



Design & Control

Design and Commissioning of a New Thruster Assisted Mooring System (TAMS) for Global Producer III

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Design and commissioning of a new thruster assisted mooring system (TAMS) for Global Producer III

Richard Stephens and Allan Meahan

■ SUMMARY

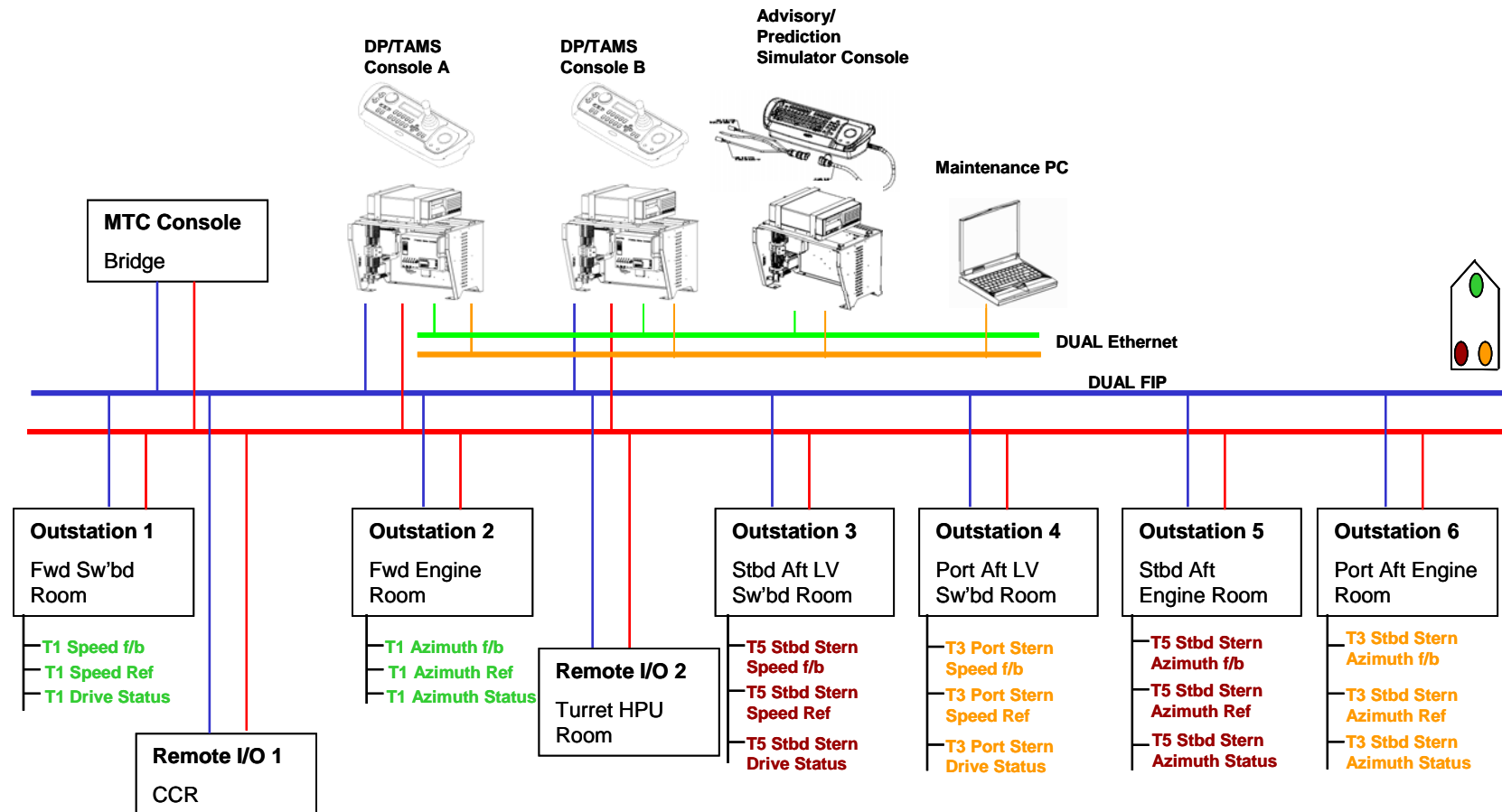
- GP3 re-fit
- TAMS/APS user interface
- Control philosophy
- Tuning
- Conclusions

| Entering dry-dock





New network layout





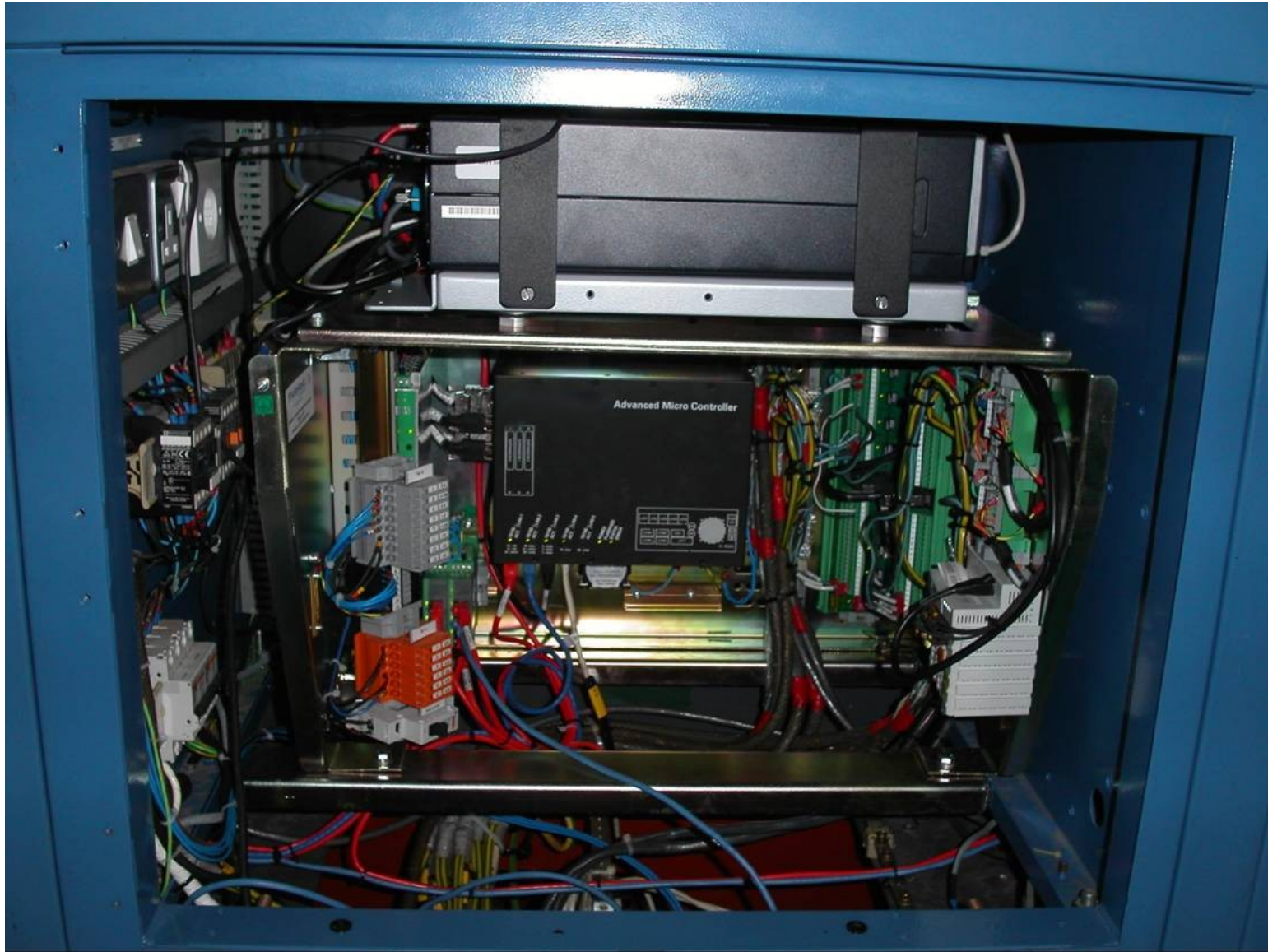
| Old consoles showing old hardware



| New consoles



| New hardware within existing cabinet



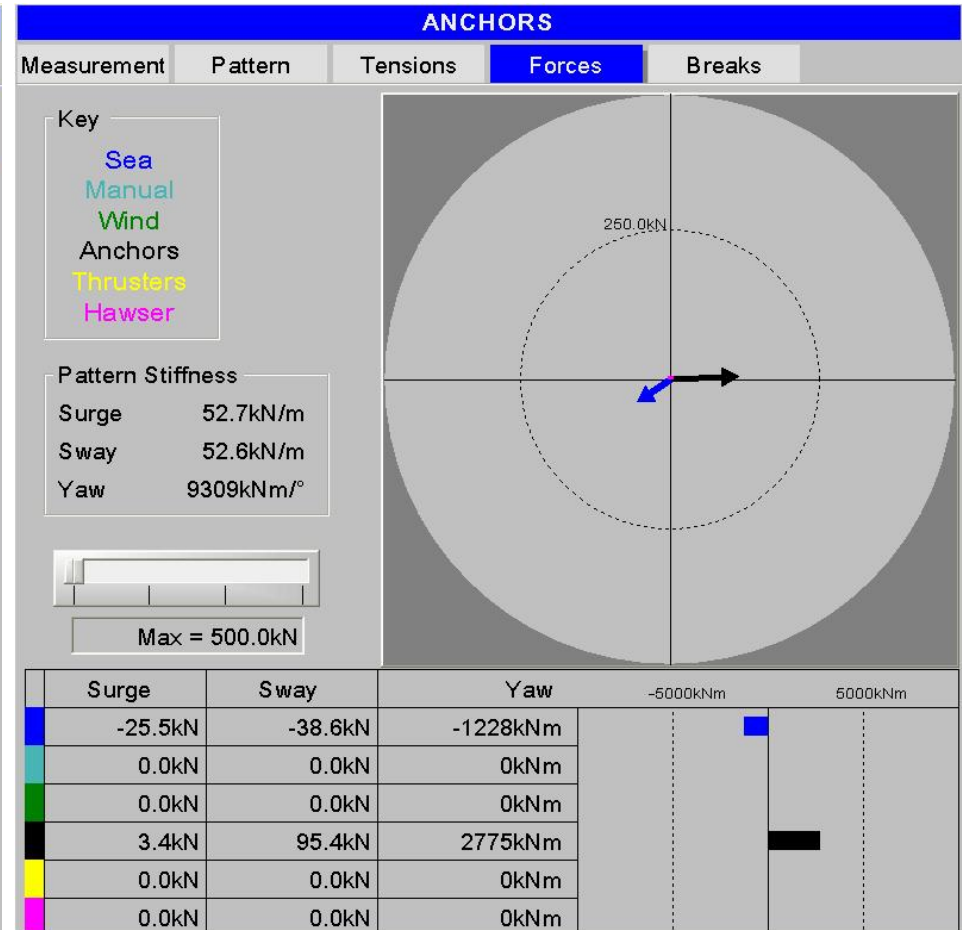
| New consoles in the existing suite



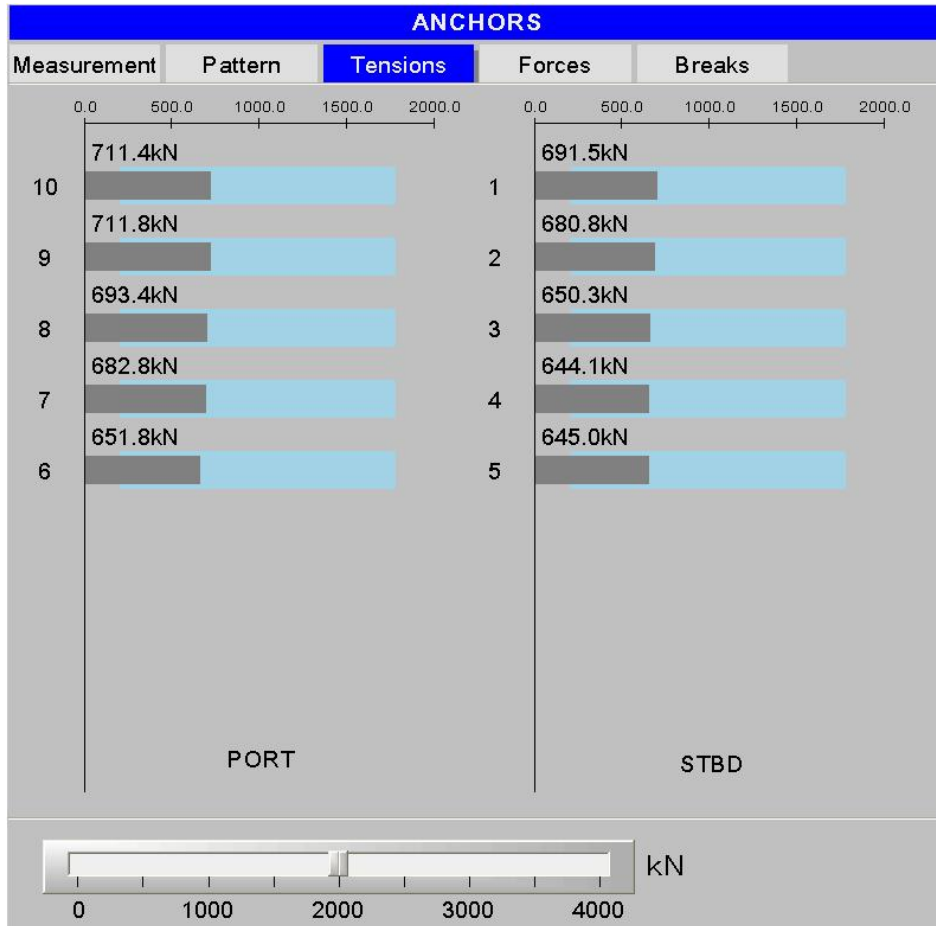
Controller screens

ANCHORS									
Measurement	Pattern	Tensions	Forces	Breaks					
Select All	Tension	EST	Alarm levels	Upper sect. Length	EST	Touchdown Distance	Total Length		
			Low	High					
<input type="checkbox"/> 1	694.2kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 2	683.3kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 3	650.8kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 4	643.7kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 5	642.5kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 6	649.1kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 7	680.8kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 8	692.1kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 9	713.0kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	
<input checked="" type="checkbox"/> 10	713.3kN	<input type="checkbox"/>	196.2kN	1765.8kN	0.0m	<input type="checkbox"/>	0.0m	800.0m	

☒ Accepted Data
 ☐ Measured Data
 ☐ Estimated Data



Controller monitoring screens



ANCHORS

Measurement Pattern Tensions Forces Breaks

Measurement	Checking enabled	Anc Sel	Sens OK	Horizontal Force	Threshold	Check for incr	Timer	Length Increase	Break Detect
1	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	39.0T	10.8T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	40.3T	10.9T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	49.8T	12.2T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
4	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	53.7T	12.8T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
5	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	62.9T	14.5T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
6	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	61.8T	10.6T	<input checked="" type="checkbox"/>	26	4.5m	<input checked="" type="checkbox"/>
7	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	60.4T	14.6T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
8	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	57.1T	14.2T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
9	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	45.5T	12.3T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>
10	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	42.4T	11.7T	<input type="checkbox"/>	89	0.0m	<input type="checkbox"/>

Break Length 4.5m

Consequence analysis screens

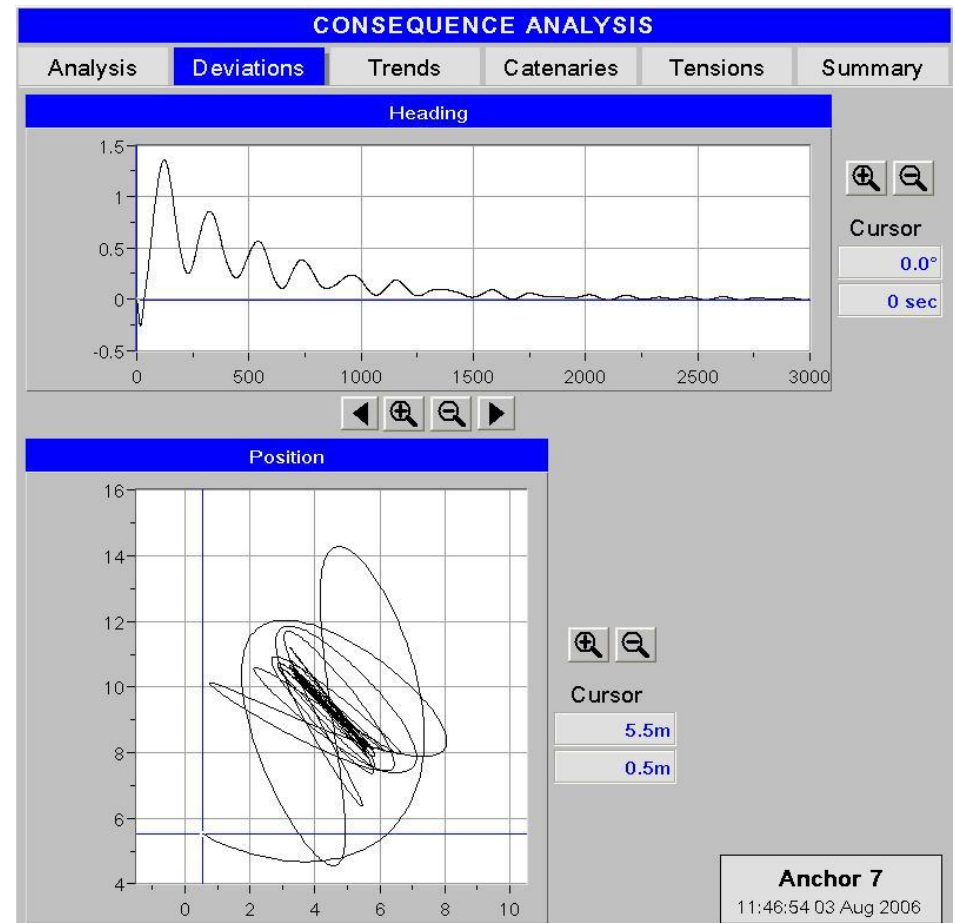
CONSEQUENCE ANALYSIS

AnalysisDeviationsTrendsCatenariesTensionsSummary

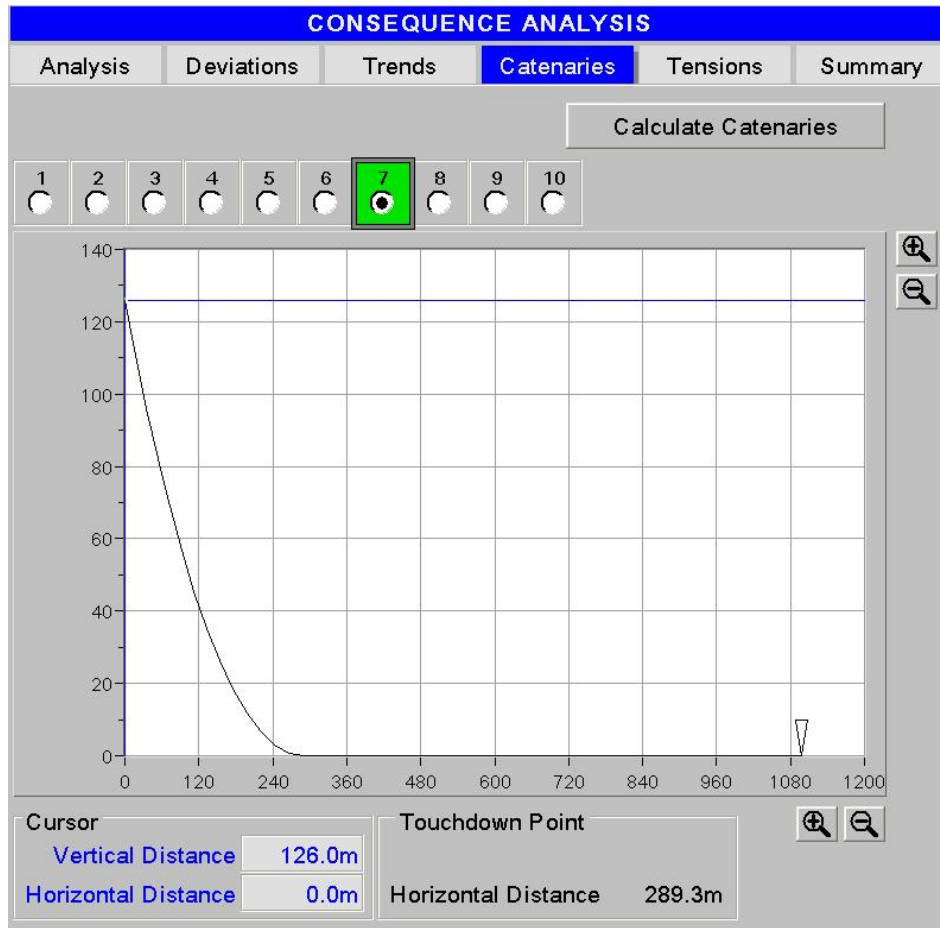
TAMS CONSEQUENCE ANALYSIS

Failure Condition	Predicted Alarms			Calc View
	Tension	Position	Heading	
Anchor 1	OK	OK	OK	
Anchor 2	OK	OK	OK	
Anchor 3	OK	OK	OK	
Anchor 4	OK	OK	OK	
Anchor 5	OK	OK	OK	
Anchor 6	OK	OK	OK	
Anchor 7	OK	OK	OK	
Anchor 8	OK	OK	OK	
Anchor 9	OK	OK	OK	
Anchor 10	OK	OK	OK	

Failure Condition	Predicted Alarms			Calc View
	Tension	Position	Heading	
Thruster T1	n/a	n/a	n/a	
Thruster T3	OK	OK	OK	
Thruster T5	OK	OK	OK	
Section Fwd(Stbd)	OK	OK	OK	
Section Aft(Stbd)	OK	OK	OK	
Section Aft(Port)	OK	OK	OK	
Section Fwd(Port)	OK	OK	OK	



Consequence analysis (2)



CONSEQUENCE ANALYSIS

Analysis | Deviations | Trends | Catenaries | **Tensions** | Summary

Pattern Stiffness	
Fore/Aft	171.6kN/m
Port/Stbd	166.4kN/m
Heading	3145kNm/°

Anchor	Measured Tension	Predicted Tension	Error	Anchor Stiffness
✓ 1	30.5T	63.9T	-33.6T	19.7kN/m
✓ 2	33.3T	65.9T	-32.7T	21.0kN/m
✓ 3	50.2T	81.2T	-30.8T	31.4kN/m
✓ 4	56.7T	88.8T	-31.8T	36.9kN/m
✓ 5	70.8T	108.9T	-37.7T	52.1kN/m
✓ 6	72.1T	110.5T	-38.1T	53.3kN/m
✓ 7	64.1T	96.7T	-32.5T	42.7kN/m
✓ 8	58.4T	88.7T	-30.4T	36.7kN/m
✓ 9	39.0T	69.1T	-30.5T	23.1kN/m
✓ 10	34.3T	65.8T	-32.0T	20.9kN/m

Consequence analysis (3)

CONSEQUENCE ANALYSIS						
Analysis	Deviations	Trends	Catenaries	Tensions	Summary	
Pattern Centre		Model Pattern Centre		Error		
58°21.28333' N 000°51.83333' E		58°21.28330' N 000°51.83342' E		0.1m S 0.1m E		
Pattern Heading		Model Pattern Hdg		Error		
340.0°		340.0°		0.0°		

Anchor	Lineout	Bearing	Horizontal Distance	Min Horiz. Distance	Max Horiz. Distance	Design Tension
✓ 1	1130.5m	007.3°	1093.9m	1004.5m	1237.2m	81.2T
✓ 2	1130.5m	025.1°	1093.8m	1004.5m	1237.2m	80.9T
✓ 3	1130.5m	079.2°	1093.7m	1004.5m	1237.2m	80.7T
✓ 4	1130.5m	097.1°	1093.8m	1004.5m	1237.2m	80.8T
✓ 5	1130.5m	150.8°	1093.8m	1004.5m	1237.2m	80.8T
✓ 6	1130.5m	168.8°	1093.8m	1004.5m	1237.2m	80.8T
✓ 7	1130.5m	222.7°	1093.9m	1004.5m	1237.2m	81.2T
✓ 8	1130.5m	240.8°	1093.9m	1004.5m	1237.2m	81.3T
✓ 9	1130.5m	295.4°	1093.8m	1004.5m	1237.2m	81.0T
✓ 10	1130.5m	313.0°	1093.9m	1004.5m	1237.2m	81.2T

Prediction simulator screens

PREDICTION SIMULATOR

Pattern Scenario Deviations Trends

SIMULATED PATTERN Copy Actual Pattern

Pattern Centre 58°21.28333' N
000°51.83333' E

Water depth 140.0m

Vessel Draft 17.0m

Pattern Heading 340.0°

Anchor 1 Position 58°21.87109' N
000°51.97637' E

Section	Type	Length	Diameter	Weight	Elasticity
Upper	Chain ▼	330.5m	108mm	203.0kg/m	62.4GPa
Middle	Chain ▼	400.0m	108mm	203.0kg/m	62.4GPa
Lower	Chain ▼	400.0m	108mm	203.0kg/m	62.4GPa

PREDICTION SIMULATOR

Pattern Scenario Deviations Trends

	Magnitude	Direction	F-Fwd	Control Mode	Gain
Wind	0.0m/s	000.0°	Measured <input checked="" type="checkbox"/>	Surge MONITOR ▼	50 %
Wave	0.0m	000.0°		Sway MONITOR ▼	50 %
Current	0.0m/s	000.0°		Yaw MONITOR ▼	50 %

Copy Control Selections

Anchors Status		Thrusters	Generators	Bus-Ties	Set Heading
<input checked="" type="checkbox"/> 10	<input checked="" type="checkbox"/> 1	<input checked="" type="checkbox"/> T1	<input checked="" type="checkbox"/> G1	<input type="checkbox"/> 1-2	000.0°
<input checked="" type="checkbox"/> 9	<input checked="" type="checkbox"/> 2	<input checked="" type="checkbox"/> T3	<input checked="" type="checkbox"/> G2	<input type="checkbox"/> 2-3	
<input checked="" type="checkbox"/> 8	<input checked="" type="checkbox"/> 3	<input checked="" type="checkbox"/> T5	<input checked="" type="checkbox"/> G3	<input type="checkbox"/> 3-4	
<input checked="" type="checkbox"/> 7	<input checked="" type="checkbox"/> 4		<input checked="" type="checkbox"/> G4	<input type="checkbox"/> 4-1	
<input checked="" type="checkbox"/> 6	<input checked="" type="checkbox"/> 5		<input checked="" type="checkbox"/> G5		
			<input checked="" type="checkbox"/> G6		

Copy Control Selections Copy Control Copy Control Copy Control

Hotel Load 0.0kW

Thruster Mode ☐ No Bias ☐ Bias

Failure Selection Anchor ▼ 1 ▼

Last Sim Status:

Pattern Modified

Perform Simulation

Advisory screens

ADVISORY								
Optimisation		Reposition						
Present Lineout Summary				Line Tension Optimisation Calculation				
Present Net		267.5kN S		Desired Net		73.0T S		
Pattern Force		697.7kN W		Pattern Force		18.0T W		
Anchor	Desired Tension <small>Set All</small>	Present			New			Req. Payout
		Tension	Tension Difference	Lineout	Tension	Tension Difference	Lineout	
1	80.0T	74.8T	5.2T	1130.5m	65.2T	14.8T	1134.6m	4.1m
2	80.0T	71.5T	8.5T	1130.5m	65.4T	14.6T	1133.2m	2.7m
3	80.0T	68.4T	11.6T	1130.5m	73.7T	6.3T	1128.3m	-2.2m
4	80.0T	69.6T	10.4T	1130.5m	78.2T	1.8T	1127.2m	-3.3m
5	80.0T	78.9T	1.1T	1130.5m	90.9T	-10.9T	1126.9m	-3.6m
6	80.0T	83.4T	-3.4T	1130.5m	93.5T	-13.5T	1127.7m	-2.8m
7	80.0T	96.8T	-16.8T	1130.5m	93.1T	-13.1T	1131.4m	0.9m
8	80.0T	98.9T	-18.9T	1130.5m	90.2T	-10.2T	1132.6m	2.1m
9	80.0T	92.6T	-12.6T	1130.5m	77.1T	2.9T	1135.1m	4.6m
10	80.0T	88.3T	-8.3T	1130.5m	72.8T	7.2T	1135.6m	5.1m

ADVISORY

Optimisation

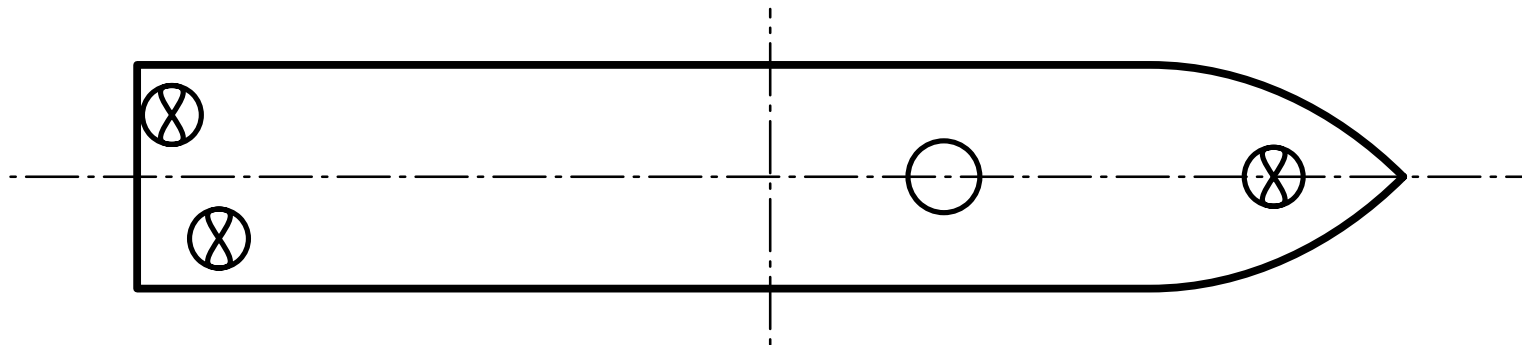
Reposition

Position Move Calculation

Position Change

20.0m N
0.0m E

Anchor	Present			New			Req. Payout
	Tension	Horizontal Distance	Lineout	Tension	Horizontal Distance	Lineout	
1	69.1T	1089.4m	1130.5m	69.1T	1069.5m	1110.7m	-19.8m
2	68.4T	1089.0m	1130.5m	68.4T	1071.0m	1112.4m	-18.1m
3	73.0T	1091.0m	1130.5m	73.0T	1087.5m	1127.0m	-3.5m
4	76.7T	1092.3m	1130.5m	76.7T	1095.0m	1133.2m	2.7m
5	90.5T	1096.6m	1130.5m	90.5T	1114.1m	1148.0m	17.5m
6	94.5T	1097.6m	1130.5m	94.5T	1117.2m	1150.1m	19.6m
7	97.9T	1098.4m	1130.5m	97.9T	1113.2m	1145.3m	14.8m
8	95.2T	1097.7m	1130.5m	95.2T	1107.7m	1140.4m	9.9m
9	80.9T	1093.8m	1130.5m	80.9T	1085.4m	1122.1m	-8.4m
10	76.9T	1092.4m	1130.5m	76.9T	1078.9m	1117.0m	-13.5m



- **Minimise points of failure**
 - Tension measurements unreliable and noisy
 - Tension model requires operator input
- **Assist (complement) anchor system**
- **Minimise thruster usage**
 - Economy
 - Noise

Anchor monitor

Manual bias

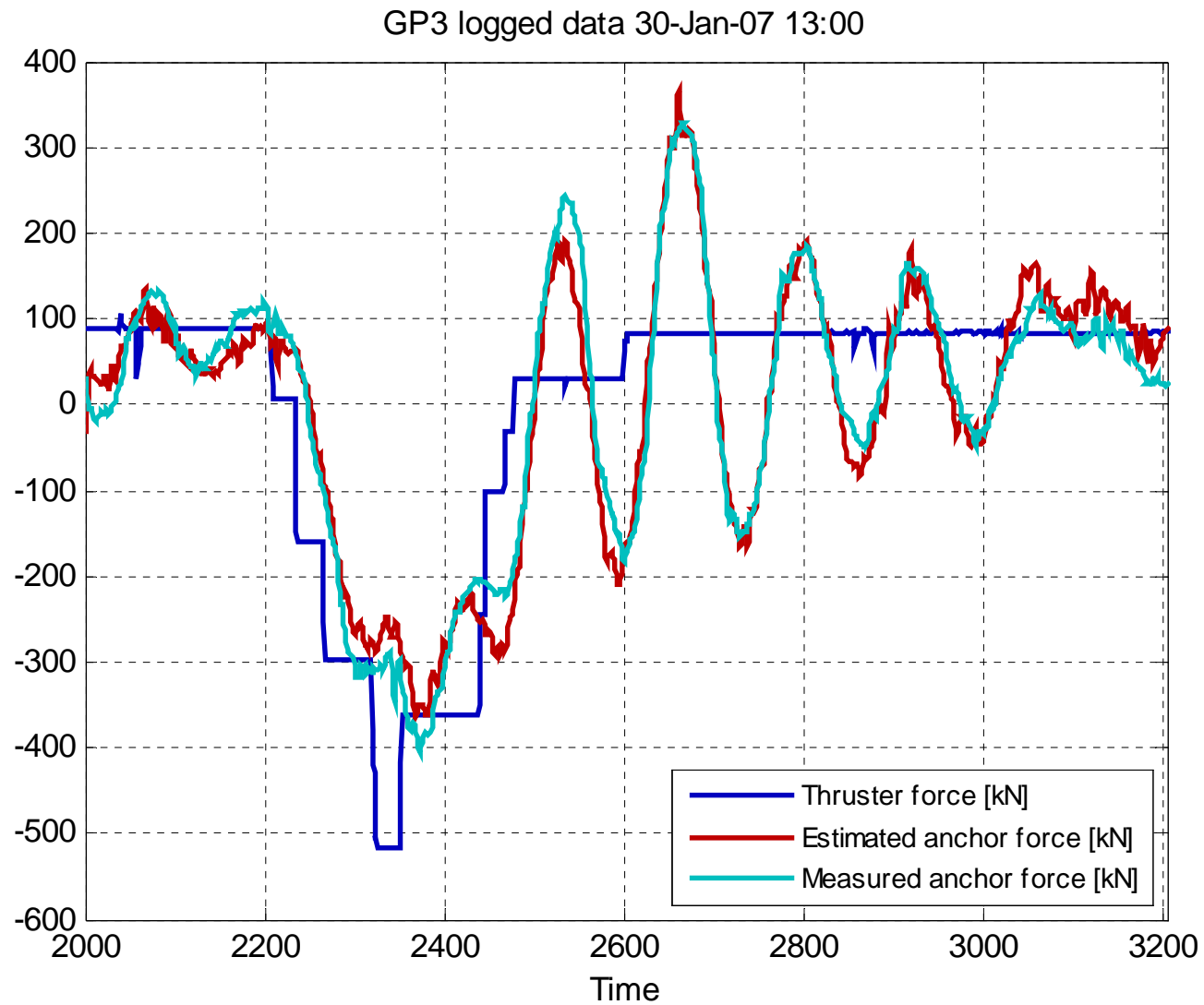
Auto heading

Anchor assist

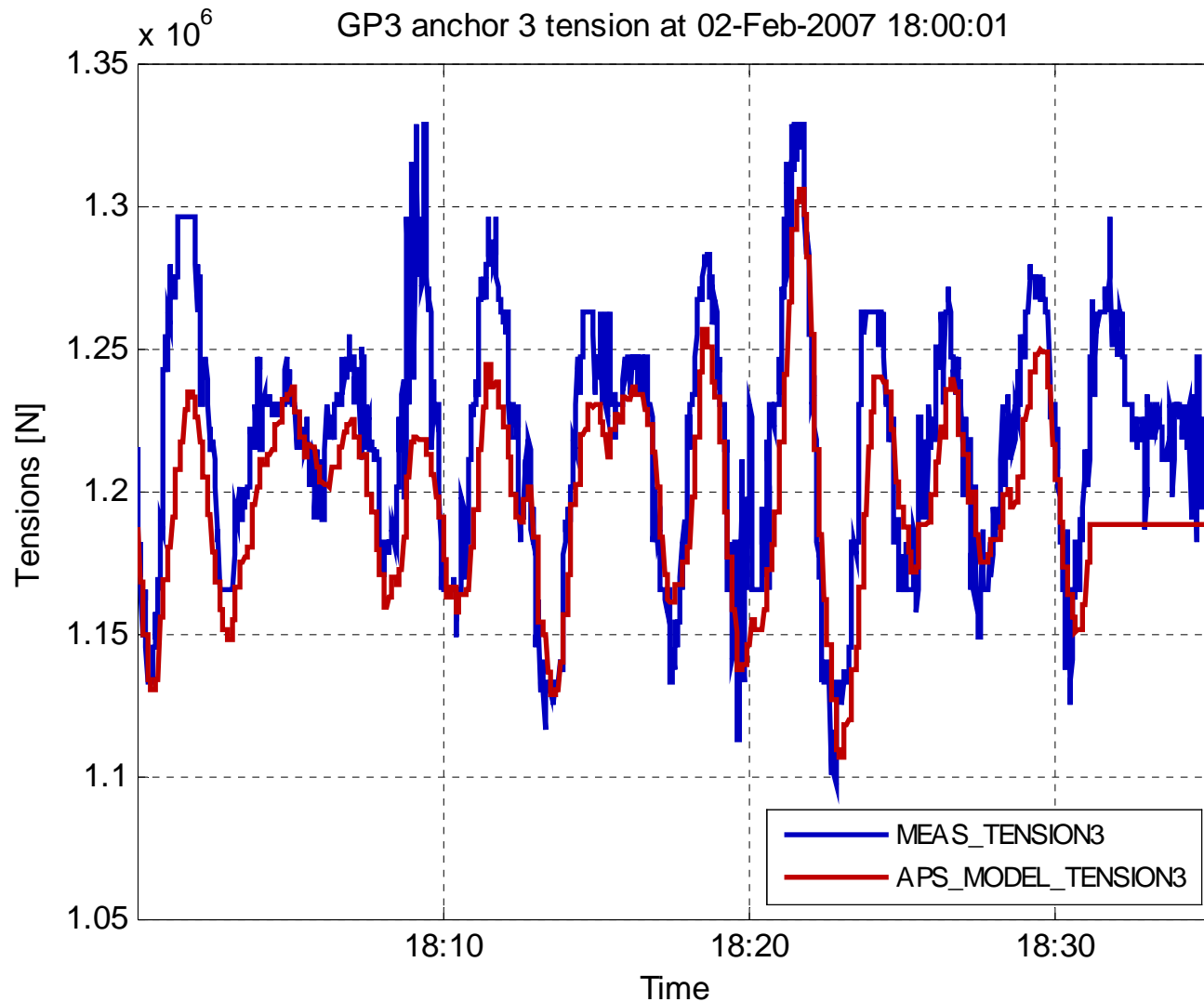
Anchor economy

‘Matrix’ mode

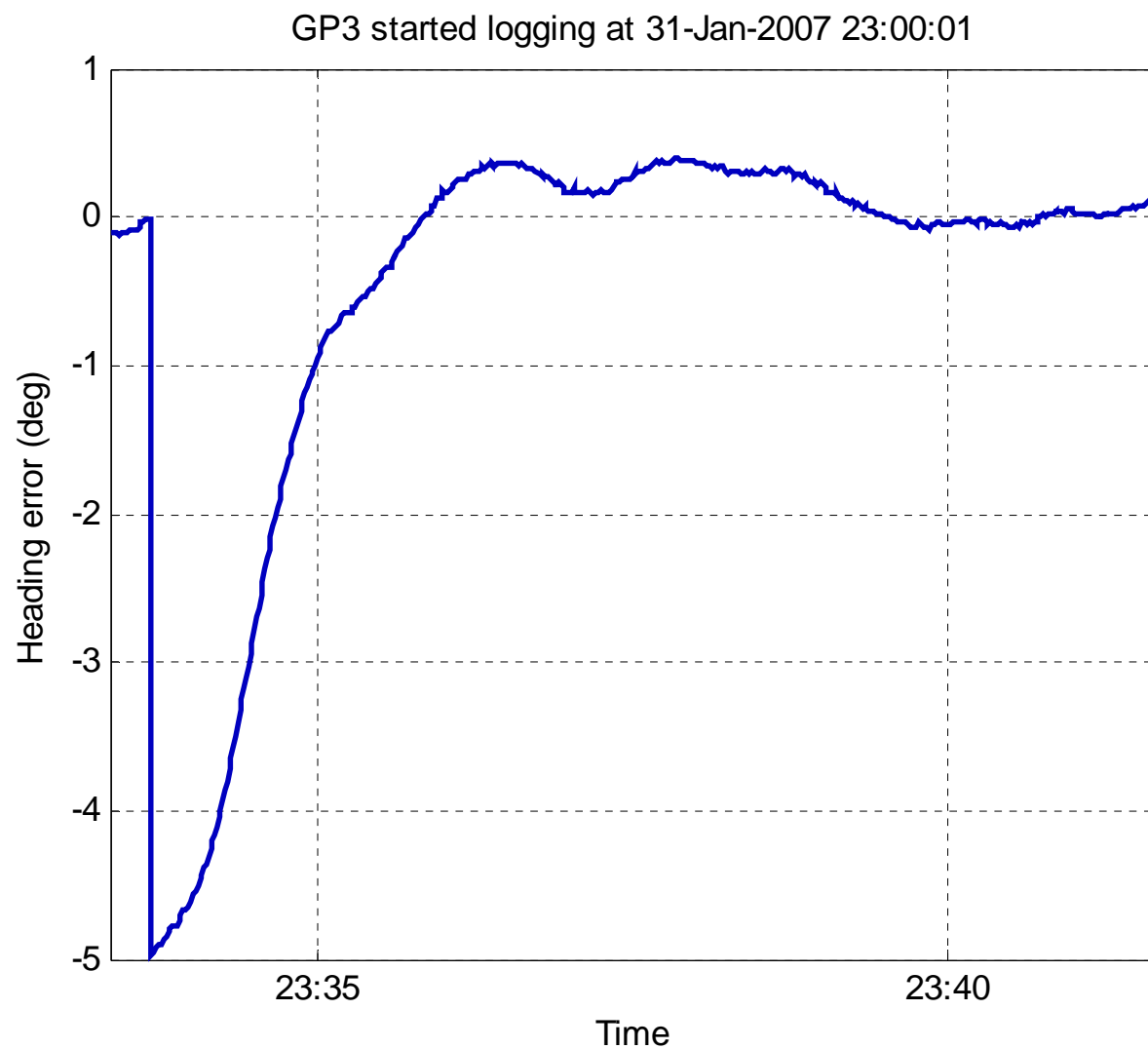
Comparison of mooring forces



Comparison of anchor tensions



Heading step change



TAMStool user interface

TAMStool 1.1.2

File About

Design Detail

	Anchor bearing [deg]	Anchor distance [m]	Total line length [m]	Fairlead to winch dist [m]	Nominal tension [kN]	Anchor position lat/long (WGS84) [deg]		Tension stiffness [kNm]
01	111.572	1053.64	1089.7	0	631.633	58° 20' 57.73" N	0° 52' 45.66" E	21.04
02	129.685	1068.89	1105.7	0	616.419	58° 20' 48.19" N	0° 52' 35.99" E	20
03	-176.478	1063.54	1099.7	0	629.342	58° 20' 35.94" N	0° 51' 41.4" E	20.87
04	-158.308	1070.17	1106.7	0	621.988	58° 20' 38.11" N	0° 51' 21.1" E	20.37
05	-104.247	1061.76	1098.7	0	613.997	58° 21' 1.803" N	0° 50' 42.14" E	19.85
06	-86.3872	1063.4	1099.7	0	626.697	58° 21' 12.41" N	0° 50' 40.16" E	20.7
07	-32.2785	1072.91	1109.7	0	616.883	58° 21' 39.57" N	0° 51' 10.18" E	20.03
08	-14.304	1067.13	1103.7	0	621.222	58° 21' 43.67" N	0° 51' 29.2" E	20.33
09	39.6121	1078.11	1114.7	0	620.624	58° 21' 37.09" N	0° 52' 27.68" E	20.28
10	57.6767	1077.25	1113.7	0	623.36	58° 21' 28.86" N	0° 52' 41.39" E	20.46
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0

Water depth: 141

Draught: 17

Turret radius: 6.1

Turret centre: 58.35284677 0.8626154677
58° 21' 10.25" N 0° 51' 45.42" E

Calc anchor dist Calc line length Calc fairlead dist Calc tension Recalc from new turret centre

Load pattern... C:\RIS\pattern.txt

Load thruster.def... C:\RIS\THRUSTER.DEF

Refresh from pattern

New HMI

No tension measurements

Minimised points of failure

Preparation via initial simulation

Commissioned with no interruption to production

Thank you for your attention

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