Basic mapping of the inspection process in offshore oil production facilities

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***Abstract*— The paper addresses the current practice for inspection processes of offshore O&G production facilities in Brazil in order to evaluate opportunities for process improvement. The inspection process consists into monitoring the operational conditions of the submersed facilities preventing and correcting failures and avoiding accidents. The mapping activities include the understanding of how the current inspection process is carried out under the different operating conditions for the various platform facilities developing a general model suitable in any operating conditions. The resulting map of the activities was then analyzed by a team of experts from de academy and from the industry to take into account the current risk management procedures associated to the inspection process. This paper is a continuation of a research entitled "Challenges for the inspection of Pre-Salt ultra-deep offshore production facilities" presented at the OCEANS 14 conference, at St. Johns, 2014. An operational scenario where inspection process currently takes place in offshore facilities, the catodic inspection, is studied and analyzed. This typical scenario was selected and mapped out using a specific mapping technique based on the integration definition method for process mapping. After that, the scenario was documented as specific inspection processes, with details of each major activity in terms of input, output, controls and mechanisms being used, as well as a list of potential improvement points. The potential improvements were organized according to their priorities taking into account the benefits versus costs. So, the result of this research is a map of the inspection scenario analyzed, documented and evaluated. The results include a description of the identified points of improvement and the assessment of their potential impacts. As the O&G industry is requiring a continuous effort for operational process improvement, this research represents a contribution toward a standard of excellence in terms of technological, operational, people and management processes. The research results are also relevant for the industry because there are a limited number of research initiatives being carried out on this subject in Brazil. The Brazilian O&G industry is developing efforts to improve its inspection processes, with particular focus on standardization and alignment with the international best practices.**

***Keywords— Mapping; inspection; O&G; ROV; offshore; IDEF0*.**

I. Introduction

This paper addresses the improvement of inspection processes of offshore O&G platforms. The inspection process involves the evaluation of the operational conditions of the oil platforms facilities and the study of the causes of their accidents and failures, aiming the implementation of mitigation measures, if necessary [7]. Besides that, the inspection of underwater facilities is primordial as data source to the industry, since it provides information and helps developing material to the oil and gas segment against the adversities experienced in the offshore O&G fields. The request for inspection activities is increasing in Brazil, due to the fact that both the Pre-salt layer itself and the adverse conditions of its environment amplify the procedure's risks [2].

Nowadays, although there are plenty of materials used in the production of hydrocarbon, the steel is the most common. Nonetheless, the steel suffers a natural deterioration process: the corrosion, which occurs when a metal is in contact with slightly acidic (or basic) water containing some dissolved oxygen. The oxygen at the edges of the ore surface is reduced by electrons donated by the ore over an area. In this way, the metal gets oxidized, leaving the solid state and becoming ionic (aqueous): $Me(s) \rightarrow Me^{+}(aq) + e^{-}(aq)$ [9]. Due to this, it is required the use of either anti-corrosion protection or others alternatives as the use of specific materials resistant to corrosion, and as well as the application of cathodic protection with or without a protective coating [2]. Those protective mechanisms must continually be tracked; after all they have a lifetime and are also subject to corrosion. In any kind of platforms, the cathodic inspection becomes mandatory to the monitoring of the natural deterioration suffered during the units' lifetime.

Currently, the inspection process is performed by Remotely Operated Vehicles (ROVs): unmanned submersible tethered vehicles. Tether is a cable that connects the vehicle to the surface, providing communication and/or power through a direct hardwire. Furthermore, the cathodic inspection is done by ROVs equipped with a Cathodic Potential Probe or CP-Probe. This probe measures the electric potential between the sacrificial anode cathodic protection and the grounded potential of the whole structure. Basically, the electrical circuit forms a huge battery with the voltage potential measured. This way, the deterioration of the cathodic protection is assessed and if necessary, actions of mitigation can be implemented [12]. An illustration of the cathodic inspection is shown in the

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Figure 1 and an example of a CP-Probe is shown in Figure 2:

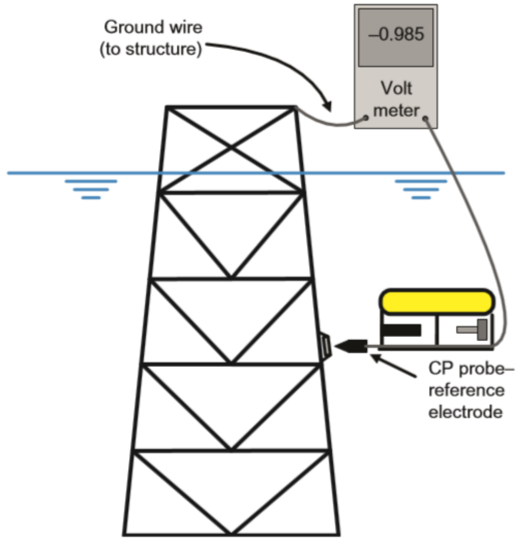


Figure 1: Measurement of the voltage potential through the cathodic inspection. Source: The ROV Manual: A User Guide for Remotely Operated Vehicles (2013)

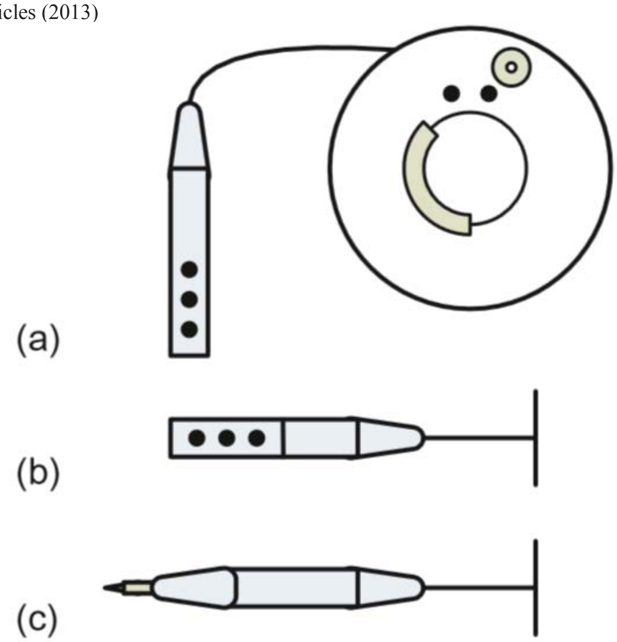


Figure 2: CP-Probes types. (a) Drop cell, (b) proximity probe, and (c) contact probe. Source: The ROV Manual: A User Guide for Remotely Operated Vehicles (2013)

This topic is relevant to the O&G Industry because an organization capable of visualizing and understanding its processes as they really occur will be able to easily control those processes and, therefore improve its result. In face of difficulties found in an oil and gas production unit, in order to improve its results and taking into account that the production unit itself looked forward to a strategic initiative of searching for the operational excellence in managing human and technological resources', mapping the processes turned out to be primordial having as a goal the quality improvement. Several of the organizations that nowadays reach high levels of performance in its management have once faced difficulties until they found a better way to manage, monitor and control their processes, obtaining, in the end, improvement and better results as well. The processes mapping becomes even more relevant for the business environment, especially in the oil and gas sector, because there are few studies on this theme, although it is straight connected to excellence in quality, productivity, and improvement and in conformity with quality management standards. Therefore, a study on the mapping of an oil platform's processes will cooperate to point out the need for investments in quality improvement and search for excellence in management [1].

Besides that, the process of inspections' optimization is an important subject to the oil industry itself and to the economy, on the whole, since the oil, because of its special features, requires the use of less capital and living labor in the process of its extraction, making available more net energy. Furthermore, energy analysis agencies and the energy industry itself don't assume the full (oil) energy replacement yet. They acknowledge the need to meet the growing demand for oil with new discovers, with the use of renewable and unconventional resources as a complement and with the energy efficiency encouragement, though [10].

The improvement of the inspection processes of O&G offshore platforms will be reached through the mapping of its processes using the 'Integration Definitions for Function Modeling' – IDEF0. It was developed in 1970 by the U.S. Air Force and consists in a method to map the processes and data that introduce an extreme organization in the flow of the information system. The method itself consists in a graphical representation of a set of linked steps or activities in which there is an input, an output, a mechanism and a control for each activity. In the IDEF0 Interface, the input is a set of data acted upon by the activity operation. The output is a set of data resulting from the activity operation. The mechanism is the set of tools that provide support to carry out the activity and the ones involved in the activity operation. And finally, the controls are a set of rules, standards and regulations of the activity operation. Each activity can be divided in as many lower-level diagrams as necessary or desired in order to cope with the need of required detailing. Figure 3 is a graphical representation of IDEF0 [4].

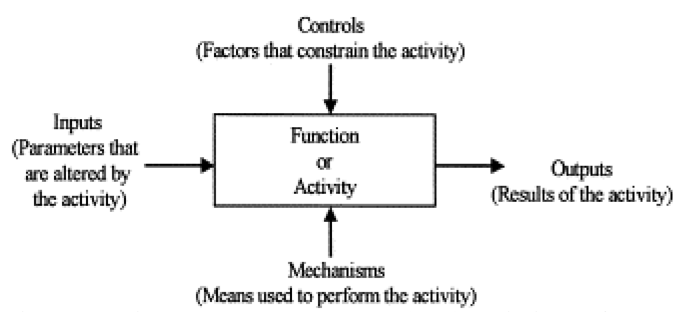


Figure 3: Basic IDEF0 Syntax 1. Source: (2002) Designing performance analysis and IDEF0 for enterprise modelling in BPR

II. Methods

The used methodology can be divided into the following topics:

- Bibliographic review and capacitation and empowerment of the authors to obtain the state-of-art
- Meetings with experts in the area in order to validate the researches in progress
- Development of a basic mapping of the inspection process based on the IDEF0 concepts of a process's data flow
- Identification of the challenges to the inspection process
- Develop suggestions for future improvements of the process.

The mapping has been done as follows:

- The development of a preliminary mapping based on the bibliographic review and informal conversations with experts
- Discussion on the created model with the experts
- Development of a final model

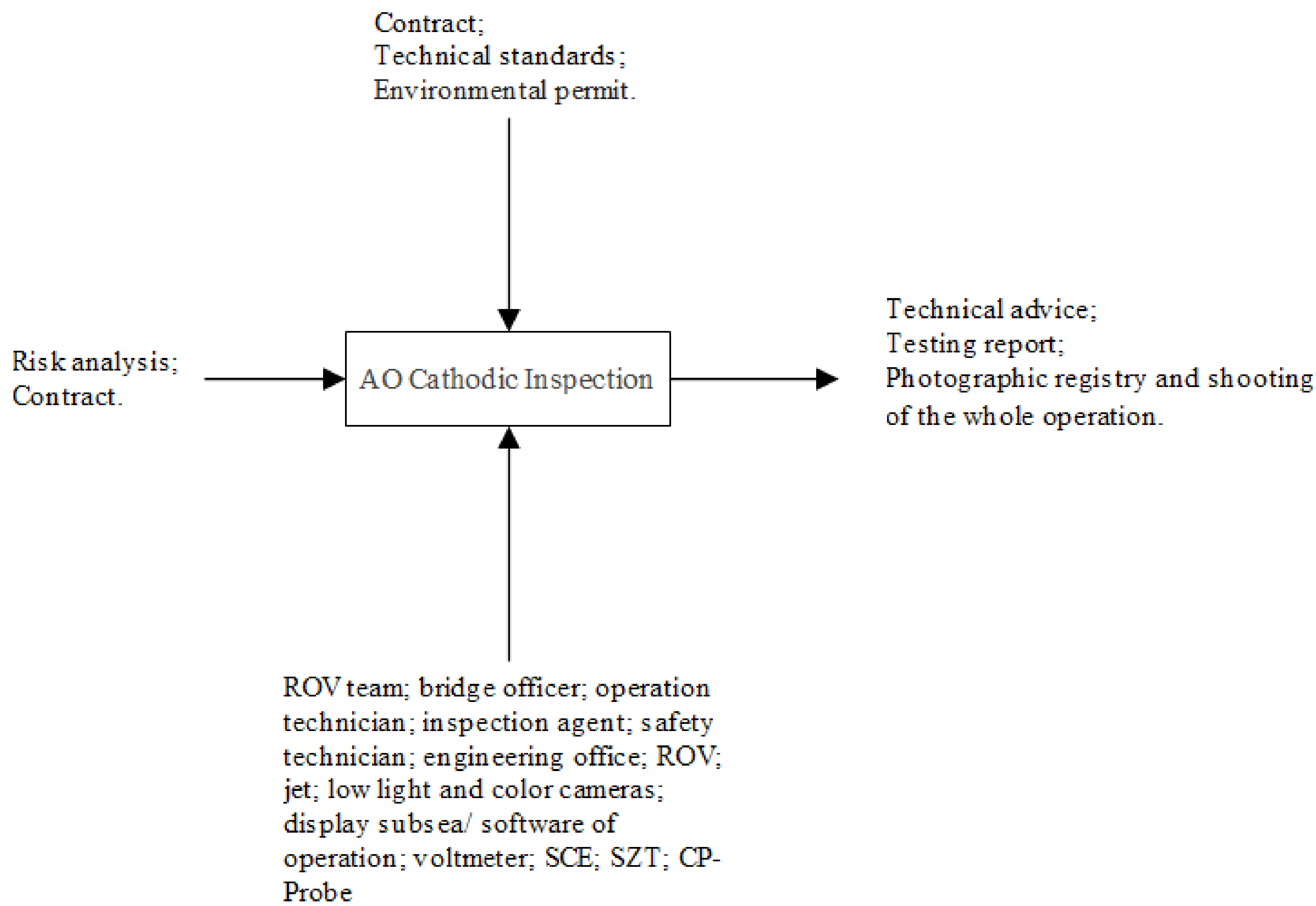
III. Results

The result of the present paper was the mapping of the cathodic inspection process. This mapping was done after a bibliographic review which indicated the cathodic inspection as one of the most common and relevant beyond equipment inspection activities. Furthermore, the mapping has been reached with support of the industry experts and the scientific community.

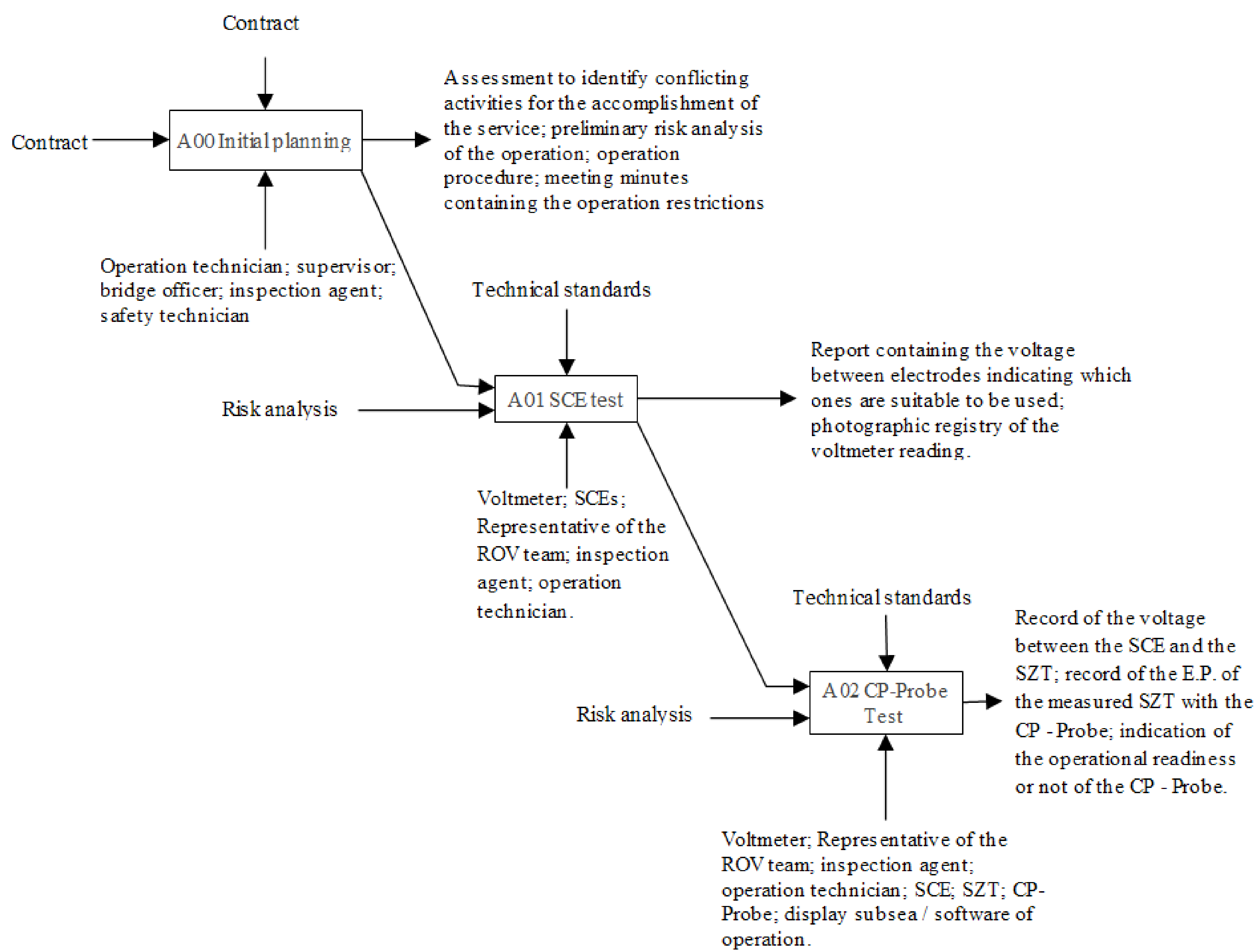
In order to have the full comprehension of the mapping, it is important to keep in mind the following definitions:

- Bridge Officer: the person in charge for the vessel.
- Operation Technician: the person in charge for the final report and for the operation.
- Inspection Agent: the representative of the contracting company of the inspection service.
- Supervisor: the person in charge for the operation and leader of the ROV team.
- Pilot: the person in charge for the conduction of ROV and member of the ROV team.
- SCE: Saturated calomel electrodes. It's a tool used to verify the calibration of the equipment used to measure the SCE: Saturated calomel electrodes. It's a tool used to verify the calibration of the equipment used to measure the Electrochemical potential
- EP – electrochemical potential
- SZT – Standard zinc (Zn) tablet – used as a reference for measuring.

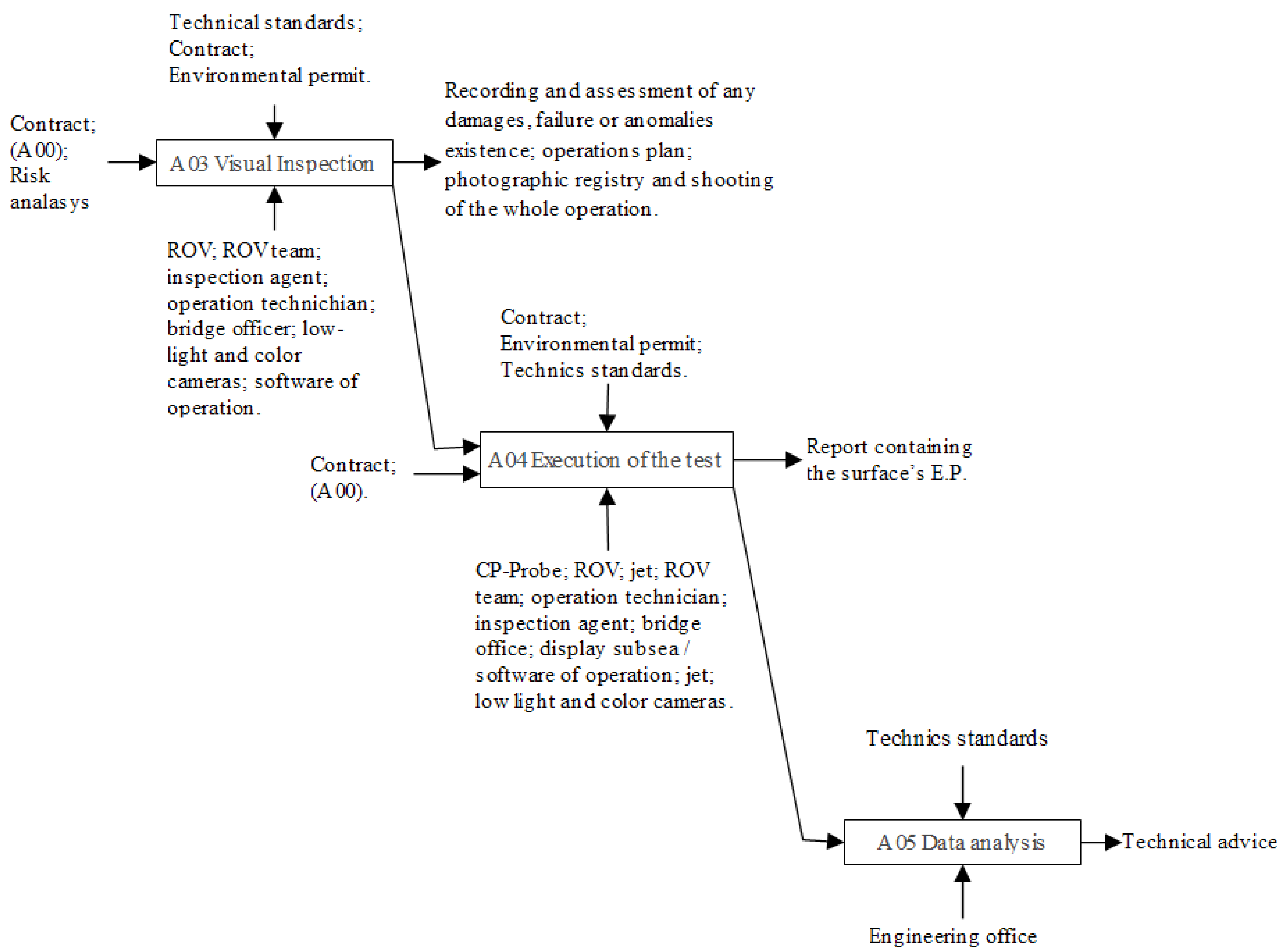
The mapping is shown in the next pages:



Activity A0 (AS-IS)



Activity A0 (AS-IS) subdivided from A01 to A05 (continuation in the next page)



Activity A0 (AS-IS) subdivided from A01 to A05 (continuation in the previous page)

Through the mapping it has been established that the inspection with CP- Probe is made due to a request made by the inspection agent responsible for this service monitoring. Then, a meeting is set with the technicians and others in charge of this service in order to plan the following operation. In cases of operations without much risk, this meeting becomes facultative. Subsequently, the equipment must be tested with exhaustive rigor to verify if they are operational. After that the ROV operator carries out a visual inspection of the structure they intend to inspect as a manner to plan the operation itself. Eventually, with the set of equipment tested and a planned operation, the test shall be conducted, getting as a result the structure's cathodic potential register.

After a wide research, the attendance in committee meetings and meetings with experts, we shall identify some points in which improvement is possible. These points are indicated in Table 1.

Table 1 –SUGGESTIONS OF IMPROVEMENT

Activity	Cost	Benefit	Priority
Replace in the contract the work time by IMCA competence	Low	Low	3
Qualification of the operator	Medium	High	1
Certification of the operator	Medium	Medium	2

The first suggestion of improvement involves the minimum working time experience that the current contracts require the ROV operators to have. It is suggested that an IMCA (International Marine Contractor Association) competence is required rather than minimum working time experience. After all, IMCA is an internationally recognized entity that comprises the necessary guidelines to measure the skills of the ROV professionals. Furthermore, working time experience does not necessarily mean competence. This change would be done at a very low cost, since it is just a matter of an adjustment in the agreement, besides the industry would earn a lot, ensuring highly qualified employees to the intended activity. However, this change wouldn't promote any higher gain or benefit, because although the working time experience does not mean competence, it is one of its indicators. As the benefit and the cost are low, the priority of this activity is 3.

The second suggestion is based on the fact that as indicated by the O&G experts, the ROV operators are being trained, but not qualified. Therefore, there is a huge demand for highly qualified professionals. The qualification would require a medium cost, after all the current courses and trainings shall be improved and new ones must be created. Nevertheless, the benefits would be high, since foolish errors would be avoided caused by lack of qualification as well as it would increase the supply of these professionals in the labor market in the coming years. Furthermore, according to the Brazilian "local content" regulation at minimum 60%-70% of the labors in the platform must be Brazilian. In this way, the qualification of the national workforce is extremely required. This suggestion requires medium cost, provides high benefits and so is number 1 in priority.

In the early years of offshore oil and gas production, the inspection service was done by divers and the depth was not superior to 30 meters. With the platforms being constructed in deeper waters, the use of these professionals was being made impossible, so that by the decade of 1980, most of the companies use ROVs. The last but not least suggestion is related to the operator's certification, since currently, in many contracts, it is mandatory a certificated professional to carry out the inspection procedure. Despite this, there is no certification for ROV operator in Brazil, only for diver. Therefore, many times the operator has to be a certified diver or a diver must be present together with the operator. It is a counterproductive waste, because in an offshore inspection at high depths, there is no need for a diver, since the ROV operator is responsible for all the work done. The certification will have a medium cost, taking into account that an institution as the ABENDI (Non-Destructive Testing Brazilian Association) will have to develop the certification. The benefit from this change is high, since the presence of a certificated diver won't be required any more, it will save money, and it will increase the number of qualified professionals. Therefore, this is a number 2 priority.

Finally, we have as a last result the development of an adequate infrastructure, the establishment of a laboratory in the campus of the Mining and Petroleum Engineering Department (PMI) of University of São Paulo's Polytechnic School (EPUSP), in the city of Santos.

IV. Discussion

From this resulting basic mapping, there can be acknowledged that the cathodic inspection procedure of the O&G offshore platforms is extremely complex. It is due to the large number of variables to be controlled and the high precision required. Therefore it is mandatory to follow the manuals and technical standards, since any error means very high financial costs. Furthermore, the contract mentions the whole operation; it specifies everything that is necessary in the operation, including the duration of the operation. The fact that there is no standardization on the part of the industry makes it much more complex. As each company makes the operation its way, it is much more difficult to come to an ideal standard for the procedure.

There could also be noticed that there are very few researches on the cathodic inspection procedure using ROV for O&G offshore platforms.

This whole complexity indicates how it is critical to develop an operating discipline of continuous improvement so improvement can be implemented and amended. In other words, to improve a procedure, the process has to be mapped, the problems have to be identified, and the suggestions of improvement must be evaluated implemented, so a new mapping is done and the cycle starts all over again.

There could also be identified many improving points (table 1). All these points are connected with improvement in professional qualification. There is also countless opportunities for technological and procedure improvement, though. The focus of these highlighted observed points indicates that qualification should currently be the priority of the area. This is due to the lack of specific qualification and certification for this procedure.

To briefly summarize, the mapping of processes is an important tool in order to improve the procedure itself. To accomplish this activity, a method that aims an extreme organization of the flow of information is the IDEF0. The bases to map a procedure are the national and international technical standards that govern a particular activity. After all this information is collected, the mapping lines up from conversations with experts. The inspection with CP- Probe, specifically, is a relevant process for the measuring of the electrochemical potential of the petroleum offshore platform's facilities, ensuring the maintenance of these facilities and increasing their lifetime as well. The mapping presented in this paper is the first step for the optimization of this process.

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