Integrated Modeling during Engineering Design

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Abstract - Engineering for oil and gas is multi-disciplinary, which require numerous input and data interaction between disciplines. In the past, we present our engineering design by reporting and collaborating with others by using two-dimensional (2D) drawing. But finally we faced classical problems like clashing among the facility and infrastructure, mismatch in major dimensions and hence this is why three-dimensional (3D) modeling is taking place. This presentation will cover the current using of 3D model in engineering and new challenge for next future.

Keywords: BIM, oil and gas industry, integrated 3d modeling, structural

1.0 Introduction

Integrated modeling is one of Building Information Modeling (BIM) processes. In this paper, we will look into the application of integrated modeling in the engineering design phase of the oil and gas industry. As we all know that oil and gas industry is multi-disciplinary and exchange of information between disciplines plays an important role.

Case studies in this report are taken from previous offshore projects performed by Petrokon Utama Sendirian Berhad (PUSB). As a brief PUSB is a multi-discipline engineering consultancy which offers design engineering, project management services in for the oil and gas industry. We are a locally own company which also tackles international and local oil and gas services. The company has established offices locally in Brunei, Malaysia and India. For more information kindly refer to our website http://www.petrokon.com

Currently, we are working with single discipline based 3D models and information is collaborated multi-discipline thru file interchange format. Disciplines work in-parallel during a project cycle with reference to the project's scope and design basis.

An integrated model is a combined models of single discipline models; the purposes of integrated model are for visualization, collaboration, coordination and exchange of information. In order to create an integrated 3D model, basically, BIM tools or CAD (Computer Aided Design) software will be utilized for constructing model and combining models. Software utilize for this study are BOCAD (www.aveva.com), SACS (www.bentley.com), and lastly PDMS (www.aveva.com). These software are used for modeling of steel structure framing, analysis and design of offshore topside and jacket structure and for integration of multidisciplinary object, respectively.

This paper presents the benefits and processes involved in creating an integrated multi-discipline 3D model, including the important activities that are involved with an integrated 3D model. As part of the BIM process we are able to provide preliminary check during the engineering design phase in terms of technical, construction, installation, operability, safety and maintenance aspect.

In conclusion, constructing an integrated 3D model during the engineering design phase benefits the overall project in terms of cost, schedule and product quality and definitely will provide benefit to owner throughout service life of the access.

2.0 Integrated Modeling

A case study was conducted on PUSB's recent offshore projects to observe the use and benefits of creating an integrated 3D model. During the course of the project, a 3D model review was carried out in order to obtain a visual walkthrough the model which will allow reviewer to identify shortfall during the design stage.

The integrated modeling is an activity which is associated with creating of one unified 3D model by combining all multidisciplinary item into single 3D model. The key elements involved in integrated modeling are:

i) Exchange of multi-discipline information
ii) Operation of software

Disciplines are able to collaborate and coordinate information with each other via interchangeable file format in CAD. The BIM process is not new in the construction or building industry; it is already present in the past however information was collaborated in the form of 2D detailed drawings. During the early stages of engineering design, disciplines are required to check each multidisciplinary set of design drawings. In some cases, where might be a total of more than 100 sheets of drawings to review, making the collaboration process time consuming. Nowadays, with the availability of 3D CAD software, disciplines are able to review multi-discipline design in a shorter amount of time and communicate changes in the design in real time. The operation of 3D CAD software is the tools used in the integrated modeling process. The results of this activity are:

i) Integrated 3D model
ii) 2D design drawings

Integrated 3D models contain information from various disciplines in which everyone can understand and interpret the project before it is built. It is beneficial in terms of:

i) Visualization
ii) Project predictability

Visualization gives an idea of how physically project is before the project is built. Because of visualization the design engineer will be able to identify design error or flew in design and eventually allow engineer to rectify and improving their design. Visualization also provide understanding of queries or concerns that are raised by other disciplines. In short an integrated 3D model is like a language barrier breaker between multi-disciplines. There are numerous of activities which are required for creating of 3D integrated model. The process of creating a model will be discussed in the following paragraphs.

2.1 Process of creating an integrated model

To simplify the process of creating an integrated model, we will concentrate mainly on birth of a 3D structural model. Before starting of any project, the purpose of the infrastructure and the required criteria or standards which are covered within the project scope are needed to be understood. There are mainly two (2) activities that go into creation of a structural framing:

i) Spatial requirements (e.g. equipment size, equipment access requirement, escape routes, space for cable trays, piping etc.) from multi-discipline
ii) Structural analysis and design. Other inputs required by the structural engineer that effects infrastructure configuration are:
    a. Loadings (environmental conditions, static and rotating equipment weights, operations weight, live loads etc)
    b. Material specifications
    c. Installation and construction methodology. For steel structures it may differ with the type of connection required by the project. i.e. welded or bolted connections

Structural analysis and design is the BIM core process for the structural engineer. He is able to simulate the structural behavior during analysis phase, he may also provide feedback to other disciplines and accommodate changes in the design and improve coordination with multi-discipline

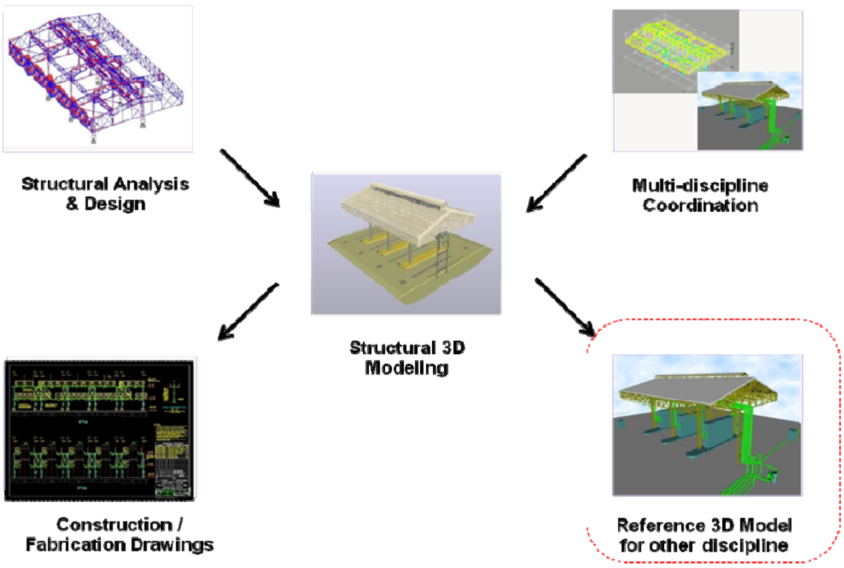

Figure 1BIM for Structural Engineering

As illustrated in Figure 1, after the completion of structural 3D model, we are able to extract information for drawing documentation. The structural engineer or designer will create structural 2D detailed drawings that will be used in construction and/or fabrication. On the other hand, the structural 3D model will be a reference for other disciplines. In the next section, a case study was performed to further illustrate the benefits of having an integrated 3D model and the collaboration process that takes place as part of the BIM process, which is 3D model review.

3.0 Case Study 1: Integrated 3D Model Review

An integrated 3D model composes of discipline-specific models such as mechanical static, mechanical piping, instrumentation, electrical, safety equipments, structural etc. Illustrated in Figure 2, snapshot of an offshore structural platform extracted from PDMS, showing a multi-discipline integrated 3D model. With this model, we are able to perform yet another important BIM activity which is 3D model review. This model shows part of the jacket structure, topside, boatlanding and other facilities.

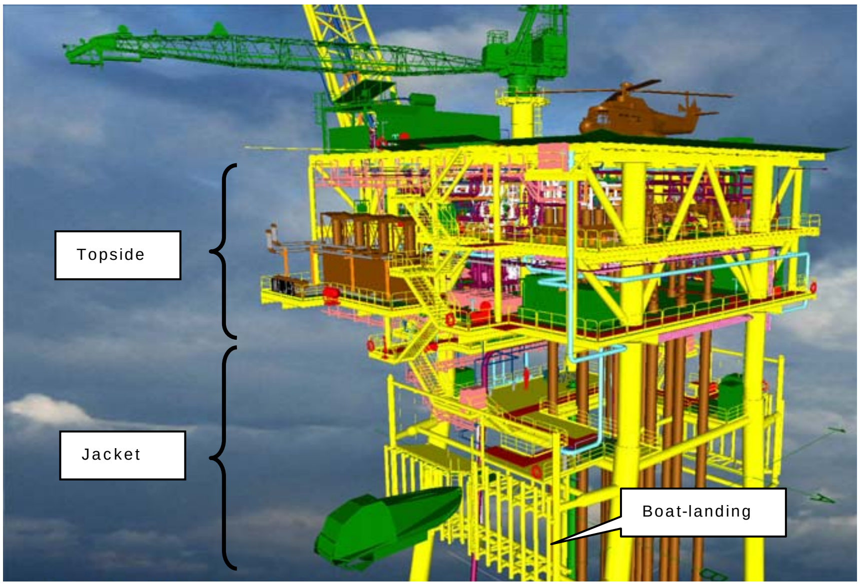

Figure 2 Integrated 3D Model of an Offshore Platform

Model review is performed during engineering design phase to provide checks for the technical, construction, operability, and safety and maintenance aspect of the project. During multi-discipline model review, we are able to have a walkthrough session throughout the infrastructure before it is built.

This case study was taken from PUSB's previous offshore project during its conceptual design stage; the following examples of snapshots are actual scenarios that were observed and noted during 3D model review.

Figure 3 demonstrates the possible safety issues that may arise during project execution. In this snap shot, it was observed that the height of the crane ladder is 2-3 times of the human height. As per client safety standard any ladder that is greater than 2 meter, it is will required to install a safety cage also known as a caged ladder. During the 2D design drawing review, engineer may have missed this issue however during the 3D model review, the reviewer are able to have a feel of unsafe due to the height of the ladder.

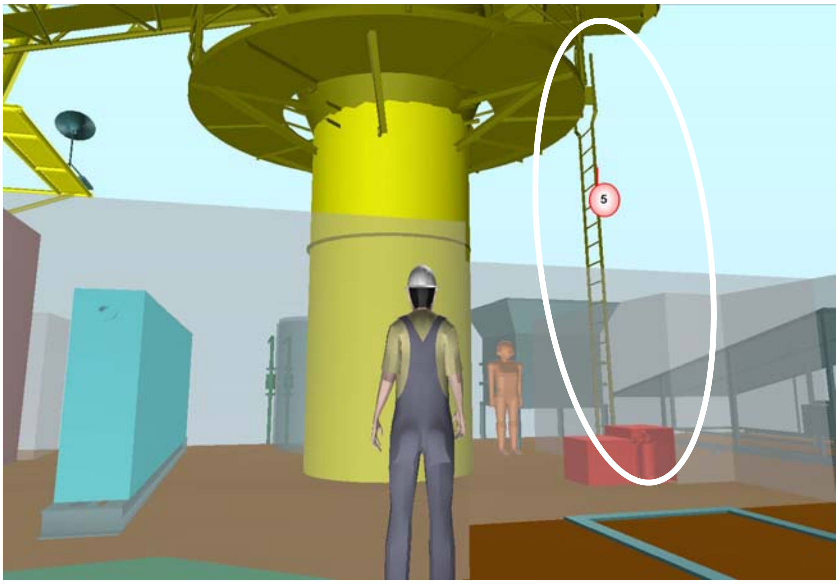

Figure 3 Safety aspect during 3D Model Review

Next we have a case of space limitation in Figure 4, observe that there is limited space between structural beam member (highlighted in yellow) and mechanical valves. During model review it was raised operation personal that this valve will require some maintenance. Sufficient space is required for operations personnel to perform their task without restriction and safety concerns.

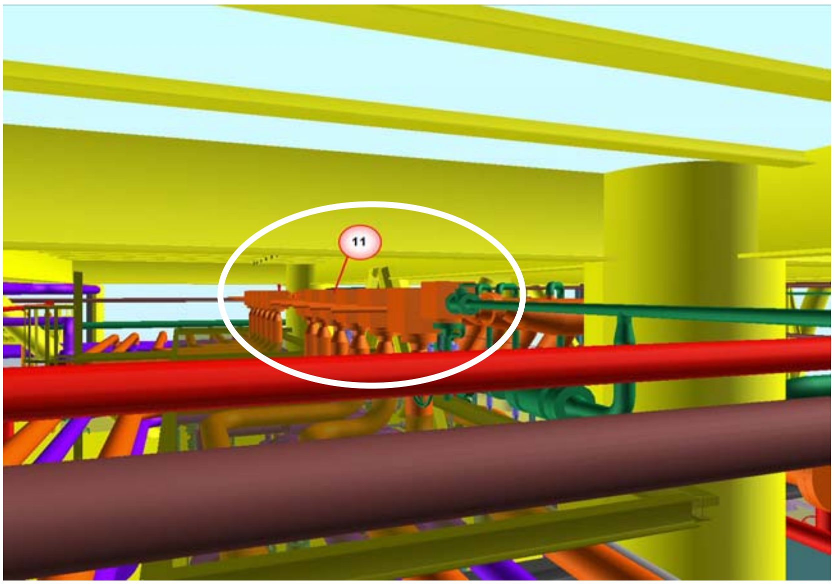

Figure 4 Maintenance aspect during 3D Model Review

In the next Figure 5 is a classical problem of clashing between structural item and piping. It was identified during the review that the piping routing needs to be re-routed to avoid clash. During engineering design stage, both structural and piping engineer shall coordinate to come up with a solution, as to avoid this problem. Being able to indentify clashes in the model will avoid major construction re-work at site, which will turn into an impact on the project overall budget and schedule. If applicable, a query on the piping purpose may also be raised during the model review to get further idea and understanding on its purpose prior to proposal of re-routing.

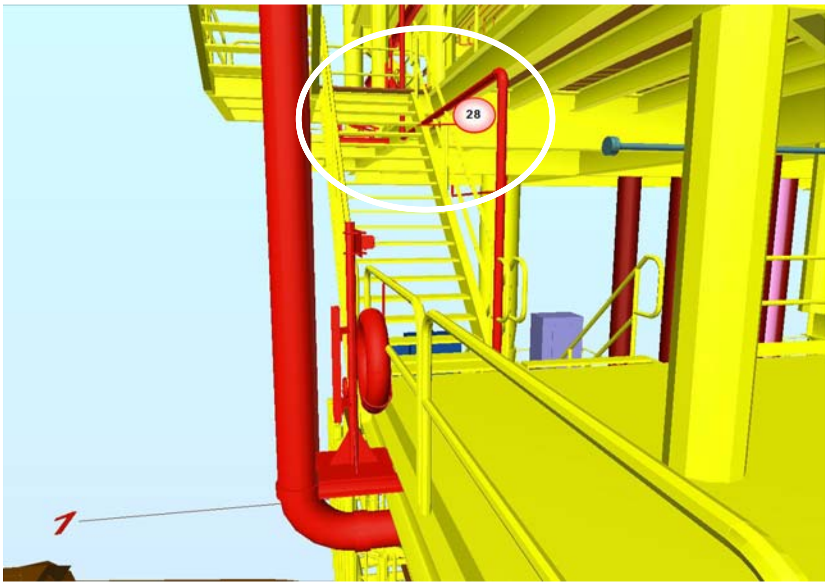

Figure 5 Clash check during 3D Model Review

The model review also covers other offshore activities during the pre-service stage. Pre-service activities are performed before the offshore platform is installed at its final location, those are the activities that occur during the transportation and installation of a platform. Figure 6 demonstrates the sling arrangement during typical lifting activity that will be performed during topside installation. During model review, it was found out that one of the sling may potentially clash with a generation. Sling arrangement is determined by the structural engineer and identifying problems during lifting activity will allow him to rearrange the sling arrangement or the generator may be shifted to avoid clash. Once again we are able to rectify the issue during the early design stage to avoid unnecessary issue during execution phase.

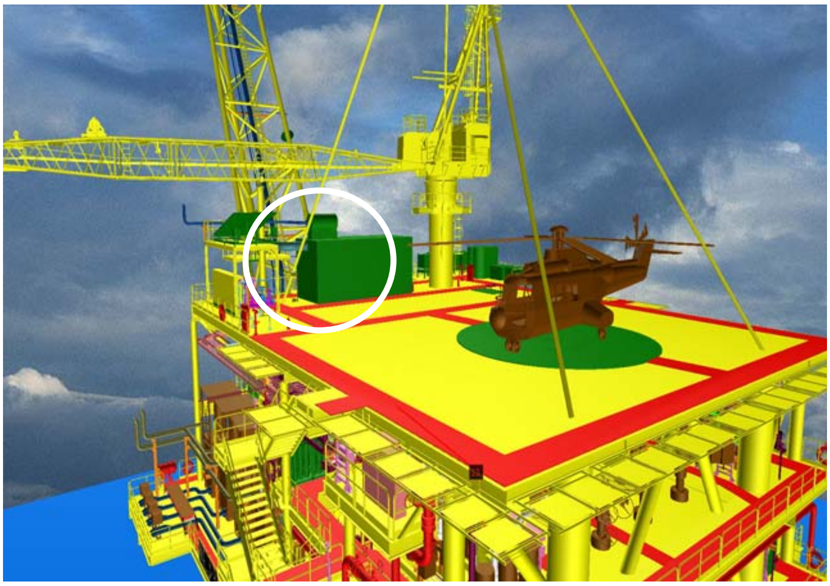

Figure 6 Installation aspect during 3D Model Review

Finally we review the operational aspect of project. Referring to Figure 7 at first glance there may seem nothing wrong with the snapshot. However, to the operations personnel the potential problem has been identified that the fluid will leak from the equipment and the leak may cause other potential problem. Identifying missing required items in the design stage eliminates difficult re-work after platform commissioning. Structural re-work is costly and potential safety issues will occur during the re-work. During 3D model review, it was identified that the vessel will require a drip-pan to collect any potential leaks. Further required details for the drip pan and structural modifications are incorporated in the construction drawings

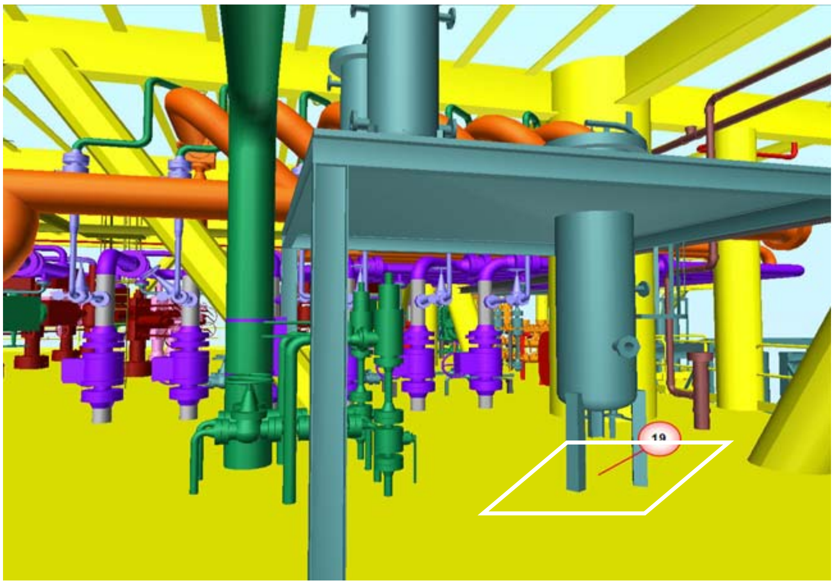

Figure 7 Operation aspect during 3D Model Review

This paper presented a few of the possible issues identified during 3D model review on an offshore oil and gas platform. As a result of this activity we were able to rectify the issues during engineering conceptual design phase and further refine the design as the project progresses.

3.1 Case Study 2: Dimension Mismatch

In this next case study, also from one of PUSB's recent projects regarding the installation of offshore boat-landing structure. Boat-landing is used by offshore personnel transfer in order to reach the platform. They will perform a boat transfer activity where in a crew boat will approach the platform. Boatlanding is usually designed to be replaceable, after sometime due to its deteriorating condition or change in environmental tide condition. Taking similar types of projects in the past and during which 3D modeling was not utilized, we come up with classical problems like dimension mismatch. The issues will occur during the installation phase and contractor will then find out that the replacement boat-landing doesn't fit on to the existing jacket.

Figure 8 Sample Boat-landing Photo

Figure 9 illustrates a sample 2D detailed design drawing of a boat-landing. During the drawing review, dimensioning and interface detailing were checked, and drawing was approved for construction. The boat-landing was later fabricated onshore as per detailed drawings. When it came to installation, it was found out that the interface between the new and existing structures did not fit. We may think that the problem may be caused by fabrication tolerances.
Referring to Figure 9, we observe that the existing jacket structure leg is battered at an angle, making it difficult to determine the correct angle and exact length of the new members. To resolve this issue we create a 3D structural model of the existing and new structure, which helps us extracting information for 2D design drawings.

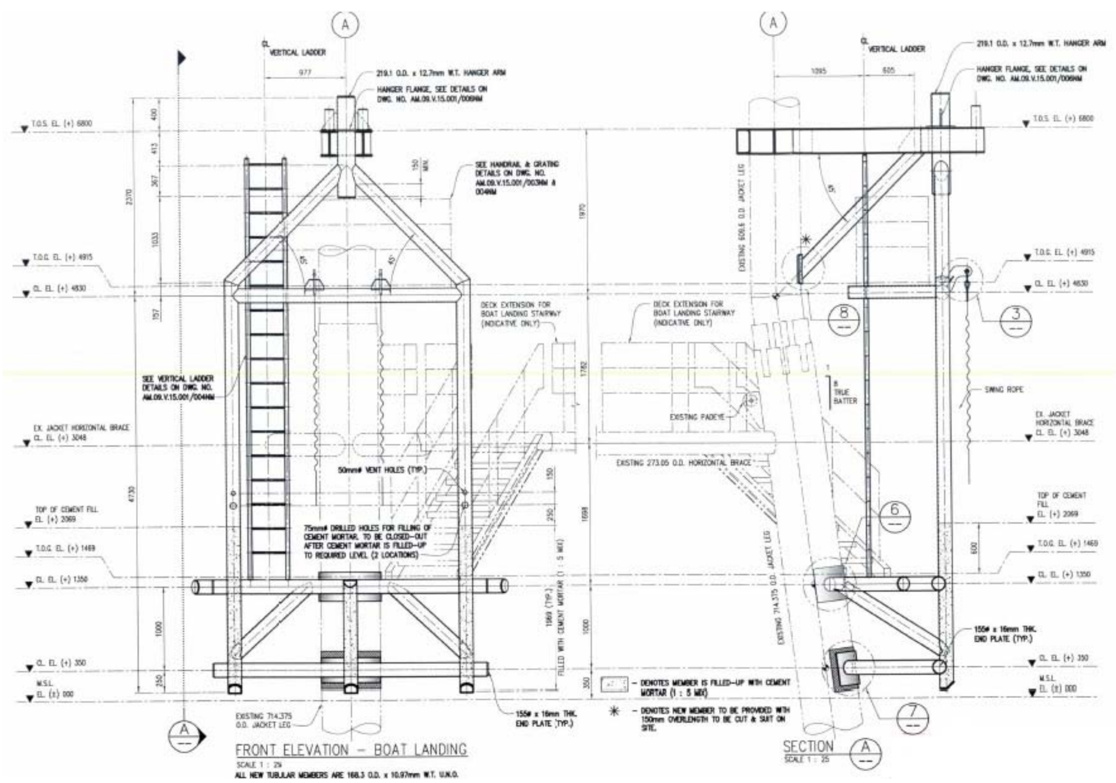

Figure 9 Sample detailed drawing of boat-landing

Utilizing this BIM process facilitates the engineer and fabricator to visualize the design before it is built. Figure 10 shows a structural 3D model, with this model we are able to determine the correct interface angle between the new and existing steel structure. In this example, the interface is single discipline and we still face classical issues at the end of the day.

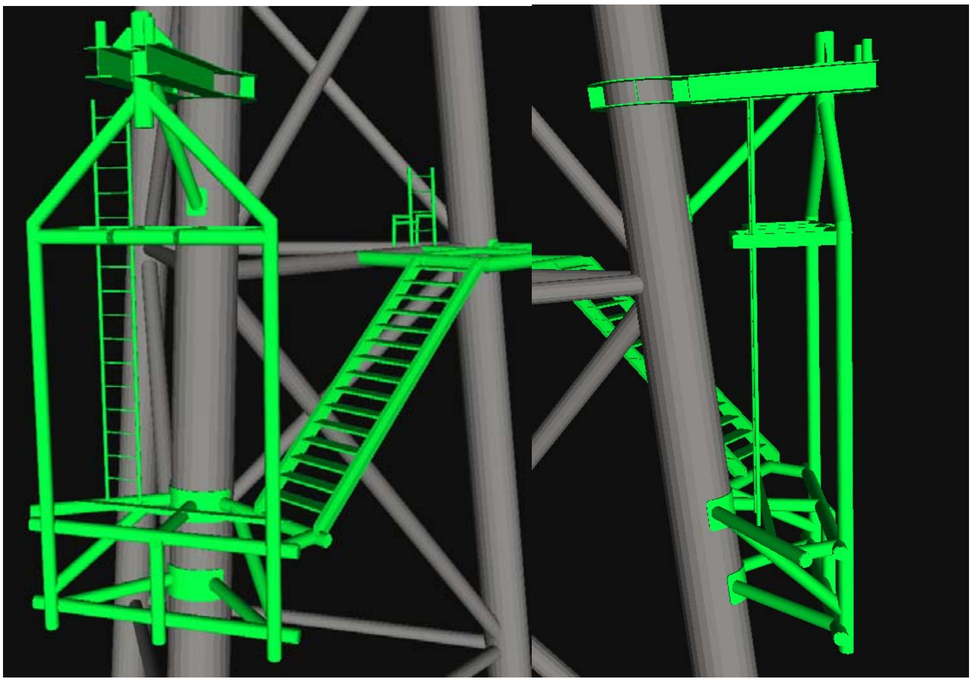

Figure 10 3D Model of boat-landing

4.0 Conclusion

In conclusion the BIM processes of creating a 3D integrated model and review during the engineering design phase, benefits the overall project outcome. We are able to identify issues and design error before it is built. Collaboration between multi-disciplines is more efficient in terms of having visualization from an integrated 3D model. The BIM process generally reduces the amount of time required for design review and also reduces the time required for 2D drawing detailed drafting. In the next future project for the oil and gas industry we look forward to creating a database of information for offshore platforms as it benefits the owner in of cost, schedule, product quality, future renovation and maintenance.