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EMPOWERING USERS TO MODEL AND DEPLOY PROCESS-ENGINEERING-BASED: AN O&G COMMISSIONING SYSTEM USE CASE

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Oil and Gas industrial plants commissioning processes are vital to assure quality and safety performance and also to allow fast operation and financial results. However, the on-site procedures of inspection and tests are mostly still managed by conventional ways paper-work-based. However, although some applications based on information technologies have already started to bring digital solutions to the field (e.g., tablets and PDF files), that is not enough. Lacking interoperability and the use of proprietary closed software systems are persisting issues that inhibit process-oriented management. Based on that, CERTI Foundation, a Centers of Reference in Innovative Technologies and an O&G Company from South America, deployed a research and technological development project to implement a solution that allows middle-users to model and deploy commissioning process-task-based. The project aimed to develop a web-based system with a mobile application interface that can implement commissioning procedures (e.g., inspections and tests) customised by engineers (middle-users) to be deployed on-site. Workers and inspectors can receive and record on mobile devices the tasks information. This work presents the solution concepts and the practical results surveyed during the development. The conclusions highlight how important it is to empower users to customise and deploy process-oriented tasks to achieve better results.

Keywords: Oil and Gas commissioning; process management; IDM information delivery manual; BPMN business process modelling notation; process-oriented-system.

CAPACITAR A LOS USUARIOS PARA MODELAR E IMPLANTAR PROCESOS: UN CASO DE USO DEL SISTEMA DE COMISIONAMIENTO DE O&G

Los procesos de comisionamiento de plantas industriales de petróleo y gas (O&G) son vitales para garantizar calidad y seguridad en la ejecución. Sin embargo, los procedimientos de inspección y pruebas en las plantas son, en su mayoría, gestionados usando métodos convencionales. Sin embargo, aunque algunas aplicaciones basadas en tecnologías de la información ya han comenzado a traer soluciones digitales al campo, esto no es suficiente. La falta de interoperabilidad y el uso de sistemas de software cerrados propietarios son cuestiones persistentes que inhiben la gestión orientada a procesos. Basado en este contexto, la Fundação CERTI y una empresa de O&G de América del Sur, desarrolló un proyecto que permite a los usuarios intermedios modelar e implementar procesos de comisionamiento basados en tareas. Para esto fue desarrollado un sistema web y una aplicación móvil que permiten realizar procesos de comisionamiento personalizados por ingenieros para su ejecución. Los trabajadores pueden recibir y registrar en dispositivos móviles la información de las tareas. Este trabajo presenta los conceptos de solución y los resultados prácticos obtenidos durante el desarrollo. Las conclusiones destacan la importancia de capacitar a los usuarios para que personalicen e implementen tareas orientadas a procesos para lograr mejores resultados.

Palabras clave: Comisionamiento de Petróleo y Gas; gestión de proceso; manual de entrega de informaciones IDM; notación de modelado de procesos de negocio BPMN; sistema orientado a procesos.

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1. Introduction

Brazil has abundant oil reserves (IBP, 2019), where Oil and Gas (O&G) projects have substantial budget investments, multiple interfaces, and complex engineering endeavours (Badiru & Osisanya, 2013). Oil and Gas industrial plants commissioning processes are vital to assure quality and safety performance and allow fast operation and financial results. The on-site commissioning of industrial plants involves testing all equipment and systems installed to evaluate performance, ensuring final compliance (Arnold, 2017). However, the on-site procedures of inspection and tests are mostly still managed by conventional ways paper-work-based. The commissioning operations' digitalisation provides digital data traceability (Jain et al., 2010) and increases on-site performance (Lu et al., 2019). Given the relevance of these activities, it is vital to invest in improving and digitising on-site commissioning procedures.

Once O&G industrial plants assembly is consolidated, and before operations, a detailed commissioning process is mandatory (Wanasinghe et al., 2020) to guarantee assets' tests and preservation and documentation database update (ASHRAE Handbook, 2011). While some authors can separate activities into pre-commissioning and commissioning, others consider commissioning a unique phase that falls within the pre-operation and construction phases (Bendiksen & Young, 2005; David Horsley, 1998). The commissioning information management success is connected to integrating and managing information through systems and databases. The O&G company over study uses three basic activities over the commissioning process:

- Commissionable tagged items – Assets previously identified with a vital function over the industrial plant process.
- Systems Mesh verification – Interconnected set of commissionable assets that compose a system-mesh often correlated to a plant piece of processing (e.g., gas injection system, cooling water system).
- Preservation - Cyclical activities aim to preserve the best conditions and functioning of the industrial plant assets.

The industry has gradually realised that a good communication environment can reduce costs and improve operation and maintenance efficiency (Lu et al., 2019). Most likely, the primary commissioning systems available are linked by a massive connection database structure created by someone with no understanding of what the users require (Bendiksen & Young, 2005). Increasing communication and collaboration processes between expert teams can improve the effectiveness of asset procurement and just-in-time delivery of goods (Nascimento et al., 2018). Good communication occurs when a shared understanding of information processes between the communicator and the target is adequate (Badiru & Osisanya, 2013). Finally, implementing process changes is challenging and should focus on simple and user-friendly interfaces (Bendiksen & Young, 2005).

Poor data management can significantly threaten project performance (Bendiksen & Young, 2005). For O&G projects, information management is crucial and directly impacts project quality assurance (Samie, 2016). In a non-automated process, paper documentation assigned forms will prove the procedure execution. The information generated during the commissioning process must be harmonised and correspond to the project requirements (Samie, 2016). Often, last moment data collection and reports preparation to deliver to clients' impact project performance. Also, periodic reports are vital for the commissioning execution as the engineers' teams can exchange information about the project's progress identifying possible bottlenecks (Bendiksen & Young, 2005). Therefore, a commissioning system should fully visualise the processes and enable communication between those involved. Innovation and processes can bring several benefits to the industry, such as increased efficiency, reduced costs and production time and improved process quality (Radnejad & Vredenburg,

2019). The digitalisation process should focus on human-centric digital transformation (Wanasinghe et al., 2021). Companies that master advanced automation and flexibilization in technology implementation can gain a competitive advantage (Frank et al., 2019).

Based on that, an O&G Company from Brazil and the CERTI Foundation (Centers of Reference in Innovative Technologies) deployed a research project to implement a solution that allows middle-users to model and deploy commissioning process-task-based. The project aimed to develop a web-based system with a mobile application interface that can implement commissioning procedures (e.g., inspections and tests) customised by engineers (middle-users) to be deployed on-site. Workers and inspectors can receive and record on mobile devices the tasks information.

This work identifies the status quo and allows the understanding of detailed commissioning specifications concerning stakeholders, processes, systems, and information. The commissioning processes' map will be presented following the BPMN notation (Abdirad & Dossick, 2020; Barontini et al., 2021; Patacas et al., 2020; Sharafat et al., 2021; Tsai & Hsieh, 2016; Tu et al., 2018). The primary outcome is the digitalisation of mainly manual commissioning procedures. The research novelty is regarding deploying the digitalisation of commissioning procedures using a process-engineering-based approach that increases usability by providing a tailor-made tool. The topic has limited applied research in the scientific field, and this paper contributes to enhancing future works. The contribution of significance to the O&G sector is boosting industrial installations' quality assurance, safety, and productivity. Finally, this research's main objectives are:

- Presents the current commissioning procedures process.
- Presents the new commissioning procedures process.
- Highlight the solution novelty of empowering users to model and deploy process-engineering-based.

2. O&G Commissioning Procedures - Use Case

2.1 Current process diagnosis

The case study starts with the company process diagnosis. First, meetings were held with the O&G company commissioning managers team to understand their most prominent issues. Then, having defined the priorities, the act of collecting requirements and mapping the current process began. For this, it was carried out:

- Meetings with the management team to understand the current process.
- Interviews with workers involved in the daily activities.
- Study of documents related to the commissioning procedures.
- Use and testing of existing software.
- Mapping of item verification, mesh verification and preservation procedures.
- Meetings/focus groups for validation of mapping flowcharts performed.

The diagnosis process was extensive and allowed a deep understanding of the status quo. It was possible to identify recurring errors and bottlenecks in the systems and opportunities for improvements. During this stage, we went into many details about each part of the commissioning procedures, the difficulties encountered in the day to day of the on-site workers and pieces that seem small but directly impact the quality and efficiency of entire processes. It is possible to highlight that the commissioning staff was excited about the digital process

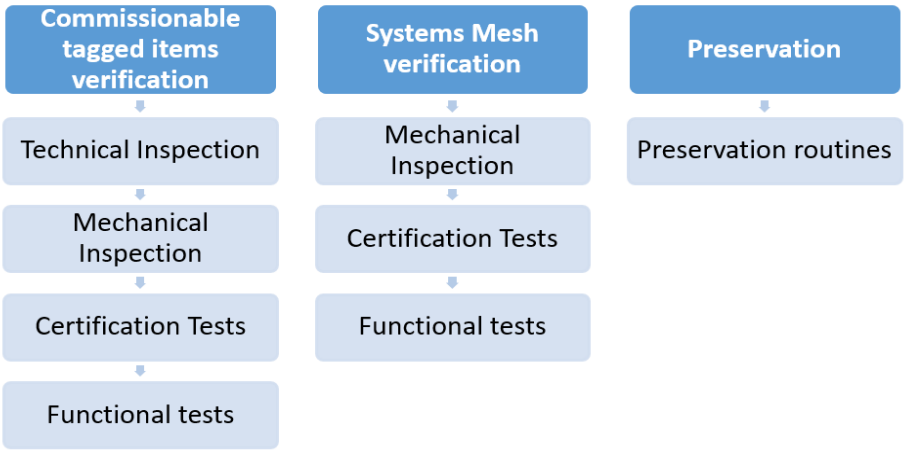
concept since the beginning of the development. Due to this, they have always been participative in the solution design with explanations, clarifications, and ideas.

The commissioning procedures and details of the system will be explained below. But in general, it was diagnosed that the current process works but that it has several steps that happen on paper bases that end up blocking and delaying the process, not to mention the possible loss of documentation and information. Most importantly, the commissioning procedures suffer from significant restrictions due to the inflexibility of the software, as it was developed years ago and did not allow changes in the processes to be deployed on-site.

2.2 Current process analysis

The O&G company commissioning procedures studied and explained below are performed in a database software system paper-oriented. The system works fixedly based on a flow developed years ago. The system is restricted and does not allow tool changes or process updates. As stated before, the commissioning process concerns three main procedures; each one has its main steps, as exhibited in Figure 1.

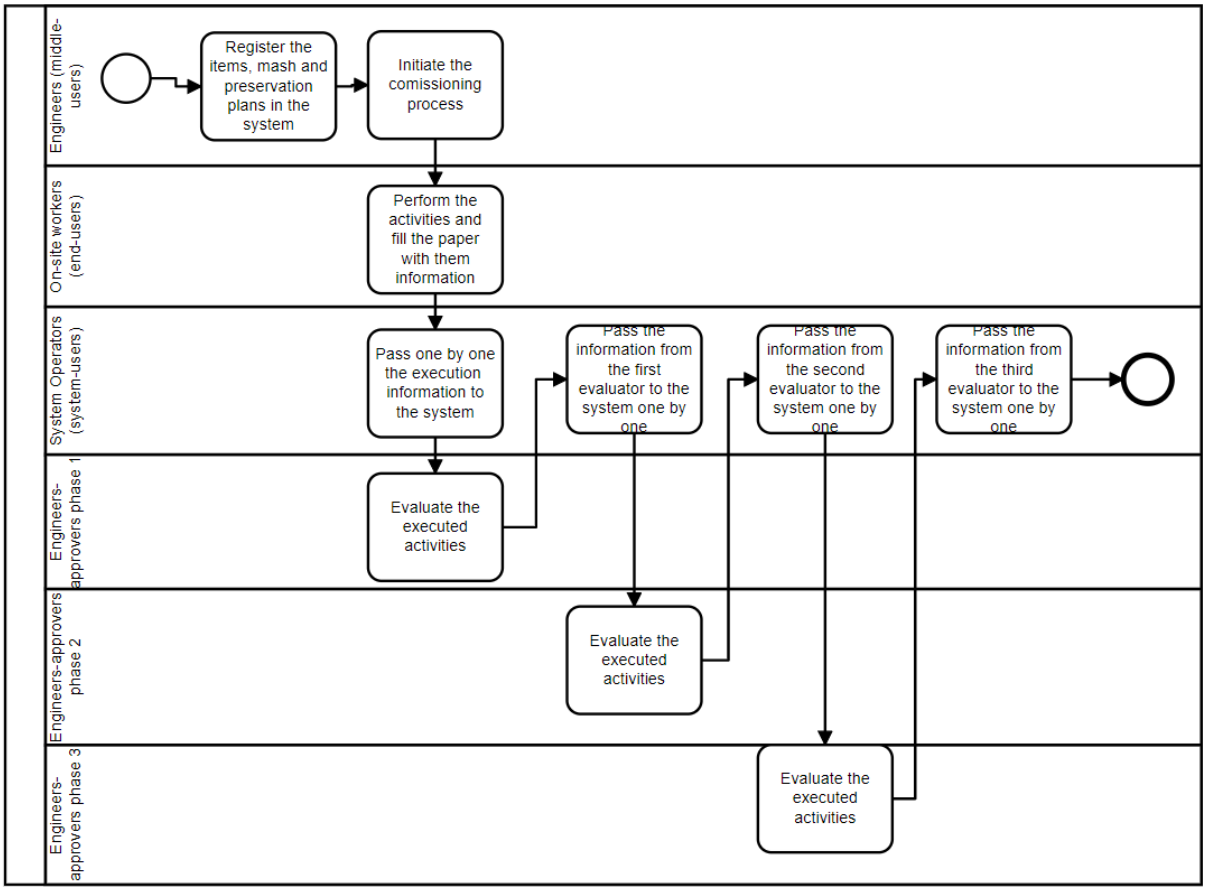
Figure 1: Commissioning activities



There is an extensive control process for all steps in items and mesh verification to ensure that the execution activities were carried out correctly and that all procedure information is passed to the system. It is essential to highlight that for each tagged item and mesh, there are several subcategories, separated by classes and disciplines, where each one has different tasks to be performed. There is no difference in the process flow before them in the current system. The procedure that is done for a valve and a pump is the same at the software level and cannot be altered or adapted. Figure 2 represents the current process mapped.

It is possible to note the large number of phases involved. Also, it is possible to see that there are three evaluation steps. During the mapping process, it was reported that having all of them on every item is repetitive and exhausting and not valuable. Also, sometimes it was a job by the same person; that is, there was no direct impact on the quality of execution as the information was only filled in for the software to allow the flow to proceed to the next step.

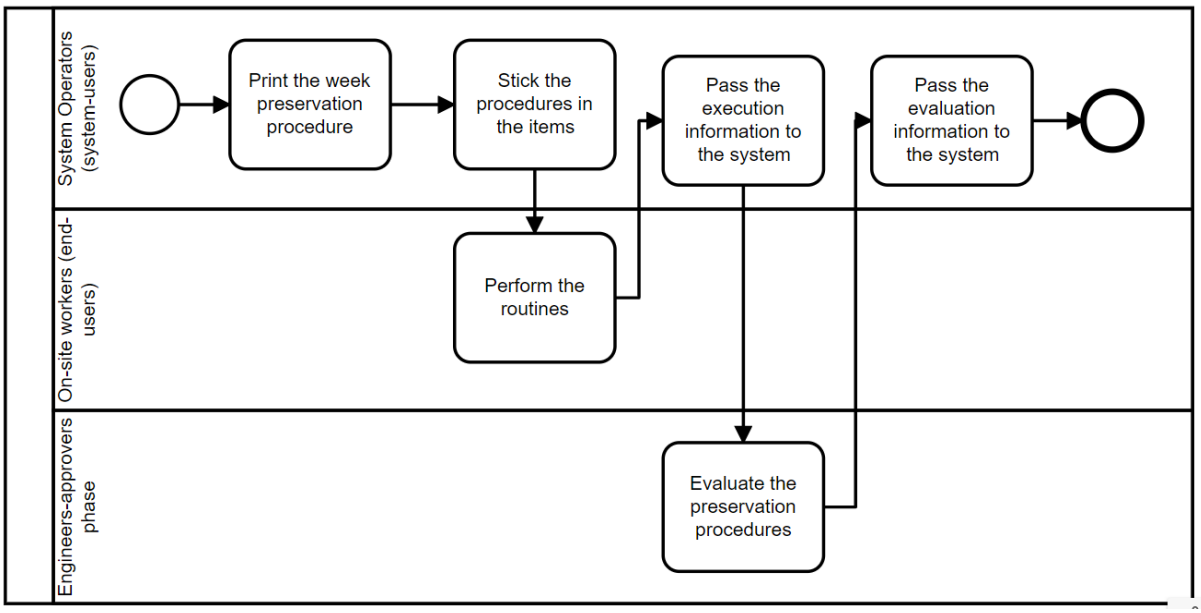
Figure 2: Current items and mesh verification procedures mapped



The preservation process is performed for all tagged items parallel to the items and mesh verification. During all commissioning processes, it should be done to ensure that all items will be installed according to the client's requirements. Figure 3 generically presents the preservation flow mapped.

Currently, there is a weekly liberation of a preservation plan. Every week, the system will release the preservation routines previewed for that week. Also, it will remove the delayed routines and the ones that were previously disapproved. As a result, occasionally, there are a lot of the same routines in the queue, which causes confusion, delays, and decreased execution quality, as they can be done in a hurry to fulfil the system requirements.

Figure 3: Current preservation procedures mapped



2.3 New solution process-engineering-based

As identified, the main bottleneck was related to fixed processes and manual (paper-work-based) commissioning activities, instructions, and reports. Based on that, the new process designed targets eliminate all paper-related steps and promote the execution of commissioning procedures routines tailor-made. That concept will increase quality assurance where the company engineering team is now in charge of modelling the procedure flows and checking the field procedures execution.

As the process is dynamic, it is possible to add to the process as many approval steps as they want to assure that the correct information is uploaded. So, if one activity is refused, it will return to the on-site workers with the appropriate guidelines for correction. And until the evaluator disapproves, the activity does not follow the flow. The new processes facilitated and eliminated users' work increasing efficiency. The following steps demonstrate the new approach:

- Engineers (middle-users): To log in to the web application to design a commissioning procedure using standardised processes or model new ones.
- On-site workers (end-users): To log in to the mobile application and identify the procedures to be conducted. To perform and report the activities execution concerning the items verification, system mesh verification and preservation.
- Engineers (middle-users): Receive the procedures completion alerts and directly in mobile or web applications perform the approval or not.

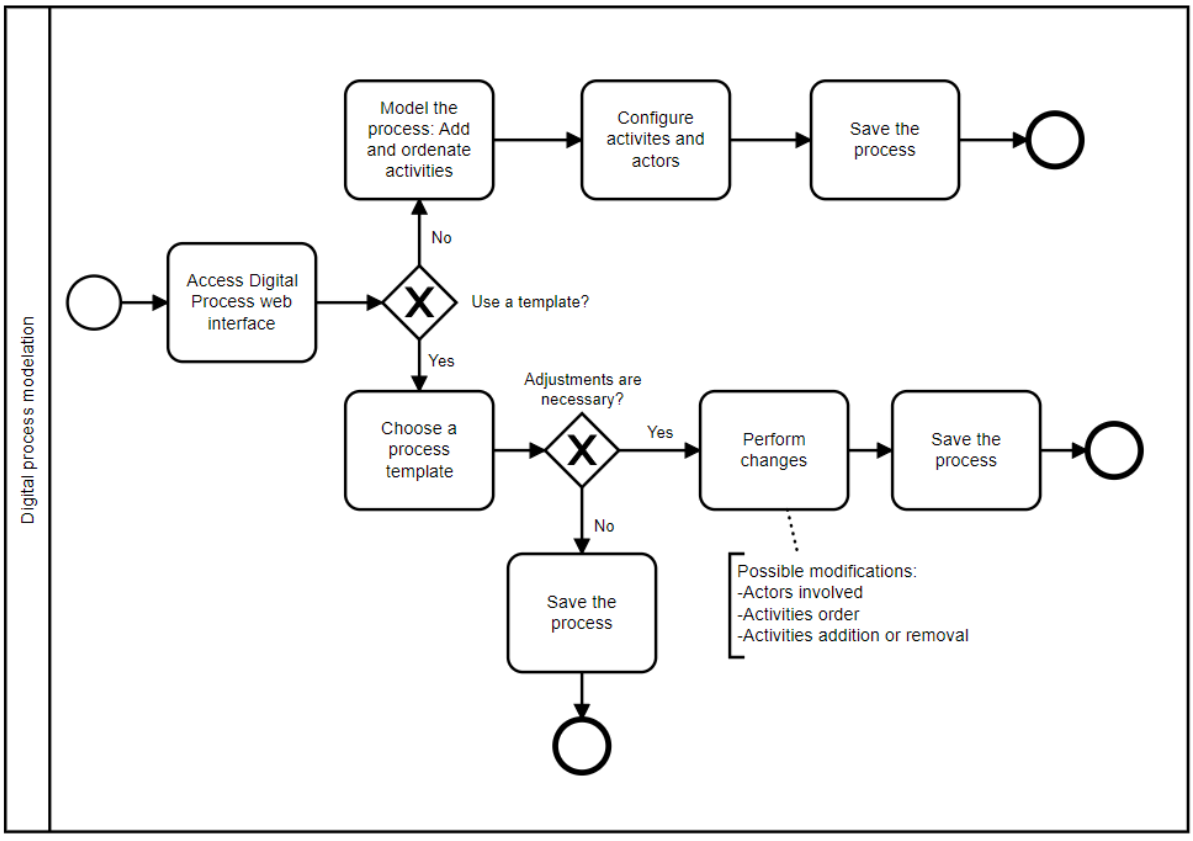
With the newly designed flow, there is no longer a need for a dedicated System Operator as Managers can quickly check the data loaded and the activities performed. In addition, managers can adapt the procedure's workflow through the system to meet new demands. The software will have continuous improvement incorporated since it is possible to analyse the

newly designed workflows and implement improvements in the procedures. This dynamic digital process allows three main actions:

- Create the process structure (template).
- Instantiate the process.
- Run and manage activities execution.

Figure 4 represents a process diagram of the first item, creating digital processes in commissioning projects. First, the user starts accessing the web interface of the digital process. Then he chooses to create a new process or use a template. If he decides to use a process template, he will select the one that best suits his needs, if necessary, and save the process. If he chooses to model the process from scratch, he will go to the BPMN process modeller interface and start modelling the process according to his needs. After each interaction, the procedure processes will be configured, selecting operators that aggregate all activities as part of a commissioning procedure.

Figure 4: New commissioning system process



It is important to note that the process will not have an activity for approval as it currently exists. When the middle-user chooses the actors, he will choose which ones will participate in each commissioning procedure. With this, within the task, he will decide if it will only have the execution of the procedure or will have the approval process as well. If the action needs it, the actors will choose how many and which ones will define this approval flow. Figure 5 demonstrates the use case for the digital process, showing in more detail the actions that the middle-users (engineers) can take:

- Create a process template.
- Add or remove a step/activity in an existing process.
- Change activities orders.
- Choose activities type (manual, service, script, etc.).
- Add actors or change the ones that are already inputted.
- Change the actor's order.

Figure 5: Engineers (middle-users) process creation - use case

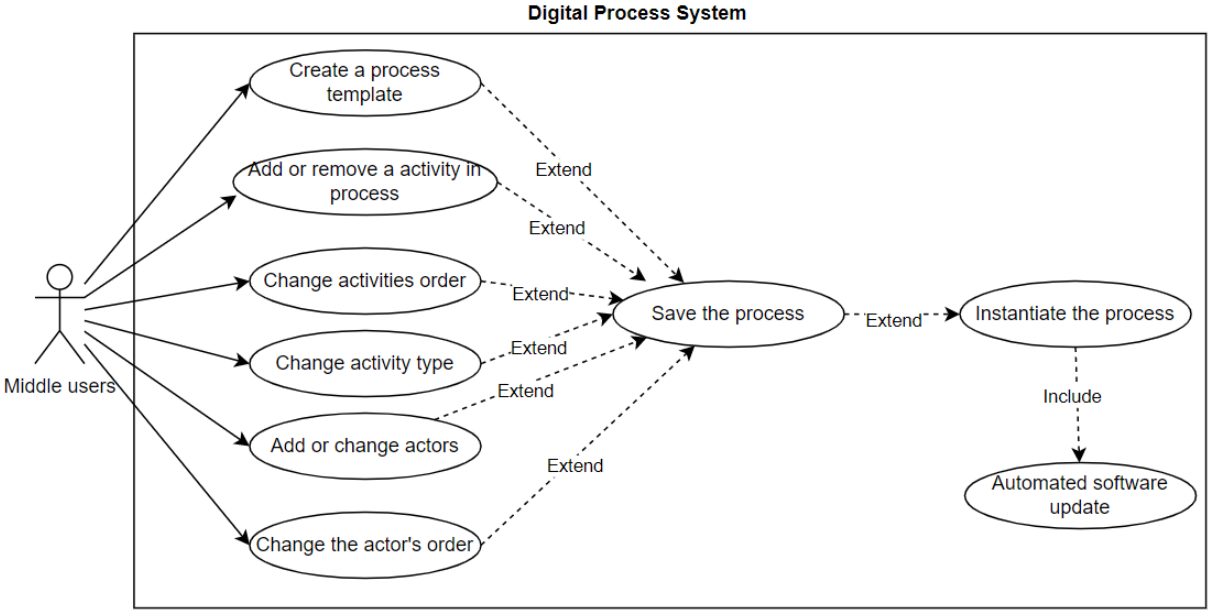
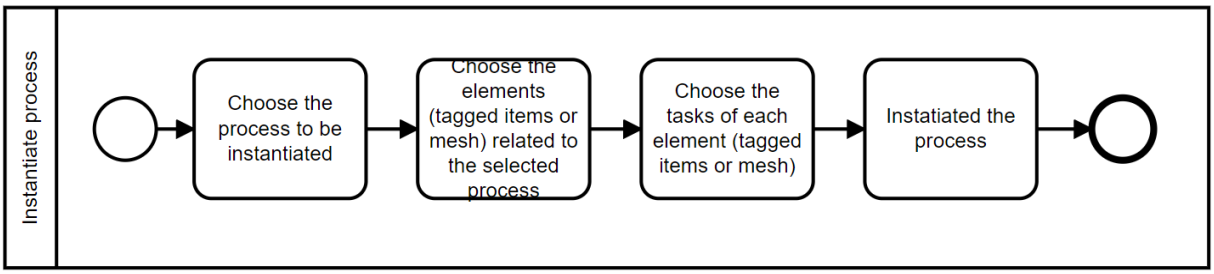


Figure 6 demonstrates the instantiation process. Instantiating a process means applying the template to a commissioned asset. When the process is instantiated, the intermediate user must enter checked items or meshes referenced to that process. The user must choose which tasks will be related to each element in the sequence. Finally, the user can instantiate the process and start executing the commissioning procedure. When the process is instantiated, the software will automatically adapt to be able to apply the procedures to each of the commissioned items and actors and finally run the process.

As explained earlier, it is possible to link the digital process to any asset, in this case, any commissioned item. However, the system allows the process to be linked to anything with an identification code, such as a system, subsystem, or area. As a result, the system can be adapted to any business that goes through the commissioning process by changing just a few settings.

The dynamism of the process also ensures that information is entered into the system as different approval steps are added. Another positive aspect is that any other factor will be necessary for the knowledge of software development to make the desired changes in the flow. The user with the process adjustment can adapt the process to their needs. Furthermore, with the possibility to model and see the flow directly in BPMN notation, it is easier for users to find bottlenecks and process improvements.

Figure 6: Engineers (middle-users) process instantiate flow



3. Conclusions

The current commissioning procedures process presented allowed to demonstrate the status quo and the necessity of changes. On the other hand, the new commissioning procedures process designed displayed the new solution targets. Finally, it is possible to highlight how important it is to empower users to customise and deploy process-oriented tasks to achieve better results. Since the beginning of the project, the company's team felt engaged and motivated because they were responsible for designing the commissioning rules and creating the processes. Engineers (middle-users) in the role of modelling the commissioning procedures can customise the flow of the tasks approvement concerning the unique reality of systems and contractors. Engineers (middle-users) give positive feedback that the opportunity to mix actor roles increase workforce awareness avoiding standardised uses and customs. The reuse of previously created processes allows the application of lessons learned. It is also possible to envisage that other systems such as quality control and assets procurement can also apply process-engineering-based approaches.

3.1 Limitations

It stands out as a limitation that the system is currently still in the initial implementation and testing phase. The first reports about the solution's performance only reflect the view of the managers of the commissioning of the O&G company. Complete and current use and a broader survey with all stakeholders will bring greater feedback and opportunity for improvements in the system

3.2 Future Lines

New tools using artificial intelligence could support better decision making. Further research directions will focus on machine learning to interpret the development patterns and success of new processes able to introduce best practices to users.

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Communication aligned with the Sustainable Development Objectives