Risk

Sedco Express DGPS Operations
Five Years of Lessons Learned

Lew Weingarth and Stephane Angue

Transocean, Inc.

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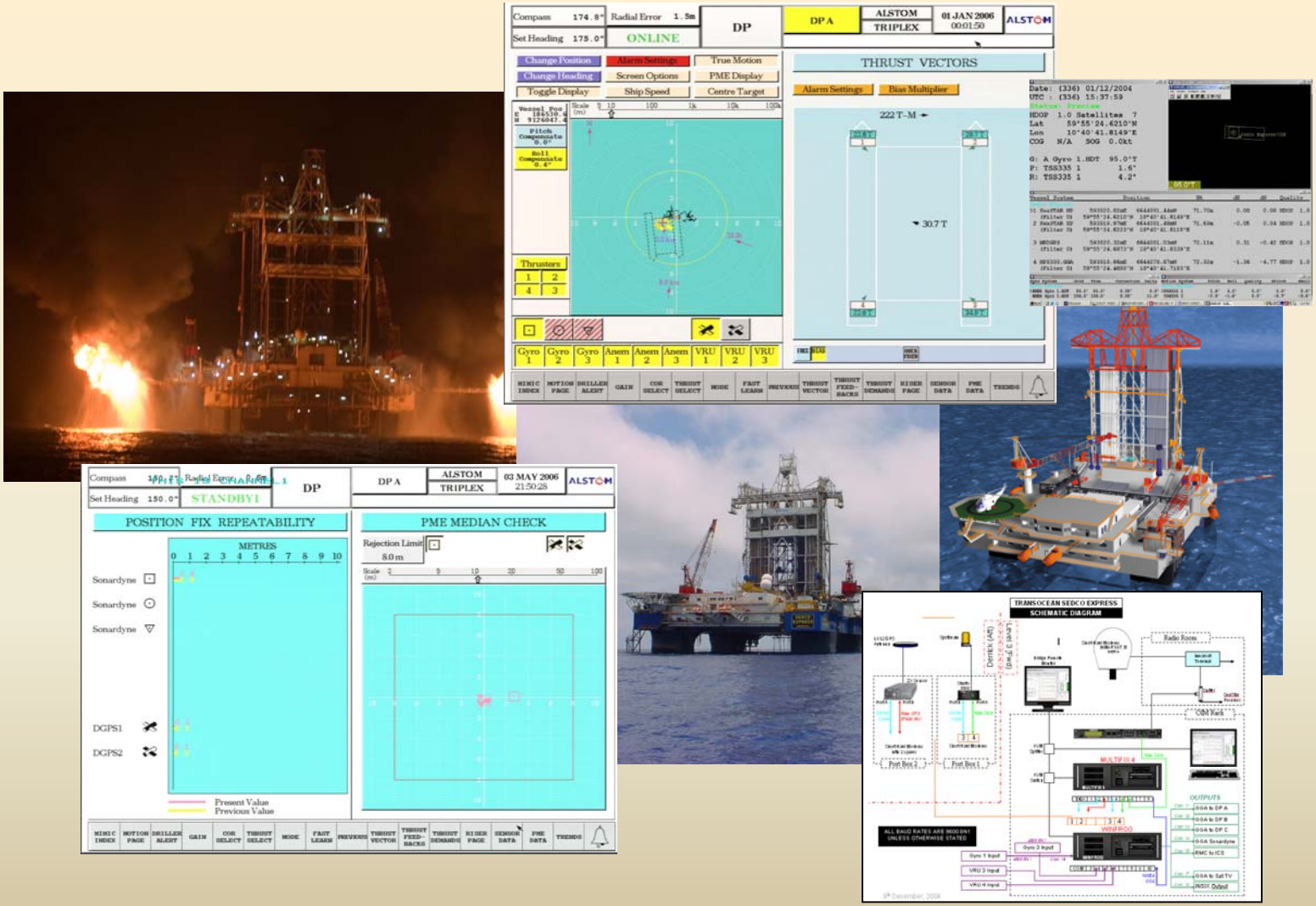
SEDCO EXPRESS DGPS OPERATIONS
Five years of lessons learned



SEDCO EXPRESS

- DP 5th generation semi submersible / DP class 3 ABS
- 4 azimuth thrusters (7MW each) and 6 generators (4.4MW each)
- ALSTOM 903 DP system
- 2 DGPS position reference systems
- 1 Acoustic position reference system
- ALSTOM ICS (VMS/PMS) system on the bridge (engine control room)

Transocean technical specifications for DGPS suite installation

- 2 separate DGPS suites (hardware/software)
- Dual frequency GPS receivers
- Redundancy in correction links
- Separate UPS for each DGPS suite
- User friendly system
- Compliance with industry standards for reliability, fault tolerance and fail safe behavior

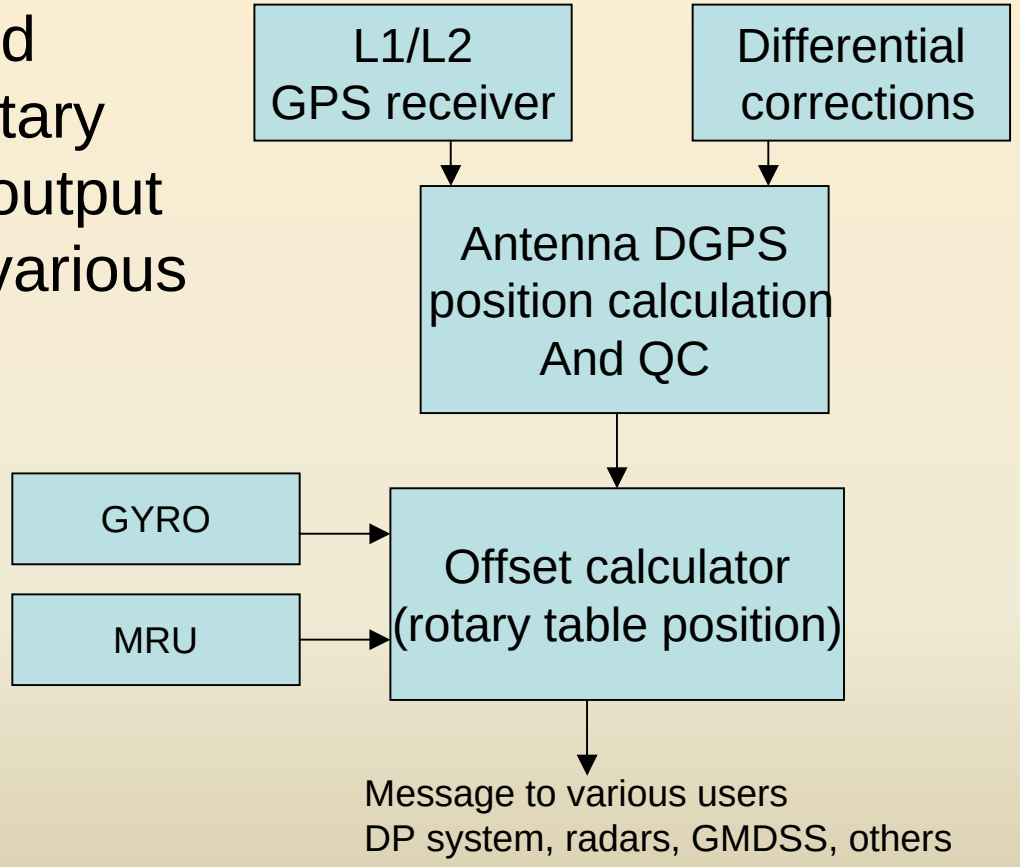
DGPS systems replaced in 2005

Decision was made to replace DGPS suites on board due to:

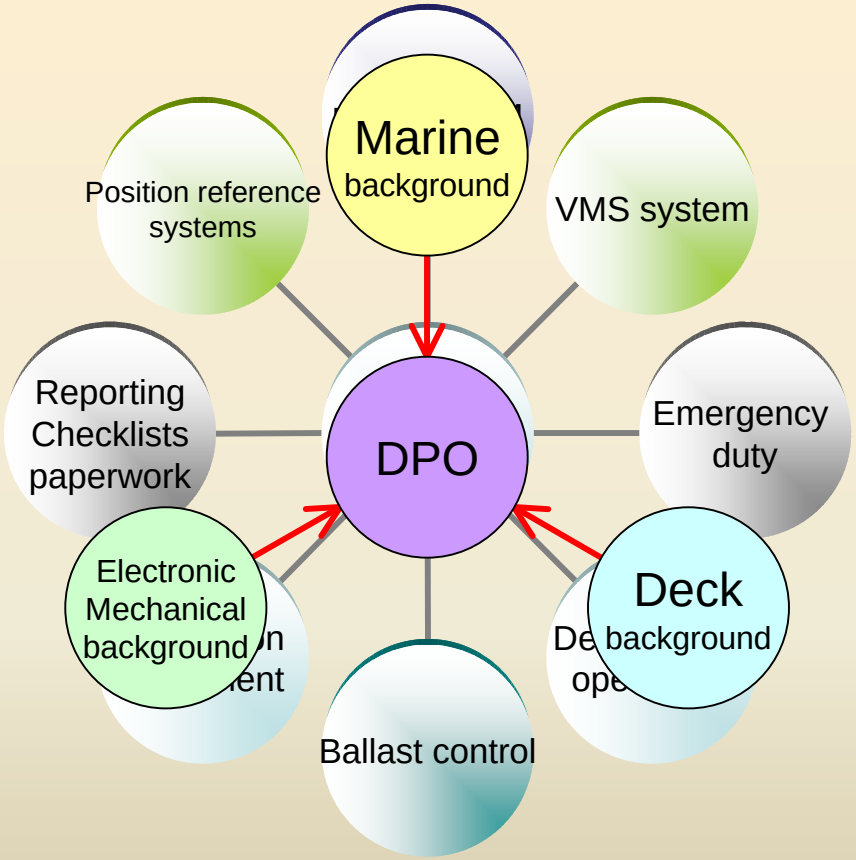
- Identical software running on both DGPS suite
- Obsolete GPS receivers and computers
- Poor performance during scintillation periods
- No more vendor support
- New sensors and software with better performances available on market.

DGPS system basic design layout

- A motion compensated offset position of the rotary table is required to be output to the DP system and various users.



DPO background and areas of influence



DPO expectations in Reference position systems performance

- Reliability and accuracy
- Easy man machine interface
- Internal redundancy
- Low variance
- Easy data download and analysis
- Vendor support

Positioning data validation tests performed by the DP system

- Prediction test
- Variance test
- Median check test
- Hardware / system problem test
- Signal latency / age limit
- Freeze test

Position reference and DP system

- Losing one Position reference is not defeating station keeping but the operation status may be affected → Downtime?
- DPO input in DP system is significant regarding position reference performances

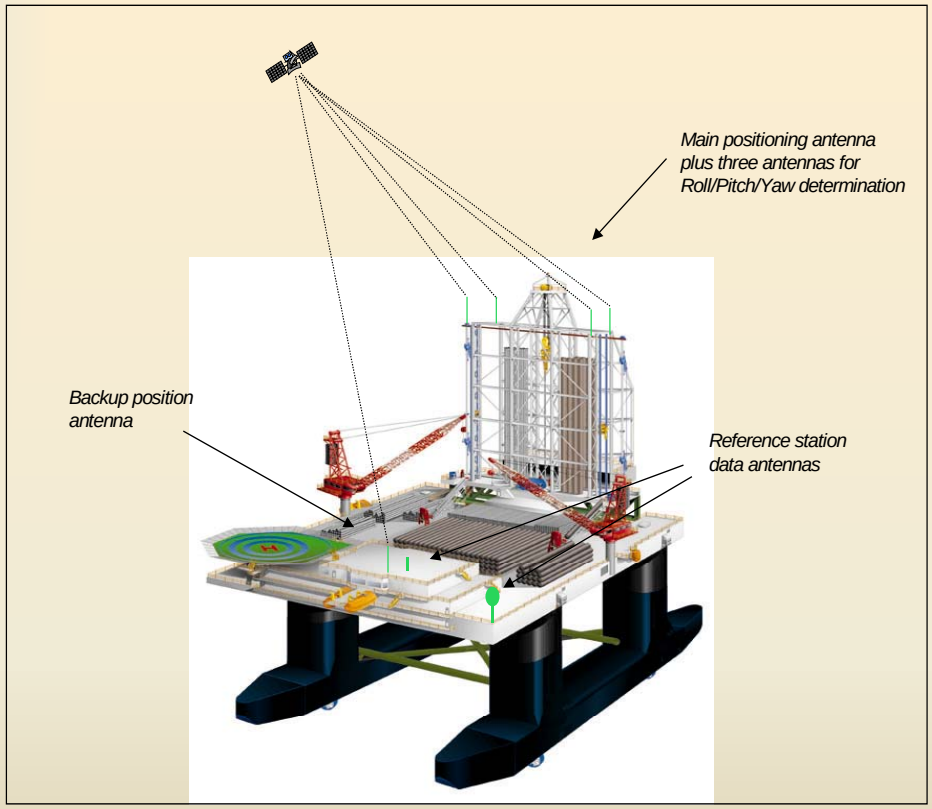
a) set up of the median check limits

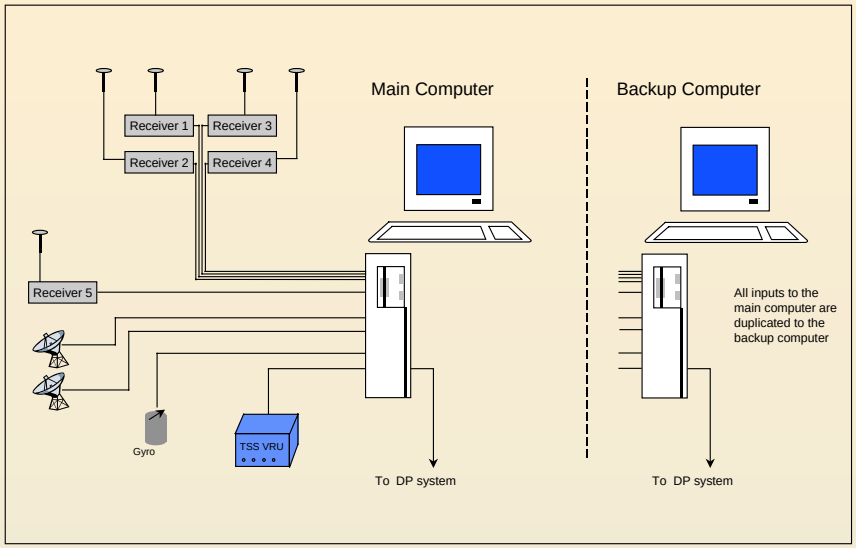
b) set up of the prediction windows limits

c) set up of position reference weighting

d) Set up Kalman gain parameter

Former DGPS system - TRINAV





TRINAV system

ADVANTAGES	DISADVANTAGES
•Simple man machine interface	•Obsolete (poor Dual frequency performances)
•Good internal redundancy (GPS receiver and differential links)	•Poor performance during scintillation period
•1 GPS receiver+ 1 differential link installed on bridge mast	•No quality control except the DQI parameter
•HF link correction available	•Same software on both system
•DPO / ET system experience	•Multiple GPS receiver failures or loss of performances
•Spare parts available on board	•RTCM link hardware failures
	•Unix O/S
	•Software failures and bugs
	•No remote control from backup room system

DP event 1– Yellow alert – 15/11/2002

Scintillation was affecting the DGPS prior the event.

- 2216 within 2 seconds acoustic PME, DGPS1 and DGPS2 failed to DP system and DP entered in model control.
- 2217 Yellow Alert activated manually by DPO
- 2217 Acoustic available and selected. In DP
- 2218 DGPS available, 7m drift off due to model control and unstable positioning prior the event
- 2231 position stabilized and Green light on.

DP event 1– Yellow alert – 15/11/2002 Analysis

- Poor performance of DGPS during scintillation. Both DGPS inputs Rejected from DP.
- No specific reason found to explain the acoustic PME rejection (isolated jump / failure)

DP event 2 – Drive off – 29/06/2004

- DGPS 1 and 2 with DQI of 3 but variance was acceptable (<1m).

01 24 33 Acoustic rejected by DP system on median check. Both DGPS drifted to NW.

01 24 37 DGPS 1 rejected by DP system

01 24 38 DGPS 2 rejected by DP system. Entered model control. Yellow alert activated manually by operator.

01 25 14 Acoustic available and selected. Rig in Auto DP

01 26 05 DGPS 1 selected in DP

01 30 21 DGPS 2 selected in DP. Rig position stabilized 20m NW of original position.

01 35 52 Rig back to original position

01 43 00 Green light on

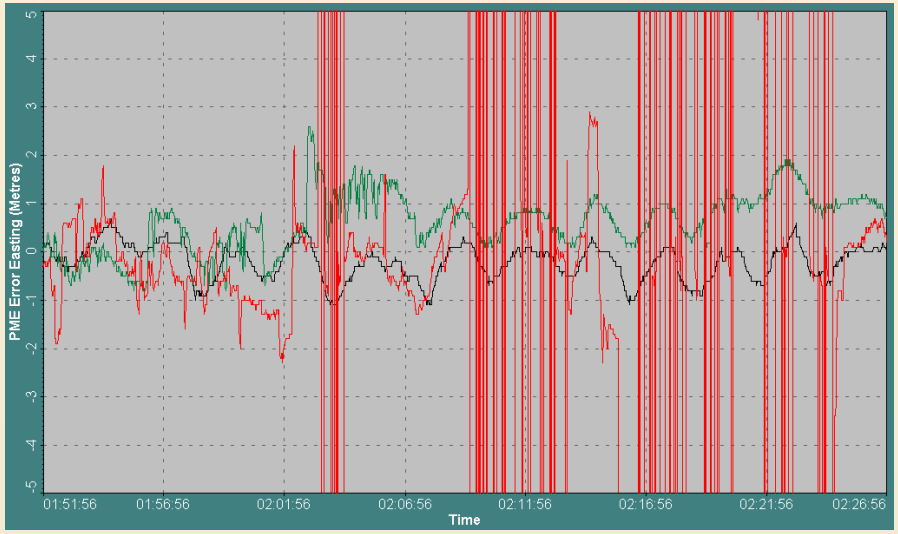
DP event 2 – Drive off – 29/06/2004 Analysis

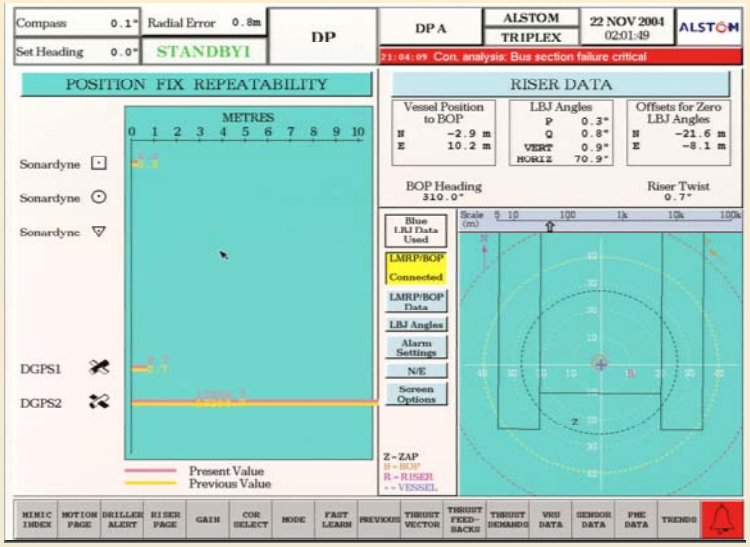
- DGPS 1 and 2 were setup differently (different GPS receiver and correction link)
- DQI 3 indicates poor position precision
- PME weighting was in auto.
- Acoustic rejected on median check
- DGPS 1 and 2 rejected on prediction test

DGPS position was affected by poor geometry and low number of satellite was in use.

GPS receiver was unable to use low elevation satellites.

DGPS degraded status – 22/11/2004

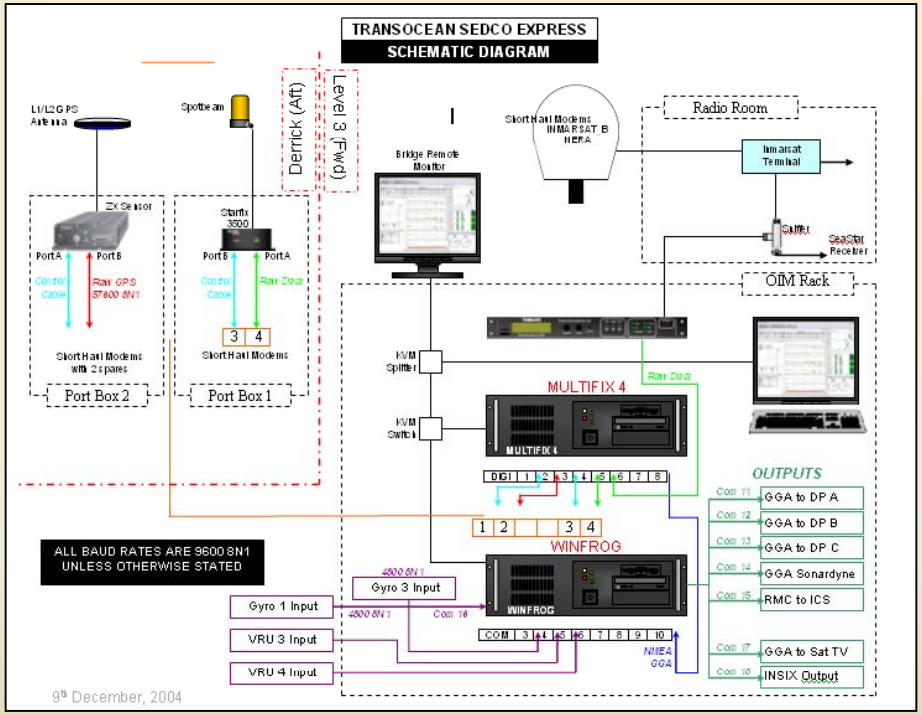




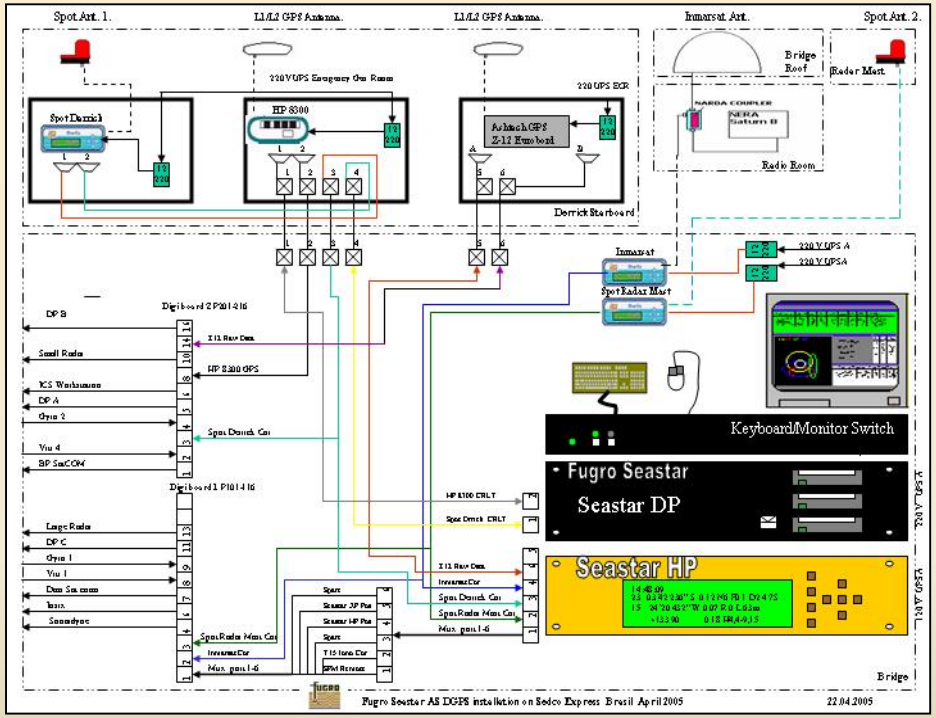
- Software failure. Backup solution @ 141km from primary solution. No operator warning.
- Primary solution failing and Trinav switch to backup solution. Rejected by DP (jump of 141km).
- GPS receiver reset to clear the fault.

New DGPS systems installed in 2005

MULTIFIX 4 / WINFROG



SEASTAR DP



Multifix-Winfrog / Seastar DP

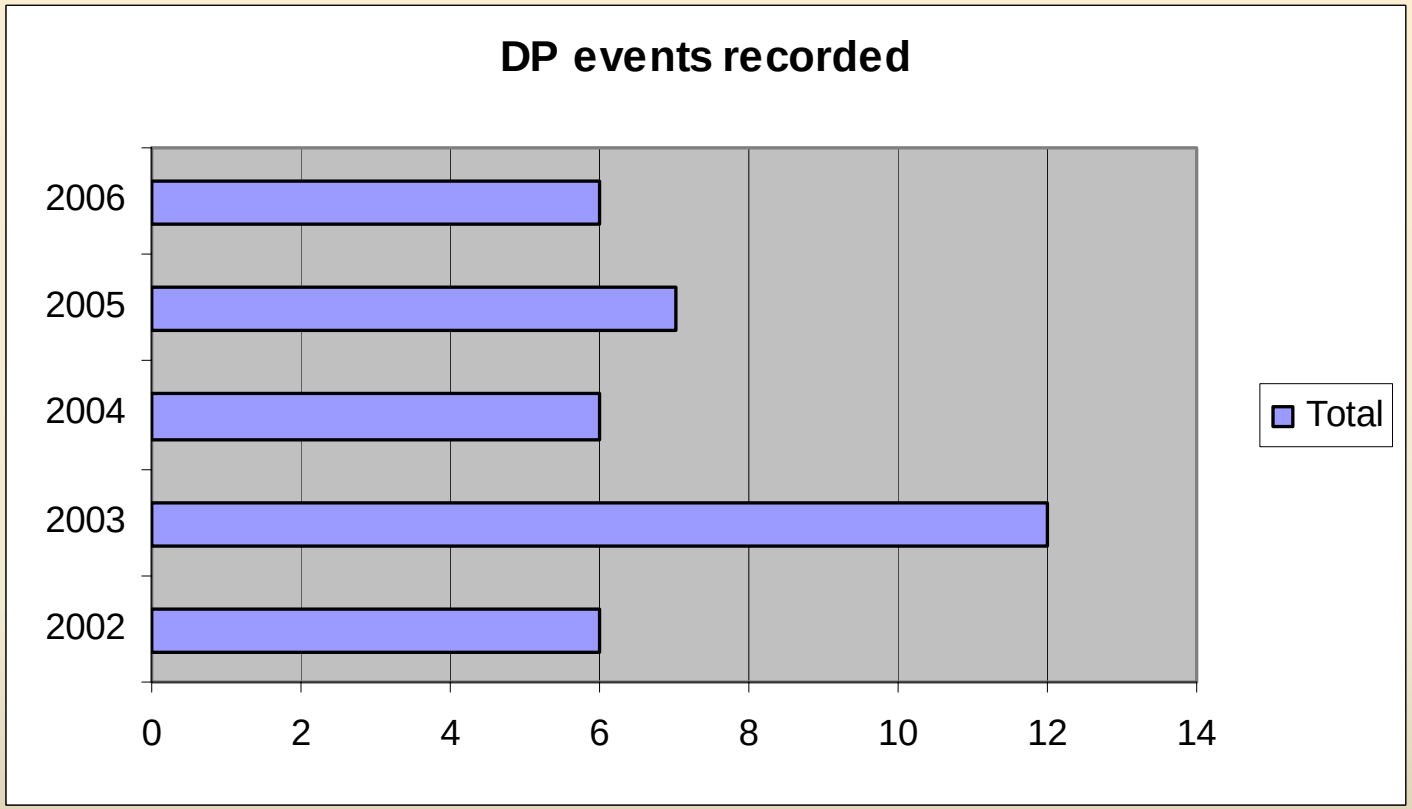
ADVANTAGES	DISADVANTAGES
•2 separate and independent systems (software and hardware)	•All equipment installed on derrick (except 2 RTCM link antennae)
•XP correction type quality (orbital and clock)	•No backup GPS receiver on Multifix/Winfrog system
•Redundancy of RTCM correction type and links	•Poor reliability of the HP solution on Seastar DP system
•Vendor support	•Some compatibility problem with DP system (latency)
•Quality control (multifix system)	•Spare parts (expensive / limited on board)
•Remote control of the backup room system from DP desk.	•Download and replay facilities on the 'online machine'
•Good repeatability/variance	
•Possibility to use The GPS without the 'D'	

Multifix-Winfrog / Seastar DP concerns

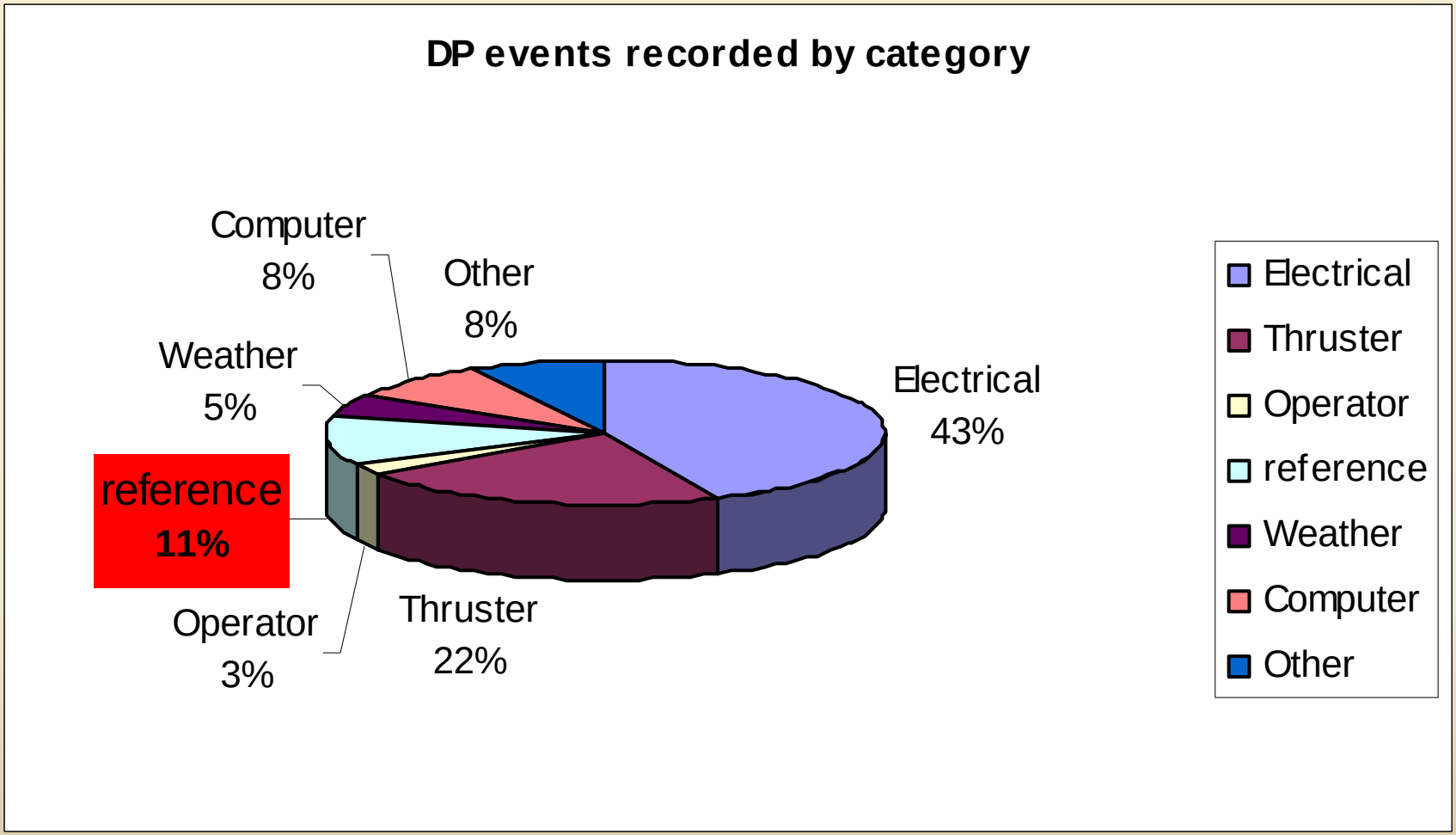
- Poor reliability of HP solution in Seastar DP (>1200 solution reset in one year)
- Computer failures on reboot process (Seastar DP)
- Software failures (Input/output management software – Seastar DP)
- MRU loss of performance not detected by Multifix software causing position reference rejection in DP
- Software glitch on Multifix 4 (Sunday 0000 GMT bug- negative latency figure)

37 Recorded DP events

From January 2002 to October 2006



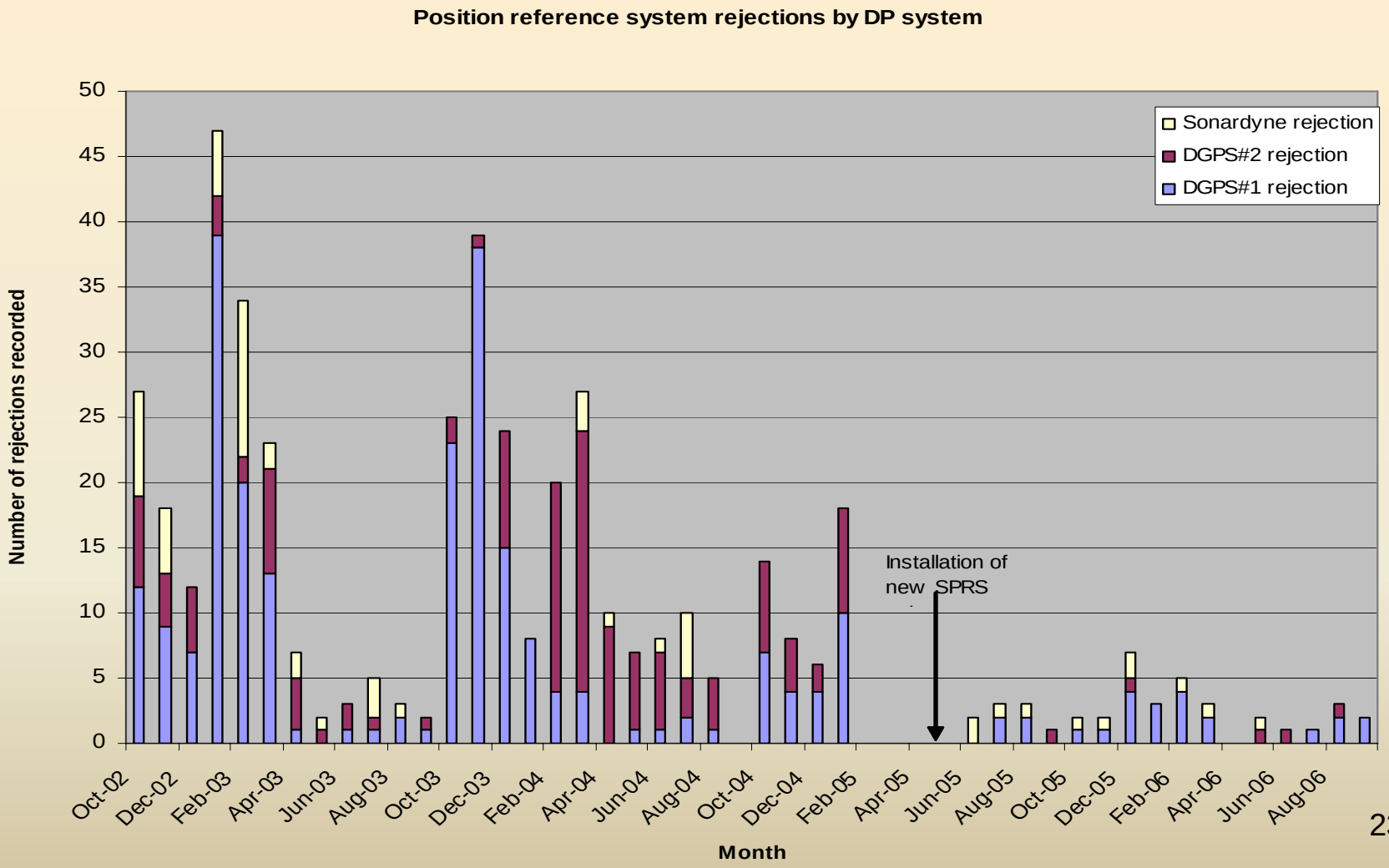
Recorded DP events by category



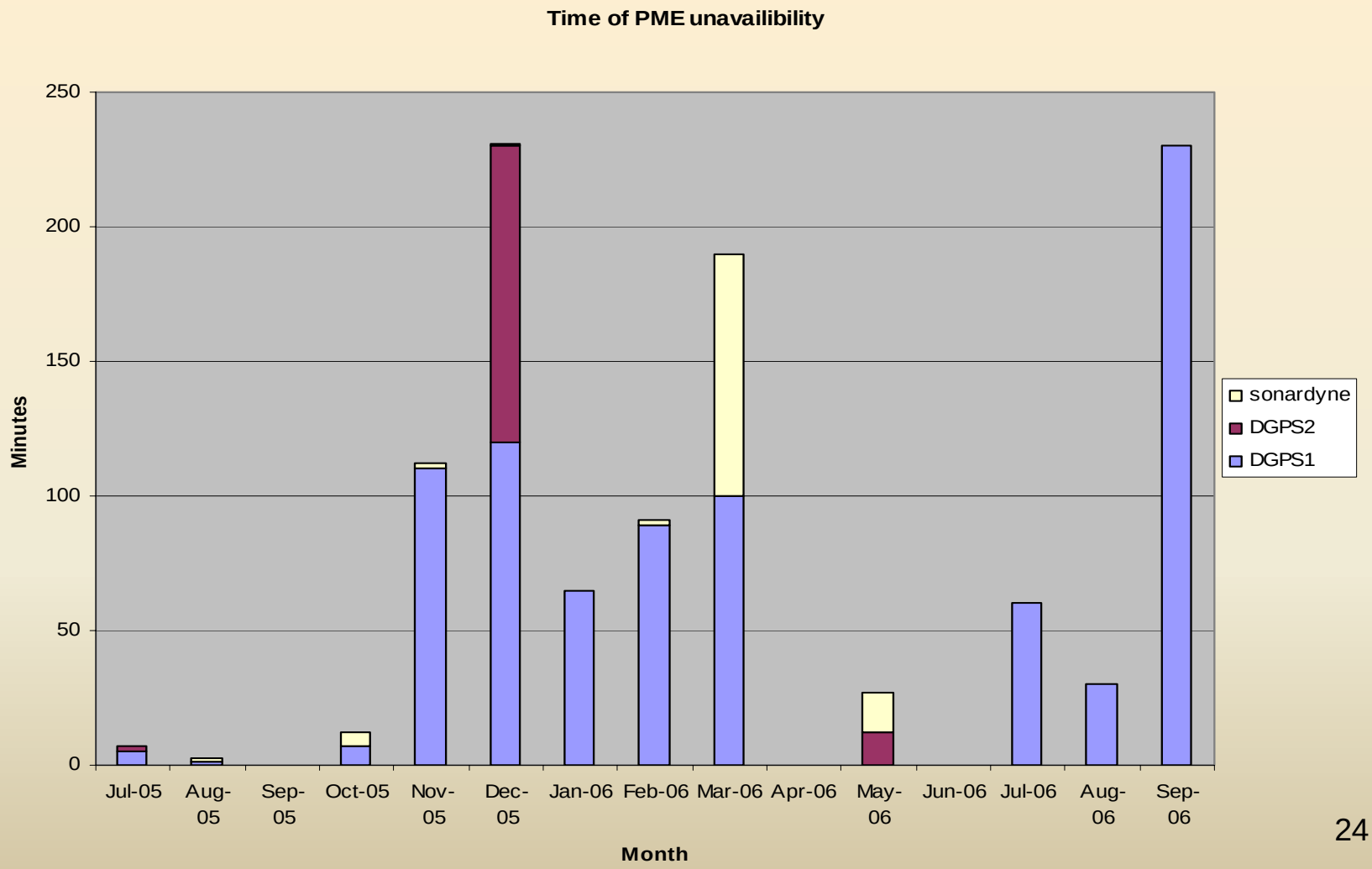
DGPS related DP events / Yellow-Red alerts

- Around 1500 days of rig operation
- 6 Yellow alert conditions occurred since rig start up. No Red (disconnections) occurred.
- 2 of DGPS system failures leaded to Yellow alert conditions (33% of total yellow alerts)
- No Recorded event related to DGPS since new system installed

Position reference system rejections by DP system since Oct 2002



New DGPS system time of unavailability since installation



Possibility of future improvement on DGPS system design

- A position reference system is only a ‘tool’ for the DPO in order to perform his duty: Keeping the rig on location.

- Position reference system need to be designed to require the minimum operator input and to provide the highest level of reliability (fail safe / internal redundancy).

<u>Areas where improvement might be beneficial:</u>

- Management of the system redundancy
- Operator interface

Management of system redundancy

Hardware

- Backup GPS receiver on every system
- Separate installation area for each GPS receiver
- Use of all available correction type
- Separate data logger for efficient position reference data analysis and monitoring

Software

- Fail safe software (no data output if gyro/MRU input failure)
- No automatic reselection of primary solution after failure.

Possible improvements: Operator interface

- Operator “sound” warning/alarm
- “watch circle” input in DGPS on initial position (available on Winfrog)
- Scatter plot of all available solutions (offset position)
- Confirmation after configuration change
- Easy selection of the primary solution within all available solutions list
- Configuration access through password

Conclusion

- DGPS related DP events have high level of criticality when occurred.
- DP Operator training should be reinforced
- DP Operator and engineer have a different opinion regarding system design and expected performances.
- Technology is moving fast and vendor must consider the DP operator first when designing a new system.

Thank you