Dynamic Positioning Committee
Marine Technology Society

Foresight in Offshore

September 28-30, 2004
DP Design & Control System

A Feasible Concept of Bi-axial Controlled DP for FPSOs in Benign Environment

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HOLDING STRUCTURE

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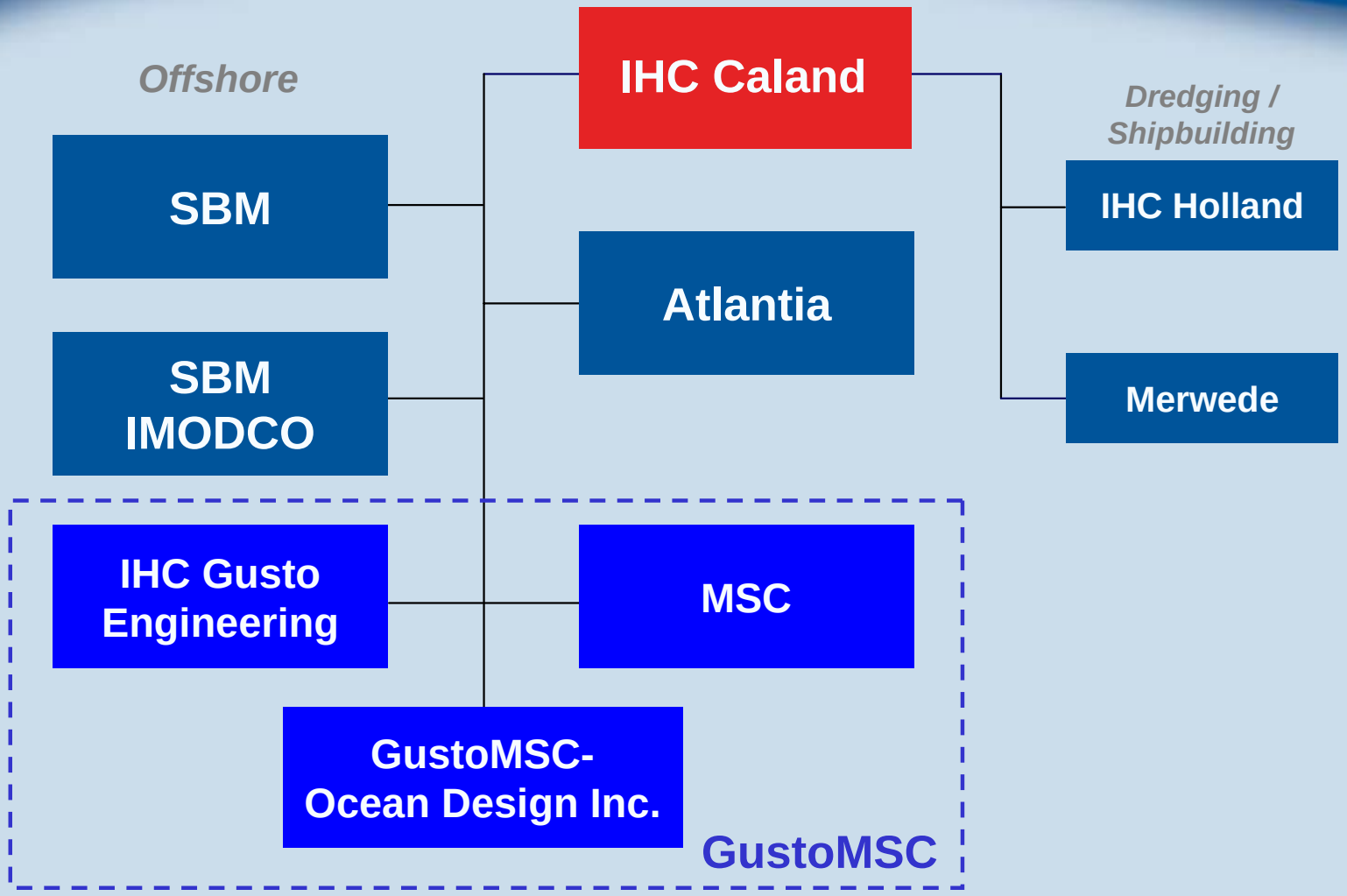

IHC CALAND

Dutch holding of international companies working in offshore, dredging and marine industries

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Content

- History
- Theoretical Background
- Design
  - Knowledged based design
  - Software use
  - FPSO concepts
  - Environmental conditions
- Results
- Conclusions

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History

- **Basic idea created in 1971**
  - to investigated stability
- **Bi-axial DP was introduced in the late 1980's:**
  - SWOPS II
  - model tests
  - simulations
- **Never actually applied**
- **Conventional DP**
  - 154,000 DWT
  - Weathervaning mode
- **Only one FPSO with DP**

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Theoretical background

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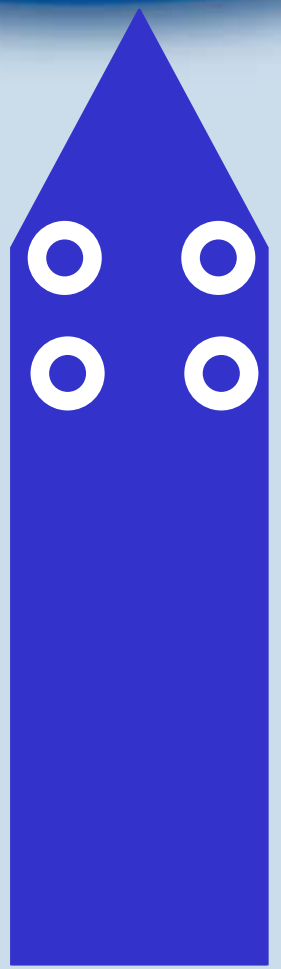
- **Modern DP control systems can be divided in two separate functions:**
  - PDI-control
  - KALMAN control
- **Thruster system**
- **Bi-axial DP**
  - concentrate thrusters at one end of the vessel, COT_x
  - no heading control

$$F_{x,req} = P_x \cdot \Delta x + D_x \cdot \Delta \dot{x} + I_x \cdot \int \Delta x \, dt$$
$$F_{y,req} = P_y \cdot \Delta y + D_y \cdot \Delta \dot{y} + I_y \cdot \int \Delta y \, dt$$
$$M_{\psi,req} = F_{y,req} \cdot COT_x$$



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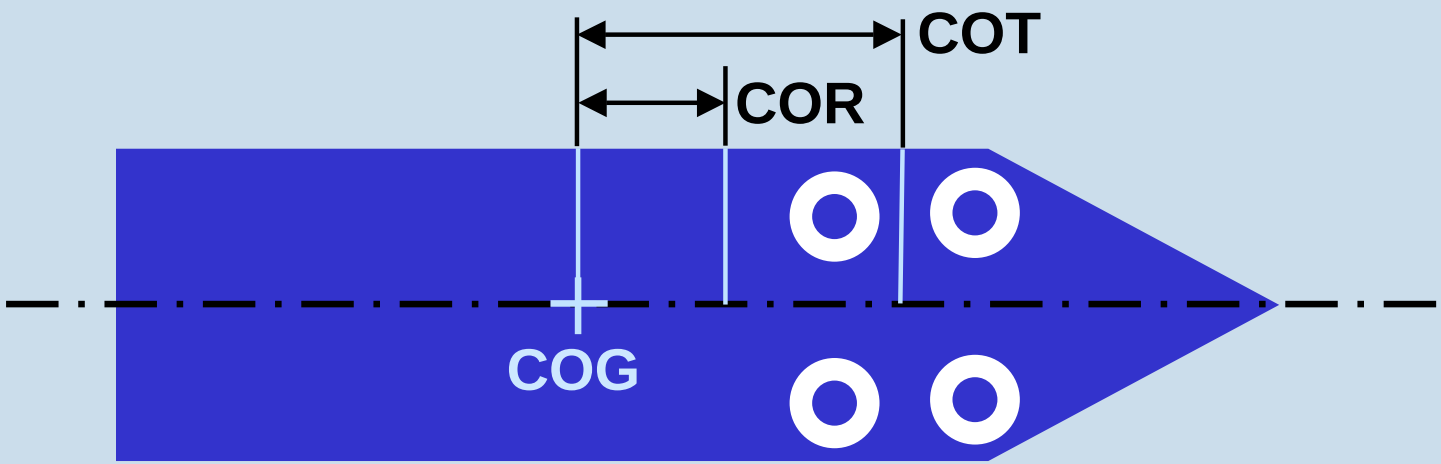
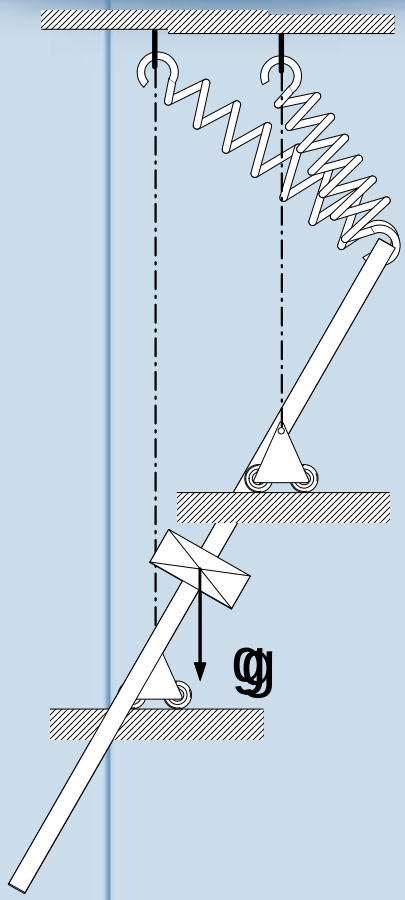
Theoretical background

- **Choice of center of thrust**
- **Choice of center of rotation**
- **Stability of DP-control**
  - Naturally stable, COR forward of COG
  - Unstable, COR aft of COG





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Design Bi-axial DP controlled FPSO's

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Combining know-how:

- **Drill ships**
- **FPSO's**
- **Dynamic Positioning**
  - DP vessel designs
  - In-house developed software
- **Equipment**
  - Thrusters
  - Retrieval systems
- **Contacts:**
  - Sister companies
  - Technology institutes

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Validity of Software

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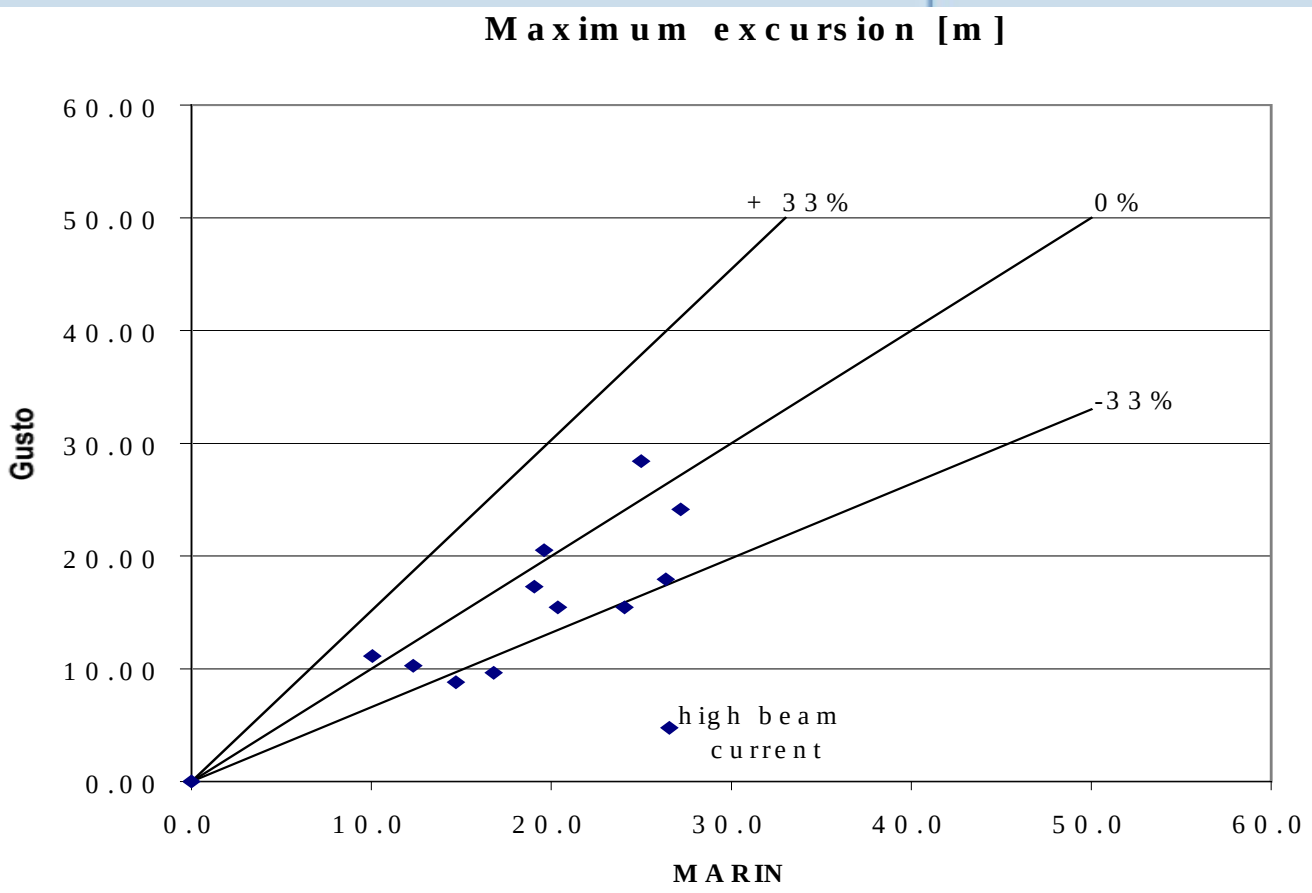
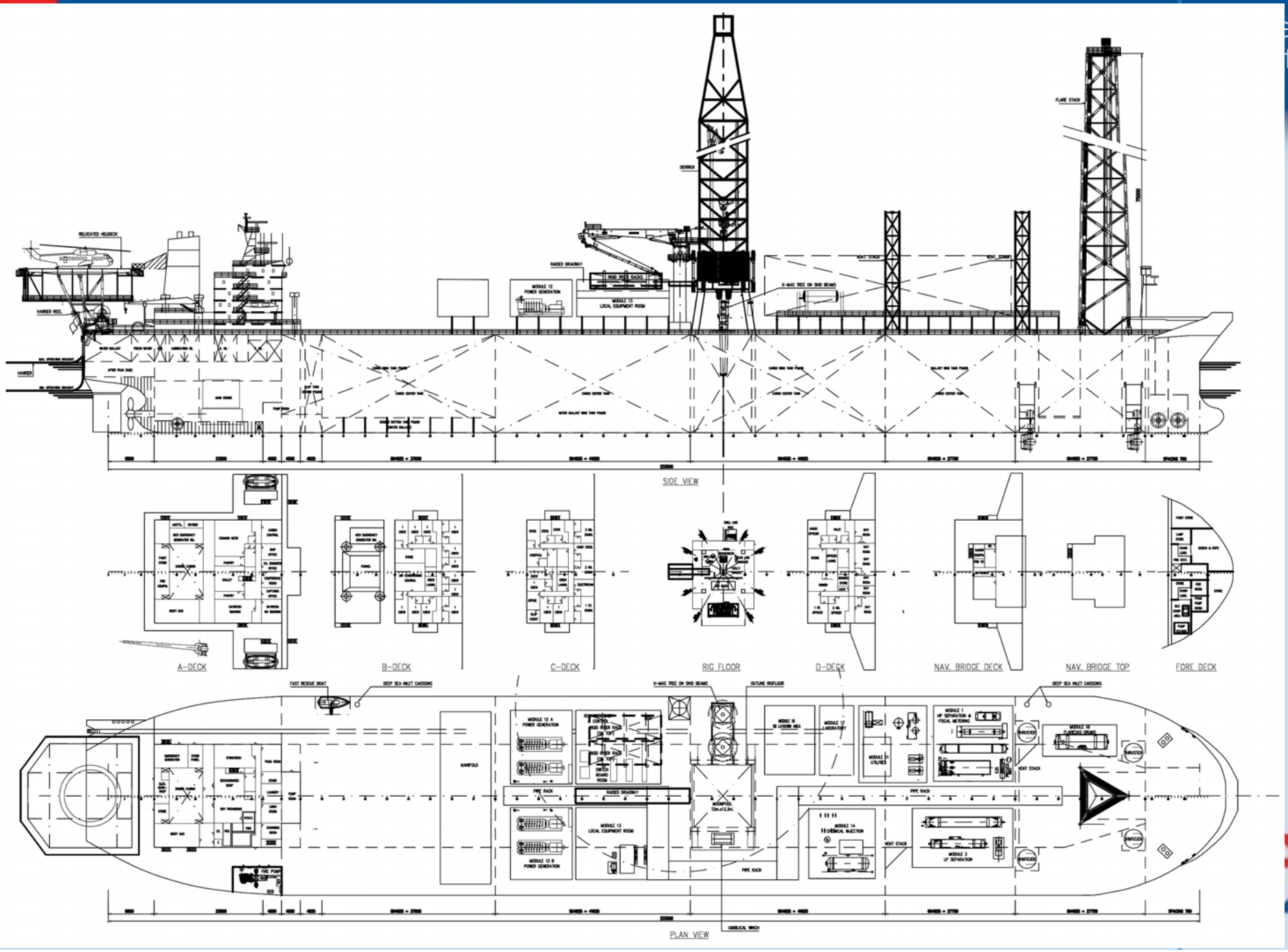
- **Software validated against model tests**
  - DP drill ship (Glomar C.R. Luigs, Glomar Jack Ryan)
  - Moored FPSO's
- **Feedback from clients**
  - Drill ships
  - Dredgers



Concept 1 – Early Production FPSO



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Concept 2 – New-built 2mln barrel FPSO

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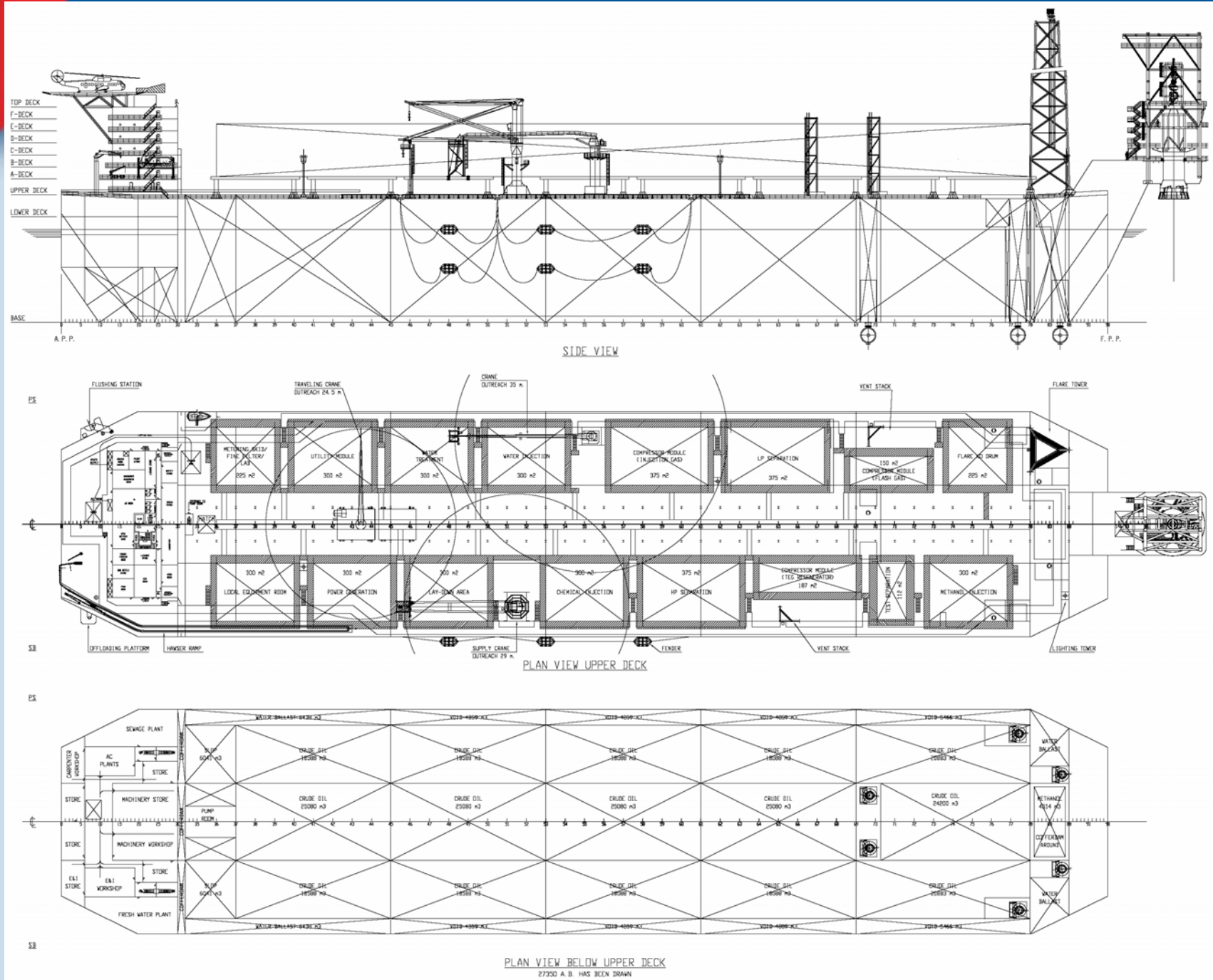

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Environmental Conditions

- **Bi-axial DP tested in 9 squall events:**
  - Increasing speed and shifting direction
  - Maximum squall wind speed is 28 m/s
- **Feasibility of concept 1:**
  - Sea-states related to squall events
  - 1-year return Brazilian condition
- **Feasibility of concept 2:**
  - Squall events combined with 10-year West of African swell

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Environment – squall events

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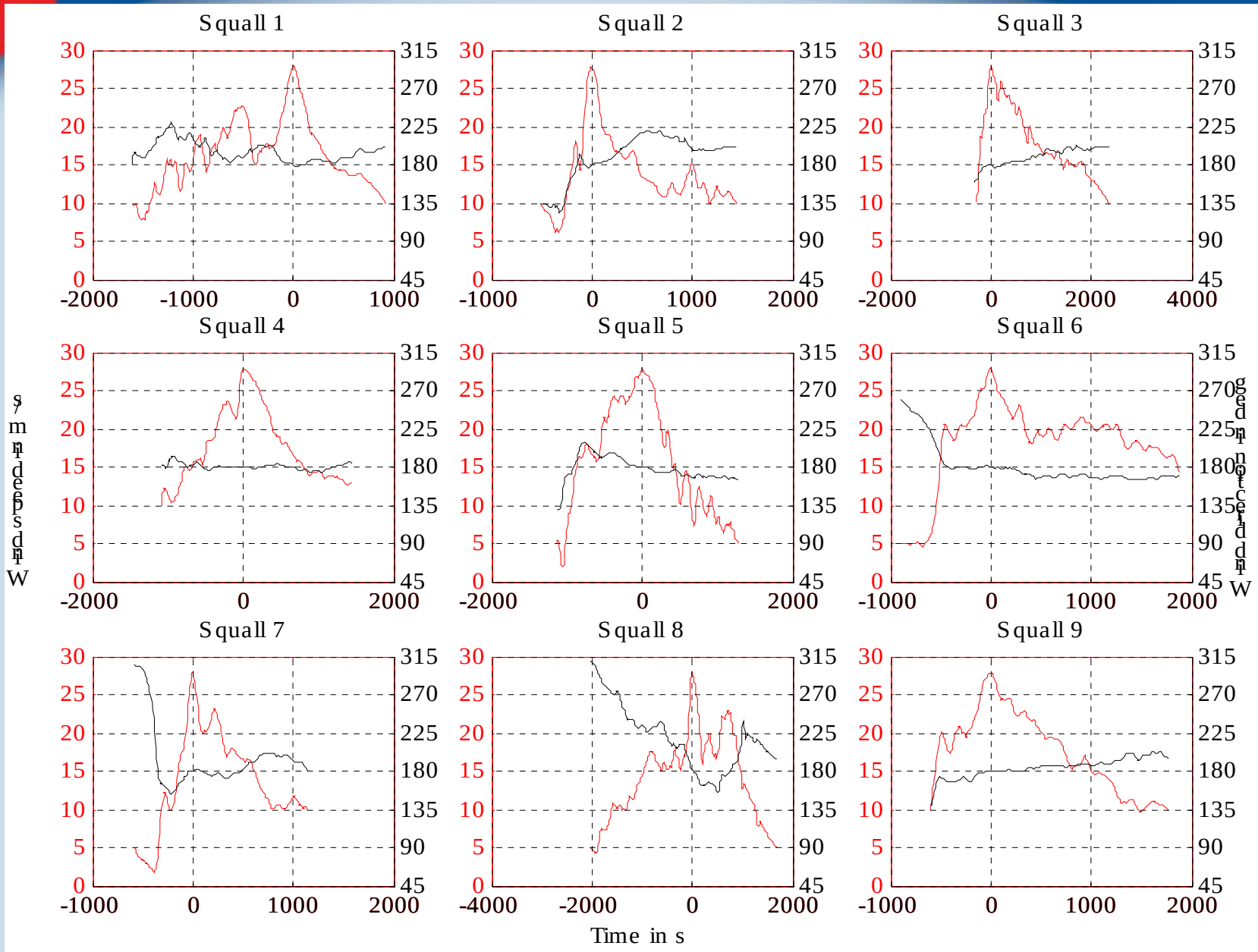

Results – Concept 1

- Added 4x3.6 MW thruster power versus 6x2.7 MW for conventional DP concept
- No thrusters added in the pump room
- Lay-out changed to ensure stable bi-axial control
- Maximum offset in 1-year Brazilian condition appr. 36.2 m
- Operation in water depth larger than 600 m

Results – Concept 1

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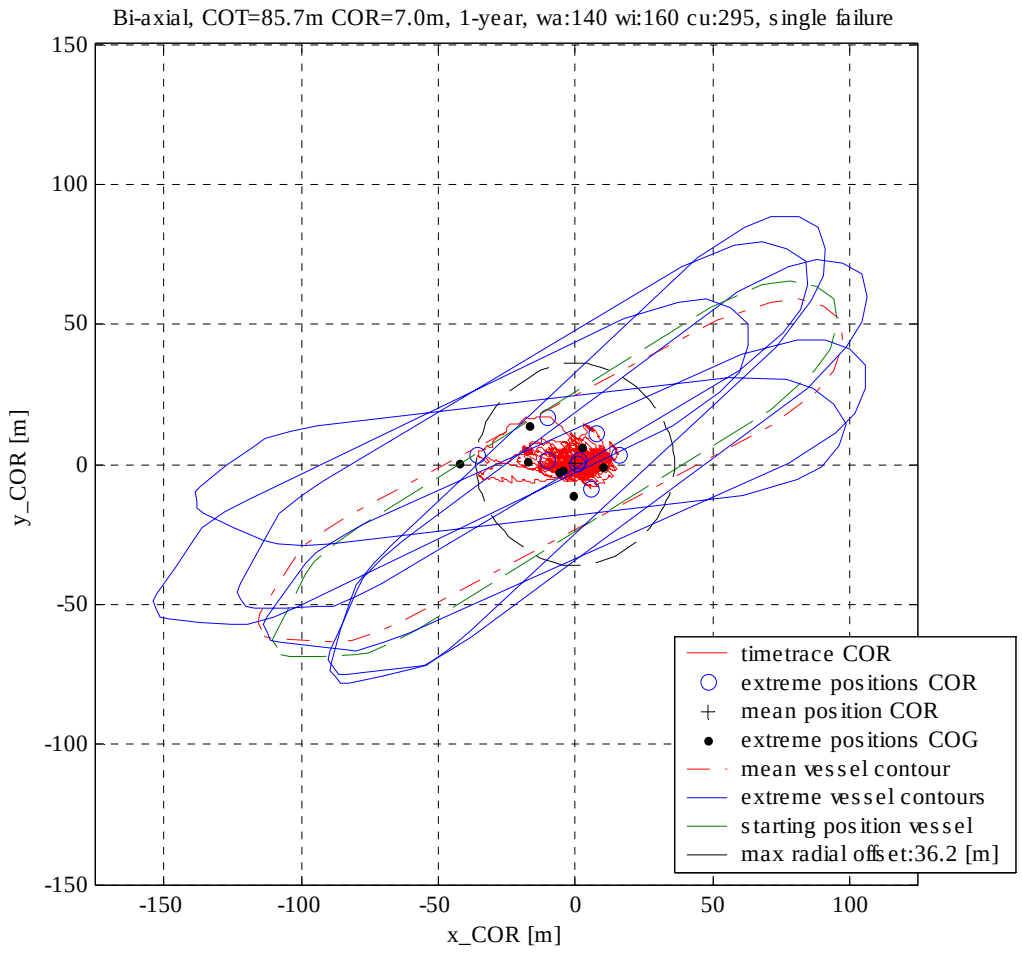

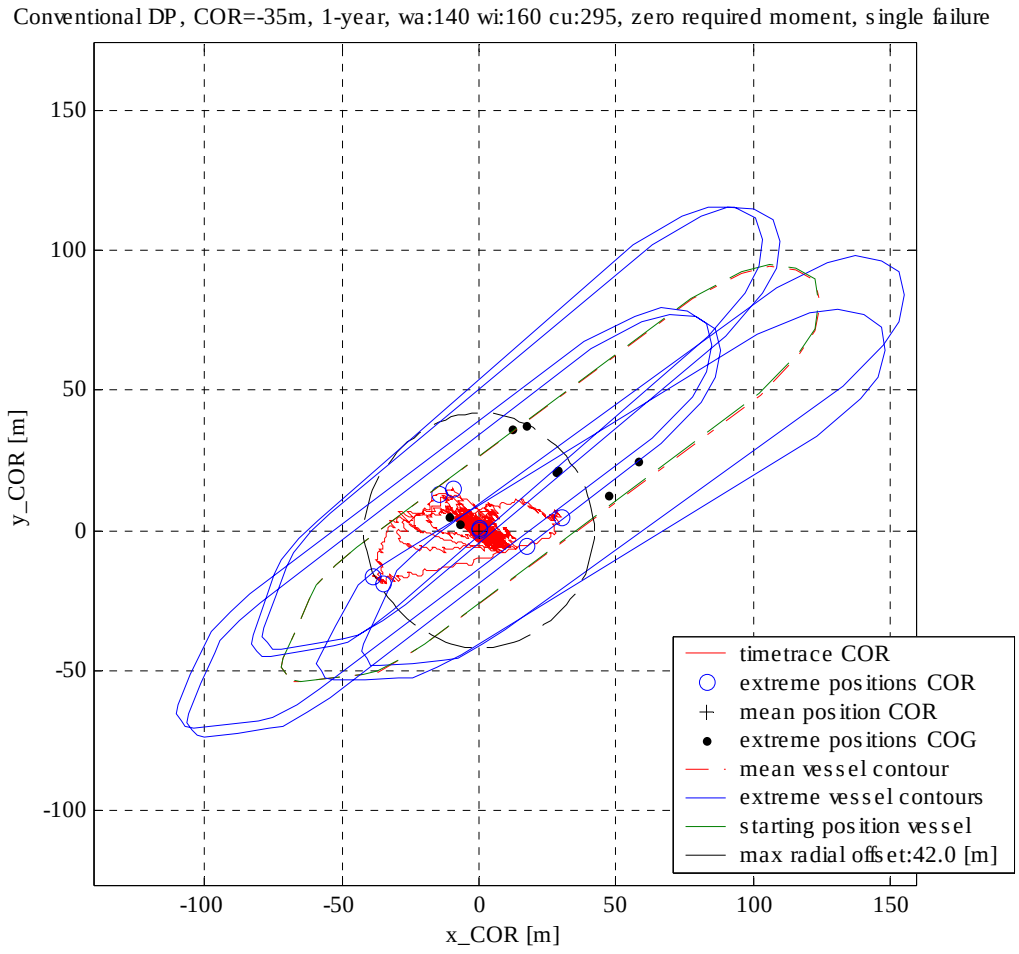

Demo Concept 1

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Results – Concept 2

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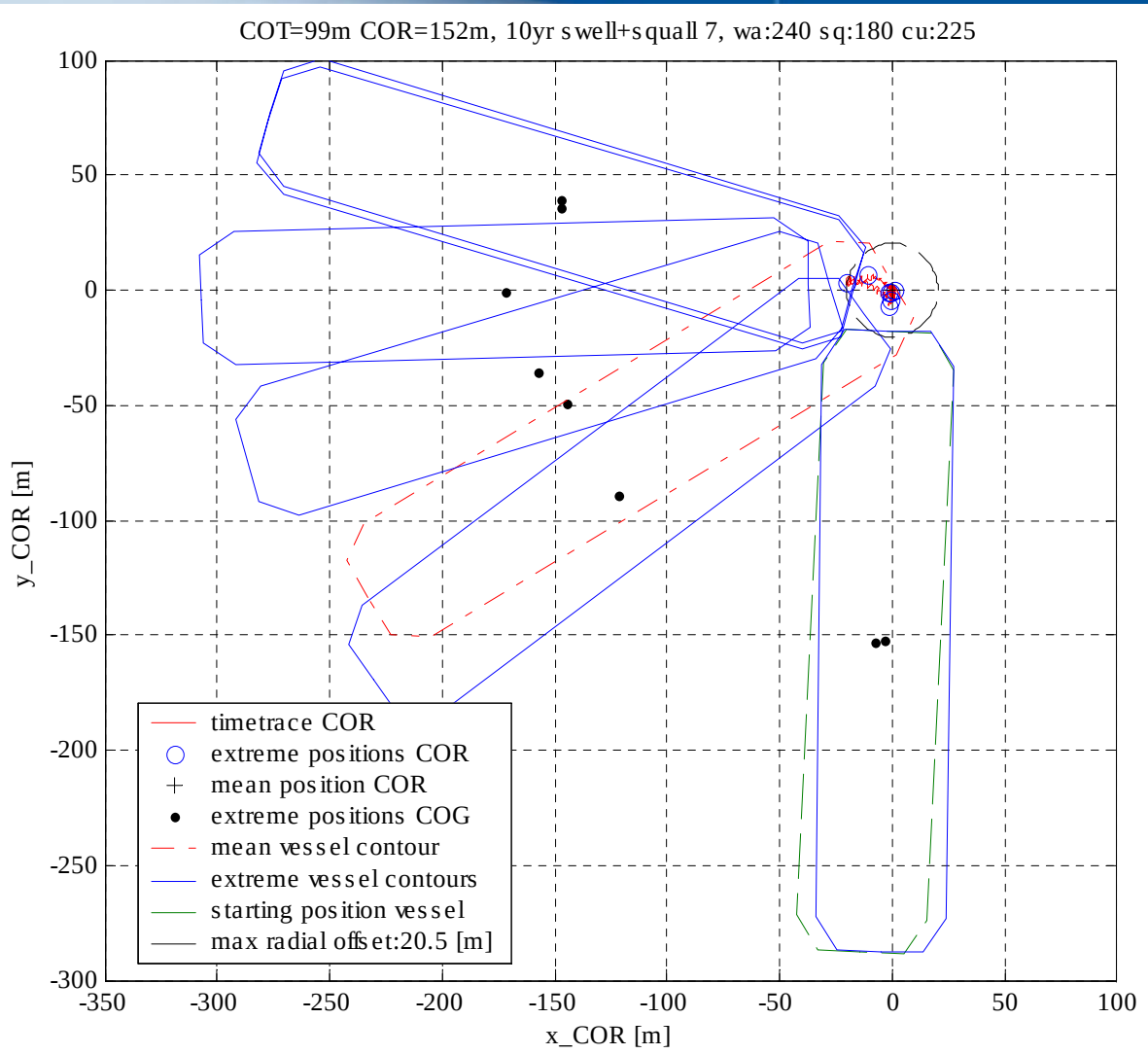
- 6x3.6=21.6 MW total thruster power
- Single thruster failure allowed
- Maximum simulated offset appr. 20.5 m



Demo Concept 2

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Conclusions

- **Concept 1 – Early production FPSO**
  - Reduction of installed thruster power
  - Reduction of conversion costs
  - Behavior comparable to Conventional DP
  - Single thruster failure allowed

- **Concept 2 – 2mln barrel FPSO**
  - 21.6 MW installed thruster power feasible for West of Africa
  - Single thruster failure allowed
  - Competitive with turret moored system

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Summary

Bi-axial DP

Passively react on large and rapid environmental changes,

without use of algorithms determining the best heading

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