Project Management Institute

CASE STUDY

Project Management Excellence on Display in Mumbai High North Project by Larsen & Toubro (L&T)

L&T breaks new ground in offshore engineering and construction using sophisticated project management techniques

India's heavy and growing dependence on imported energy is putting financial strain on the economy. More than half of India's $191 billion trade deficit in the financial year 2012-13 was due to oil imports, of which 82 per cent came from Gulf countries. Geo-political events such as the civil war in Syria or unrest in the Middle East have left the country vulnerable to price spikes. To meet the growing energy demand and enhance its energy security, India is making major investments to augment its own oil exploration and production capacity.

Mumbai High is an oilfield with big potential. Located in the Arabian Sea about 160 km west of the Mumbai coast, Mumbai High has more than 551 oil wells and 33 gas wells, and is operated by Oil and Natural Gas Corporation Ltd. (ONGC), the largest producer of oil and natural gas in the country.

The Mumbai High North Project

On 27 July 2005, the Mumbai High North (MHN) platform was gutted in a devastating fire that caused major production loss. ONGC decided to redevelop Mumbai High by reinstating production facilities destroyed in the fire, besides building new facilities as part of a new MHN complex.

ONGC awarded this project to Larsen & Toubro (L&T) Ltd., one of India's largest engineering and construction companies, with extensive experience in hydrocarbon EPIC (Engineering, Procurement, Installation and Commissioning) business. L&T won the project against stiff competition from international players such as National Petroleum Construction Company, Hyundai, and Samsung. The MHN project was valued at $1.1 billion, and is considered one of the largest and most sophisticated projects undertaken anywhere in the world.

The contract included construction of multiple platforms for the processing of oil and natural gas, commonly referred to as Mumbai North Platform (MNP). These would include three process gas compression (PGC) modules (separate contract to L&T for 3 PGC modules); Mumbai Living Quarter (MLQ) platform for safe operational and life support requirements for those working offshore; and two flare platforms for residual/unused gas, during the extraction of petroleum crude oil at production sites. All of these platforms were to be connected by bridges to form a single complex. The massive project would require a total of 80,000 metric tonnes of steel.

The scope of work for L&T included surveying, engineering, procurement, fabrication, installation, and commissioning of the facilities.

Project Highlights

- The engineering and fabrication in India of a massive offshore process platform with a topside (commonly known as the deck) weighing 26,500 tonnes
- Construction of 13 large pre-fabricated modules, weighing a total of approximately 21,000 tonnes, integrated offshore into a single MNP platform topside
- Construction of an MNP platform jacket of 13,500 tonnes fabricated and loaded out within a record timeframe of 10 months from L&T's Modular Fabrication Yard at Sohar, Oman
- Construction of the largest living quarter (weighing 4,000 tonnes) in the Indian offshore industry with a capacity to accommodate 150 people
- The fabrication and loading within 18 months of a total of 35,000 tonnes of structures from L&T's Hazira manufacturing facility
- Construction and installation of a 137-meter bridge, the longest bridge in Indian offshore

This project set many records in the Indian offshore industry that led L&T to win the 2013 PMI India Best Project of the Year award for project management excellence.

The Prime Project Objectives

A key project objective was to achieve a total well fluid handling capacity of 270,000 barrels of liquid per day and 6.9 million metric standard cubic meters per day of compressed gas and a total oil handling capacity of 50,000 barrels of oil per day.

For operational safety, the new living quarter platform would be separate from the production and accommodation facilities. It would include safety accessories, support systems, a switchgear room, an integrated control system, transformers, utilities, and an emergency diesel generator.

All the new platforms would be interconnected and the new facilities connected with the existing platform, commonly referred to as the Mumbai North West (MNW) platform.

In addition to the new platforms, the scope also included additional facilities for the MNW platform, such as an additional survival craft for rescue operations and a new 15 metric tonnes capacity overhead crane, removal of 2.9 km of existing subsea pipeline, and a new mooring facility for supply boats.

Abbreviations for Quick Reference

ONGC - Oil and Natural Gas Corporation Ltd

MHN - Mumbai High North

L&T - Larsen & Toubro

EPIC - Engineering, Procurement, Installation and Commissioning

MNP - Mumbai North Platform

MLQ - Mumbai Living Quarters

PGC - Process Gas Compression

MNW - Mumbai North West

WBS - Work Breakdown Structure

PAUT - Phaser Array Ultrasound Testing

SIMOPS - Simultaneous Operations Study

EHS - Environment and Health Safety

Critical Stakeholders

Sr. No.	Project Function Description	Name of Stakeholder / Company
1	Pre-engineering survey	Fugro, India
2	Engineering	L&T Valdel, Bangalore
3	Engineering review	Aker Solutions, Malaysia
4	Procurement	L&T Upstream Procurement Department
5	Fabrication - MNP & MLQ jackets	L&T MFY- Oman
6	Fabrication - MNF1 & MNF2 jackets, MNP topsides, MLQ topsides, flare stacks, bridges	L&T MFF- Hazira
7	Load-out - MNP & MLQ jackets	Mammoet, UAE
8	Loadout - MNF1 & MNF2 jackets, MNP topsides, MLQ topsides, flare stacks, bridges	Lift & Shift, India
9	Transportation of launch barge	Saipem, Malaysia
10	Transportation of cargo barge	Cashman, Singapore
11	Transportation of cargo barge	Posh, Singapore
12	Installation of jackets in Phase 1	L&T Sapura Offshore, India
13	Installation of MNF2 jacket & MLQ deck	Mcdermott, UAE
14	Installation of topsides in Phase 2	Seaway Heavy Lift (SHL), Netherlands
15	Hook-up sub-contractor	PCTS, Mumbai
16	Inspection & quality control	L&T - QA/QC and Bureau Veritas, Mumbai
17	Marine warranty surveyors	Matthews Daniels, Dubai
18	Gas turbine driven process gas compressors	Kawasaki Heavy Industries, Japan with Solar, USA
19	Gas turbine power generator	Solar, USA
20	Gas dehydration and gas sweetening package	NATCO, Japan
21	Living quarter & building module architectural and HVAC contractor	Speciality Services, Dubai

The Challenges

Scope and Schedule

The project's initial execution timeframe of 39 months was reduced to 33 months due to an extended tendering and evaluation process. Project estimates were based on inputs and the size/area of the platform available in the bid documents. Elaborating on the challenges, Mr. Kumar Rudra, project director, MHN Projects, said, "During detailed engineering, we realized that we needed an additional 45 per cent area to incorporate all the facilities on the MNP platform. This led to substantial increase in the weight of the process platform and an increase in the number of splices. In effect, the MHN complex layout turned out quite different from what it looked like at the time ONGC had awarded us the contract. Further, ONGC also changed flare orientation during the engineering stage."

These fundamental changes demanded revision in engineering and design, leading to changes in L&T's scope of work, which in turn affected the schedule.

Engineering

Such heavy platforms are best suited for float-over installation. However, due to a complex network of subsea pipelines, and the presence of nearby platforms, this was not feasible. The first level of the MNP deck was fabricated in eight parts, including three cantilever frames. It further supported five heavy modules, and that load needed to be transferred onto the MNP jacket with eight legs as support structures. The conceptual design of the MNP platform was developed with the installation contractor during the early project stages.

Further, L&T had to deliver the jackets, the tubular joints that hold and support large platforms, 12 months before the topside was ready as per contract requirement. Generally, jackets are engineered after completion of topside engineering based on topside weight distribution. But in this case, L&T had to go ahead with the jackets first without having confirmed data on the topside weight because the topside design could not be finalized so early in the project.

Procurement

Challenges included adhering to the client's recommended vendors, global sourcing, development of new vendors for timely procurement and delivery of goods, and fabricating larger packages in-house. In addition, managing the logistics of multiple modules and other resources simultaneously for safe transportation as well as on time availability for 80,000 tonnes of material, including over 300 tonnes of equipment; 50,000 meters of piping; more than 10,000 valves and pipe fittings, and 650 kilometers of cables presented additional complications.

Fabrication

Fabrication was done completely in-house at L&T's Hazira Yard in India and Sohar Yard in Oman. Despite 17 million human hours, there were no fatal accidents. At peak construction, more than 6,000 people worked at MFF Hazira. Managing safety and production efficiency of the large work force was a challenge.

Managing large quantities of material proved a Herculean task, involving quality management, storage, material tracking, and allocation of resources. It was also necessary to ensure timely availability of inputs at each phase of the project. Drawings and materials of the engineering phase were made available at the fabrication stage for reference, thus minimizing standbys.

Load-out & Sail-out

The MHN project demanded back-to-back load-out of modules as heavy as 4,500 tonnes from Hazira, L&T's fabrication facility in Gujarat. However, the jetty at the Hazira yard had to deal with large tidal variations and load-out and sail-out operations were tide dependent. This necessitated micro planning of load-out and sail-out activities with continuous monitoring to avoid any schedule slippage. Missing one tidal window could cause a delay of three to seven days in sending structures offshore.

Further, many 400 class barges were required to transport heavy modules. The large size of these barges through the narrow Hazira channel reduced the number of suitable tidal windows.

Installation

The safe installation of heavy modules, while simultaneously taking utmost care of nearby structures and the network of pipelines in the seabed, was crucial. Further, integrating 13 splices of the MNP platform into a single structure offshore was one of the project's biggest challenges. All offshore related constraints needed to be envisaged well in advance to avoid any standby.

Phase two installation posed a challenge as the planned vessel did not arrive on time and arrangements had to be made for a different installation vessel. The installation engineering had to be verified and modified to suit the new vessel. Also heavy lifting slings and shackles had to be mobilized within a short time span.

Hook-Up & Commissioning

Defining scope and contracting, managing a large number of workmen, offshore logistics, timely vendor mobilization for commissioning, and the on time availability of hook-up materials were some of the challenges faced.

Though a majority of the spool joints erected inside individual modules had already been tested at the fabrication yard as per the bid requirement, L&T had to conduct hydro testing and leak testing on the balance piping loops at the offshore location.

Human Resources

Co-ordination, complexities, innovations, work conditions, and human resource deployment among the L&T group companies and its national and international partners for the project demanded synchronization and sequential execution of high-level project management activities at all times.

Project Management Techniques Behind Project Success

Executing a project of this nature meant L&T combined tried and tested project management approaches, techniques, and tools, with some innovative methods to take the project to fruition. The team adopted processes and guidelines prescribed by PMI's *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* for thorough planning and meticulous execution.

Mr. Rupchand Lohana, deputy general manager, Hydrocarbon Upstream Division L&T, said, **"PMI techniques are very generic and following these guidelines helps in project management. PMI techniques and guidelines help in addressing issues in a structured manner."**

L&T created a work breakdown structure (WBS) to the micro level and forecasted future time to be taken for each task phase-wise. A detailed WBS was prepared right from the engineering phase through procurement, fabrication, installation, hookup, and commissioning phases.

Comparison of the master schedule depicting planned tasks versus actual schedule reports, forecasts and catch-up schedules helped keep a check on schedule progress. Mr. Lohana further explained, "We followed the S curves technique that allowed for overall progress tracking. We compared baseline targets with actuals in a graphical presentation, especially to tap delays and catch ups."

Apart from this, it is very important to monitor activities on critical path on a weekly basis and identify any risks which can delay critical path activities.

Time management was another crucial element. Integrated project schedules, identification of critical tasks, progress reports on monthly, weekly and daily basis, and management reviews were some of the measures adopted to manage time well.

A project of this magnitude generates a huge number of documents. **The document control index consisted of all the drawings and designs to be delivered by engineering with their scheduled start and end dates, review dates, and client approvals, which were compared with actuals as the project progressed.**

Engineering deliverables were prioritized as per procurement and fabrication requirements to minimize impact on overall project progress. Overall engineering was delayed due to various external factors. However, the impact on the latter stages was minimized due to prioritization. This also helped avoid the standby cost on fabrication resources.

Innovative construction techniques, state-of-the-art infrastructure, micro level planning at each stage of the project, and the integration and synchronization of inter- and intra- personnel tasks led to many engineering wonders. **The team conducted over 1,000 structural analyses for optimizations and adjustments, and used the laser-mapping technique to achieve fine tolerances during fabrication. In many cases, the advanced Phaser Array Ultrasound Testing (PAUT) technique was used instead of the traditional radiography testing to compress testing schedules.**

The use of superior technology and project management processes allowed L&T to manage a 45 per cent increase in the size of the platforms without a major impact on timelines.

L&T took proactive measures for potential troublesome areas based on its experience from past projects. The quality plan, inspection plan, inward material inspection report, ISO certification documents, and technical quality documents pertaining to painting, welding, materials, and workmanship were maintained as per project specifications. New and innovative techniques such as the PAUT technique ensured accuracy, speed and safety, no downtime for inspection, and no evacuation of radiography testing production personnel.

Procurement challenges were handled through material control charts. They tracked and monitored all materials and every drawing starting at the engineering phase and looping all the stakeholders involved to maintain transparency during work flow. Procurement management involved standard processes and documentation such as request for quotations, purchase orders, and negotiation documents.

Cost monitoring for the project was done at the detailed WBS level. Monthly cost reports were generated. These tracked actual costs incurred,

commitments made to vendors through letters of intent, purchase orders, and balance costs that were yet to be incurred. This data was compared with the WBS-level budgeted costs. Budget controls at the WBS level were institutionalized and any increase in WBS costs required approval from higher authorities.

Apart from cost monitoring, cash flows are equally important for the project. **Both monthly cash inflows and outflows were planned at the time the project was awarded and actual progress was monitored for negative working capital.** Continuous focus on milestone certifications ensured that amounts related to completed activities were received without any delays. This helped reduce working capital requirements.

The use of a risk matrix ensured timely risk identification and classification at all stages of the project and helped build a competent mitigation plan. **A risk register recorded all the new risks identified during project execution, and the risk management plan was used to track the status of the risks according to their severity and probability.** A review with the board of directors or senior management was conducted every three months to address and mitigate these risks.

With multiple stakeholders involved, coordination was critical for project progress. **Senior project managers and coordinators were primarily responsible for team formations and interface management. Interpersonal team skills needed periodic monitoring and training.** The attrition rate, especially of critical resources, had to be kept in check. For all the above stated activities, there were weekly or fortnightly meetings where bottlenecks and new challenges were identified and brainstorming of solutions done to meet stakeholder's expectations.

Project integration was critical, and a strong integrated schedule was followed throughout the project execution phase to achieve this. **All the stakeholders had monthly review meetings to discuss integration processes. A repository of communication, Encorr (an external correspondence system), was created through which internal stakeholders could access all emails, meeting records, and review notes.**

A communication matrix was established early in the project stage to manage information distribution. This resulted in early dissemination of information to the right people and helped in project coordination among the stakeholders across management levels, averting issues related to inefficient communication.

Safety measures such as a safety incentive scheme, field safety audit, safe manpower transfer, trainings, briefings, safety awareness sessions, a system to issue permits to contractors and clients to work at the site, and Simultaneous Operation Study (SIMOPS) to ensure safety during operations of multiple barges in close vicinity were adopted. L&T also conducted safety studies during engineering, execution, and offshore installation to ensure that all risks during construction, installation and operations are identified, addressed, and mitigated before closeout.

Technology also played a big role in project execution. State-of-the-art commercial engineering software such as Hysys, PDS, SmartPlant, and SACS were used for engineering. L&T chose Primavera, a planning tool that helped integrate the overall project schedule. MS Excel was used for tracking the large number of deliverables.

Other software used during the project execution included:

- e-ALPS, an e-Activity Level Planning System, is an in-house software used for tracking material status and quality checks at each stage of procurement and fabrication
- Centenary, an in-house software for tracking commissioning activities, and
- Navisworks, a 3D modeling viewer extensively used offshore to support hookup activities and checks

A combination of technical tools, innovative construction methods, mature project management processes to monitor and manage change, and a team experienced in managing projects of this magnitude ensured the project was rolled out in 39 months despite major change requests and reduced timelines.

Tangible and Intangible Benefits

The completed MHN platform, with its enhanced fuel and gas handling and pumping capacity, now generates revenues of over Rs.15 crore ($ 2,426,550) a day for ONGC. The increased fuel production is helping India to improve its energy security. By involving more local contractors, vendors, and consultants from India, the project helped retain a significant percentage of wealth within the nation. By restoring a previously destroyed platform, L&T helped ONGC regain control over and monetize a key asset in this fuel-rich region.

L&T has also created an online document management system and knowledge management system called KnowNet to institutionalize the learning resulting from this infrastructural feat, including technical process improvements, so that other project teams are benefited.

The process improvements that L&T introduced have not only helped save time and reduce costs but have also improved productivity, hence enhancing the quality of services provided to the client.

Many other process improvements were implemented in areas such as fire proofing, adoption of the assembly-line approach for spool fabrication, improved weld groove design and backing methods, and laser mapping for dimensional control.

The project complied fully with Environment and Health Safety (EHS) standards. Some of the key EHS measures undertaken were the safety incentive scheme, safety field audit, safe manpower transfer, EHS training, regular EHS inspections, and SIMOPS with a detailed analysis of various scenarios and safety aspects while two major operations are going on simultaneously taken during project execution.

"We, at L&T, believe in continuous education. We have instituted the L&T Institute of Project Management which is affiliated with PMI. The institute conducts regular training programs as well as management and certification courses. We are encouraging our employees to get formal certifications such as PMI's Project Management Professional (PMP)®," said Mr. Lohana.