DYNAMIC POSITIONING CONFERENCE
October 15-16, 2013

DESIGN AND CONTROL SESSION 1

The Next Level DP Capability Analysis

Øyvind Smogeli, Nguyen Dong Trong, Brede Børhaug, Luca Pivano

Marine Cybernetics
DESIGN AND CONTROL SESSION I

THE NEXT LEVEL DP CAPABILITY ANALYSIS

Øyvind Smogeli, COO
Nguyen Dong Trong, Brede Børhaug, Luca Pivano

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DP CAPABILITY

Simple to analyze?
The limiting wind speed is found for each angle of attack.
THRU5T ENVELOPE

For a given design environmental condition the thruster utilization in % is found for each angle of attack

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WHY CAPABILITY PLOTS?

Design
- Thruster layout/rating
- Power system

Planning
- Operational window
- Contingency

Charters
- “Ticket to business”
- Vessel selection
INDUSTRY CHALLENGES

- IMCA M140 specification is too basic

- Possible to extend with more realistic assumptions and models
  - But this is not standardized

- Questions have been raised concerning DP Capability plot applicability

Are they conservative or non-conservative?

Can they be compared?

Can they be trusted?
FULL-SCALE RESULTS FROM A SEMI-SUB


Wind Speed in m/s vs Direction in deg

DPCap analysis   Full-scale trials

Thrusters:

<table>
<thead>
<tr>
<th>No</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intact</td>
</tr>
<tr>
<td>2</td>
<td>Failed</td>
</tr>
<tr>
<td>3</td>
<td>Failed</td>
</tr>
<tr>
<td>4</td>
<td>Intact</td>
</tr>
</tbody>
</table>

V_{current} = 0.75 m/s
KEY LIMITATIONS

- Static force balance
- Mean environmental forces
- Fixed vessel position
- Fixed dynamic allowance
- No transients
- No dynamic external loads
- No DP system dynamics
- No thruster/rudder dynamics
- No dynamic thrust loss effects
- Fixed acceptance criteria

Quasi-static
CONVENTIONAL STATIC ANALYSIS
SOLUTION: CLOSED LOOP VESSEL SIMULATOR
Acceptance criteria can be tailored to each vessel and operation.
DynCap results can be presented as conventional wind and thrust envelopes
DYNAMIC VS STATIC CAPABILITY: CASE STUDIES

Comparison study 1 – Supply Vessel

Comparison study 2 – Shuttle Tanker

Comparison study 3 – Semisub
CASE STUDY 1: SUPPLY VESSEL

Current speed: 0.50 (m/s)

- **Case 1**: Intact DP Cap, 0% dynamic allowance, no thrust loss
- **Case 2**: Intact DP Cap, 20% dynamic allowance, with thrust loss
- **Case 3**: Intact DynCap, acceptance limit: 20m/20deg
- **Case 4**: Intact DynCap, acceptance limit: 10m/10deg
- **Case 5**: Intact DynCap, acceptance limit: 5m/5deg

Current speed: 0.50 (m/s)

- **Case 1**: WCSF DP Cap, 0% dynamic allowance, no thrust loss
- **Case 2**: WCSF DP Cap, 20% dynamic allowance, with thrust loss
- **Case 3**: WCSF DynCap, acceptance limit: 20m/20deg
- **Case 4**: WCSF DynCap, acceptance limit: 10m/10deg
- **Case 5**: WCSF DynCap, acceptance limit: 5m/5deg
Example DynCap analysis with footprint, time series and acceptance criteria
CASE STUDY 2: SHUTTLE TANKER

Current speed: 0.00 (m/s)

Wind speed in m/s
Wind direction in degrees

Case 1: Intact DPCap, 0% dynamic allowance, no thrust loss
Case 2: Intact DPCap, 20% dynamic allowance, with thrust loss
Case 3: Intact DynCap, acceptance limit: 20m/10deg
Case 4: Intact DynCap, acceptance limit: 10m/5deg
Case 5: Intact DynCap, acceptance limit: 5m/3deg

Current speed: 0.00 (m/s)

Wind speed in m/s
Wind direction in degrees

Case 1: Wcsf DP Cap, 0% dynamic allowance, no thrust loss
Case 2: Wcsf DP Cap, 20% dynamic allowance, with thrust loss
Case 3: Wcsf DynCap, acceptance limit: 20m/10deg
Case 4: Wcsf DynCap, acceptance limit: 10m/5deg
Case 5: Wcsf DynCap, acceptance limit: 5m/3deg

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CASE STUDY 3: SEMISUB

Current speed: 0.00 (m/s)

Wind, Waves, Current

Current speed: 0.00 (m/s)

Wind, Waves, Current
DYNCAP – MAIN FEATURES

- Quasi-static force balance
- Specific acceptance criteria
- Dynamic environmental forces
- Fixed vessel position
- Fixed dynamic allowance
- No thruster/rudder dynamics
- No dynamic thrust loss effects
- No DP system dynamics
- No dynamic external loads
- No transients

- Dynamic force balance
- Dynamic environmental forces
- Free-floating vessel
- Thrusters fully utilized
- Any dynamic loads
- Thruster/rudder dynamics
- Dynamic thrust loss effects
- Closed loop with DP system
- Transient effects

Specific acceptance criteria
DYNCAP APPLICATIONS

Capability analysis
- Wind envelopes
- Thrust envelopes

Operational analysis
- Fuel consumption
- Operability charts
- Footprints

Contingency planning
- Drive-off
- Drift-off
- Degraded equipment
- Transient motion
TRANSIENT ANALYSIS: FOOTPRINT AFTER WORST CASE SINGLE FAILURE
For operations with absolute position and heading limits, the transient is often the critical period.
FUEL CONSUMPTION AND OPERABILITY

Discretize scatter diagram from metocean data:
• optimize number of simulations
• capture main metocean data characteristics

Closed-loop vessel model

• Station-keeping performance
• Operation OK?
• Fuel consumption

Each simulation: 3 hrs
Total simulation time: N x 3 hrs

Location

Metocean data

SeaState1

Simulation 1

SeaState2

Simulation 2

SeaState N

Simulation N

Annual fuel consumption and operability
**EXAMPLE: FUEL CONSUMPTION ANALYSIS FOR SIEMENS**

**Task:** calculate annual fuel consumption for two vessel designs at given locations, comparing five different power system configurations including Siemens' new closed ring bus solution.

<table>
<thead>
<tr>
<th>Setup</th>
<th>Class</th>
<th>Bus setup</th>
<th>Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DYNPOS AUTRO</td>
<td>split bus</td>
<td>one gen per bus (3 total)</td>
</tr>
<tr>
<td>2</td>
<td>DYNPOS AUTRO</td>
<td>closed bus</td>
<td>minimum 2 gens</td>
</tr>
<tr>
<td>3</td>
<td>DYNPOS ER</td>
<td>closed bus</td>
<td>minimum 2 gens</td>
</tr>
<tr>
<td>4</td>
<td>DYNPOS AUTRO</td>
<td>closed bus</td>
<td>minimum 3 gens</td>
</tr>
<tr>
<td>5</td>
<td>DYNPOS ER</td>
<td>closed bus</td>
<td>minimum 3 gens</td>
</tr>
</tbody>
</table>

**Graph:**
- **Fuel consumption (10^3 tonnes)**
- **Fuel saving (%)**