FLNG – Floating Liquefied Natural Gas

Critical Success Factors in a FLNG project

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ABSTRACT

Floating Liquefied Natural Gas (FLNG) platforms are a recent type of floating platform that has made it possible for the Oil and Gas companies to produce LNG in offshore stranded gas fields. However, like other offshore projects, the management of a FLNG project is a complex endeavour that operates in harsh environments and requires a large amount of capital investment. This complexity in other types of offshore projects have often led to their failure.

For this type of project, which often require innovative solutions, it is important for the management team to be aware of the factors that are critical to the success of the project. These factors are called the Critical Success Factors (CSF). The aim of this paper is to determine the CSF in a FLNG project.

The methodology involved three stages: (1) formulation of a hypothesis through literature review to establish the CSF for a project of this nature. The literature review focused on the CSF of megaprojects, in Oil and Gas projects and in LNG projects; (2) reformulation of the hypothesis by interviewing Oil and Gas industry experts with experience in project management; (3) testing the hypothesis using an online questionnaire aimed at experienced project managers in Oil and Gas projects, including FLNG projects, by grading the importance of each CSF. Thirty responses were received.

It was concluded that the four most relevant CSF in a FLNG project are: “Good project formulation”, “Project Team”, “Realistic project schedule” and “Monitoring and control in the execution phase”.

**Keywords:** Critical Success Factors (CSF), Floating Liquefied Natural Gas (FLNG), Liquefied Natural Gas (LNG), Oil & Gas, Project Management

INTRODUCTION

The world’s growing demand for energy has been one of the main themes of the day. Until recently this demand was mainly due to the economic growth of several emerging countries, such as China and India. However, the global demand for energy is expected to continue to increase in the coming decades. This demand has created a need to find more energy sources not only from the traditional fossil fuels but also from other sources such as renewable and nuclear sources (BP, 2018).

Natural gas has been one of the fastest growing energy sources in some areas of the world in the last two decades. Presently, the liquefied natural gas (LNG) industry is an industry that still requires large amounts of capital and involves supply chains with many players in long-term contracts. In addition, it is an industry that involves, with great attention, the governments of the countries where it is located and also many international companies (Tusiani & Shearer, 2007). Given the many problems and uncertainties surrounding LNG-related projects, some of them have never seen the light of day, resulting in large capital losses. Despite the problems, this industry has already proven that it is capable of changing economic and market environment situations and that it is an industry with almost zero safety incidents (Tusiani & Shearer, 2007). As already mentioned, the projections indicate that energy demand will increase significantly over the next 20 years and due to recent technological innovations, it appears that many LNG-related projects will become a reality (Tusiani & Shearer, 2007).

It is estimated that most of the natural gas reserves are either located in remote areas away from consumers, or the reservoirs are too small to build an economically viable pipeline. However, small-to-medium-sized reservoirs are now known where oil companies expect to take advantage of offshore LNG technology to produce natural gas from these reservoirs. It was from these assumptions that came the idea to design an offshore floating platform that could process, liquefy, store and export the natural gas produced by these reservoirs. Platforms of this type have been designated LNG Floating
Production, Storage and Offloading (LNG FPSO), also known as Floating Liquefied Natural Gas (FLNG) (IGU, 2018).

From the above, Mokhatab (2014) assumes that the growing demand for natural gas has allowed for the development of offshore gas projects and that is why FLNG platforms are gaining interest from Oil and Gas companies. It is expected that these platforms will be a viable option in the future due to newly developed offshore gas liquefaction technologies as well as LNG offload technologies (Mokhatab, 2014). As reported by LNG News (2016), the first FLNG to enter in operation was in 2016. Since there is almost no experience in the operation of such floating platforms, there are many risks, some of them still unknown. Given the context of the world energy scene, this exploratory work aims to find out the answer to the following question: “For the Oil and Gas industry, what will be the main critical success factors for an FLNG project?”.

CONTEXT/PROBLEM CHARACTERIZATION

Although in the nineteenth century it was the first time that methane was liquefied through experiments, it was only in 1939 that the first commercial methane liquefaction plant came into operation, where LNG was contained in reservoirs at atmospheric pressure. In January 1959, the first LNG transport trip from Lake Charles, Louisiana to Canvey Island, UK was shipped in “The Methane Pioneer”, demonstrating that it was possible to transport large quantities of LNG safely by sea (Tusiani & Shearer, 2007).

As the name implies, LNG consists essentially of methane (CH4), with small amounts of other light hydrocarbons such as ethane, propane and butane in liquid state (-162° C) which makes it possible to store and transport in an economically viable way. The methane when cooled to this temperature shrinks about 600 times from its original volume, creating a cryogenic liquid which at atmospheric pressure is odorless, colorless, non-corrosive and with a large energy and volume ratio. However, the liquefaction process is complex, since it must be designed to meet the specifications required in the supply contracts and at the same time must meet the relevant regulations of the country in which it will be installed (Mokhatab, 2014). Some of the key advantages and challenges of this type of floating platforms are highlighted by Mokhatab (2014) as described below.

The goal of a FLNG project is to produce LNG on a floating platform directly from gas reservoirs located in remote areas or from smaller reservoirs encompassing in one single location the production, processing, liquefaction, storage and offloading. Another advantage of the FLNG platform is the possibility to station it very close to the production fields in remote areas, thereby avoiding the construction of extremely expensive submarine pipelines that are not economically viable for small reservoirs.

In the field of safety, in addition to regulatory requirements, the project should consider spills and its control of hydrocarbons from various parts of the platform in the gas or liquid phase. It will also need to consider the safety of the on-board personnel against possible hazards. Other challenges relate to the movement of the platform itself. Stability control systems are required to minimize the movement of equipment in the processing modules. It will also need to ensure that the cargo containment system can withstand the sudden movements of LNG called sloshing when the tanks are partially empty.

Another challenge relates to the load transfer system for an LNG relieving vessel and the hazards inherent in a cryogenic and highly volatile cargo.

LITERATURE REVIEW

Merrow (2011) defines the class of megaprojects as those above 1 billion dollars, in line with the McKinsey Capital Projects & Infrastructure Practice (2017). However, the latter presents another subclass of even more complex megaprojects as those above 5 billion dollars exceeding a 5-year time frame for completion where LNG projects can be included. As stated by McKinsey Capital Projects & Infrastructure Practice (2017), the majority of companies with experience in projects use a stage approach, with procedures and assigned responsibilities well defined among the project sponsors and the contractor teams assigned to the project. Other important factors are the human resources, with vast experience in areas such as planning, costing and project controls and other critical areas. Thus, the existence of these approaches, methodologies and processes are generally
well understood by experienced companies and are considered as part of the “science” of project management.

According to Mokhatab (2014), the project management involving LNG projects also follows the same principles of project management of most construction projects. Merrow (2011) highlights the typical approach in the management of Oil & Gas projects called the Front-End Loading (FEL) approach. The planning in each of the FEL phases is as follows: FEL 1 - Economic feasibility studies of the project (also called appraise, or project evaluation); FEL 2 - Project development phase with scope definition including selection of technologies and more realistic cost estimation, also called pre-FEED (Front End Engineering Design) or Select; FEL 3 - Once this phase is started, which is described as the most expensive phase of the initial three phases, any changes in scope imply large costs that can delay the project. It is at this stage that final details are defined. The project design and planning should be satisfactorily completed by all stakeholders and to start the selection of contractors prior to the phase called EPC (Engineering, Procurement and Construction). At the end of the FEL 3 there is the phase called FID or the “Final Investment Decision”, which is the final authorisation for the construction of the project to start.

In McKinsey Capital Projects & Infrastructure Practice (2017) it is argued that there are other aspects that go beyond the “science” in project management. Leadership, organisational skills, mindsets, attitudes, behaviours and organisational culture should also be considered in megaprojects. These aspects are part of the “art of project leadership” and they should complement the “science” to reach excellence in the project management of megaprojects.

**Critical Success Factors in a project**

Although the term ‘Critical Success Factor’ is widely used in the literature, according to several authors there is no single definition. This concept was first described as ‘Success Factor’ by Ronald Daniel in 1961 before becoming managing director of the consulting firm McKinsey & Company. Later, this concept was again redefined by John F. Rockart between 1979 and 1981 thereafter being described as the ‘Critical Success Factor’ (Rockart,1979) stating that “Critical success factors thus are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization.(…)”.

During the research phase, with focus on articles related to CSF, it was found that there has been a lot of research related to this subject. However, there was some difficulty in finding references to CSF related to Oil and Gas projects. The database used in this search was the Web of Knowledge. Keywords used in the search database were “FLNG”, “Critical Success Factors”, “Oil and Gas”, “LNG”, “FPSO” and “Project” and several combinations among them without any filtering. No relevant papers for this work could be found. Thus, it was decided to present the conclusions of four references that were considered most relevant during the research.

According to the study carried out by Pinto & Slevin (1987), the ten main CSF that determine the success of a project in the general scope were identified as follows:


In another study related to CSF within the Oil & Gas industry, Denni-Fibresima and Rani (2011) analysed the CSF for deepwater projects in Nigeria involving large oil companies. This research consisted in the elaboration of questionnaires sent to two hundred people with relevant responsibilities in projects in the oil industry in this African country. In this study, Denni-Fibresima and Rani identified 13 factors that were considered critical for the success of ultra-deepwater projects. These 13 critical success factors were as follows:

For a better understanding of the issue in question, it is also important to understand the main causes responsible for the failure of projects. Merrow (2011) in his book lists the critical errors identified over thirty years in the study of megaprojects. According to the author, these critical errors are not mutually exclusive and may arise in different combinations. Yet only one of them is enough to condemn the failure of a megaproject. Below are the seven most common mistakes identified by the author (in italics) followed by the category attributed for the purpose of this work:

1. "I want to keep it all!" – Stakeholders; 2. "I want it NOW!" – Realistic project schedule; 3. "Do not worry; we'll work out the details of the deal later." – Contract; 4. "Why do we have to spend so much up front?" – Front-end Loading (FEL); 5. "We need to shave 20 percent off that number!" – Realistic budget; 6. "The contractors should carry the risk; they're doing the project!" – Strategy of contracts with contractors; 7. "Fire those # $ @ $ ^! project managers who overrun our projects! " – Change in project team.

Finally, according to Mokhatab (2014) there are several critical issues for sponsors in the design and construction of LNG facility projects. Some of these issues are of a technical nature such as the following:

1. Selection of technologies; 2. Selection of contractors (e.g. leading EPC contractor); 3. Development of a project management team; 4. Well-considered and communicated strategies for design contracting and risk management; 5. Costs and budgeting; 6. Change orders and deviations to the selected designs; 7. Scheduling and defining meaningful milestones and targets; 8. Quality of work and performance.

From a contractual, commercial and financial point of view, other critical issues that affect the performance and results of a project, also according to Mokhatab (2014), are:

9. EPC contract structure (e.g. lump sum or gain share); 10. Liability limitations applied to contractors and suppliers; 11. Financial security to be posted by contractors; 12. Securing project finance and completion terms for drawdown of loans; 13. Negotiating local content obligations and procurement rules with government; 14. Placing the appropriate insurance and export credit guarantees as part of financing.

After analysing the several CSF, a categorisation process was carried out from the above sources. It was found that, as references became more specialised in the field under study, there was an increase of CSF to be considered. It was also verified that some of these factors were similar in several references. Others were different, as they resulted from more focused research on the general scope, on Oil & Gas, on megaprojects and finally on LNG. However, the grouping considered the common and the distinct factors.

At the end of this phase, a summary of all the CSF was carried out considering all these four references. The aim was to generate a provisional hypothesis that these factors are equally valid for an FLNG project. A summary of the twelve CSF can then be assumed as: 1. Good project formulation; 2. Project team; 3. Realistic project schedule; 4. Cost and budgeting; 5. Troubleshooting and deviation to selected design; 6. Stakeholders communication and management; 7. Proper contract planning and management; 8. Quality and work performance; 9. Risk management; 10. Understanding local environment; 11. Innovative technology; 12. Securing project finance.

**METHODOLOGY**

After establishing the first set of CSF as an initial hypothesis, the next phase resulted in obtaining information through contact with industry professionals, since the information on the problem presented was very limited. The information acquired through industry professionals went through two distinct phases, with the objective of using a sequential integration method of qualitative research with quantitative research in different phases of study, as described by Flick (2009): firstly, through face-to-face interviews with the purpose of confirming or invalidating the results of the research of literary sources, leading to a reformulation of the hypothesis, if necessary; secondly, through an online questionnaire, to support or reject the hypothesis formulated and respond to the initial problem.
Revision of the provisional hypothesis by a group of experts

To test the initial hypothesis formulated in this work, a semi-structured interview was conducted with experts according to a script agreed in advance. According to Flick (2009), semi-structured interviews have gained wide acceptance and have been widely used. In this type of interview there is the expectation that, in a situation of open questions previously elaborated, the interviewee expresses his opinion to the interviewer contrary to a standard interview or questionnaire.

However, Flick (2009) points out that one of the challenges in conducting an interview with experts is, first, identifying the appropriate experts. Another challenge is that the interviewer should have a thorough knowledge of the subject being studied, to ask the right questions. Other problems referred are the interview time, which may be limited, and the issues related to confidentiality, which may lead to the interviewee’s refusal to respond to certain types of questions or the refusal to record the interview.

The three experts were at the time of the interview involved in an FLNG project. They interviewed simultaneously for convenience and in accordance with the criteria defined by Flick (2009). Six questions with an increasing level of structure were elaborated on topics previously agreed with three experts. The experts provided their views in each question and finally listed in a ranking order the CSF from the initial hypothesis. Finally, they were asked to add any other CSF that, based on their experience, could be considered as CSF. Two additional CSF were added. The final list ranked by the experts was as follows:


Validation of the reformulated provisional hypothesis by experienced professionals in the field of Oil and Gas

To test the hypothesis formulated in the previous phase, a structured online questionnaire was prepared using the Google Forms tool. This quantitative research was directed to a group of professionals with experience in Oil and Gas projects in several geographic locations worldwide.

To find available respondents to collaborate in this research, a type of sampling called “snowball” was used. This type of research consists of obtaining a non-probabilistic sample that uses chain references given by the participants (Vinuto, 2014). According to the same author, using this specific type of sampling it is not possible to determine the probability of selection of each respondent in the study in question, but it is useful to study populations which are difficult to get access and which their numbers are imprecise. Populations of this type include those that contain few members and are scattered over a large geographical area, as is the case in this work.

According to the same author, “snowball” sampling is mainly used for exploratory purposes, which includes the objective of better understanding of a theme. However, this type of sampling has limitations and should be considered. This sampling technique, applied to large populations, is not very adequate since each referenced person does not have the same probability of being indicated to participate in the research. Another limitation of this technique is the possibility of obtaining similar arguments, since the people marked along each chain integrate the personal network of the people contacted, which may limit the variety of narratives (Vinuto, 2014). From the foregoing, a great geographic variation with different experiences of “seeds” was used for this work to obtain a greater variability of opinions.

The target population of this questionnaire refers to Oil and Gas industry professionals with project management experience relating to FLNG, FPSO or LNG projects in any geographical area. In addition to the professionals with experience in FLNGs, who are the most relevant for this research, experience in LNG and FPSO projects were also considered due to the similarity of the concept with the FLNG platforms.
During the construction of the online questionnaire, the questionnaire elaborated by Denni-Fiberesima & Rani (2011) was considered in his research. Thus, the following aspects were considered:

A presentation and introduction were made in the English language regarding the purpose and scope of the research, guaranteeing confidentiality and anonymity to the interviewees. Cooperation was also requested for the referral of the questionnaire to other professionals with relevant experience. Email contact from other professionals with experience in the same areas was also requested to obtain a representative sample. Finally, it was also possible to email with the IST domain to endorse the investigation. The questionnaire was divided into three sections, with the first two comprising multiple choice questions and the last section being an open question.

Section A refers to the respondent's professional profile. This was achieved by collecting data on age, gender, years of work experience, geographical experience, level of education, area of expertise, and actual experience in LNG, FPSO and FLNG projects. In this section, nominal and interval type of scales were used.

In Section B, a closed question was formulated to evaluate the level of agreement of the interviewee regarding the hypothesis generated using an ordinally interval hybrid scale. That is, an ordinal scale with attributes was constructed that was transformed artificially in an interval scale, assigning a value to each of them. In this way an artificial distance was created between them, to elaborate a more detailed statistical analysis as suggested by Hair, et al. (2003). Taking into account the above, for each of the categories, the interviewee had to indicate their level of agreement between five possible answers starting at '1' - 'Strongly disagree' to '5' - 'Strongly agree' in terms of importance for each of the CSF listed as used in the questionnaire elaborated by Denni-Fiberesima & Rani (2011).

In part C, a question is asked openly to the interviewee allowing him/her to express his/her opinion freely and thus to add another or other critical factors that were not previously identified. This section has also sought to obtain data in the field of other dimension in the management of megaprojects, which is the "art of project leadership", not confined to mere aspects of "science" as already mentioned.

Before the questionnaire was sent to the pre-test phase, all questions related to drafting, style, content, graphic arrangement and language were verified as suggested by Iarossi (2006).

The link to the questionnaire was sent accompanied by an introduction with a structure like the one already described, in English or Portuguese, depending on the nationality of the target population. In some cases, an email with the link was not accompanied by the introduction since the first contact was made verbally through telephone conversation with known professionals. However, the difficulty of finding professionals available to answer the questionnaire was expected in this area, and there was no guarantee that the sample was representative.

RESULTS AND DISCUSSION

This section describes the results of the research on the initial question "For the Oil and Gas industry, what will be the main critical success factors for an FLNG project?". The questionnaire retrieved 31 answers from which only 30 were validated.

Concerning part A of the questionnaire, most respondents were aged 36-45 years (63.3%) with most of them having a master's degree or equivalent (60%). Most respondents worked for an Oil and Gas contractor and had between 11 and 15 years of professional experience. Regarding the geographic area, approximately 43% and 36.6% of respondents had experience in managing projects in Asia and South America respectively. In relation to the professional area in which they worked, a large majority (73%) responded in engineering. All of them showed experience in FLNG or LNG or FPSO projects, with FPSO projects being the most predominant (90%). Because FLNG projects are relatively recent, it was surprising that 30% of the respondents had experience in this field. It was also noted that 20% of the respondents had experience in the three project fields, 13% had experience in LNG and FPSO projects and 7% had experience in FPSO and FLNG projects. None of the respondents combined experience in both LNG and FLNG projects. Finally, the thirty respondents were male.

Regarding part B of the questionnaire, it should be noted that, according to the statistical analysis presented for all results, "Monitoring and control in the execution phase" had the highest mean value
and the highest median value (see Table 1). Also, through the statistical analysis, it can be verified that the critical factor “Quality and work performance” had the same median value as "Monitoring and control in the execution phase" but with a lower mean value. It is interesting to point out that in the literature consulted previously, the factor "Monitoring and Feedback" was already mentioned, namely in the study carried out by Pinto & Slevin (1987). Despite somewhat different nomenclatures, it could be considered that there is some similarity between them. Although this factor had been initially included in the “Quality of work and performance” in the initial hypothesis, the "Monitoring and control in the execution phase" factor was suggested by the experts during the interviews.

Table 1 – Statistical analysis on the online questionnaire

<table>
<thead>
<tr>
<th>No</th>
<th>Factor Crítico de Sucesso</th>
<th>Median (All)</th>
<th>Mean (All)</th>
<th>Median (FLNG)</th>
<th>Mean (FLNG)</th>
<th>Median (LNG)</th>
<th>Mean (LNG)</th>
<th>Median (FPSO)</th>
<th>Mean (FPSO)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Realistic project schedule</td>
<td>4</td>
<td>4.13</td>
<td>4</td>
<td>4.33</td>
<td>4</td>
<td>4.36</td>
<td>4</td>
<td>4.11</td>
</tr>
<tr>
<td>2</td>
<td>Project Team</td>
<td>4</td>
<td>4.10</td>
<td>4</td>
<td>4.44</td>
<td>4</td>
<td>4.36</td>
<td>4</td>
<td>4.07</td>
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<tr>
<td>3</td>
<td>Proper contract planning and management</td>
<td>4</td>
<td>4.10</td>
<td>4</td>
<td>4.22</td>
<td>4</td>
<td>4.45</td>
<td>4</td>
<td>4.07</td>
</tr>
<tr>
<td>4</td>
<td>Stakeholders communication and Management</td>
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<td>3.83</td>
<td>4</td>
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<tr>
<td>5</td>
<td>Innovative Technology</td>
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<td>3</td>
<td>3</td>
<td>3</td>
<td>3.45</td>
<td>3</td>
<td>3.33</td>
</tr>
<tr>
<td>6</td>
<td>Good project formulation</td>
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<td>4.27</td>
<td>4</td>
<td>3.96</td>
</tr>
<tr>
<td>8</td>
<td>Troubleshooting and deviation to selected design</td>
<td>4</td>
<td>3.37</td>
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<td>3.45</td>
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<tr>
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<td>4</td>
<td>4</td>
<td>4.09</td>
<td>4</td>
<td>3.89</td>
</tr>
<tr>
<td>11</td>
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<td>4.11</td>
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<td>4.27</td>
<td>4</td>
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<tr>
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<td>4.11</td>
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<td>4.19</td>
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<td>Interface management</td>
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<td>4.22</td>
<td>5</td>
<td>4.36</td>
<td>5</td>
<td>4.22</td>
</tr>
</tbody>
</table>

The factors "Quality and work performance" and "Risk management" obtained the same mean value. However, since the factor "Quality and work performance" had a higher median value, for ranking purposes this factor was considered more relevant. For the factors "Project Team" and "Proper contract planning and management" with the same mean and median values it was not possible to establish a ranking. It should also be noted that the factor with lower median value and lower mean value, according to all the results obtained, was the "Innovative technology".

Comparing the results obtained through the questionnaire ranked by the higher median value (first criterion) followed by the highest mean value (second criterion) with the list ranked by the experts there is some discrepancy regarding the relevance order of the CSF. There are only four CSF that coincide in the ranking position considering that “Proper contract planning and management” is equally ranked as “Project Team” in the fifth position. However, it should be noted that within the group of the five most important CSF, there are only two in common with a slight difference in ranking, "Realistic project schedule" and "Project Team".

Finally, it should be noted that the CSF with the greatest discrepancy in the ranking position were "Quality of work and performance" and "Good project formulation". This discrepancy between the positioning of the CSF may be related to the high number of respondents with experience in FPSO projects regarding the number of respondents with experience in LNG and FLNG projects.

Another analysis of the data was carried out using the cross-tabulation technique. This technique selects the field of experience of each of the respondents and each CSF, and the percentage of the respondents from each field of experience that selected the maximum value (‘5’ - ‘Strongly agree’) of the scale for each CSF.

The analysis concluded that the CSF related to "Monitoring and control in the execution phase" was obtained from a greater percentage of respondents with experience in FPSO and LNG projects. However, in the case of respondents with experience in FLNG projects, and within the same category, the CSF related to "Good project formulation" was the highest percentage of respondents.
Another analysis of the data using the cross-tabulation technique was carried out by ranking the most relevant factors in the field of experience of each of the respondents (see Table 1). The aim was to find out which were the most important CSFs for the respondents with experience in FLNG projects. To establish a ranking, the initial criterion used was the highest median value followed by the highest mean value obtained in each field of experience. In case of two factors having the same values in both criteria, the same criteria were applied using the results obtained from all the respondents. The results are presented in Table 2.

### Table 2 – Ranking of the CSFs in the field of experience based on the statistical analysis

<table>
<thead>
<tr>
<th>Critical Success Factors (FLNG)</th>
<th>Critical Success Factors (LNG)</th>
<th>Critical Success Factors (FPSO)</th>
</tr>
</thead>
<tbody>
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<td>Good project formulation</td>
<td>Monitoring and control in the execution phase</td>
<td>Monitoring and control in the execution phase</td>
</tr>
<tr>
<td>Project Team</td>
<td>Quality and work performance</td>
<td>Risk management</td>
</tr>
<tr>
<td>Realistic project schedule</td>
<td>Risk management</td>
<td>Risk management</td>
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<tr>
<td>Monitoring and control in the execution phase</td>
<td>Realistic project schedule</td>
<td>Realistic project schedule</td>
</tr>
<tr>
<td>Proper contract planning and management</td>
<td>Project Team</td>
<td>Project Team</td>
</tr>
<tr>
<td>Quality and work performance</td>
<td>Quality and work performance</td>
<td>Proper contract planning and management</td>
</tr>
<tr>
<td>Risk management</td>
<td>Cost and Budgeting</td>
<td>Interface management</td>
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<tr>
<td>Cost and Budgeting</td>
<td>Interface management</td>
<td>Cost and Budgeting</td>
</tr>
<tr>
<td>Stakeholders communication and Management</td>
<td>Good project formulation</td>
<td>Good project formulation</td>
</tr>
<tr>
<td>Understanding Local environment</td>
<td>Stakeholders communication and Management</td>
<td>Stakeholders communication and Management</td>
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The results in Table 2 showed that, similar to the ranking carried out by the experts, the factor “Good Project Formulation” was considered the most important for professionals with experience in FLNG projects. It was also noted that within the group of the five most important CSF, three of them were common in each one of the three groups of professionals. These were “Project Team”, “Realistic project schedule” and “Monitoring and control in the execution phase”.

Regarding the open question in part C of the questionnaire, the results were somehow repeated, as almost all the respondents listed some subfactors that can be considered already included in the list presented to them in advance. Hence it can be concluded that the factors presented previously to the respondents, resulting from literary research, although they include many subfactors and are subject to different interpretations, corroborate a reality already identified in the scope under study.

One particular comment which could be inserted within the subject "Project team" is one provided by a respondent who indicated "Team with the right experience". This respondent highlighted the importance of project team quality from a holistic point of view. This suggests an understanding of the issue raised by McKinsey Capital Projects & Infrastructure Practice (2017) on the complementarity between "science" and "art leadership projects" in the management of megaprojects.

Other comments that could not be included in any of the subjects presented throughout this research work are related to “Safety”, “Gas monetization”, “Local gas demand” and “Volume of condensate in the reservoir”. Furthermore these additional factors were interpreted, not as CSF, but as potential criteria for the success of an FLNG project, when the platform is at its production phase. The topic of "Safety" however, was understood to be relevant not only during the production phase but also during the project phase, particularly during the commissioning stage, since there is very little experience. Thus, the “Safety” factor, as suggested by two respondents was considered CSF of a project of this nature.

### RESEARCH LIMITATIONS

After presenting the analysis and discussion of the results, the following section discusses the limitations found throughout this work.

During the literature review it was noted that there are few studies in relation to CSF in Oil and Gas projects. It was also noted that most of the scientific publications found were of a technical or engineering nature. Furthermore, it was verified that the information available related to megaprojects was even scarcer probably due to their long-term duration and little replicability. Finally, FLNG projects are still very recent, where experience is still very limited. Other limitations included the geographic coverage and the limited availability of experienced professionals for face-to-face interviews. As expected, a lot of information/data was considered confidential or subject to intellectual
property law, which limited the scope of research. In addition, it was also difficult to access relevant professionals to answer the online questionnaire. Hence the use of the “snowball” technique, which allowed access to relevant professionals, but some answers, may have been biased linked to non-probability sampling.

The number of respondents to the online questionnaire could have been greater. Unfortunately, some cases were reported whereby anti-virus software installed on computers prevented access to links via electronic mail. For this reason, some respondents may have lost interest in participating in this study. Finally, only a small sample was obtained from the questionnaire phase, which makes it difficult to validate against the interview results.

CONCLUSIONS

After an initial phase of exploratory research on the specificities of a megaproject, namely of an FLNG platform, a suitable methodology was selected for this purpose. This involved not only a literature review, but a face-to-face interview with three FLNG experts and an online survey of experienced Oil and Gas professionals.

Although this research points to a certain trend in the context under study, to carry out generalizations and draw more solid conclusions, more research is needed. This could be achieved by involving a greater number of professionals chosen at random, a fact that could not be achieved in this study.

The CSF in an FLNG project found by order of relevance are presented in Table 3.

The factor "Good Project Formulation" was the one that weighed more, in terms of importance in the list of those considered more critical in consonance with what was reported in the interview with the experts. It should be noted that, within the different areas of professional experience, this was the factor that weighed most in the category of greater agreement in the response given by respondents with experience in FLNG projects. However, this CSF only appears listed in ninth place in the general ranking of the questionnaire.

In the case of respondents with experience in LNG and FPSO, the factor that weighed most in the category of greater agreement was "Monitoring and control in the execution phase". It is concluded that the type of project influences the ordering of critical success factors, probably due to the existence of a higher number of projects completed and more experience in these areas.

Regarding the CSF suggested by the respondents, many already fall within the subjects already defined as CSF. However, there was some incongruity between the suggestions given by the respondents and their expressed opinion, within the corresponding subjects. This circumstance may be related to other interpretations related to the question addressed. Thus, the four additional factors understood and interpreted as critical to the success of a project of this size by some respondents

<table>
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<th>Ranking</th>
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<tr>
<td>1</td>
<td>Good project formulation</td>
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<tr>
<td>2</td>
<td>Project Team</td>
</tr>
<tr>
<td>3</td>
<td>Realistic project schedule</td>
</tr>
<tr>
<td>4</td>
<td>Monitoring and control in the execution phase</td>
</tr>
<tr>
<td>5</td>
<td>Proper contract planning and management</td>
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<tr>
<td>6</td>
<td>Quality and work performance</td>
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<tr>
<td>7</td>
<td>Risk management</td>
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<td>8</td>
<td>Cost and Budgeting</td>
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<td>9</td>
<td>Stakeholders communication and Management</td>
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<td>10</td>
<td>Interface management</td>
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<td>11</td>
<td>Understanding Local environment</td>
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<td>12</td>
<td>Securing project finance</td>
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<td>13</td>
<td>Innovative Technology</td>
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<td>14</td>
<td>Troubleshooting and deviation to selected design</td>
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are: (1) “Safety”; (2) “Volume of condensate in the reservoir”; (3) “Gas monetisation”; (4) “Local gas demand”. However, only “Safety” was considered as a CSF whereas remaining three were considered as potential criteria for the success of a FLNG project.

It should be noted that during the writing of this paper there was not much research on CSF of Oil and Gas projects, much less for FLNG projects. However, it has been found through literature research that, although many factors are already identified and assimilated by the industry, many megaprojects continue to fail as mentioned by Merrow (2011).

Finally, another conclusion emerges: only one respondent mentioned, in the open-ended question, matters related to the "Art of project leadership" in a megaproject, while all other factors mentioned by others were in the field of "science" in project management. A more in-depth research was also needed in the field of "science" as well as in the "art of project leadership" in the management of megaprojects, as described in McKinsey Capital Projects & Infrastructure Practice (2017).

Yet, the CSF presented can only be validated in the future with the development and expansion of FLNG projects.

References