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"Where will our knowledge take you?"

Concept Planning For FLNG/LNG Using Economic and Operational Performance Simulations to Make Project Decisions

FLNG Global 2017
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Introduction

- *Challenges of FLNG Design & Operation*
- *Metocean Conditions*
- *Reliability Availability Maintainability (RAM)*
- *Operational Simulation – Case Study*
- *Commercial & Safety Benefits*

Drivers and Challenges of Offshore FLNG

Drivers

- Remote stranded gas fields
- Difficult onshore conditions
- Benign Metocean conditions
- Fast track development
- Scale can be customised
- Reduced permitting issues
- Environmental impact is minimal
- Easily relocated

Challenges

- Metocean conditions
- Multi-vessel operations
- Complex berthing & offtake
- Emergency disconnect time
- Design life is untested
- Complexities of processing (i.e. motion of vessel)

Key Safety Aspects & Issues for Consideration

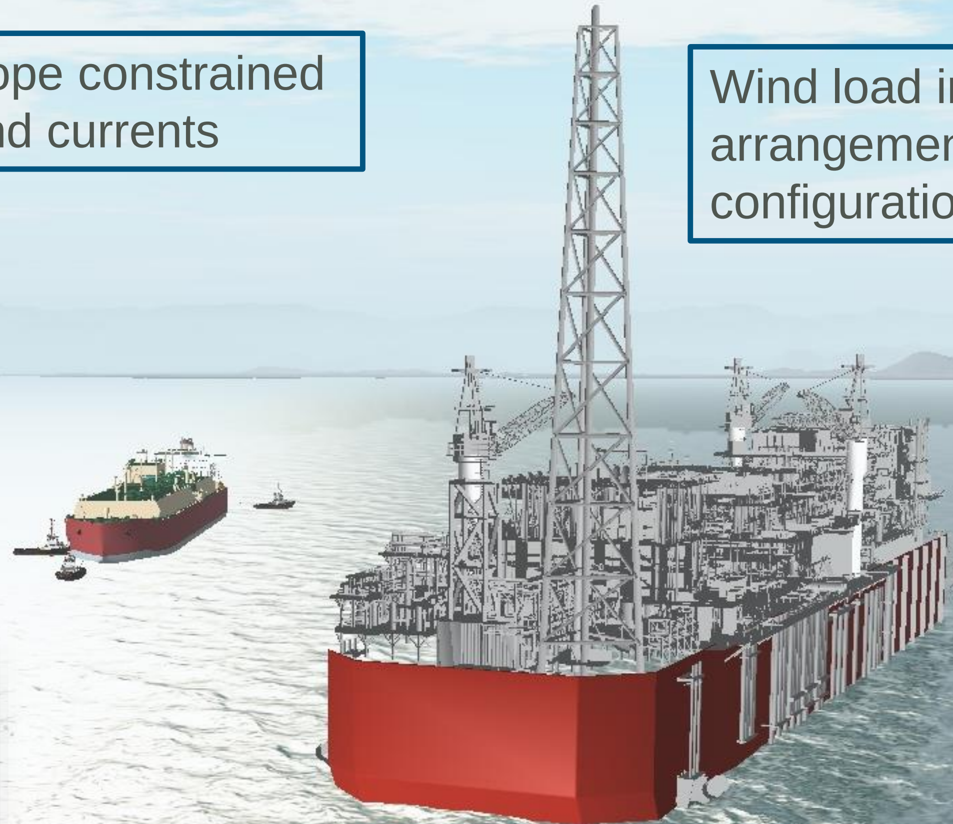
There are many issues that need to be carefully examined when considering a floating LNG facility……

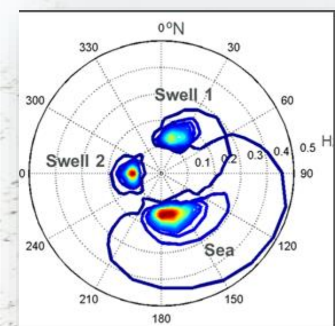
- *Location & site sea conditions*
- *Mooring of the facility*
- *Access for import vessels (tugs & pilotage)*
- *Type of vessel & containment system*
- *Method of transfer of cargo (offshore LNG offloading)*
- *Type of regas plant – Marine environment impact – Reliability, availability and maintainability.*
- *Topsides & deck congestion*
- *Safety issues (fire and explosion, dropped objects, collision, emergency response & evacuation, security, in service maintenance & inspection)*
- *What if the LNG supply vessel must leave partially loaded?*

Metocean Environment

Offloading envelope constrained by wind, wave and currents

Wind load impact on berthing arrangement for offloading configurations





Impact of metocean conditions on motion of the vessel & containment – sloshing

Uses of Reliability, Availability & Maintainability (RAM)

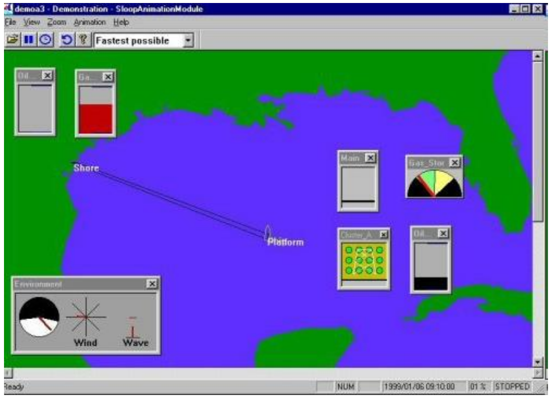
Warfare

Stock market

Factory Production Lines

Port Operations

Renewable Energy



Oil & Gas

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Reliability, Availability & Maintainability (RAM) Modelling

Oil and gas, whether it is a receiving terminal or an FLNG, has especially embraced the idea of RAM analysis for driving design improvements to:

- Reduce costs associated with equipment failure
- Improve production, through the analysis of root cause and impact of downtime

RAM Process

Information Gathering	• Equipment List • Analysis of PFDs and P&IDs • Understanding of failure modes • Historical and estimated failure rates • Logistic times, understanding of crew staffing, spare parts holding, etc • Failure impact on production, capacity and safety • Understanding of any third party requests for shutdown
Development of Reliability Data Set	• Historical operating records • Offshore Reliability Data (OREDA) • Equipment vendors • Engineering judgment
Assumptions	• Identification of equipment critical to production • Development of RBDs (understanding of equipment redundancy and configuration) • Operations and maintenance • identification of sensitivity analyses
Model Construction & Simulation	• Monte Carlo Simulator • Perform simulation with various model inputs
Results	• Quantify performance of the system in terms of overall availability • Presentation of P10, P50 and P90 scenarios for understanding confidence levels • Annual availability distribution • Average duration spent delivering different capacities • System criticalities • High equipment contributors to downtime

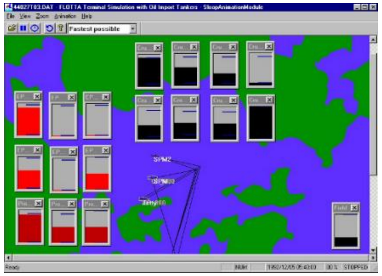
Operational & Economic Simulation

Concept Evaluation, Design and Operational Planning

Typical applications

SLOOP can be applied to an almost limitless array of operational assessments because of the software's versatility. However, some of the more common applications are as follows:

Platform Instillation	Drilling Operations	Vessel Spot-Hire Arrangements
Shuttle Tanker Operations	Planning of Productions System Outages and Maintenance	Intervention and Sub-sea Maintenance Tasks
System Reliability and Weather Dependence	Berth Availability	Offshore and Onshore Storage Capacity Optimisation



Modelling the impact of Weather

One of the key features that BMT's SLOOP operational simulation software is designed to model is the impact of the weather. The weather and ocean conditions affect almost all offshore operations and can significantly extend operation times, increase risk and reduce production rates if poor decisions are made without considering its impact. SLOOP has powerful features for investigating the influence of the met-ocean environment on the development and/or operation of a field. Wind, waves, currents, ice or any other property that can be represented by either a continuously varying value, or by a number of discrete states, may be modelled.

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BMT's SLOOP

SLOOP.2

Operational simulation tool for offshore and marine applications

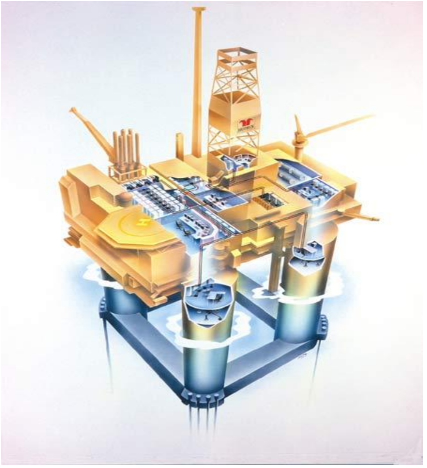
Applications

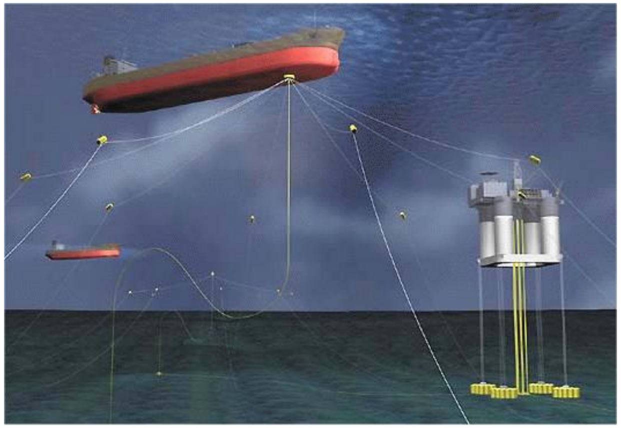
- Productivity & maintenance of offshore oil & gas fields
- Oil & gas field installation & development
- LNG (or CNG) production & transportation
- Shuttle tanker operations
- Renewable energy

SLOOP can model an entire operation, or any specific aspect, as appropriate to the study in question.

Heidrun TLP – Design Optimisation

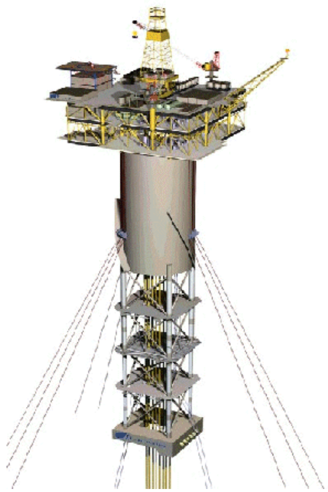
- Heidrun – First major application of SLOOP was in planning for a Norwegian offshore oil field development.
- Demonstrated that crude oil storage could be dispensed with if two loading terminals were installed.
- Extremely important financial benefit to the project





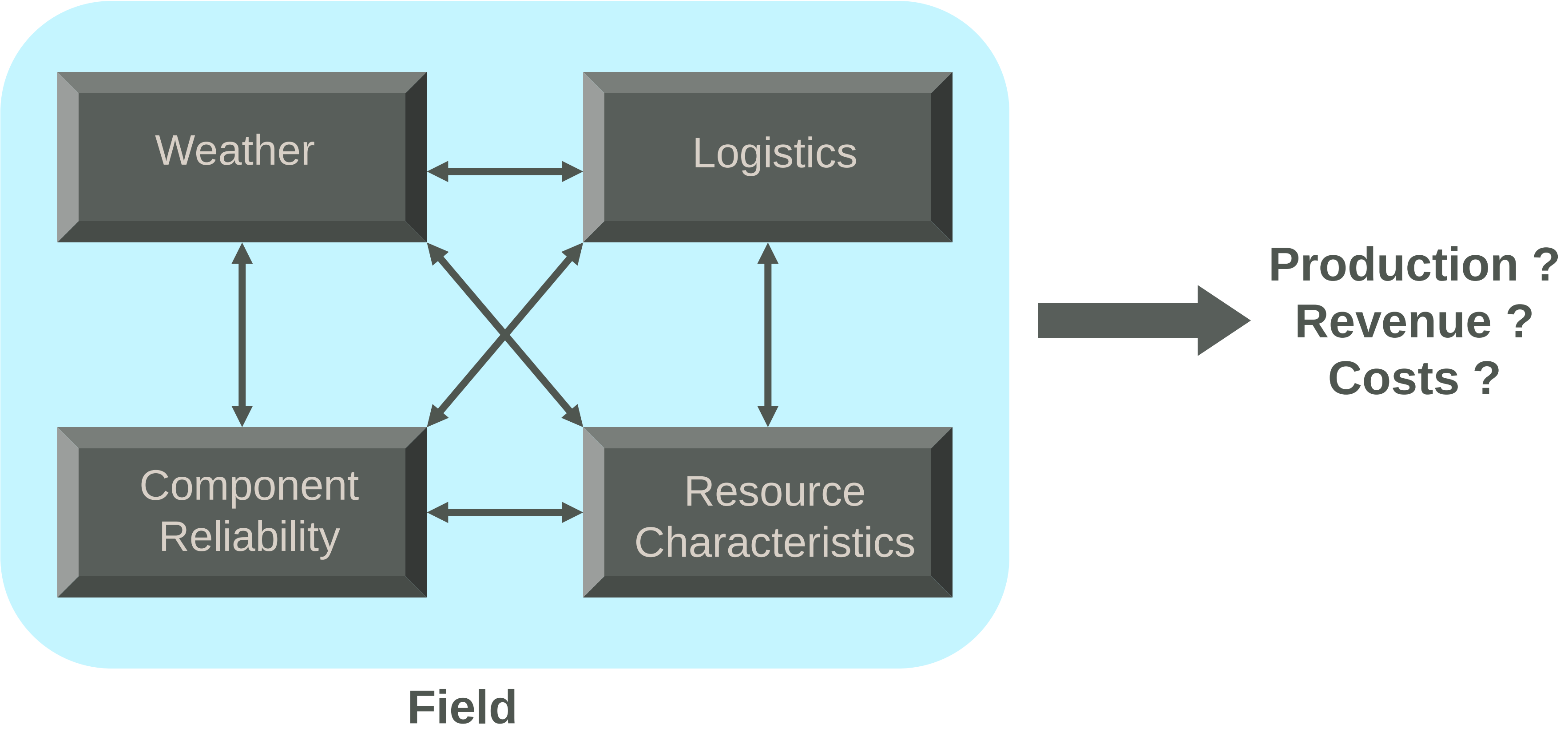
Horn Mountain

- SLOOP instrumental in demonstrating that the second phase of development drilling operations could be performed using a DP drilling rig whilst pulling the Spar over to one side.
- Resolved one of the key potential obstacles to selecting a relatively cheap and fast 'truss spar' option, and opened the way for a very economic fast track project.



Why use SLOOP?

- To determine expected performance of a FLNG development



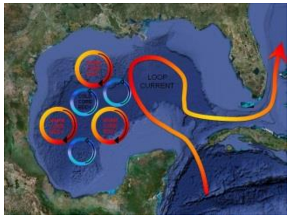
What Differentiates SLOOP?

- SLOOP is specifically designed for simulating offshore and marine operations
  - Has an in-built understanding of key components
  - Fast to build models (do not have to specify all details)
  - Fast to run (can study more cases)

- SLOOP has a strong focus on the impact of metocean conditions. Particularly useful in locations with challenging conditions.


Storms


Hurricanes


Loop Currents


Ice


Swell


Fog

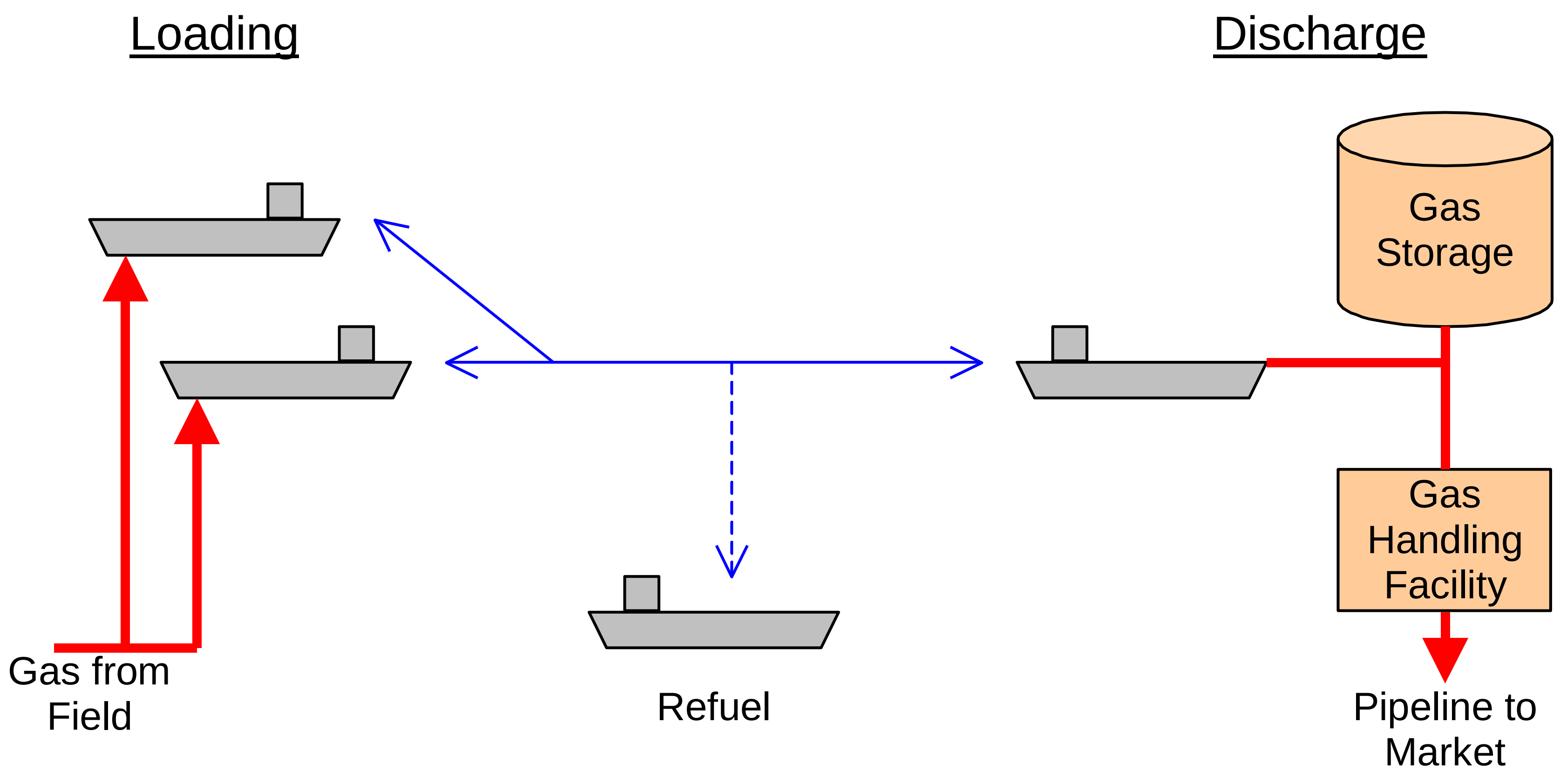
- Supplies Independent Intelligence to support key decisions

FLNG Operational & Economic Simulation Example Study

Study Objective Information Gathering

- The FLNG Unit is planned to be located in exposed waters
- Offload directly to LNGCs through flexible hoses
- Offload directly to LNGCs through fixed loading arms
- Offload to a shuttle tanker that will then sail to a sheltered location and perform offloading to a LNGC
- Carry out offloading at a different location but consider additional LNGCs due to the longer transit distance between the FLNG Unit and offloading port

Typical Simulation Model



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FLNG Operational & Economic Simulation Example Study

Development of Reliability Data Set & Scenario Planning

- LNGC arrives in the field
- LNGC then attempts to connect to the FLNG. Connection may be prevented / delayed by:
  - *Wind speed and wave height limits.*
  - *Connection restricted to daylight hours only.*
  - *There may be a limit on visibility*.
- Time to moor LNGC to the FLNG Unit and preparing transfer
- Transfer Operation Preparation (cooling down of hoses / arms, LNG transfer, monitoring and control)
- LNGC starts to load from the FLNG
- Probability of the off-take system failing. If this happens the failure has to be repaired before loading can commence.
- If there is a deterioration of the weather, the LNGC may be forced to cease loading, disconnect and stand off until conditions improve.

FLNG Operational & Economic Simulation Example Study

Model Construction & Simulation

for 300 years, and repeated 10 times, starting in different years of the environment record,

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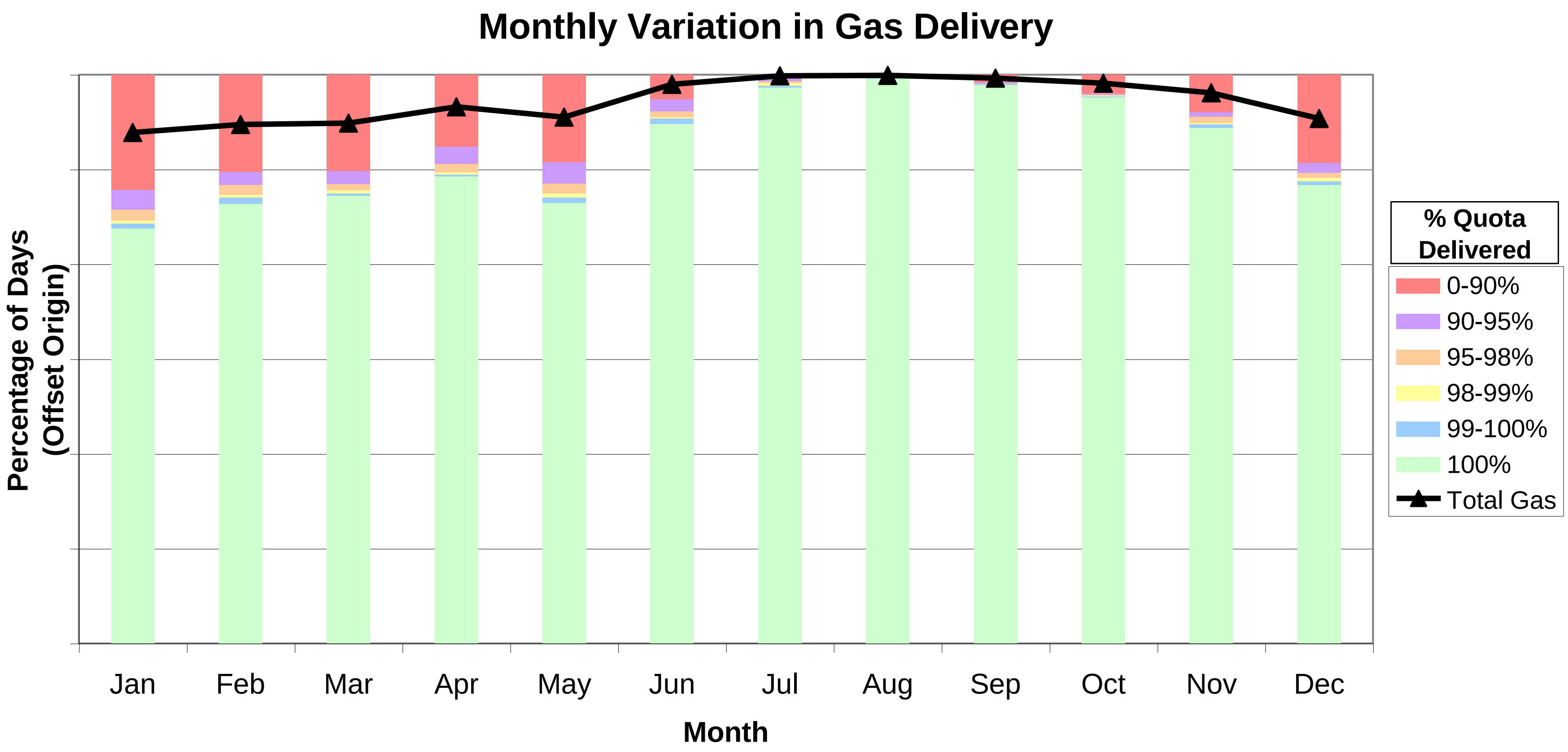
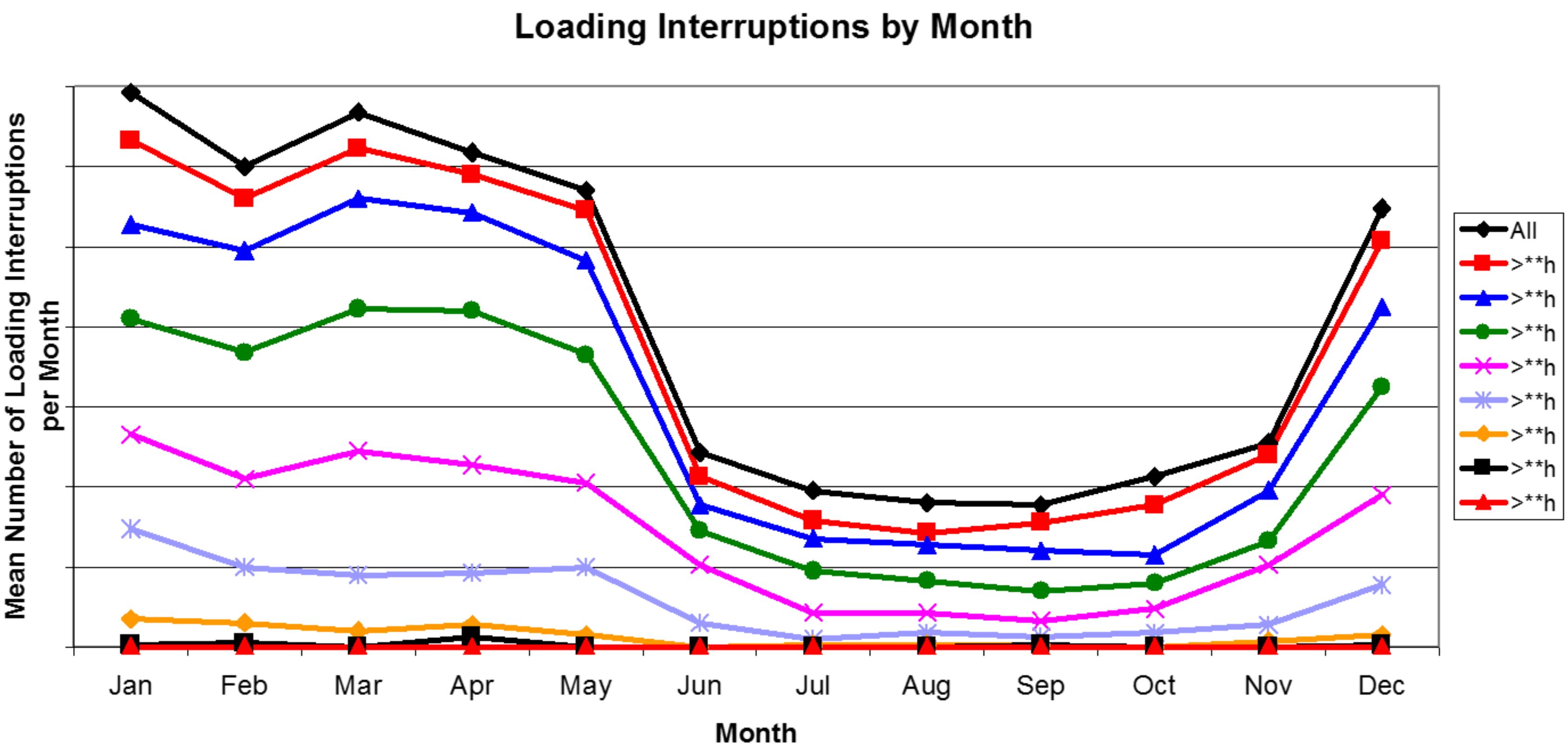
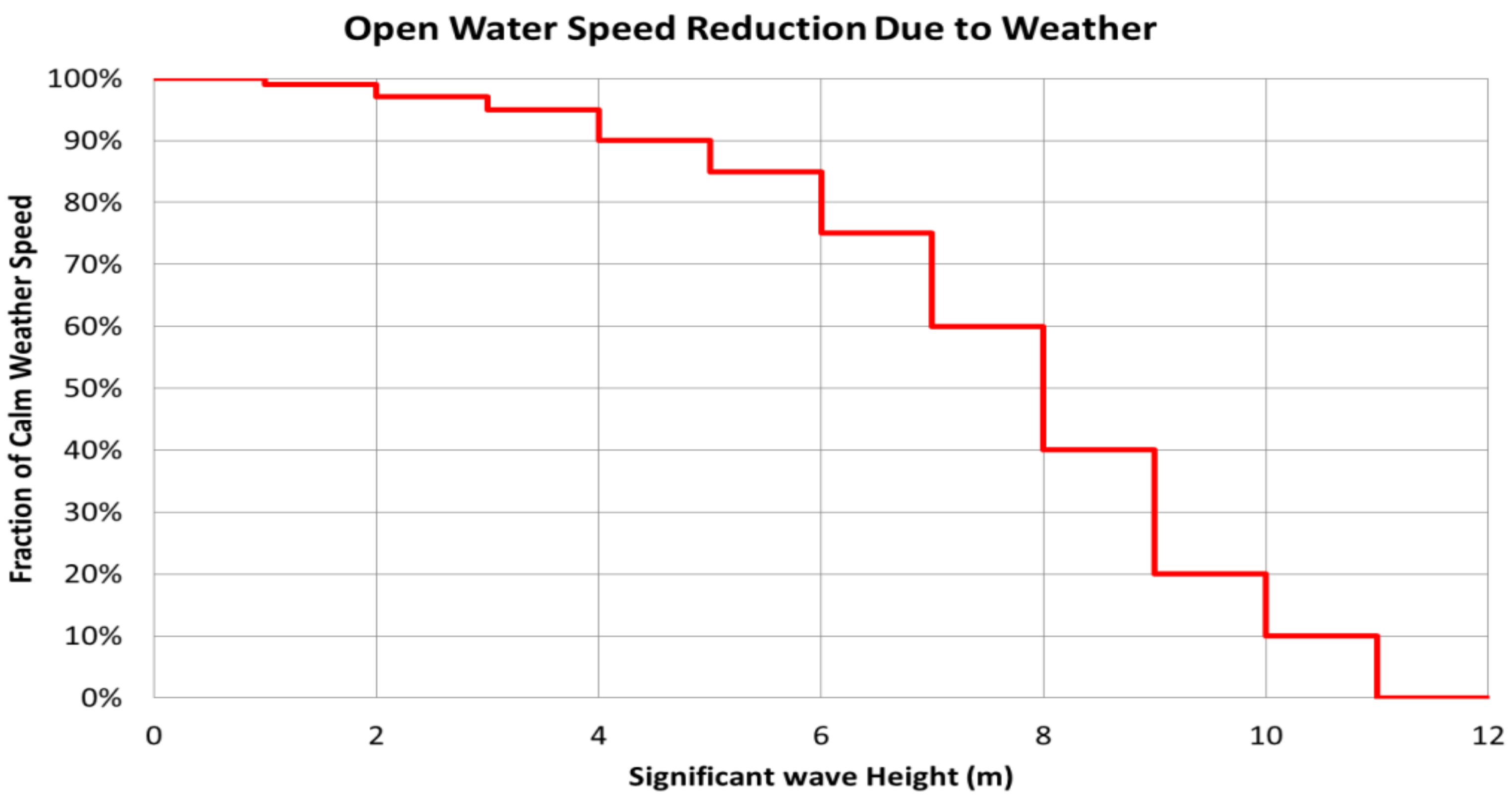
Example Output of SLOOP - Gas Delivered



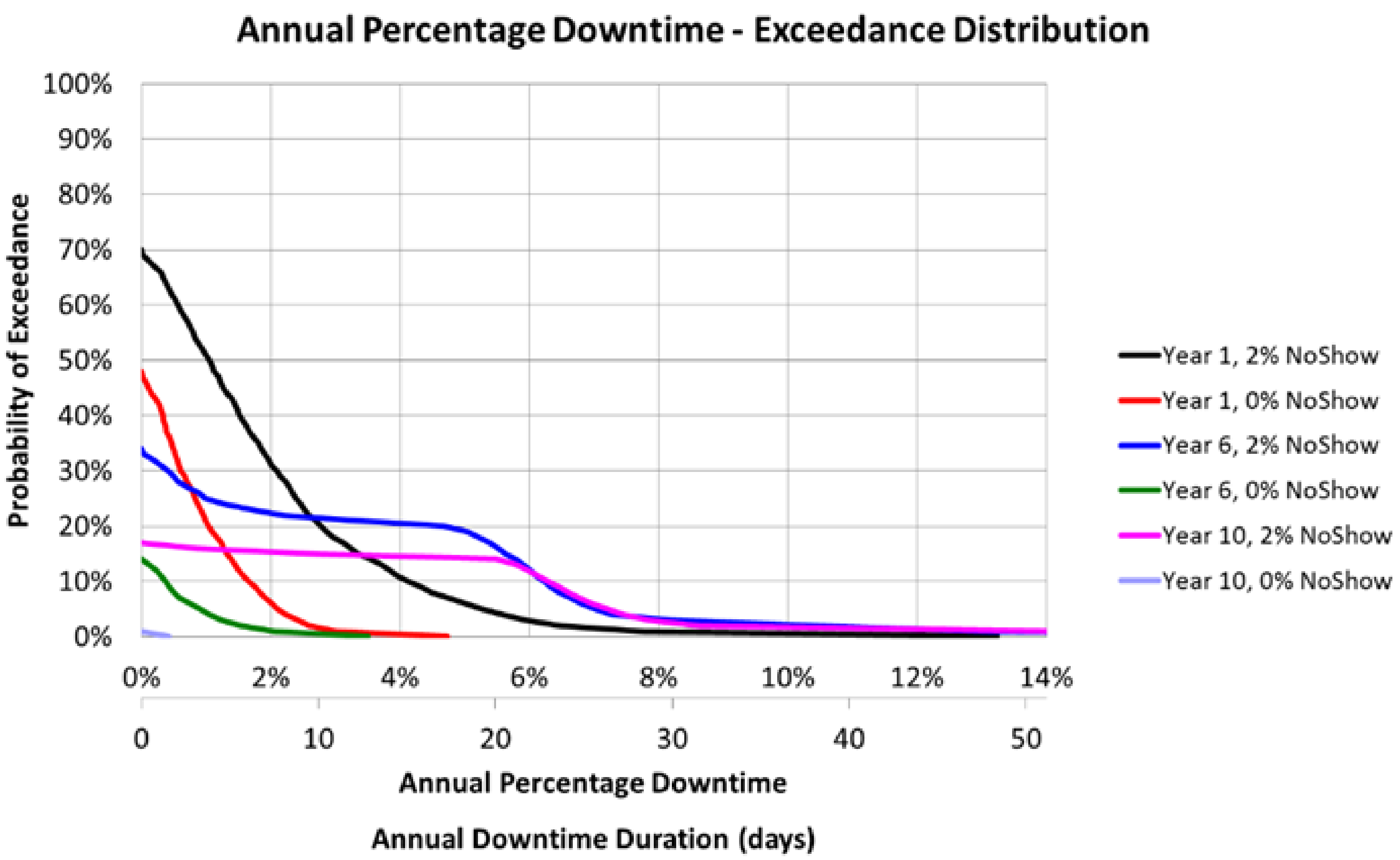
Example Outputs from SLOOP – Loading Interruptions



Reduction in LNGC Speed Due to Weather



Output of SLOOP Final Results - Quantified Availability



FLNG Operational & Economic Simulation Example Study

Results - Discussion / Findings

exceeded 60% of the time, so restricting pilot boarding to that limit would have a substantial effect on performance. If the pilot boarding location is further offshore with more severe waves a higher boarding limit, the use of helicopters will be

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Conclusion – Optimisation of Operability & Economics

Operability

- *Evaluate, compare and optimise concepts*
- *Understand the influence of weather limitations on the performance of your operation*
- *Plan production system outages and maintenance*
- *Compare different maintenance and repair strategies*

Economic

- *Set robust strategies to deliver high NPV at an acceptable level of financial risk*
- *Compare the full life economics of competing development solutions*

Evaluate different development and production options whilst understanding the economic implications to your project

Questions

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