



Design & Control

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

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October 9-10, 2007

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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

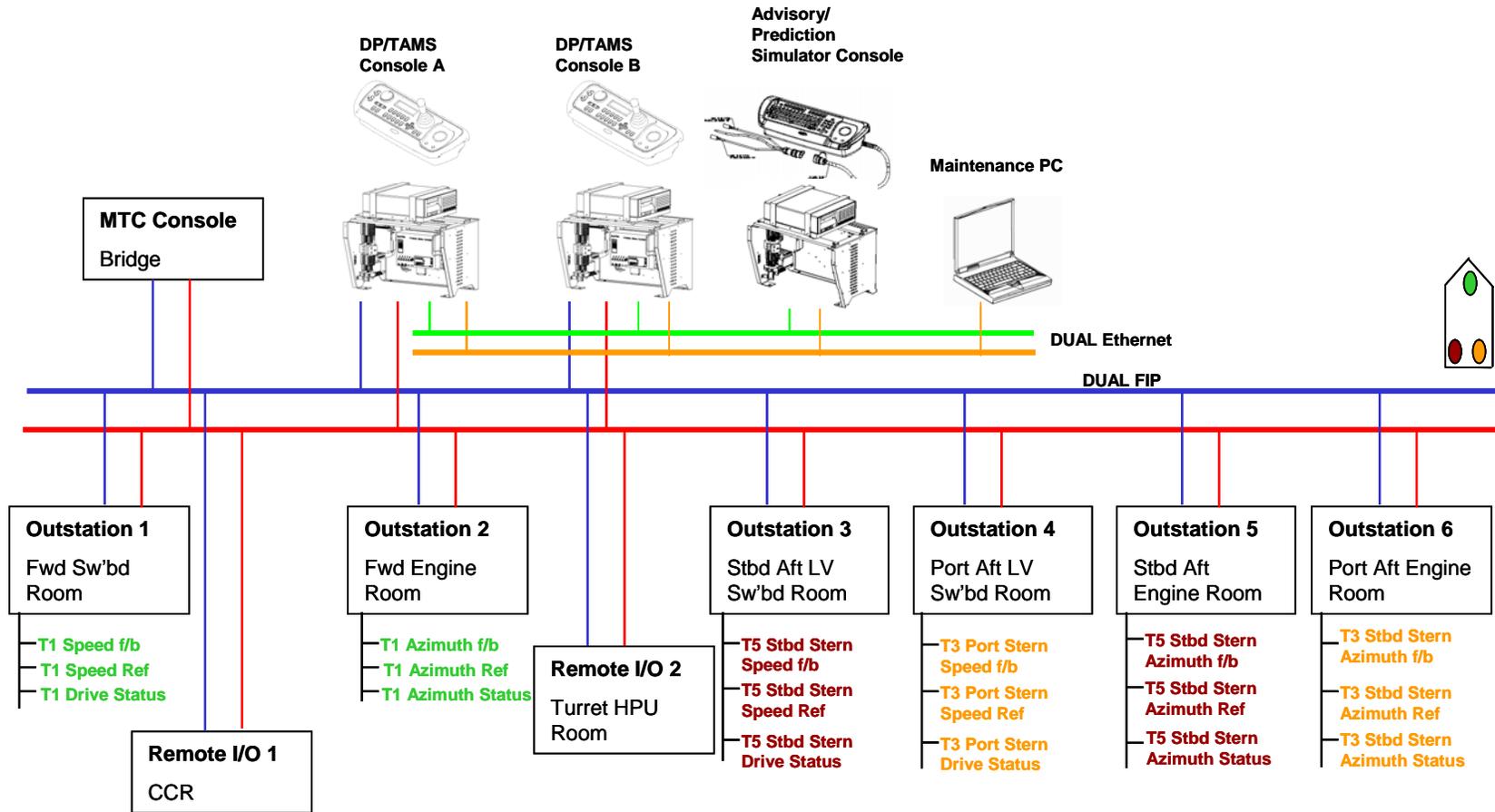
- GP3 re-fit
- TAMS/APS user interface
- Control philosophy
- Tuning
- Conclusions

Entering dry-dock





New network layout





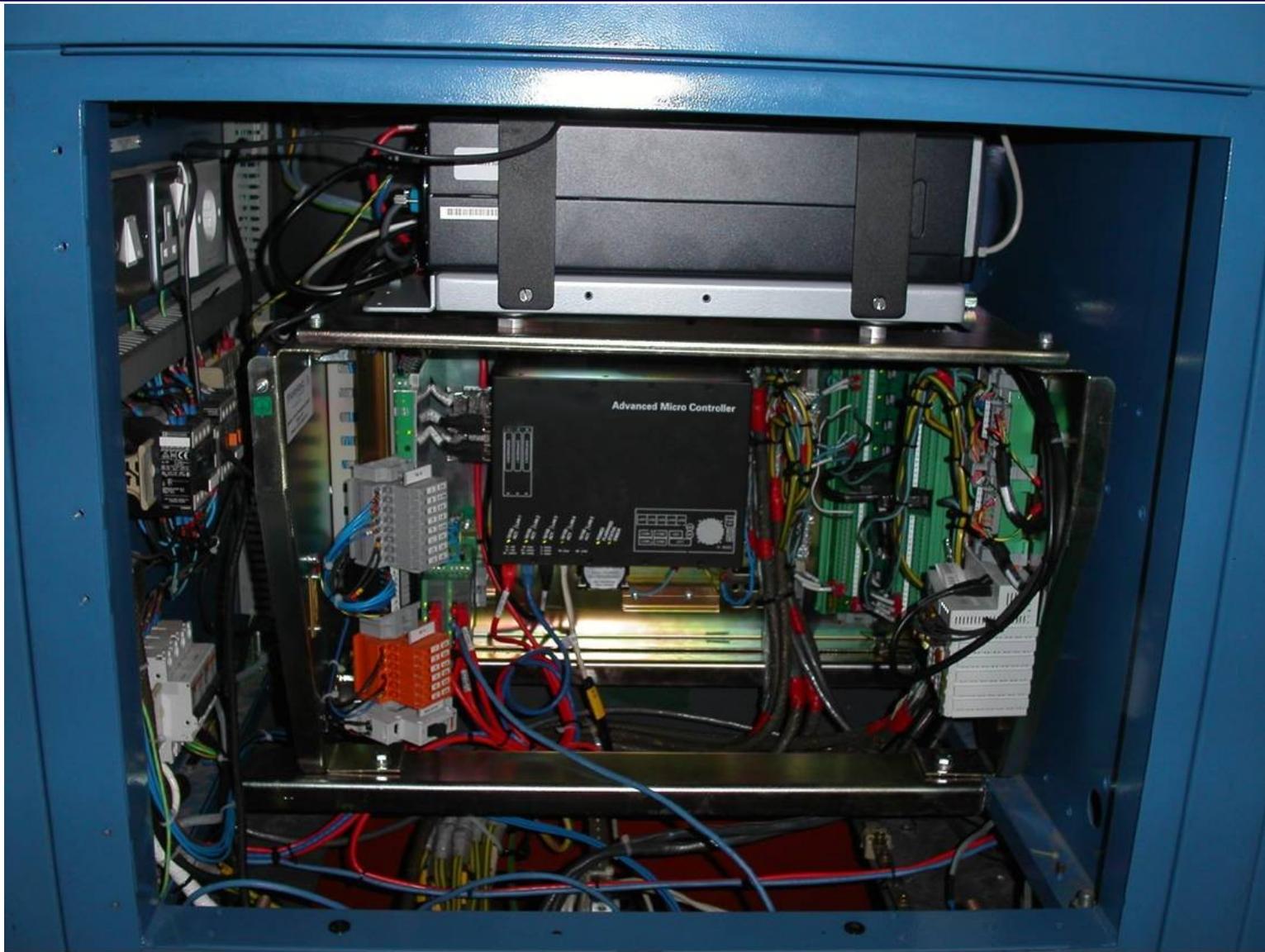
Old consoles showing old hardware



New consoles



New hardware within existing cabinet

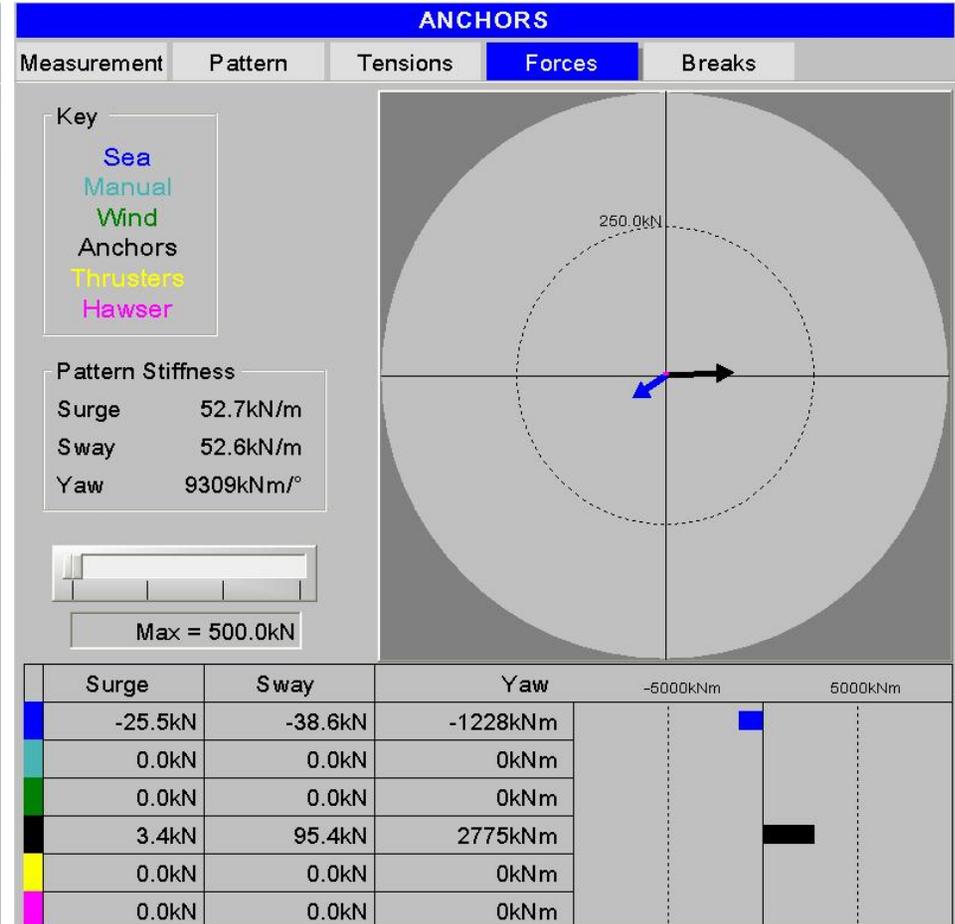


New consoles in the existing suite

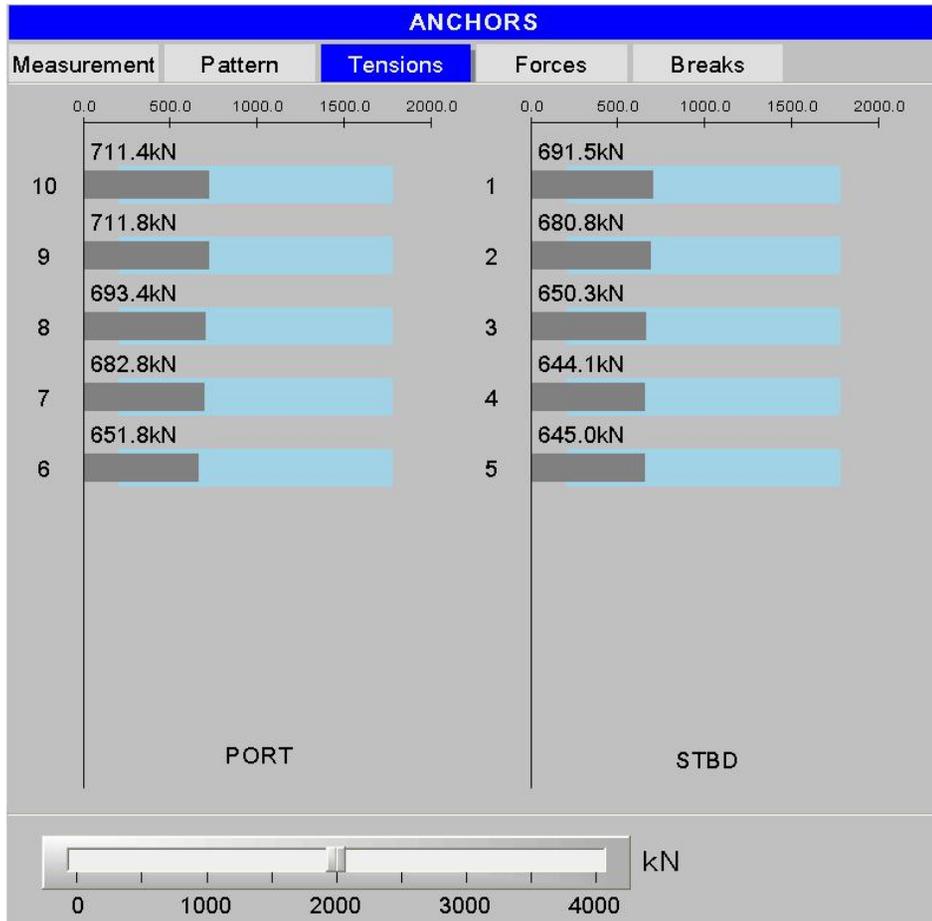


ANCHORS							
Measurement	Pattern	Tensions	Forces	Breaks			
Select All	Tension	Alarm levels		Upper sect. Length	Touchdown Distance	Total Length	
		Low	High				
<input type="checkbox"/>	1	694.2kN	196.2kN	1765.8kN	0.0m	0.0m	800.0m
<input checked="" type="checkbox"/>	2	683.3kN	196.2kN	1765.8kN	0.0m	0.0m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

Analysis | Deviations | Trends | Catenaries | Tensions | Summary

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

Analysis | Deviations | Trends | Catenaries | Tensions | Summary

Heading

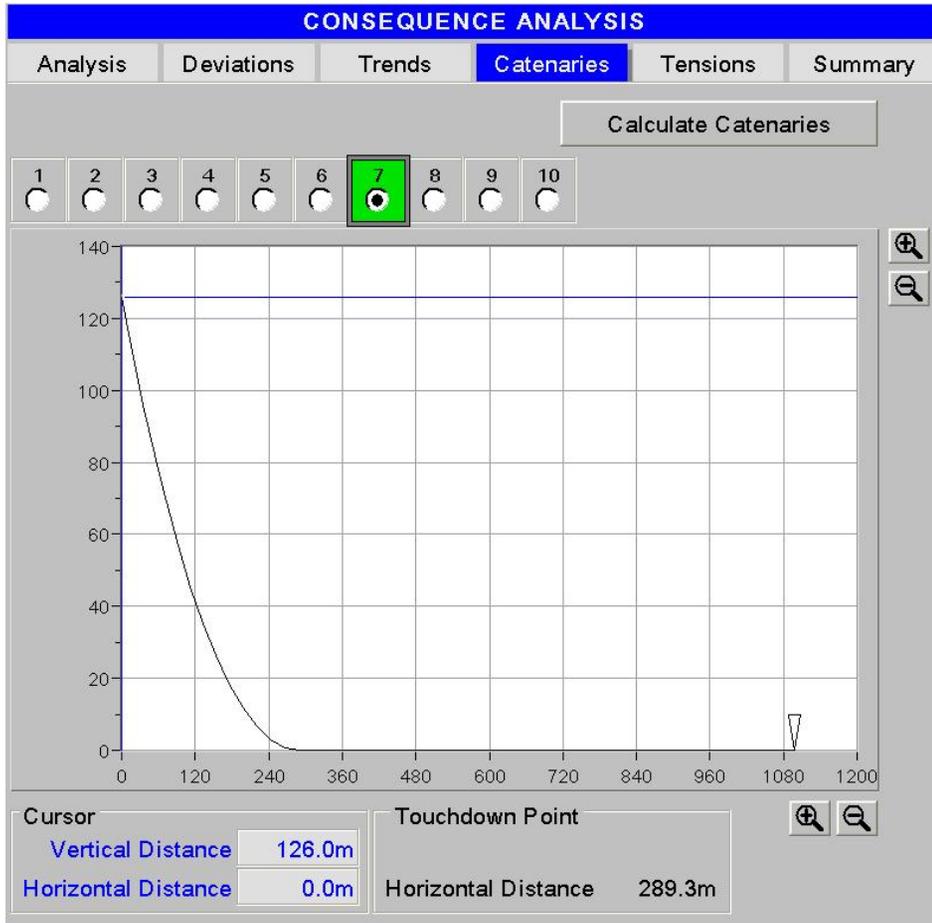
Cursor
0.0°
0 sec

Position

Cursor
5.5m
0.5m

Anchor 7
11:46:54 03 Aug 2006

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

Anchor	Thrusters	Generators	Bus-Ties	Set Heading
<input checked="" type="checkbox"/> 10	<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"/> T2	<input checked="" type="checkbox"/> G2	<input type="checkbox"/> 2-3	
<input checked="" type="checkbox"/> 8	<input checked="" type="checkbox"/> T3	<input checked="" type="checkbox"/> G3	<input type="checkbox"/> 3-4	
<input checked="" type="checkbox"/> 7	<input checked="" type="checkbox"/> T4	<input checked="" type="checkbox"/> G4	<input type="checkbox"/> 4-1	
<input checked="" type="checkbox"/> 6	<input checked="" type="checkbox"/> T5	<input checked="" type="checkbox"/> G5		
<input checked="" type="checkbox"/> 5		<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

Optimisation **Reposition**

Present Lineout Summary

Present Net 267.5kN S
Pattern Force 697.7kN W

Line Tension Optimisation Calculation

Desired Net 73.0T S
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

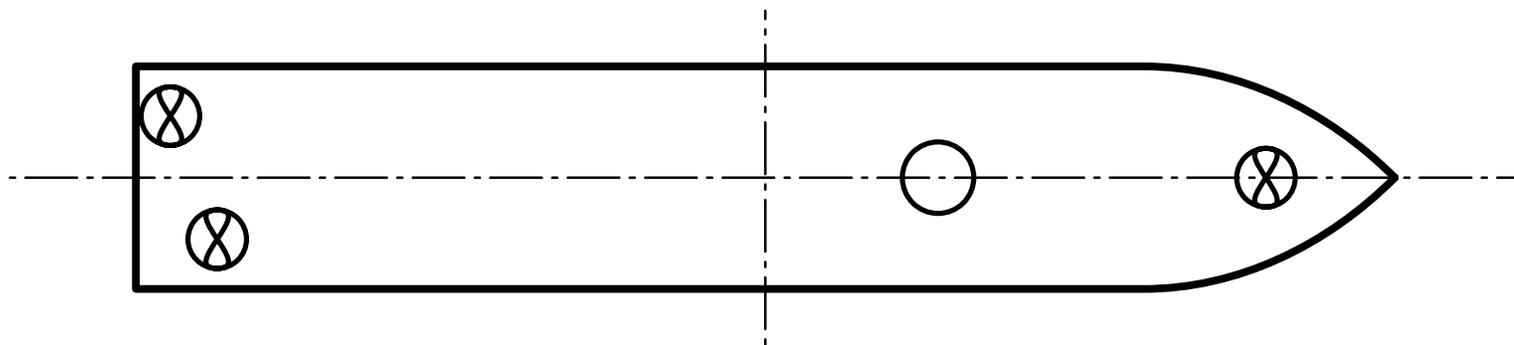
ADVISORY

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

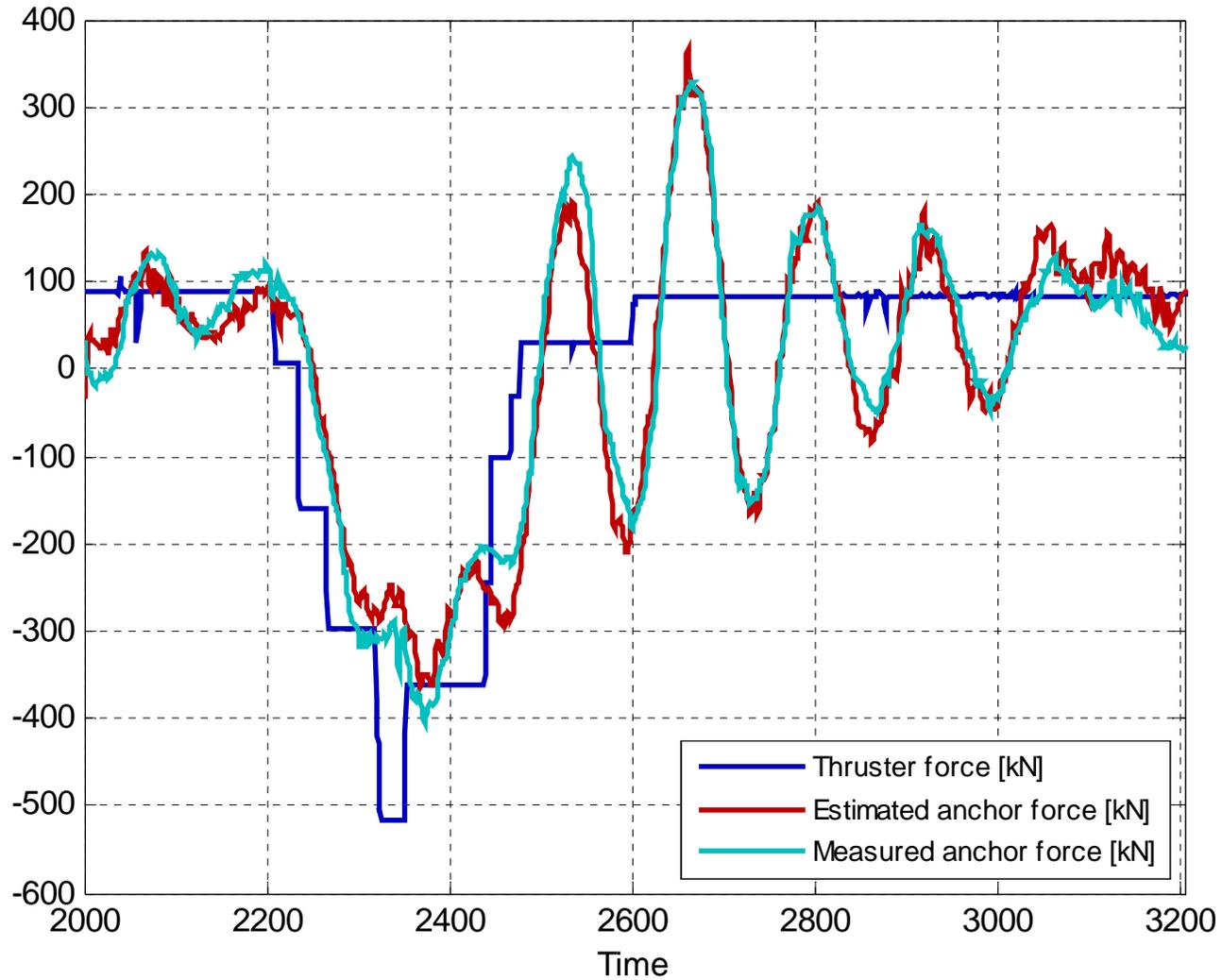
Anchor assist

Anchor economy

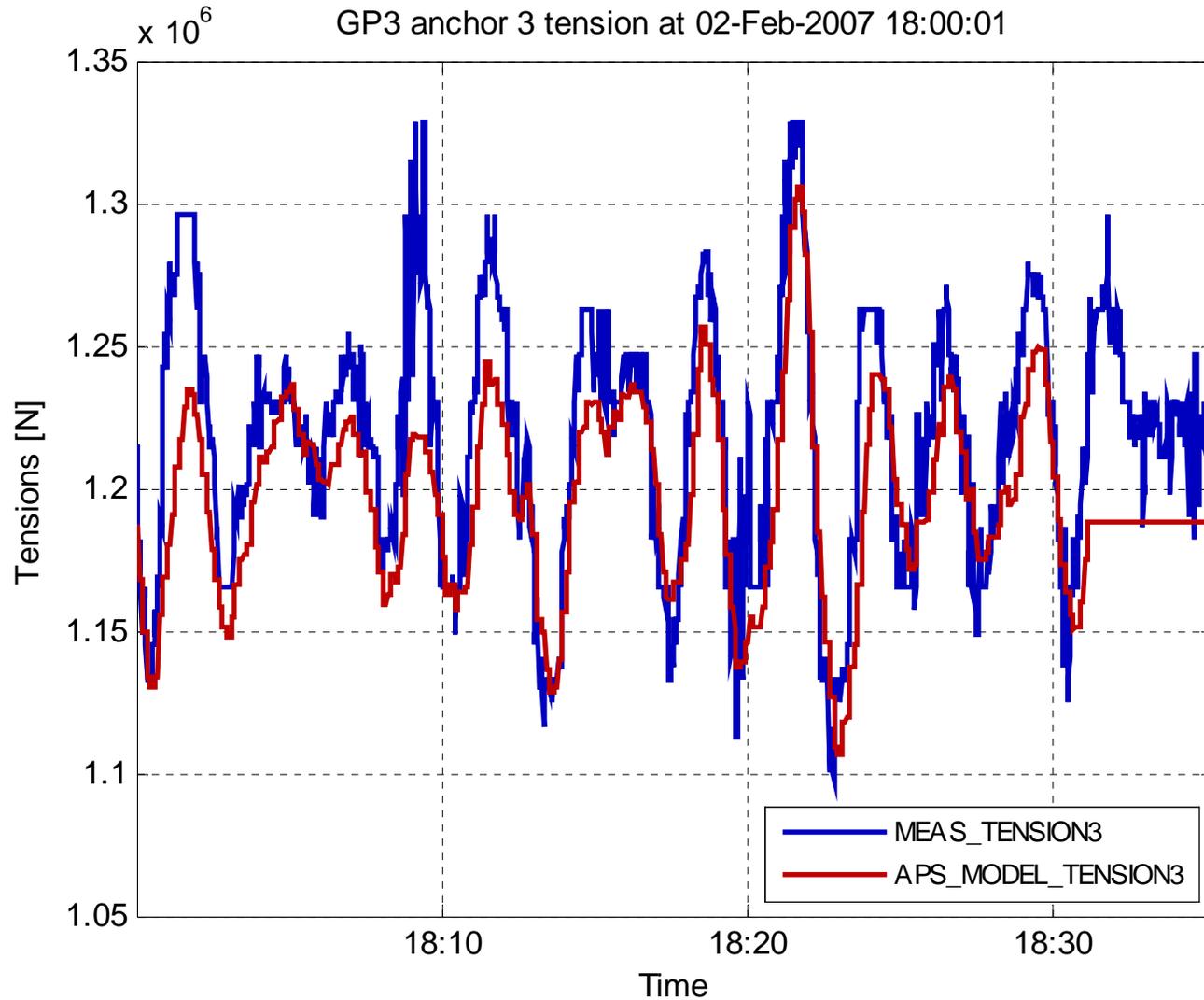
'Matrix' mode

Comparison of mooring forces

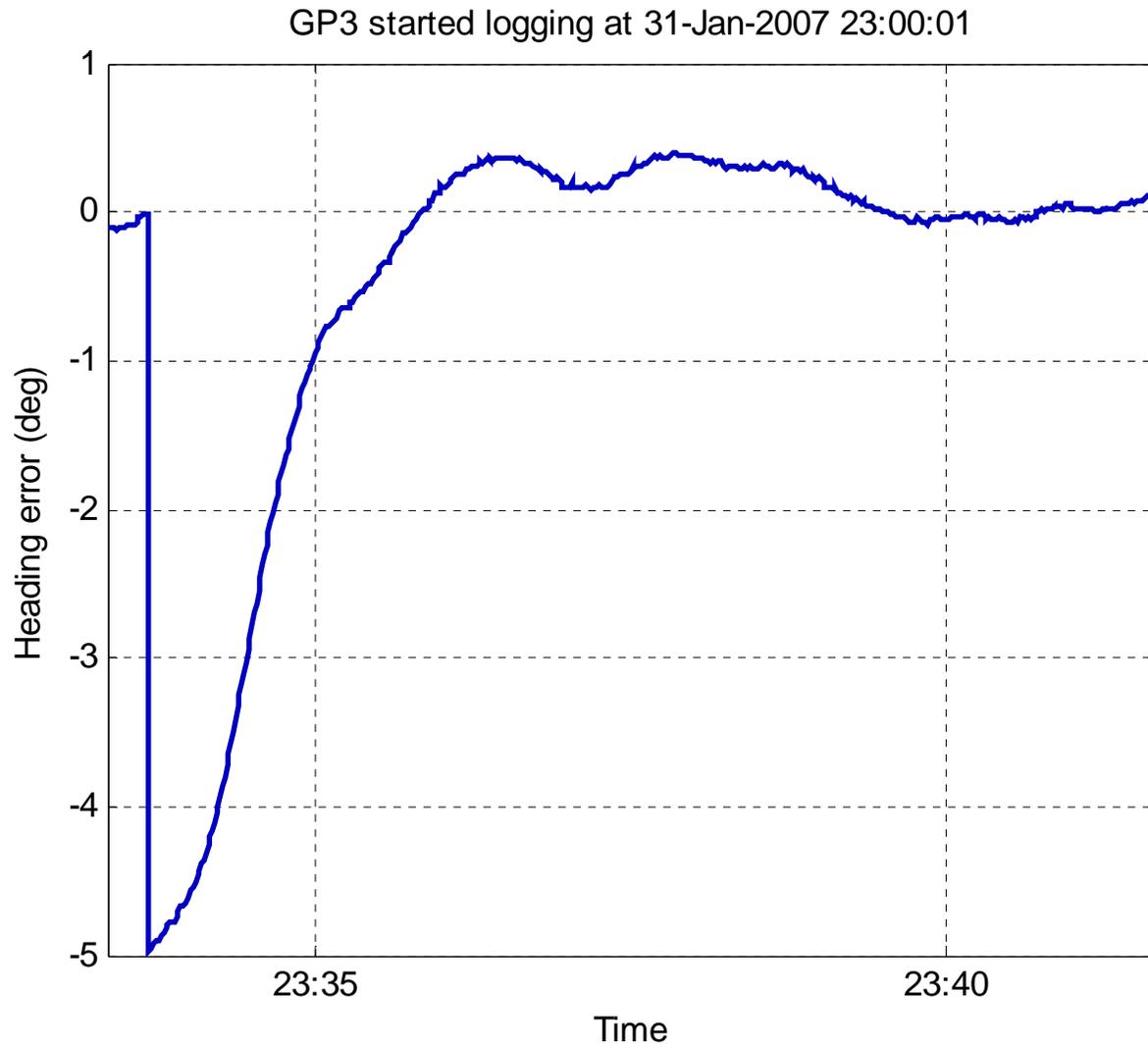
GP3 logged data 30-Jan-07 13:00



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

Adipiscing editLorem ipsum dolor sit amet, consecetur adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat. Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan.

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