisational structures. The paper will also explore the benefits and challenges of standard adaptations in organisational management systems highlighted through comparison of two specialised works on system engineering management. Moreover, this paper will contribute to the ongoing debate about the effectiveness of international management standards and the ways in which they can be adapted to meet the needs of diverse organizations. Also, this work brings a unique contribution on how theoretical elements can be adapted for practical use in organisations.*

Keywords: *ISO, management systems, organisations, standard adaptation*

INTRODUCTION

Behind the notion of modern management system standards stands a complex and vast set of guidelines, best practices, and procedures that modern organisations have come to adopt and adapt in time to effectively manage their operational activity, guarantee quality of services, and improve the overall performance of their business. [1] [2] [3] [4] [5] In today's everchanging landscape, this set of standard grows in importance every day, providing organisations with structure for better management of their resources and exceeding stakeholder expectations. [6] The purpose of this paper is to give an overview on the theoretical findings surrounding the adaptation of the international standards in modern organisational management systems. This will include the literature review on international standards such as ISO/IEC/IEEE 15.288:2015, and a series of examples in which standards have been adapted in modern literature to meet the needs of organisational structures. The paper will also explore the benefits and challenges of standard adaptations in organisational management systems. Moreover, this paper will provide contribute to the ongoing debate about the effectiveness of international management standards and the ways in which they can be adapted to meet the needs of diverse organizations. Also, this work brings a unique contribution on how theoretical elements can be adapted for practical use in organisations.

THEORETICAL BACKGROUND

1.1 Theoretical Background to SEM in ISO/IEC/IEEE Standards

In the context of industrial engineering, the concept of *systems engineering management* is considered by specialists in the field to be a subset of the *systems engineering* discipline. As the authors argue, systems engineering management, as an organizational concept, should focus on the technical issues relevant to project and/or system development, while retaining the connection to the overall system engineering activities and interfaces to other engineering systems across the environment in which it activates. [7] As it stands, this idea is in line with the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) view.

For this reason, the current draft version of the ISO 15288 standard as of summer of 2022 lists *systems engineering* under the *Terms, definitions, and abbreviated terms* as: "*transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems using systems principles and concepts and scientific, technological and management methods"*. [8]

The current version of the international standards which captures the guidelines and best practices has the reference ISO/IEC/IEEE 15288:2015 and covers "*Systems and software engineering – System life cycle processes"*. From the start, the authors of the standard consider that as of 2015 (when the document was published), the complexity associated with the man-made systems has reached unprecedented levels. This situation has allowed for both opportunities and challenges to develop within professional organizations, which can lead to the creation and utilization of systems. In this context, the current International Standard is offering to the users, in both the business and technology environment, a process framework which can address in a common way the life-cycle of systems which have been created by humans, through the adoption of a System Engineering approach. For this reason, the ISO/IEC/IEEE 15288 also provides *system engineering* with the following presentation: *System Engineering is an interdisciplinary approach and means to enable the realization of successful systems. System Engineering is an interdisciplinary approach and means to enable the realization of successful systems It focuses on defining stakeholder needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem*. [9]

1.2 Definitions of system components

As with previous definitions, system engineering is presented once again as focusing on both the human factors (stakeholders), as well as the elements which provide quality to systems (synthesis, documentation, development cycle, etc.). Thanks to their wide reach, systems can be found as stretching across the entire life cycle, which grows the demand for delivery of qualitative deliverables and differentiation of system concepts.

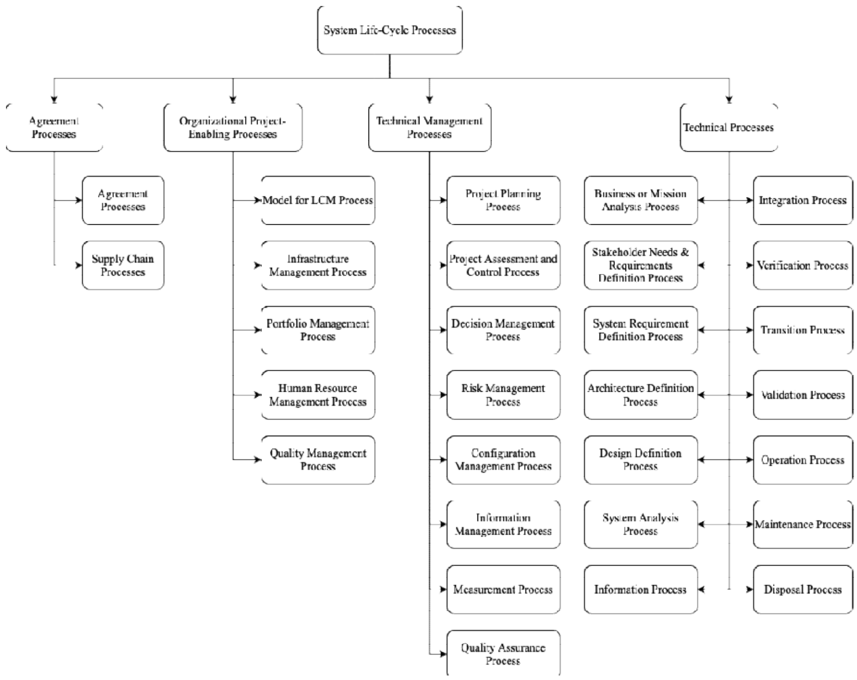

Figure 1: ISO/IEC/IEEE proposal for system life-cycle processes
(Adapted from ISO/IEC/IEEE 15288:2015, 2015, page 24)

Under the same ISO/IEC/IEEE standard, there are four main terms which refer to systems. These are:

- *system* – which is defined as a "*combination of interacting elements organized to achieve one or more stated purposes"* with the note that a system can be interchangeable with *product* or *service* depending on the context;
- *system element or sub-component* – is defined as a "*member of a set of elements that constitute a system"*; as with *system*, it recognizes the elements as having additional meanings, this time as data, facilities, hardware, humans, materials, processes, software either as standalone or in various combinations;

- *system-of-interest* – is considered to be a "*system whose life cycle is under consideration in the context of the standard"*; This definition is of importance because it recognizes the system associated with life cycle, thus situating systems as a success factor for the overall deliverable;
- *system engineering* – is the last term defined under the systems family as "*interdisciplinary approach governing the total technical and managerial effort required to transform a set of stakeholder needs, expectations, and constraints into a solution and to support that solution through its life"*. [9]

According to the ISO/IEC/IEEE 15288:2015, there is a life-cycle in every system. The collective group of authors consider the life-cycle to be a functional model, abstract, which is used to represent the conceptualization of a requirement within the system, from its definition, through implementation, improvement, and up to its disposal. [9] Following each step taken as part of the life-cycle, a system progresses from one phase to the other. Although the Standard does not prescribe a fixed life-cycle process, but it does provide a sequence of steps, with a dependency on the objectives of the project under consideration for development, along with the model in scope for the same development opportunity.

Depending on their own development requirements, organizations can decide to adopt and adapt the above-mentioned stages in a different sequence for the benefit of bringing business benefits and managing risks associated with their projects under development. [10] An example of the system life-cycle processes which could be adopted and adapted can be found in **Figure 1**.

When tailoring the processes to the organizational needs, the International Standards group recommends that the processes be split into the four categories mentioned above:

- **Agreement Processes**
- **Organizational Project-Enabling Processes**
- **Technical Management Processes**
- **Technical Processes**

When looking into **Agreement Processes** it is important to remember that organizations can play the role of both the products, as well as the users of the systems which are being developed when it has all the resources to do so. When an organization does not have all the needed resources, the development activity is most likely outsourced to another organization. In both the above cases, there is a need to have in place agreements. Depending on the requirements, scope of work, data sensitivity, and many other factors, these agreement process can have varying levels of formality.

While the first two sets of processes are mainly oriented to the business side, the group of processes looking after **Organizational Project Enabling** aspects mostly deals with making available the resources (e.g., human resources, financial, physical, security, etc.) which will enable the project to set the targets requested by the organization. This set of processes has a strong impact on the business image across not only the organization undertaking the project, but also its third parties.

The next two process groups refer to the technical side of processes. The **Technical Management** processes address the way in which resources are handled and the way in which assets are allocated within the organization, so that they contribute to the delivery of the organizational requirements. This set of processes is also used to put in place and carry out the technical plans of the project, control the technical activities so as to obtain their desired completion state, and to support in decision-making processes. An important note to make is that this group of processes works in conjunction with the International Standard ISO/IEC/IEEE 24765:2017 which addresses the terminology used for the system and software engineering fields.

The final process group concerns the **Technical Processes** which deal with the day-to-day technical activities carried out across the life-cycle. Their main purpose is to support with the creation and usage of the system developed, regardless whether it is a live production environment or a non-production environment. [9]

RESEARCH CONTENT

1.3 Approach to SEM according to Blanchard & Blyler

In order to exemplify how the standards are adapted into practice, two works of reference which address international standards have been selected for an in-depth review as art of the research effort of this paper: System Engineering Management by Benjamin S. Blanchard & John E. Blyler, and Essentials of project and systems engineering management by Howard Eisner. Through the life-cycle of the project duration, the SEMP should act as a guiding document which can be referred back to in case of required guidance and directives for the successful implementation of the project.

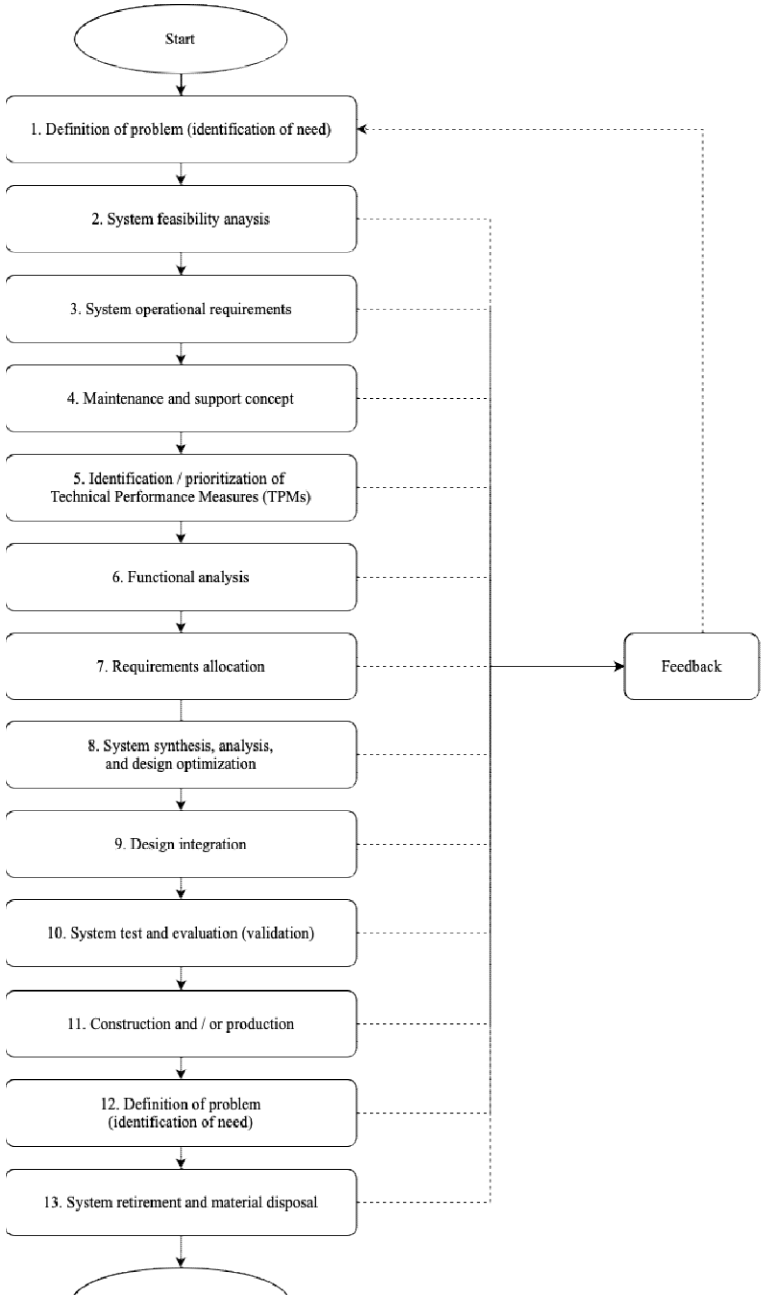

Figure 2: Blanchard & Blyler's system engineering process across the life-cycle
(Adapted from System Engineering Management, 2016, page 54)

This structure, represented under **Figure 2** has been called by the authors *system engineering process in the life cycle* and includes:

1. Definition of problem (identification of need) - the discovery of the problem which the customer/user is facing and subsequently defining the need of the customer/user
2. System feasibility analysis - carrying out a system feasibility analysis
3. System operational requirements - mapping out the system operational requirements, closely followed by
4. Maintenance and support concept - understanding the maintenance and support concepts
5. Identification or prioritization of the technical performance measures (TPMs) - this step aims to arrange for high-priority requirements to be worked on as soon / early as possible

6. Functional analysis - performing a functional analysis
7. Requirements allocation
8. Synthesis, analysis, and design optimization of the system in scope
9. Design integration – once each component is delivered, it needs to be integrated with the previous delivered work
10. System test and evaluation(validation) - testing and evaluating / validating the system developed based on the data collected during the previous steps
11. Construction &/ production - the construction or the production of the new system
12. Definition of problem (identification of need) - getting system operational use and life-cycle support, and finally
13. System retirement and material disposal - the retirement / decommissioning of the system and the disposal of the system which is in place [11]

1.4 Approach to SEM according to Eisner

As shown in the work belonging to Eisner, the notion of system can be defined as "any process that coverts inputs to outputs", which is the same definition given by other experts in the system engineering field, namely W.L. Chapman, A.T. Bahill, and A.W. Wymore. In support of the definition, Eisner argues through exemplification that systems are not standalone structures, but that they provide outputs through subsystems. This type of structure altogether can then be part of another wider system that provides its own functions, or it can be part of another subsystem.

To add more complexity to the notion, based on the environment in which the system is set up, it can also include elements such as: hardware, software, human resources, all which are expected to operate in such a way that they provide value through their implementation. Given all the above elements, the success of a system relies not only on having everything required, but also on making sure that all the elements fit together to achieve the intended goal. [12]

While the discipline of project management is centred around the Project Manager (PM) as a role, Eisner

Given the variety of information available on the concept of system, it is worth pointing out the following common points and differences among the definitions, captured in **Table 1**.

Table 1: Common points and differences in "system engineering" definitions

Common points	Differences
All the identified definitions acknowledge system engineering to have an interdisciplinary approach, which encourages development of knowledge in various areas;	The concept of retyring a system is present only in the INCOSE and NASA definitions, while the other definitions treat this sort of approach as part of the lifecycle flow;
In all definitions, the system engineering process is highlighted to have an iterative flow, focusing on continuous improvement;	In the DoD definition, system engineering insists on pointing out that design activities be considered for hardware and software components alike, while the other definitions combine the two components and treat them as one item;
There is a strong demand for setting up structured and aligned processes which in turn are expected to support the development and management of systems;	The DSMC definitions stand out with the idea of having an integrated and balanced set of system solutions, while the other definitions take this idea for granted or disregard it at all.
The customer needs and requirements are at the centre of the definitions;	The definition provided by NASA stands out as being heavily technical oriented;

The second series of guiding steps refers to a flow of activities which, if followed as required, lead to the development of a cost-effective system, supported by a structured architecture design, and a subsystem design. The 17 steps are:

Step 01: **Requirements definition** – represent the starting point, and the information should come from the end user and/or customer who will benefit from the implementation of a system. Once agreed upon, these requirements become the scope which will remain unchanged, unless changes are requested and approved through official processes and documented as such. It should be pointed out in this case that although the business requirement is defined by the business representative who signs off the system, the technical requirement should be defined and signed off by a representative of the technical team.

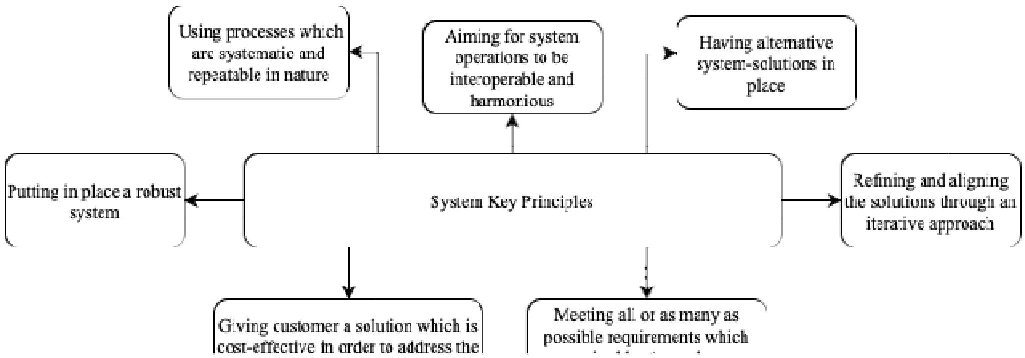

Figure 3: Eisner's System Key Principles (conceptual representation)

Step 02: **Project Plan** – is the document containing the statement of requirements which is usually developed by the Project Manager persona assigned to oversee the work. Depending on the organisational structure and team assigned for the project, the project Manager can work with other stakeholders to develop the Project Plan.

Step 03: **Functional Design of Alternatives** – consists of the architectural design belonging to the system which is operational at a basic level such as: the criteria based on which the system will distinguish components (e.g., hardware, software, work orders, etc.). Depending on the project in scope for development, these alternatives could lead to either a high or a low system performance.

Step 04: **Analysis of Alternatives** - after the alternatives mentioned din Step 03 are designed, each alternative item needs to be evaluated based on the agreed criteria (e.g., cost, customer satisfaction with developed requirement, component performance within the overarching system, etc.) By carrying out such analysis, the project team will have the possibility to evaluate, both from a qualitative, and a quantitative viewpoint the attributes of each alternative component. Again, depending on the defined requirements, one or more alternatives can be taken into consideration for the final project.

Step 05: **Evaluation Criteria** – refers to the analysis of the selected criteria from Step 04 against the criteria defined as part of the requirements of the project (e.g., interoperability, growth capacity, acceptable risks, etc.). Before this kind of evaluation can take place, a framework for evaluation is developed and agreed upfront.

Step 06: **Preferred System Architecture** – represents the selection of the system which, after all the previous analysis and evaluations, is deemed to be the most cost-effective for the project scope.

Step 07: **Accepted Requirements?** - although it is implied that decisions are requested and made in previous steps, this action is required in order to guarantee that the system architecture selected at Step 06 is the one that meets all the requirements requested during the initial planning (Step 01). Should there be even one item which is does not fit the criteria, the process will be rolled back, and other alternatives will be considered. Should all the requirements fit the agreed criteria, then the deliverable(s) can move to the next step.

Step 08: **Subsystem Design** – by this point, it becomes clear how the system architecture will look like, so it will become possible to move to the next phase, that of designing the subsystem. Depending on the project, the subsystems can include elements such as: hardware, software, and/or work orders. In some cases, it is also preferred that subsystems be classified and structured in units which are called configuration items, components, or any other notion that distinguishes them as smaller deliverables.

Step 09: **Analysis of Alternatives** – this can be seen as a replication of the activities from Step 4, but at a smaller scale.

Step 10: **Trade-Off Studies** – again, depending on the available alternatives, decisions can be taken in order to choose the best sub-system components. Where applicable, an iterative loop can be used in order to make the most cost-efficient decision for the life-cycle of the project.

Step 11: **Preferred Subsystem Designs** – similar to Step 06, the preferred subsystem designs are evaluated and considered for implementation within the final project.

Step 12: **Accepted Requirements?** - consists of replication of activities from Step 07, at a subsystem level.

Step 13: **Subsystems/Build** - now that the subsystem elements are agreed, the construction of the system can begin, in alignment with the entire subsystem design. Depending on the project, the notion of build can refer to different activities undertaken to fulfil the hardware, software, or work order requirements.

Step 14: **Subsystems/Build Integration –** once a configuration item is built, the next expected step is to integrate the smaller component into the overarching structure.

Step 15: **Subsystems/Build Test –**as the name says, each deliverable needs to go through a series of tests in order to determine the integrity of the deliverable and it alignment with the previously agreed requirements.

Step 16: **System Test and Evaluation** – this refers to the final evaluation and testing that it meets both business and technical requirements, and it can also include an end-to-end final check of the entire system deliverable before it is handed over into operations.

Step 17: **Cost-Effective System** - after all the previous steps have been carried out, the requester can benefit from a cost-effective system. [12]

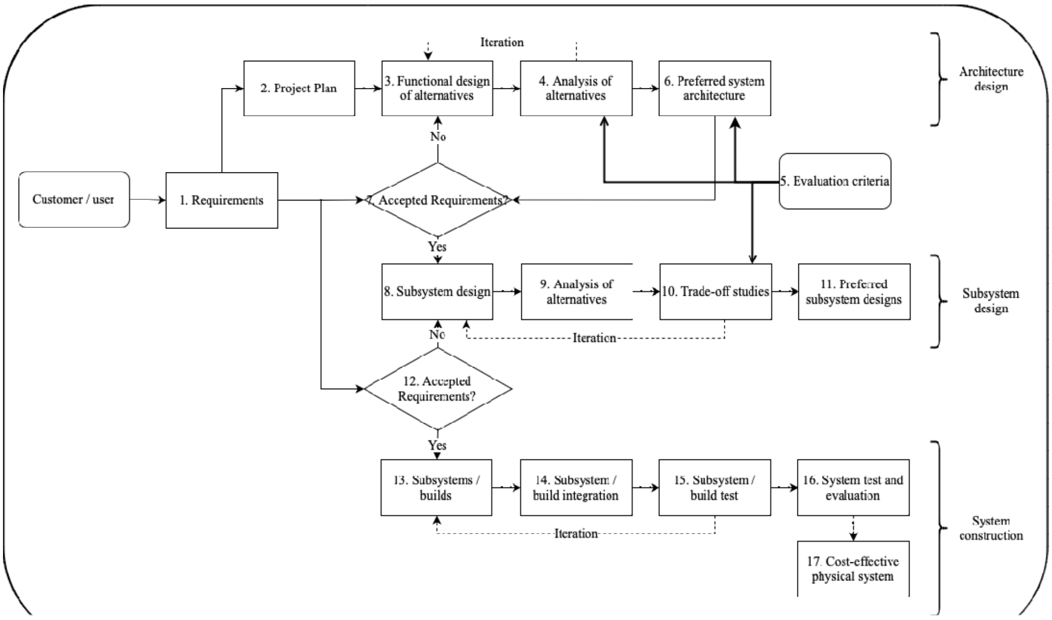

Figure 4: Eisner's activity flow for a cost-effective system
(Adapted from Essentials of Project and Systems Engineering Management, 2011, p.20)

FINDINGS

To get a better understanding of how international standards such as ISO, IEC, and IEEE are recommended to be adapted in organisational management systems, a systematic literature review has been performed and two major works were selected for an in-depth review. The selection was based firstly on the conceptual similarities and secondly based on the high-level applicability of the model to modern organisational structures. As the deep dive in these two examples has shown, adapting standards in modern organisational systems benefits from a robust academic literature availability. The review of these examples can lead to increased value for organisations seeking to enhance their performance record, enhance effectiveness of its processes, and/or drive efficiency across the organisation.

As Eisner's shows, there tends to be a more top-down approach, with iterative steps built-in. As in the case of Blanchard and Blyler's approach, the resources required for such an implementation depend on the low-level details of the organisation and its processes impacted by them.

Also, by comparing the two approaches from a customer point of view, the available information indicates that a simplified and iterative approach, such as the one proposed by Blanchard and Blyler, could be the winning combination to identifying the needs of the customer early on, and addressing any misunderstanding or adaptations along the way, without the need for much rework. On the other hand, Eisner's approach would indicate that a change in requirements or needs could in fact be more costly than presented.

While each author or group of authors has their own advantages and disadvantages to the theoretical models proposed, it should be pointed out that they provide insights into the applicability of management systems, which are applicable in real-life cases. The success lies with the organisation's capacity for adapting and adopting the method, in line with the business landscape trends.

CONCLUSIONS

This paper investigated and provided theoretical findings on international standard adaptations (ISO/IEC/IEEE) in organisational management systems. Through this theoretical literature review on international standards ISO/IEC/IEEE 15.288:2015 and the series of examples in which standards have been adapted in modern literature to meet the needs of organisational structures, this paper has contributed to a better understanding of the theoretical component adaptations into models which can be replicated within a variety of industries and at different levels of the organisation. This paper can also serve as a basis for a future research paper on systems mapping within organisational structure and dependency mapping between organisational structures which adopt the models. This said, the limitations concern the dimensions of management systems where these models are adopted.

The notion of system engineering management continues to evolve as a complex and interdisciplinary field that focuses on a structured approach in order to answer the demanding need of managing complex systems across their entire life cycle. Authors and organisations alike have come to develop and build ideas in the concept of SEM based on the needs of their customers and organisational structures. As the works of Blanchard & Blyler vs Eisner show the approach to implementing and monitoring a system engineering management structure is subject to heavy personalisation, despite the international-agreed standards in place.

Looking at Blanchard and Blyler's approach on management systems, it can be noticed that the authors place an emphasis on the need for having a continuous improvement process. Moreover, this process is expected to be submitted to loops of review and adaptation, presumably in line with the everchanging environment of the organisation. Depending on the process to which it is applied, and the size of the organisation, such processes can take shorter or longer times to implement end-to-end and by the time that a cycle of iterations is completed, the environment in which organisations do business can change entirely, as well as its organisational contributors, managerial and individual contributor staff.

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