



Upscaling the modularization concept in offshore facilities

▲ By Abdullah J. Albahrani and Abdulmuti W. Al-Ruhaili

This article covers the importance of reducing brownfield works by utilizing the modularization concept in offshore projects. This approach is crucial to minimize the construction work on live hydrocarbon facilities during the construction phase. To achieve this goal, projects tend to implement various technologies at an early stage.

In the Marjan Gas-Oil Separation Plant 4 (GOSP-4) project — part of the ongoing Marjan Increment Mega-Program being executed by Saudi Aramco — the team explored the possibilities of minimizing the future brownfield works by implementing the modularization concept at a larger scale.

Introduction

The Marjan GOSP-4 offshore facility is a new bridge-connected multiplatform facility. The GOSP-4 part of the Marjan Increment Program is considered the largest offshore facility to be built by Saudi Aramco. The purpose of the new offshore GOSP is to increase the production capacity of both oil and gas, meeting the corporate objectives to remain a reliable supplier of hydrocarbons. Due to the nature of the reservoir, this is planned in a two-phase development program, where additional processing equipment, e.g., HPPTs, crude shipping pumps, and gas compressors will

be required at a later stage in two of the six platforms: the Gas Compression Platform (GCP) and the Production Platform (PP). Phase 1 of the project is faced with the challenge of designing the facility in terms of space, layout, tie-ins, etc., for seamless expansion and integration with the future Phase 2 project.

Fixed offshore platforms consist of two major parts: the jackets, which are the submerged steel structure of the platform functioned to lift the second part, which is the topside. The structure hosting the processing equipment usually consists of multiple decks. In Marjan GOSP-4, both the GCP and PP topsides are four level decks (main, mid, cellar, and sub-cellar). The Production Platform will house the HPPTs, de-sander, crude shipping systems, and the associated utility systems while the Gas Compression Platform will house the gas compression, cooling and sea water systems, and the associated auxiliary systems. In the future Phase 2, there will be a requirement for a major expansion of these systems, including an additional separation, crude shipping, and gas compression trains. To put things in perspective, the space required for the expansion is 17m x 62m, which is equivalent to 22% of the current PP layout, and 30m x 54m, which is equivalent to 50% of the current GCP layout. This expansion will entail

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brownfield work at a live offshore hydrocarbon facility, which poses great technical, logistical, and safety risks in the construction phase. Reducing the brownfield scope and duration is the main challenge to be addressed.

Challenge Solutions

• Layout Consideration Concept

One solution to this challenge is to build the topsides with the structural space requirement for Phase 2, where it can be loaded and installed at once and leave the piping and equipment installation to be done later at the offshore facility. However, this approach has major disadvantages that can be summarized into three main points:

- Increased safety risks during future Phase 2 construction due to space constraint. Another aspect is the limited accessibility to install the large equipment at its location, which creates more complicated critical lifts over company assets, especially the equipment located at mid and cellar decks.
- Installation limitations to the current Phase 1 project due to the immense topsides. Phase 1 topsides are already massive and require a super X-class vessel for the float-over installation. The weights of the PP and GCP, without considering Phase 2 expansion, are 23,700 MT (metric tonnes) and 20,000 MT, respectively, while the estimated weight for Phase 2 expansion is

4,570 MT for PP and 6,060 MT for GCP. These additional weights will impose complexity to the installation methodology and type of vessels to be used.

- c. Escalated costs to Phase 2 project due to extended offshore works duration. The execution cost for offshore construction work is more expensive than similar scope done at onshore fabrication yards. In general, brownfield work often results in schedule delays and cost overruns [1]. The logistical issues of having the required manpower is another cost adder, specifically in offshore projects. The total duration to execute the scope is longer due to limited access to manpower; a typical jack-up barge can accommodate 100/250 workers, while contractors can deploy double this number at fabrication yards.

This option has been intensively studied for the GCP. The offshore work will require an extended facility shutdown for more than two (2) months, which will interrupt the production. This shutdown will be required to complete the brownfield works, which include the installation of major equipment, ~600 line pipes, electrical, instrumentation, and safety systems.

• Modular Concept

Modular construction as defined by the Modular Building Institute is “a process in which a building is constructed off-site,

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under controlled plant conditions, using the same materials and designed to the same codes and standards as conventionally built facilities.” [2]. Alternative to the first option is to locate all the future required equipment at one side of the facility and only consider their requirements in the jacket design. This approach has been pursued with the purpose of simplifying offshore construction, reducing the cost significantly by shifting construction scope from offshore to onshore, and mitigating the risks associated with brownfield works.

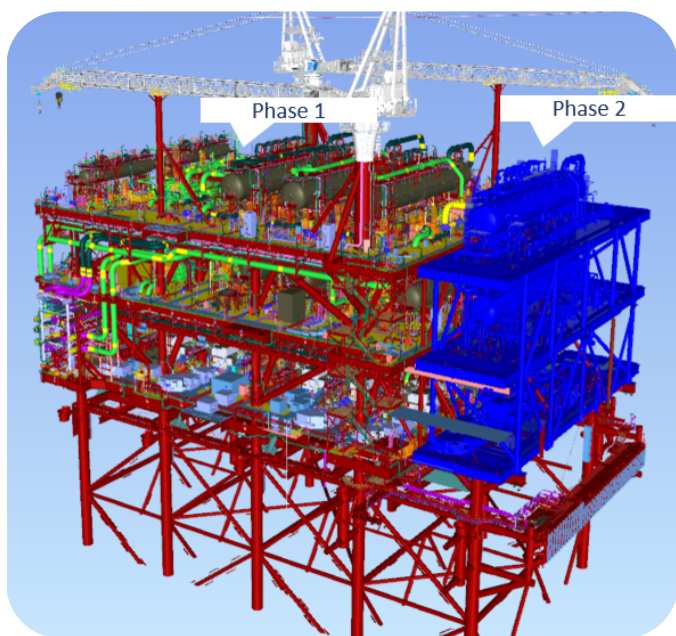


Diagram 1: PP Future Module 3-D Model

In GCP, the future module will have approximately 600 tie-ins that are required to be connected into the existing Phase 1

lines which exceed 2,500 lines of various sizes for the various systems. With the modularization concept, all these tie-in connections are limited to the corresponding header connection in the current Phase 1 facility. This minimizes the quantity of offshore hook-up work.

To achieve optimum cost solution for offshore projects, the goal is to transfer as much work from offshore to onshore fabrication yards. In this case, the required 6,062 MT of fabrication for GCP, inclusive of major equipment, piping, structure, electrical, instrumentation, and safety systems, can be installed at the yard, thereby reducing the duration of the offshore installation campaign.

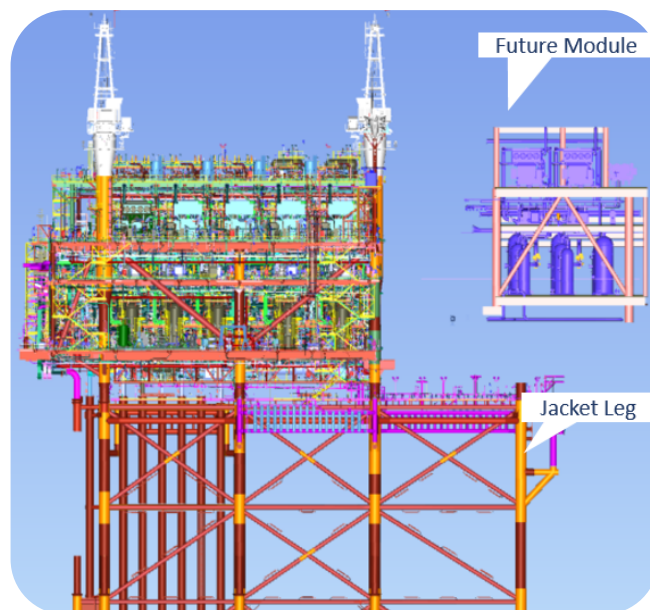


Diagram 2: Installation of GCP Future Module

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Considering the modular approach, the jacket will be designed with all the anticipated loads, thereby avoiding any strengthening to the jacket structure at a later date, which is expensive. Future module installation challenges are addressed in the current design by providing bumpers on the jacket structure. The bumpers will mitigate the future installation risks that might lead to damage of the existing facilities. These additional loads from installation are addressed in the current design.

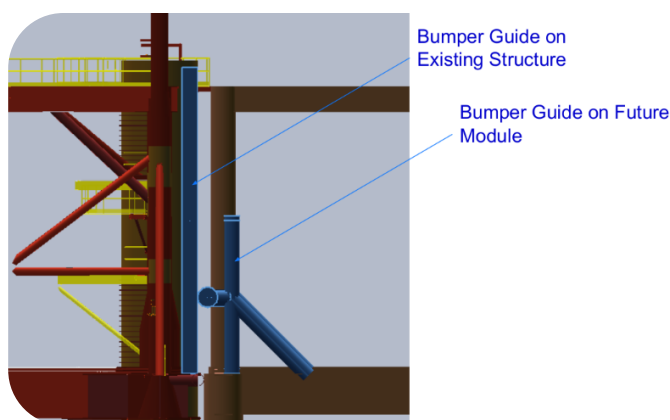


Diagram 3: Bumper Guide Design

During Phase 2 design, guides are to be attached to the future modules to securely engage with the current facilities by bumping against the existing structure for a smooth and correct position. The offshore welding work is minimally restricted to only the welding onto two columns, since all the piping headers are inside the perimeter of the modules.

One of the main challenges for Phase 2 will

be the selection of the heavy lift vessel for installation of the future modules. The installation will require vessels with higher crane capacity, which comes with its costs. However, the cost of mobilization of heavy lift vessels (which currently are available in the market) will be much less compared to other methodologies, e.g., stick-built construction, selected for future expansions at offshore plants.

Most importantly, going with the modular approach will reduce the safety hazards associated with brownfield works, as well as the shutdown and process interruption to the live facility. In general, the fabrication activities in the onshore yards have more control measures when it comes to working from height, dropped objects, and lifting operations which are the leading cause of accidents in offshore work [3].

Conclusion

Minimizing the construction activities on live hydrocarbon facilities can be achieved through the adaptation of modular design. Modularization in general has more advantages than disadvantages. Adopting this approach in Marjan GOSP-4 will minimize production interruption, enhance safety, and reduce costs for any future expansion.

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