DANSK STÅLDAG den 24. November 2011

THE NEXUS FPSO PROJECT

BY HENRIK MØLLER,
DEPARTMENT DIRECTOR, RAMBOLL OIL & GAS

RAMBØLL

RAMBOLL OIL & GAS
- A SHORT PRESENTATION

ABOUT RAMBOLL OIL & GAS

- A global business unit within the Ramboll group
- 8 offices in Denmark, Norway, Russia, Qatar, United Arab Emirates & India
- Approximately 700 employees
- Head office in Esbjerg

STRUCTURAL DEPARTMENTS

- Based in Esbjerg (65), Sandefjord (15), Qatar (40)
- Service areas:
  - Jackets
  - Topsides
  - FPSOs
  - Onshore Refineries
  - Hazard Engineering and Vibration analysis/measurements

RAMBØLL

NINI / CECILIE PROJECT

We designed the two light weight and robust monopod platforms, Nini and Cecilie, for the Siri field in The North Sea.

ANHOLT TRANSFORMER PLATFORM

In 2010 we performed the detailed design of the 400 MW Anholt Transformer Platform

THE NEXUS 1 FPSO PROJECT

- TOPSIDES DESIGN CONTRACT

FPSO =

FLOATING PRODUCTION, STORAGE AND OFFLOADING

RAMBØLL

TOPSIDES DESIGN CONTRACT

- FEED contract:
  - Client: Nexus Floating Production
  - Awarded July 2006
  - Approx. 45.000 hours


Ramboll sikret rekordavtale

- Detailed Design contract
  - Client: Samsung Heavy Industries
  - Awarded January 2007
  - Approx. 300.000 hours
  - Project Period: 15 month

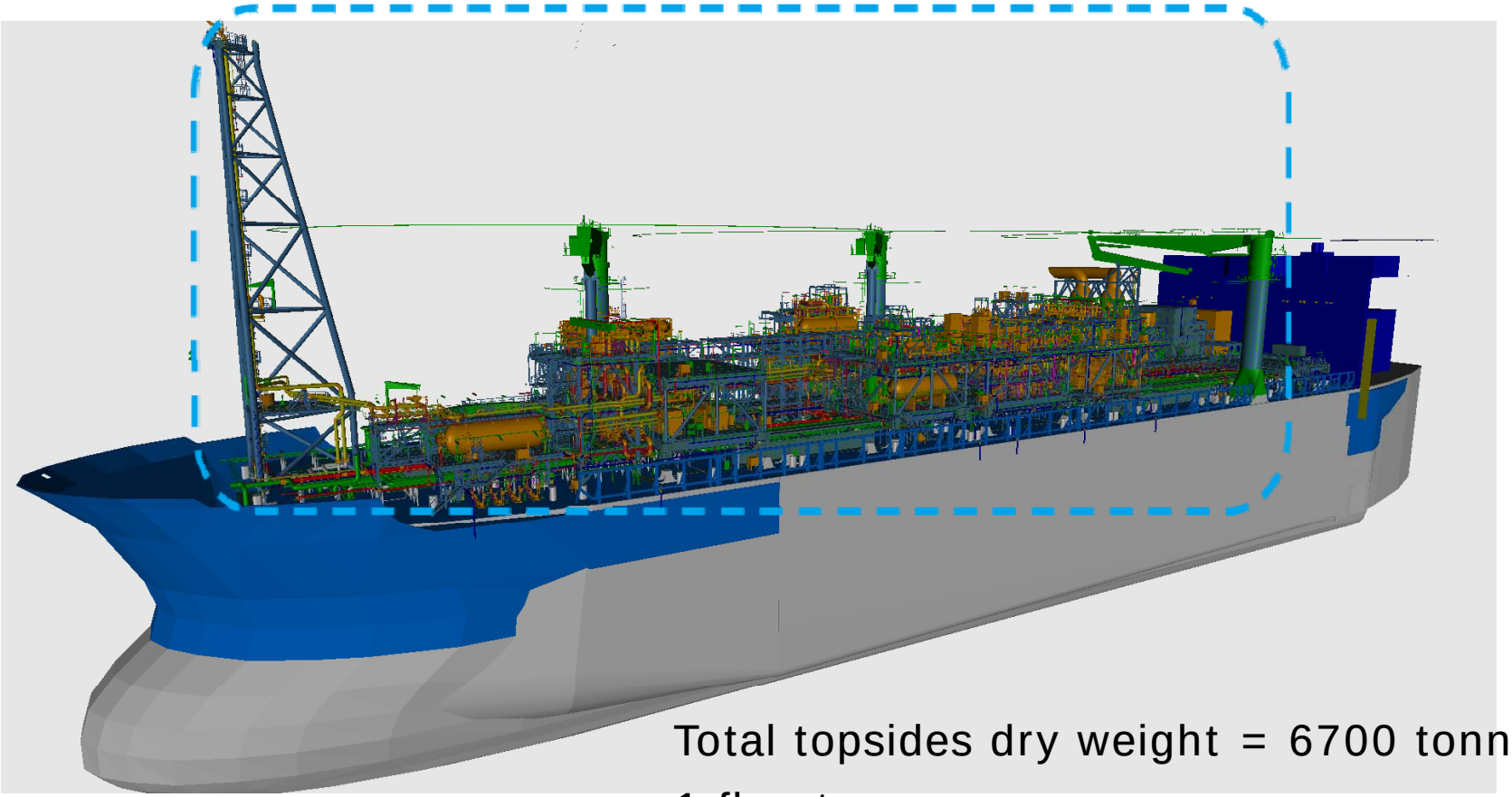

Rekordkontrakt til Ramboll Oil & Gas

TØNSBERG: Ramboll Oil & Gas har skrevet kontrakt med det koreanske verftet Samsung. En kontrakt som er den største til nå Sandefjord-selskapets historie.

sweetdeal

RAMBØLL

TOPSIDES DESIGN CONTRACT



Total topsides dry weight = 6700 tonnes

1 flaretower

13 modules

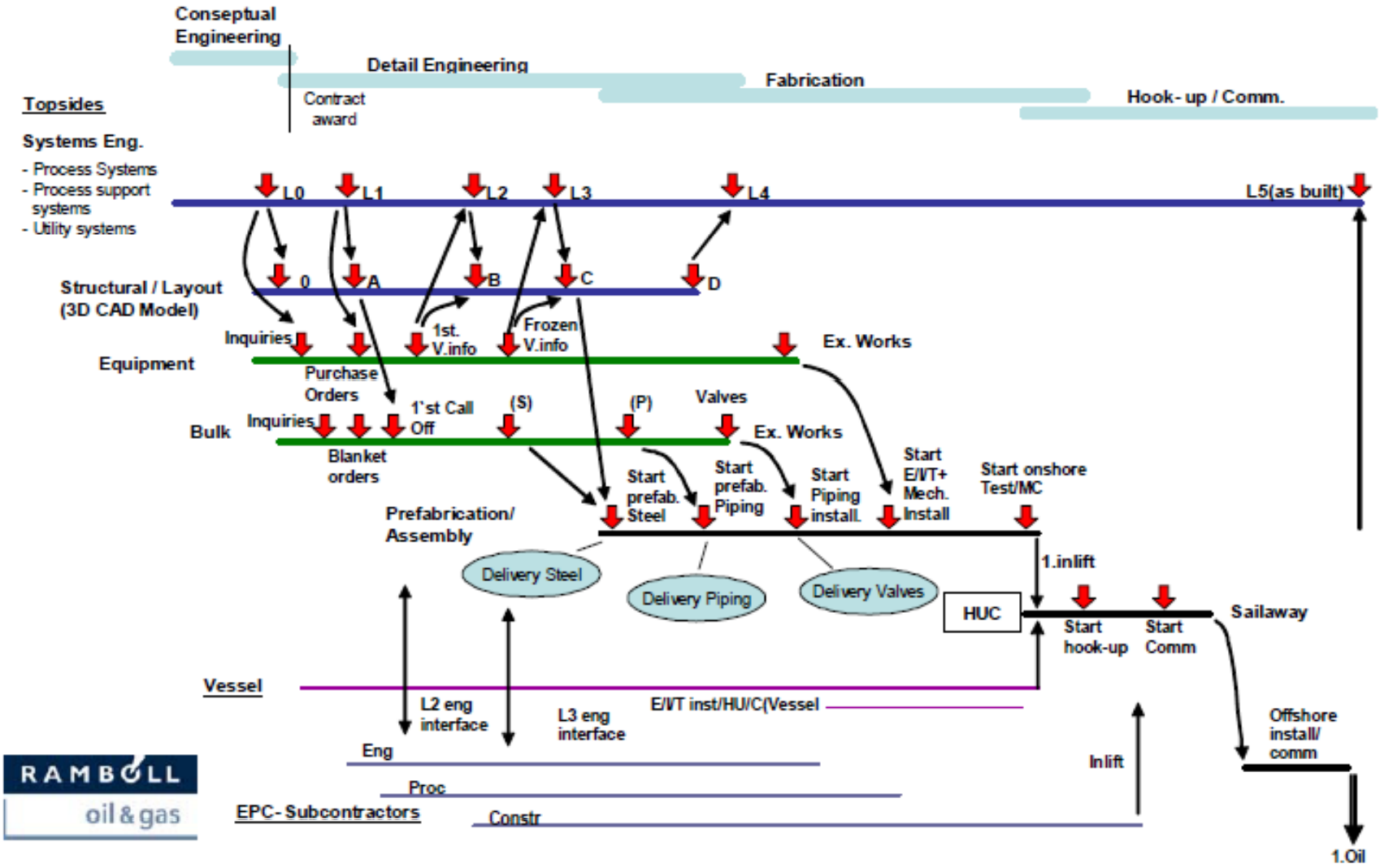
8 pipe racks

TOPSIDES DESIGN CONTRACT

- Design performed with split location set-up between offices in Sandefjord/Esbjerg
- Design using PDMS - multi-disciplinary design environment for full 3D modelling
- Total engineering team of 200 engineers
- Samsung engineering follow-up team of 25 engineers

RAMBØLL

EPCI EXECUTION WORKFLOW



THE NEXUS 1 FPSO PROJECT

- GENERAL DATA & LAYOUT

FPSO is

FLOATING PRODUCTION, STORAGE AND OFFLOADING

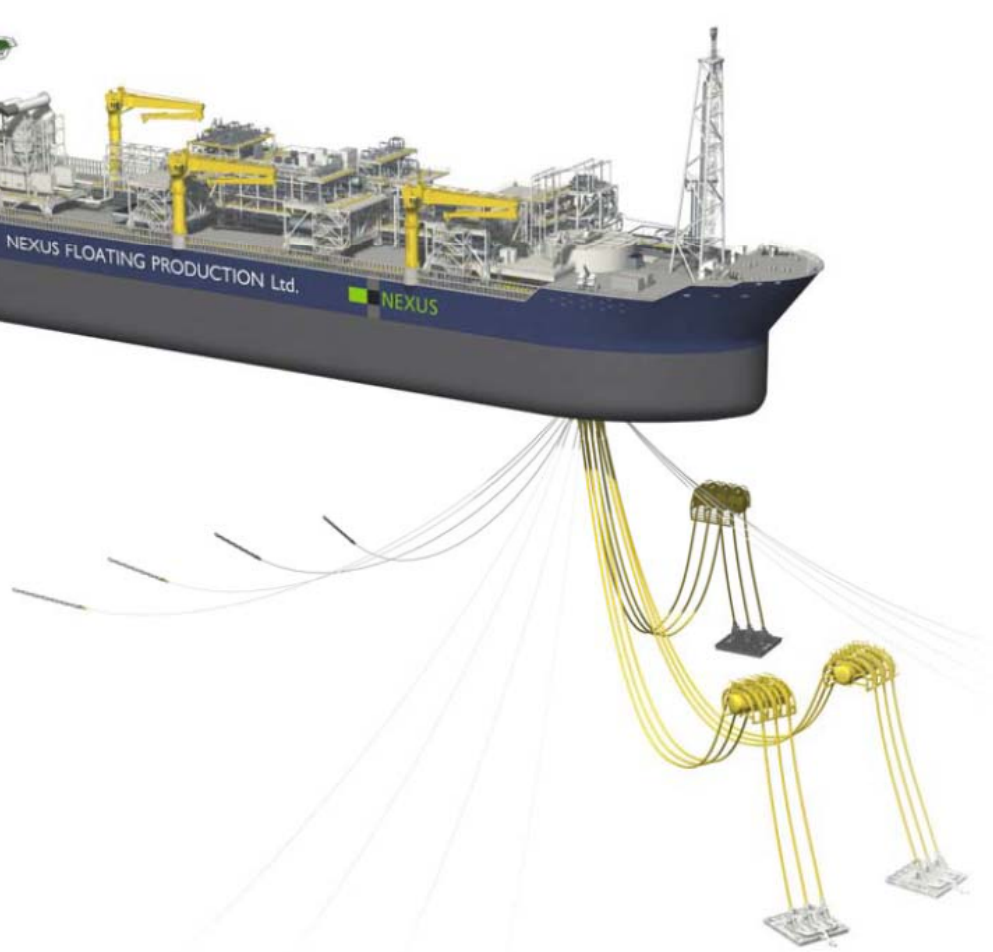
RAMBØLL

NEXUS 1 FPSO

The NEXUS 1 FPSO was build on speculation and designed based on a generic design basis.

Build by Samsung Heavy Industries

NEXUS 1 FPSO - PRODUCTION



: Main Features

: Hull & Marine System

: Topside Process Facilities

: Turret & Mooring System

RAMBOLL

TURRET / MOORING SYSTEM

- Free passive weather waning of the FPSO (use of thrusters not required)
- Allows mooring and riser installation decoupled from FPSO hookup
- Riser/umbilical and mooring terminations in buoy.
- Design for 30-2500m water depth
- Significant waves Hs 3-18m
- Redundant over pressurized seal barrier fluid system with remote diagnostics for seal monitoring

RAMBØLL

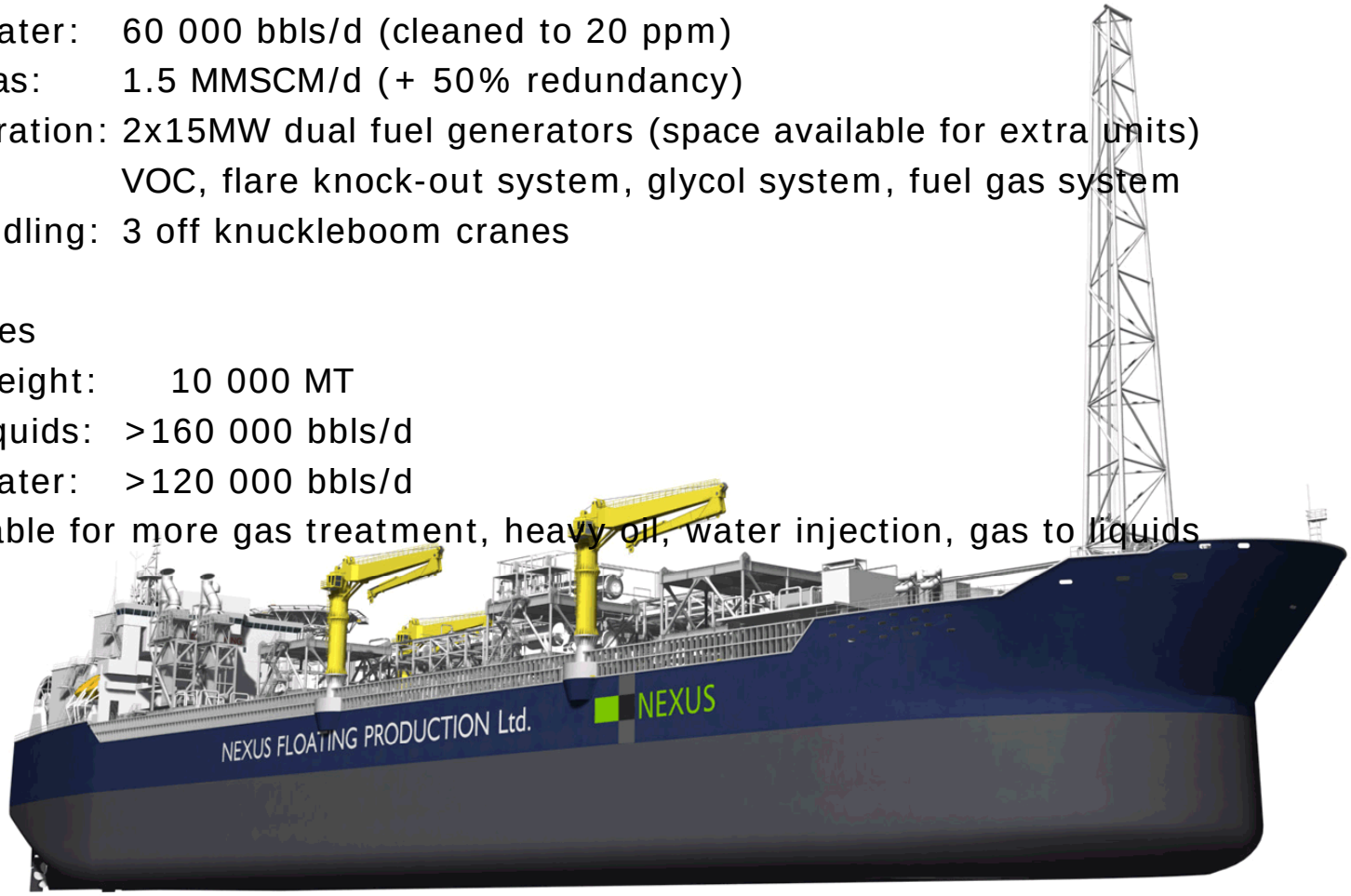
TOPSIDE PROCESS FACILITIES

Base case

- Weight: 5 900 MT
- Maximum liquids: 80 000 bbls/d (+ 30 000 bbls/d test)
- Maximum oil: 60 000 bbls/d (API 35)
- Maximum water: 60 000 bbls/d (cleaned to 20 ppm)
- Maximum gas: 1.5 MMSCM/d (+ 50% redundancy)
- Power Generation: 2x15MW dual fuel generators (space available for extra units)
- Additional: VOC, flare knock-out system, glycol system, fuel gas system
- Material handling: 3 off knuckleboom cranes

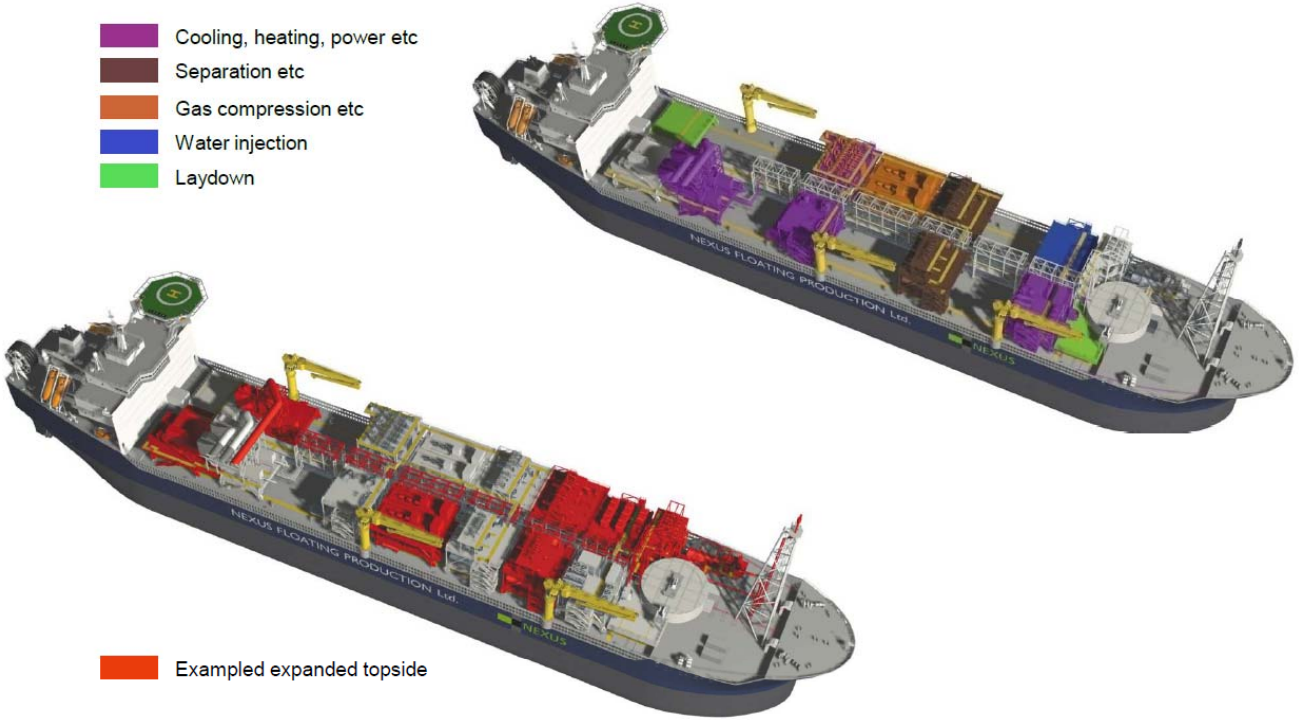
Potential upgrades

- Maximum weight: 10 000 MT
- Maximum liquids: >160 000 bbls/d
- Maximum water: >120 000 bbls/d
- Space available for more gas treatment, heavy oil, water injection, gas to liquids



RAMBØLL

TOPSIDE PROCESS FACILITIES - LAYOUT



Generic Design:

- Available deck space and modularized topsides design for easy expansion/adaption
- Good area division for safe operation
- Central piperack prepared for future expansion
- Modular layout prepared for possible increase in capacity

RAMBØLL

THE NEXUS 1 FPSO PROJECT

- STRUCTURAL DESIGN

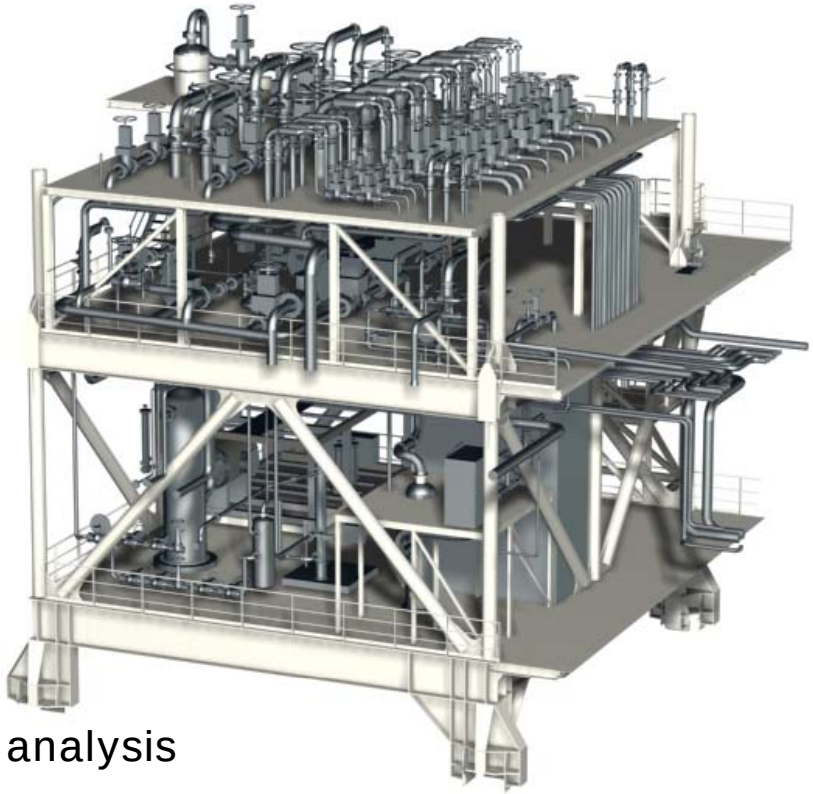
RAMBØLL

REGULATIONS, CODES AND DESIGN STANDARDS

- DNV-OSS-102. Rules for Classification of Floating Production Storage and Loading Units, April 2007
- DNV-OS-C101. Design of Offshore Steel Structures, General (LRFD Method), April 2004
- NS-ENV 1993-1-1. Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings. February 1993.
- DNV-RP-C203. Fatigue Design of Offshore Steel Structures, August 2005

LIMIT STATE ANALYSES

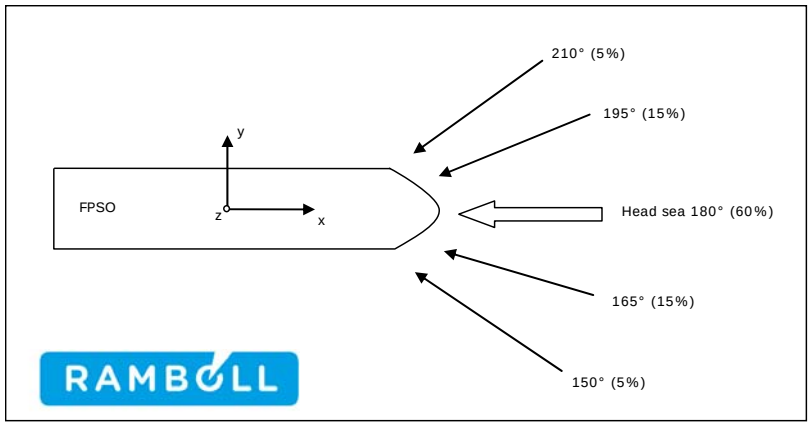
- Servicebility Limit State
  - Vibration analysis (rotating equipment)
- Ultimate Limit State
  - In-place analysis
  - Installation analysis
- Accidental Limit State
  - Explosion analysis
  - Vessels accidental static heel (27 deg.) analysis
  - Fire analysis
  - Dropped / Swinging Objects analsys
- Fatigue Limit State



RAMBØLL

DESIGN LOADS

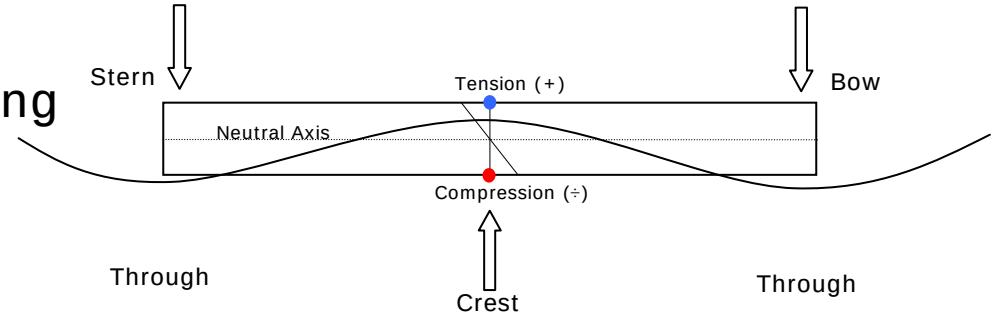
- Permanent loads
- Variable loads
  - Incl. Live loads
- Environmental loads
  - Wind Loads
  - Inertia loads from FPSO wave motion responses
  - Ice and snow loads

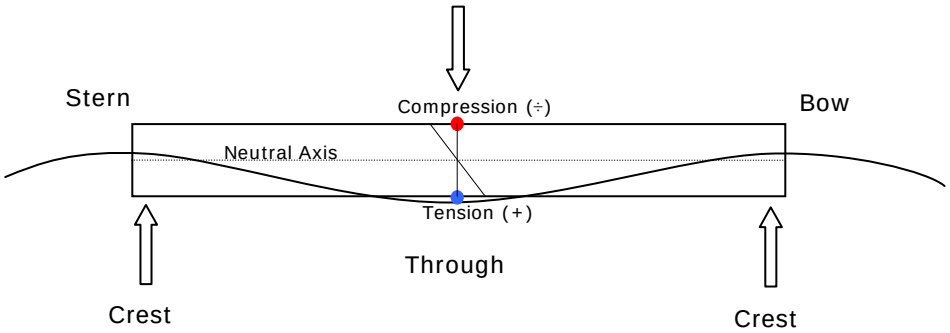


- Deformation loads
  - Deformations due to Hull Hogging/Sagging
- Accidental loads
  - Explosions
  - Fire
  - Dropped objects and swinging loads
  - Tilt
  - 10.000 year extreme event

DESIGN CASE
HOGGING / SAGGING

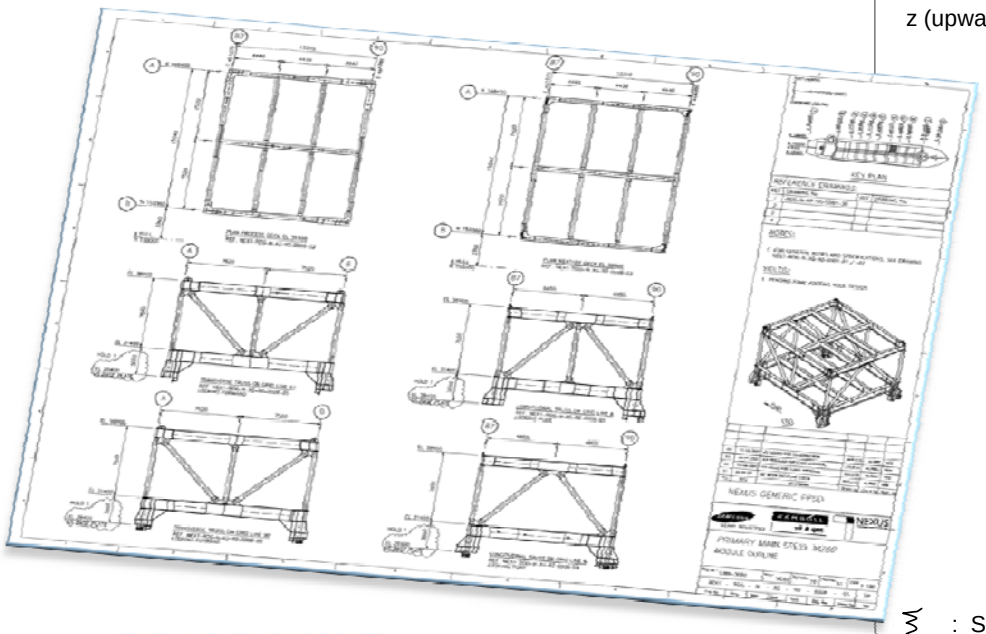
- Deformations due to hull hogging and sagging are causing difference displacements between the module supports.
- Elongation/contraction of deck plate is approx. +/- 1 mm/m or +/- 15 mm between module suppor
- Module support design to account for this scenario to avoid failure or fatigue issues



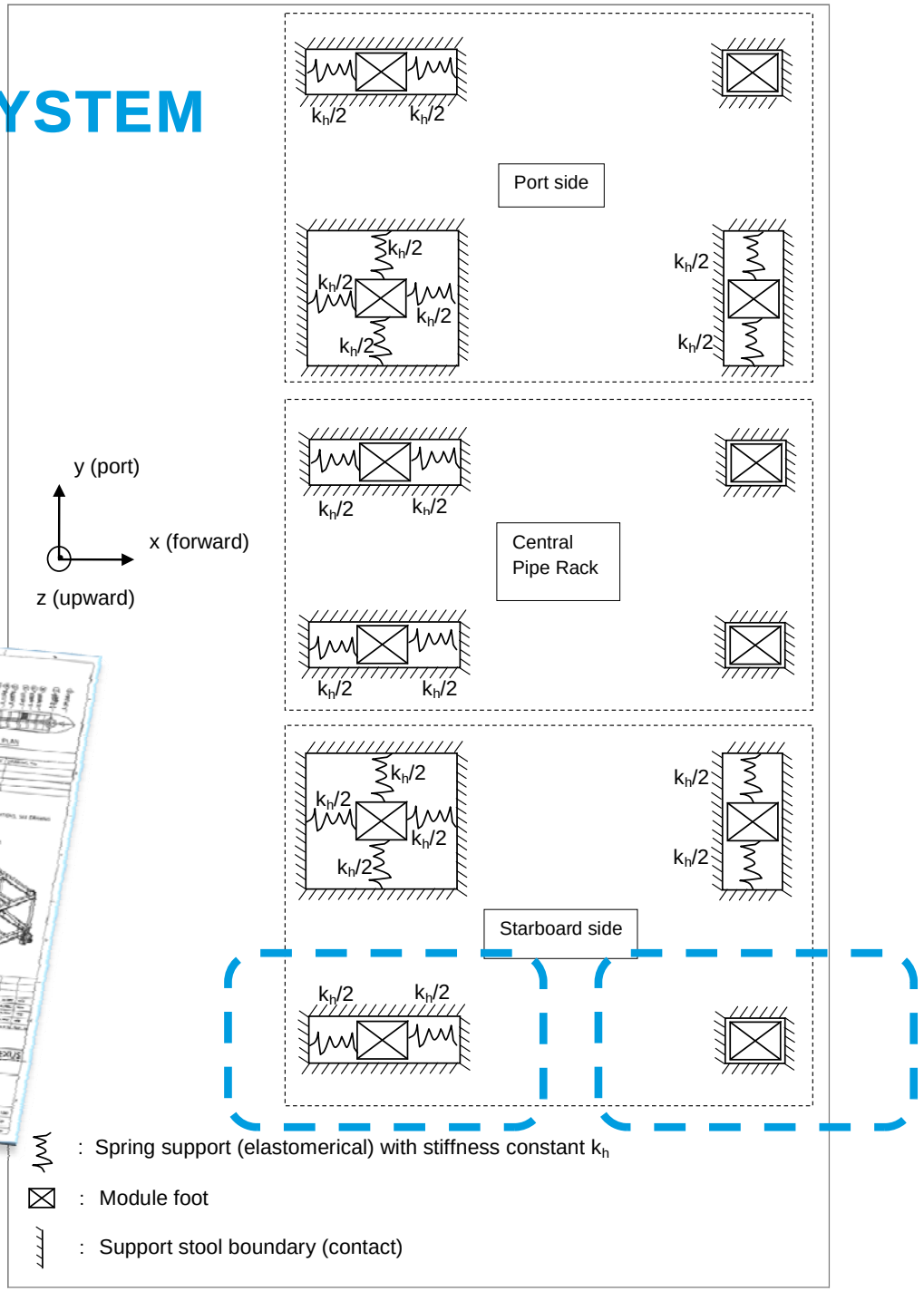


MODULE SUPPORT SYSTEM

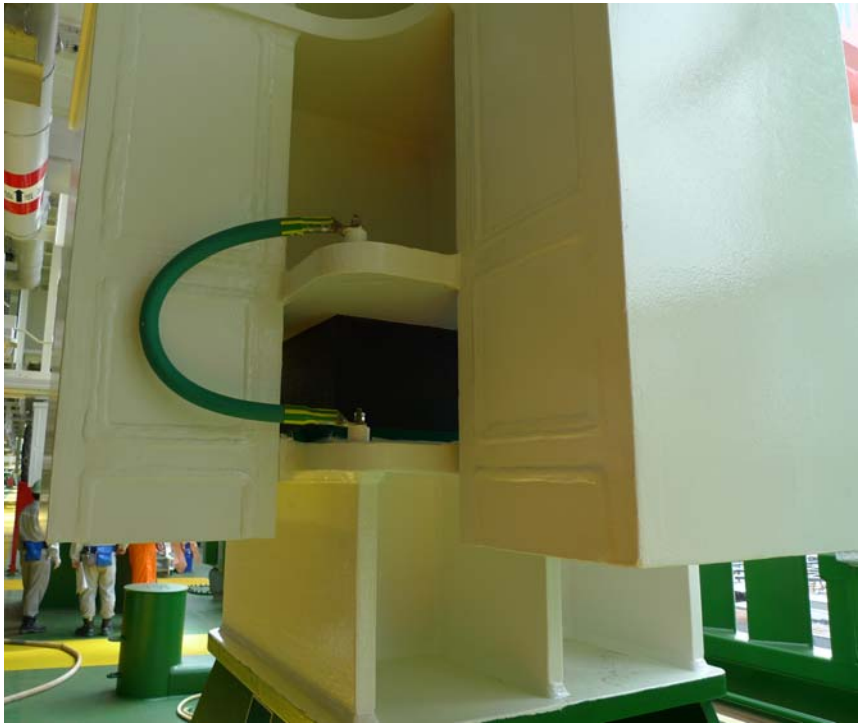
- Modules and pipe racks supported on stools
- Supports accommodate elastomeric bearings



RAMBØLL



MODULE SUPPORTS INCL. ELASTOMERIC BEARINGS



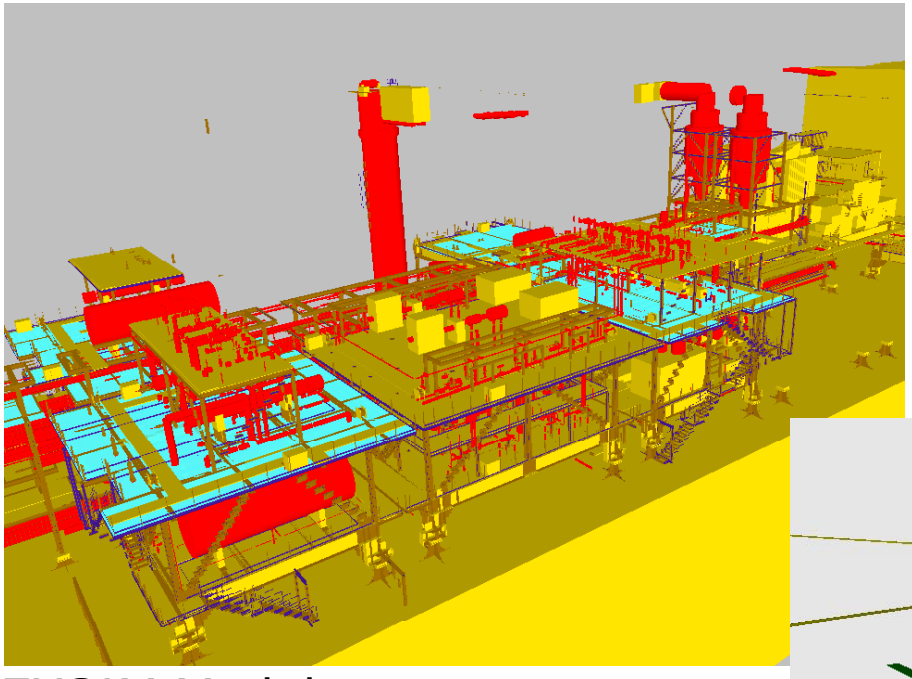
DESIGN CASE
GAS EXPLOSION

METHOLOGY

- Conversion of models (PDMS, Microstation, Exsim/Flacs)
- Risk assessment (component count, leak rates, leak frequencies, ignition probability, representative scenaria)
- Dispersion simulation (exceedance curve, cloud sizes)
- Explosion simulation (representative scenaria)
- Design accidental loads (DAL)
- Structural response analysis

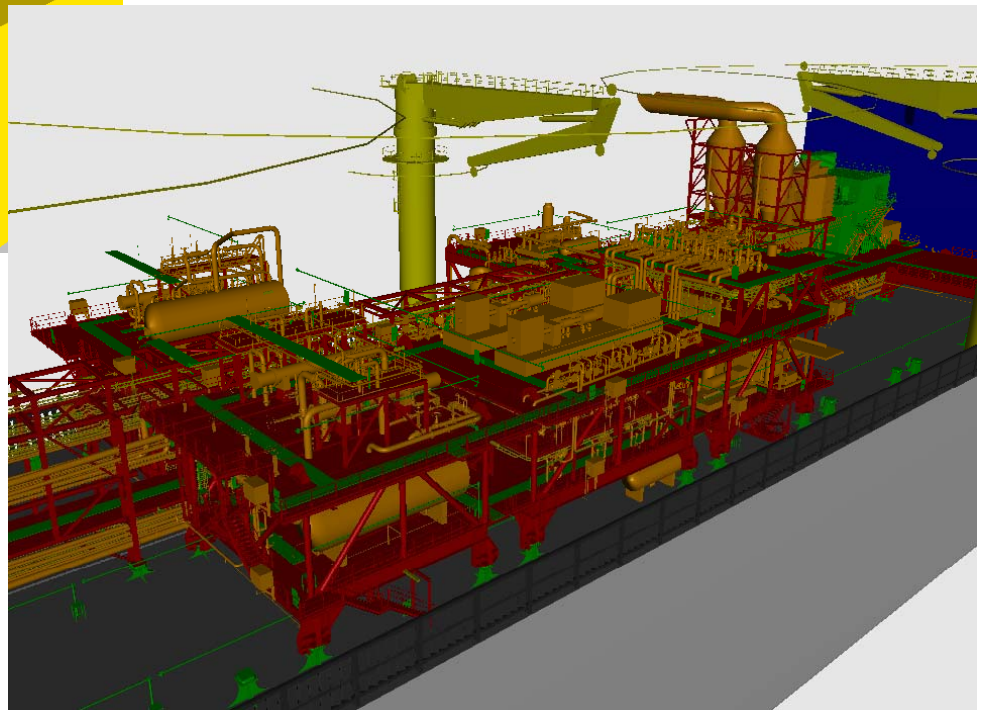
RAMBØLL

CONVERSION OF PDMS MODEL TO EXSIM



EXSIM Model

PDMS/Microstation Model

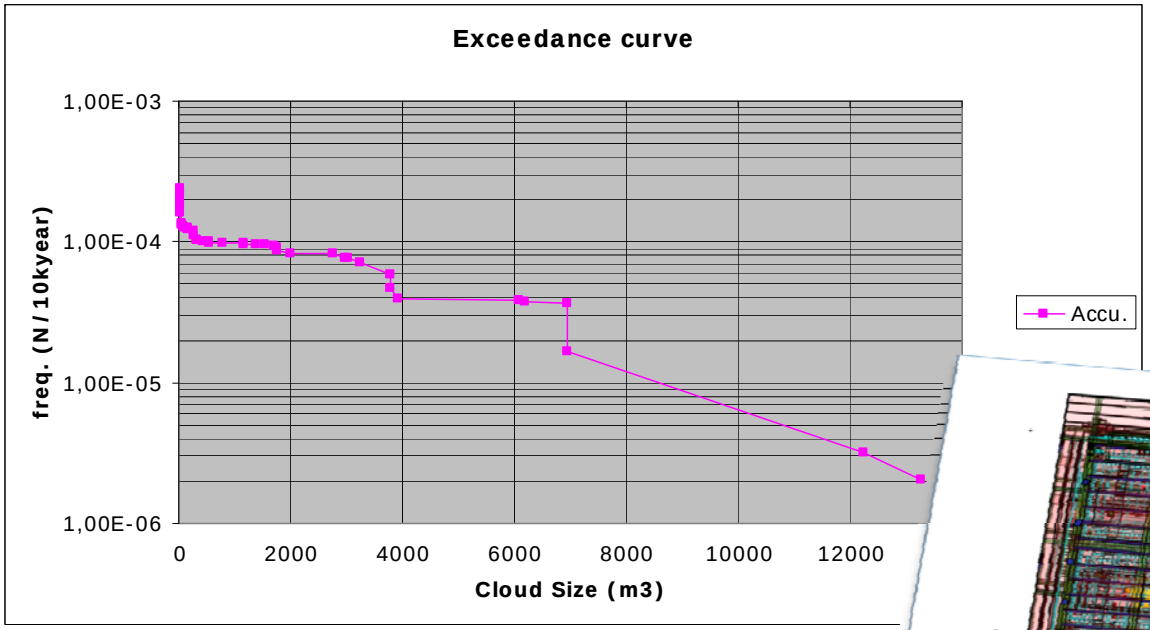


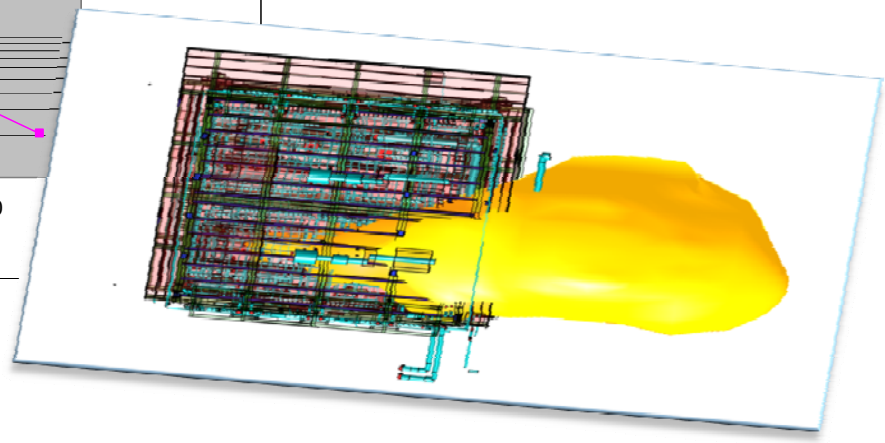
RAMBØLL

GAS DISPERSION ANALYSIS

Combination of statistics with simulations,

Exceedance curves - Design accidental loads (DAL's)

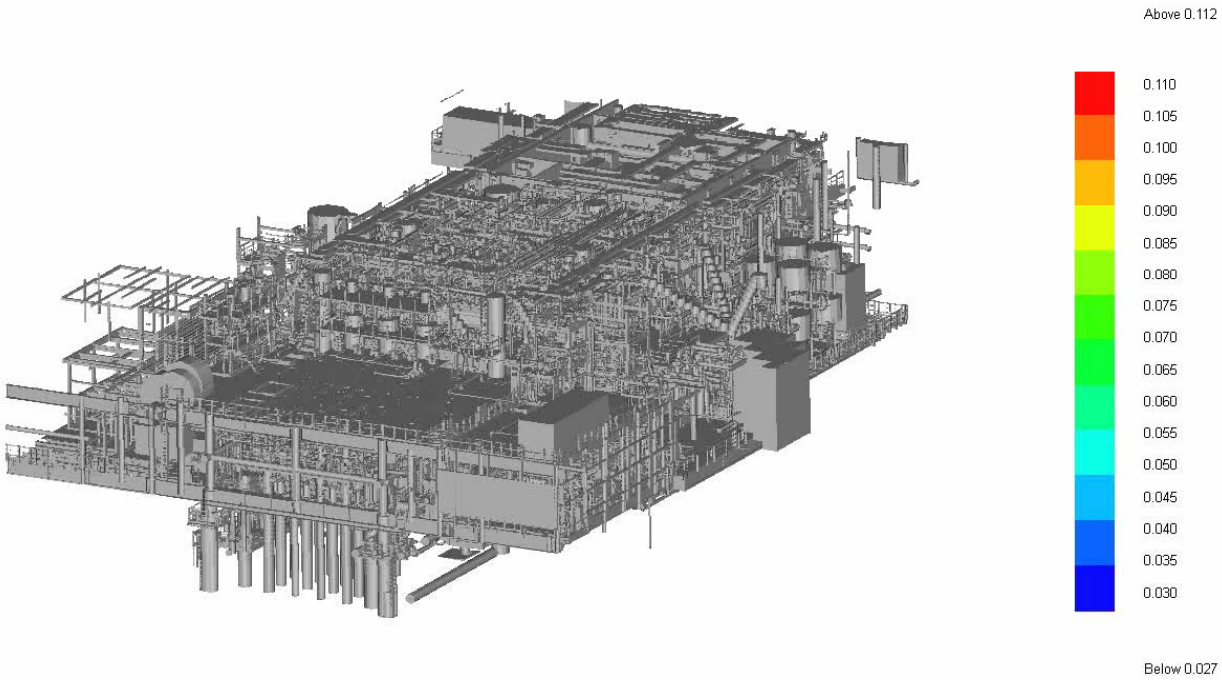




RAMBØLL

CASE STORY – SOUTH ARNE PLATFORM

Gas dispersion – Development of gas cloud

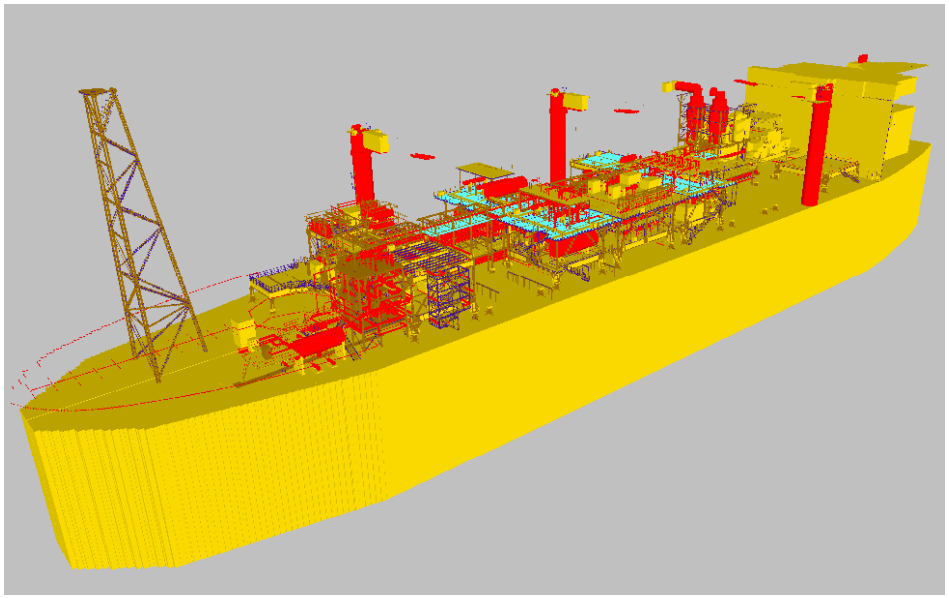


RAMBØLL

GAS EXPLOSION SIMULATION

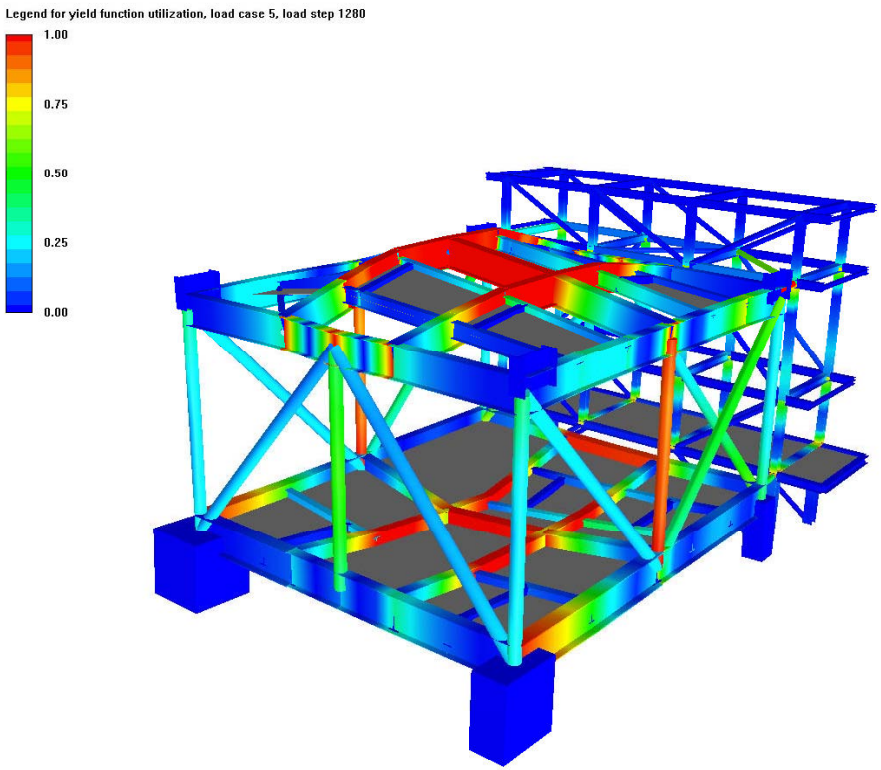
Design Accidental Loads (DAL's):

Area	Blast Pressure	Drag Load	Comments
Area A1: Modules M260, M280, M290, M320	0.36 barg	0.15 barg	
Area A2: Modules N130, N150, M200, M220, M340, M400, M430, M410	0.15 barg	0.05 barg	
Area A3: Main Deck (Hull) in area A1.	0.36 barg	0.15 barg	
Area A4: Main Deck (Hull) in other areas.	0.15 barg	0.05 barg	
Area A5: Pipe Racks	0.36 barg	0.15 barg	
Area A6: Turret, Cranes, Living Quarters, Generator Exhaust	0.10 barg	0.05 barg	
Area A7: Flare	0.05 barg	0.02	



GAS EXPLOSION
PLASTIC RESPONSE ANALYSIS

- Structural response analysis using Ramboll program RONJA
  - Non-linear dynamic FE analysis including:
    - Dynamic loading
    - Strain hardening
    - Strain rate effect
    - (Failure)
  - Plastic capacity



WEIGHT BUDGET AND MONITORING DESIGN AT 99% PROGRESS

1.1 Weight Summary

This table shows the overall weight status of the project.

Description	Current Budget Weight	Current Reported Weight	Last Reported Weight	Change from the last report		Deviation from Weight Budget	
				[T]	[%]	[T]	[%]
Tot. Topside Dry Weight	6577	6756	6494	262	4,0	179	3
Tot. Topside Oper. Weight	7666	7666	7450	216	2,9	0	0

- Budget weights not updated for adjustments to design (equipment moved / module split)
- Weight report updated on monthly basis all through project

RAMBØLL

THANK YOU