PROJECT-INTEGRATED LNG OFFLOADING AVAILABILITY ASSESSMENT FOR FLNG

Mikhail Santosa
Floating Systems Engineer
mikhail.santosa@intecsea.com

Holger Kelle
Vice President Floating Systems Melbourne
holger.kelle@intecsea.com

Anne Barthelemy
Senior Naval Architect
anne.barthelemy@intecsea.com

1 ABSTRACT

The poster explains a combined heuristic, analytical and probabilistic process to evaluate LNG offshore offloading availability in combination with facility uptime and commercial drivers such as LNG sales and supplies contracts.

The heuristic assessment is informed by facility operators, LNG Carrier (LNGC) masters and tug operators experience in offshore offloading and berthing operations. The analytical process includes assessment of met-ocean, mooring, manoeuvrability simulation, model testing and event forecasting methods. Gaps of uncertainties for future predictions are filled by probabilistic Monte-Carlo simulations. The heuristic, analytical and probabilistic approach, combined with commercial drivers, is put together into a multi-parameter algorithm for uptime assessment in order to forecast the techno-commercial performance of the facility. The process described is specific to side-by-side offloading operations; however it can also be adapted to standard jetty offloading operations and tandem offloading operations.

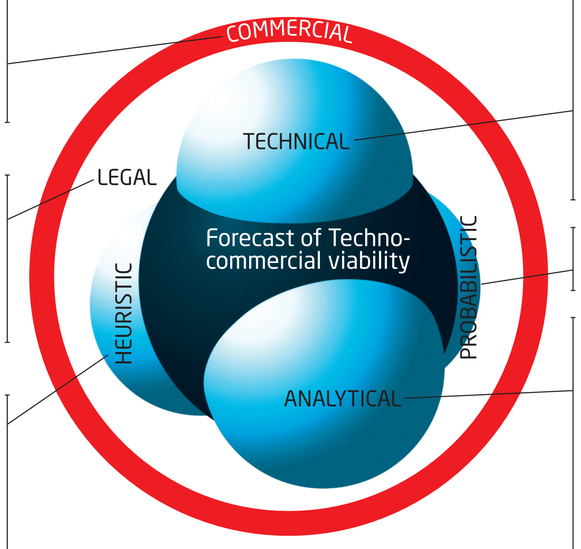
This process has been developed within INTECSEA over the last 6 years and has been applied to over 23 LNG export terminals (FLNGs) and LNG import terminals (FSRUs) at varying geographical locations.

2 PROJECT-**INTEGRATED** MULTI-PARAMETER ALGORITHM TO ASSESS LNG TERMINAL TECHNO-COMMERCIAL VIABILITY

- Cash flow
- NPV
- IRR
- Tariff
- Project finance
- Tax treatment

- Gas sales agreement
- Terminal agreement
- Lease / charter contracts
- Supply and tug vessel charter

Experience Based:
- Subject matter experts
- Precedence
- Risk
- Perception
- Human factor



- Facility design
- Storage size
- Ramp-up/ramp-down
- Reliability and maintenance
- Data collection
- CAPEX
- OPEX
- Schedule

- Monte-Carlo approach for uncertainties in heuristic assumption

- Data processing
- Metocean study
- Mooring analysis
- Offloading analysis
- Navigational simulation
- Berthing simulations
- BOG handling
- Terminal time domain analysis

3 OBJECTIVES

To forecast the **techno-commercial viability** of a terminal:

Creates **confidence** in...

- Achievable uptime and LNG throughput
- The best for facility
  - Configuration
  - Storage size
  - Offloading technology
  - Location
- Commercial viability
- Contractual viability

The forecast is the key to terminal export/ import performance guarantees.

4 KEY PERFORMANCE INDICATORS

A **good performing terminal** will have:

Loading/unloading availability	Availability to export/import LNG from/to the facility
Uptime	Facility availability where gas production/send-out can be performed
Downtime	Facility shutdown when gas production/send-out cannot be performed
Demurrage	The period when loading/unloading delays cause LNGCs to remain longer in the terminal than the contractually agreed period to load/unload
Partial loading/ unloading	The event when an LNGC can only load/unload part of its LNG parcel due to insufficient volume/storage in an FLNG/FSRU to send/receive the full LNG parcel
Cancelled cargoes	Cancelled shipments due to terminal unavailability to receive an LNGC
Terminal congestions	Occurs when LNGCs and other product off-takers (such as condensate and LPG) are at the terminal at the same time due to loading/unloading delays

HIGH

LOW

5 COST OF **UNDER**-PERFORMANCE

The assessment gives indications of expected **additional operational cost** due to: **downtime, demurrage, cancelled cargoes** and **partial loading/unloading**.

EXAMPLE from past project: **LNG import terminal**

- 250 million SCFD (1.9MTPA) gas send-out capacity
- 3 days of buffer volume
- Take-or-pay agreement
- Using 10 years of metocean hindcast data
- Target 95% uptime

The target 95% uptime was achieved

However, the results also showed:

- Average of one cargo cancellation per year
- Up to one day of demurrage per offload
- Up to five partial offloads per year (to avoid cargo cancellations)

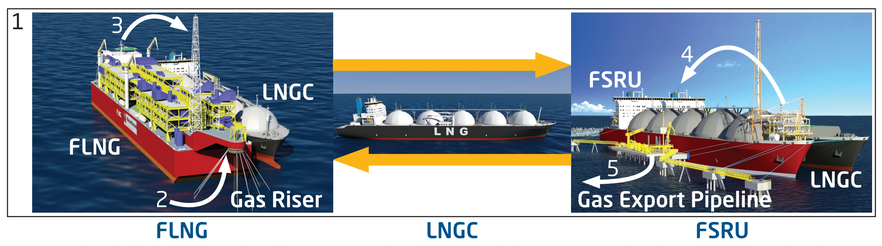
This amounted to additional operational cost: in the order of **USD 100 million per annum** or **~20%-40% increase in the tariff**

6 KEY PARAMETERS TO A VIABLE TERMINAL

LNG Loading/Unloading Availability
Critical to ensure that LNGCs can berth to load/unload at scheduled times with minimal delays

Gas production/send-out availability
Optimum FLNG/FSRU buffer storage volume is the key to maintain gas production/send-out availability when there are LNGC loading/unloading delays

LNG Supplies and Sales Agreement
Impacts LNG supply chain and its management



1. LNG sales and supplies agreement
2. Gas production availability
3. LNG loading availability
4. LNG unloading availability
5. Gas send-out availability

FLNG (LNG Export Terminal) — **LNGC** (Logistic Chain) — **FSRU** (LNG Import Terminal)

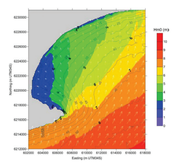
7 METHODOLOGY

HISTORICAL HINDCAST METOCEAN TIME SERIES

Wind, wave and current are the main drivers for:
- LNGC berthing/ unberthing operations
- loading/unloading operations
- gas production/send-out operations

Typically, coastal modeling is required to numerically transform historical hindcast metocean data from a nearby location to the specific project site location.

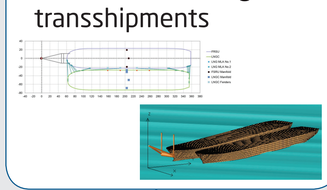
In-house modelling enables assessment of various sites.



MOORING ANALYSIS

To determine the limiting environmental conditions for safe:
- mooring operations
- loading/unloading operations
- gas production/send-out operations

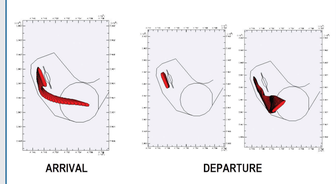
Mooring analysis results are benchmarked against:
- INTECSEA performed model test on side-by-side offloading
- Operators' experience in offshore side-by-side LNG, LPG and crude oil offloading and transshipments



NAVIGATION STUDY

To determine the limiting environmental conditions for safe tug operations:
- escorting LNGCs in the channel
- assisting LNGCs in berthing and de-berthing maneuvers

Berthing simulation results are benchmarked against:
- JIP results on safe tug operations (incl. model test and real world test)
- Tug and LNGC master input full mission and desktop bridge simulation



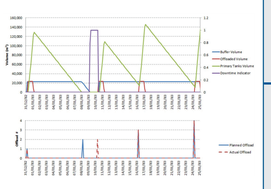
LNG SUPPLIES AND SALES AGREEMENT

Typical/expected agreement is used to model the operational philosophy of the terminal.

This includes conditions that define:
- laytime
- demurrage
- laydays
- laycan
- sales agreements
- minimum availability and throughput
- partial loading/unloading

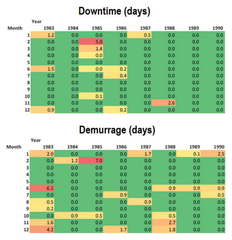
UPTIME SIMULATION

The terminal model (storage size and configuration) along with its associated operability limits and operational philosophy are then taken to the time domain simulation through the transformed historical hindcast metocean time series to simulate the terminal techno-commercial performance through the time series.



TERMINAL KEY PERFORMANCE INDICATORS

Key performance indicators are then extracted to assess the viability of the terminal.



8 PAST PROJECT EXPERIENCE

Assessed **techno-commercial viability** of over 23 LNG export terminals (FLNGs) and LNG import terminals (FSRUs) at various geographic locations over the last six years.

The assessment has aided owner(s) and/or operator(s) in **better decision making** for the project's direction:

- Decision to discard or optimise **breakwater** to reduce CAPEX
- Decision to discard or select **terminal location** based on commercial achievable performance
- Selection of possible terminal mooring systems; therefore allowing owner(s) and/or operator(s) to select the best **terminal configuration** for optimum commercial performance
- **Offloading configuration** selection for metocean condition of the terminal location, i.e. side-by-side or tandem offloading
- Viability of pre-investment for **terminal expansion**
- Optimised **buffer storage volume** to meet logistical chain requirements
- Allowing owner(s) and/or operator(s) to minimise/ mitigate potential **operational risks** shown by uptime assessment in the terminal agreements
- Key input to **LNG supplies and sales contracts**
- Forecasting operational costs for more accurate **tariff calculations**
- Determining the best periods for **inspection/maintenance** and associated equipment reliability requirements

9 CONCLUSIONS

The objective is to **forecast the techno-commercial performance** of offshore LNG terminals, allowing to gain **confidence** on:

- achievable **LNG throughput**;
- the best for facility – **configuration, storage size, offloading technology** and **location**;
- facility's **CAPEX** and **OPEX**;
- assessment of **contractual viability** for LNG off-takers and suppliers

The multi-parameter algorithm to assess the techno-commercial viability has been developed and used by INTECSEA in the past six years for the purpose of assessing **project-integrated LNG offloading availability for FLNG, all assessments and simulations are analysed in-house using a multidisciplinary team**.

It is the **key to terminal performance guarantees** for LNG or natural gas off-takers and suppliers.

Past project experience has shown that assessment carried out during the early stages of the project development can aid in better overall commercial and technology selections.