MTS DP CONFERENCE

2002

'PROBLEMS' SESSION

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Session Aims

- ‘Highly Interactive’
- ‘Audience participation’
- ‘Real Events’
- ‘Real Issues (at end)’
- ‘Highlight of the conference’

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Other Session Aims

- Review The key issues
- Think About them for the end
- Three biggest problems we face today in DP

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Session Format

- Five minutes for me.
- One or two problems each participant.
- Five to seven minutes each and three minutes for questions.
- ‘Overflow’ into the cocktail party.

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The Participants

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Sean Hickey

- Joined the ‘Oil patch’ in 1972 – Navigation Systems.
- Joined Sedco 1977 as DPO then electrical supervisor on Sedco 472.
- Left 1983 to 1993 – teaching, design and consultancy.
- 1994 Joined Global Industries as DP Systems Manager.
- Four very diverse DP vessels.

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Gary Miller

- Started out with Coast Guard, marine tech and mate.
- 28 years experience as Ship Master
- 1978 to 1987 Marine Superintendent for Point Marine
- 1987 to now – Fleet Manager for Stolt Offshore – 18 dive vessels – 5 with DP.

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Chuck Simms

- Got into DP in 1972 Sedco 445 as DPO the electrical supervisor
- Systems Engineer – Sedco 471, 472 and 709
- Moved into submersible design, research, Florida Power and Light.
- Returned to DP with Global Marine – Glomar Explorer, CR Luigs and Jack Ryan

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Steve Savoy

- BSc and MSc in Physics.
- 7 years as field service engineer Geophysical Systems
- DPO for Sedco 1981 to 1991.
- Left for three year then back working for Global Industries, Nautronix and now Ensco
- Electrical Support Engineer on ENSCO 7500

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Pete Fougere

- Been involved in the offshore industry since 1975
- Been with Transocean's Engineering Dept as Power and Controls Manager since 1984
- Since 2001 as Senior Engineering Manager – Control Systems
- TSF Largest Offshore drilling contractor
- 22 DP vessels

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Chet Skowronski

- BSc Marine Transportation Kings Point 1961
- Six Years in the Merchant Marine
- Master in 1970
- Global Marine Drilling, Biehl Offshore, Sonat Offshore Drilling and Diamond Offshore Drilling
- Drilling Ops, Marine Ops, Drill Super, Capt and OIM
- Since 1997 – Master and OIM of Ocean Confidence

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In Common

- Got to know them all through Nautronix
- Majority of the ex Sedco DP gang only one missing is Rec Stanbery
- Leaves me ----------

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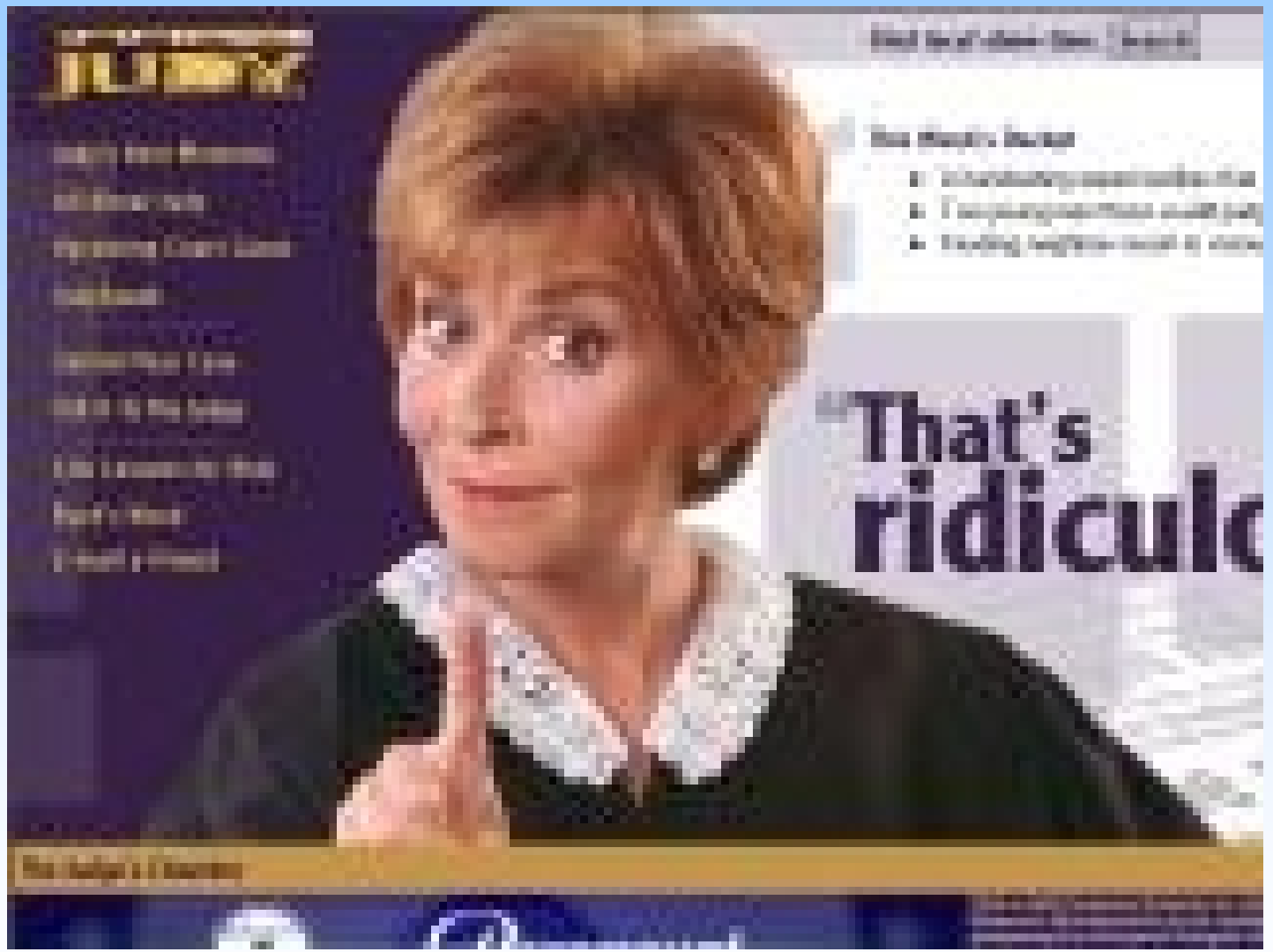

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Sean Hickey Number 1

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Why is Software so bad?

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Incident Report

WX: Seas 2-4', wind SE 10 kts.

While laying away in track mode the vessel experienced a **drive off.** Vessel was coming **out of a PI** when the incident occurred. Vessel speed was **25 fpm**, master console was ASK 1, DGPS1, 2 and Glonas2 were online with DGPS1 as reference. Both gyros, vru's and wind birds were online. There were **no sensor failures**. The operator did **not perform any maneuver** other than coming up to speed on the pot several minutes earlier. As the vessel was coming out of the PI it appeared that the system **computed a false set point – By the time the pipe was stopped and the we regained control** of the vessel, we experienced a loss of position as follows: yaw **74 degrees, 550 feet astern and 40 feet to port. Currently assessing damage**.

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Data Logger

Time	ASK1_AbsStptE	ASK1_AbsStptN	ASK1_ContrlDevS	ASK1_ControlDev	ASK1_ControlDev
22:13:00	2,367,825.50	10,101,978.00	-1.28	0.17	0.01
22:13:01	2,367,825.50	10,101,978.00	-1.28	0.17	0.01
22:13:02	2,367,825.50	10,101,978.00	-1.28	0.17	0.01
22:13:03	2,367,824.00	10,101,978.00	-1.4	-0.24	0
22:13:04	2,367,824.00	10,101,977.00	-1.4	-0.24	0
22:13:05	2,367,824.00	10,101,977.00	-1.4	-0.24	0
22:13:06	2,367,822.50	10,101,977.00	-1.45	-0.42	-0.02
22:13:07	2,367,822.50	10,101,977.00	-1.45	-0.42	-0.02
22:13:08	2,367,822.50	10,101,977.00	-1.45	-0.42	-0.02
22:13:09	**2,368,557.25**	**10,101,977.00**	**498.6**	**974.79**	**46.99**
22:13:10	2,368,557.25	10,101,977.00	498.6	974.79	46.99
22:13:11	2,368,557.25	10,101,165.00	498.6	974.79	46.99
22:13:12	2,368,557.25	10,101,165.00	499.93	975.14	46.97
22:13:13	2,368,557.25	10,101,165.00	499.93	975.14	46.97
22:13:14	2,368,557.25	10,101,165.00	499.93	975.14	46.97
22:13:15	2,368,557.00	10,101,165.00	500.88	975.47	46.96
22:13:16	2,368,557.00	10,101,165.00	500.88	975.47	46.96

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Field Service Excerpts

12:25:51 Transfer of control to System 2 (in curve section)
12:29:54 System 1 initialized from System 2
12:30:17 System 1 regains control
13:54:09 Track Offsets entered: 222 Along, -45 Across
(14-54-07 ~ 15:21:03) Track direction reversed (in curve section)
15:21:03 System 2 initialized
(15:40:11 ~ 15:44:41) Track direction reversed (in curve section)
22:14:01 Erroneous heading/position setpoints

Vessel coming off the final curve onto the last straight leg line precisely when the following changes took place Immediately:

Instantaneous North Stpt: from 10,101,977 to 10,101,165 (812 ft jump)
Instantaneous East Stpt: from 2,367,822 to 2,368,557 (735 ft jump)
Instantaneous Heading Stpt: from 255 to 208 (47 deg jump)

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Field Service Conclusion

Looking further into the couple dozen parameters sent from Master to Backup revealed a parameter called “Phi”, which is relied upon to add up all of the cycle-by-cycle angular changes along a curved section. When Phi reaches the angle of the next linear segment, the waypoint index used for extracting geometry from the internal data tables is incremented. It was found that if Phi was interrupted in adding up the small angles, when the time for transition comes, the waypoint index will not get updated, and geometry from the previous waypoint will be used (such as track heading). This is precisely what happened for the incident in question. When control passed from the System 1 to System 2 and then back again, this value did not get updated correctly, causing the malfunction.

Conclusions

The use of “Phi” is inherent in the design of the tracking software. As such, this makes switching between systems incompatible with operation of the track when in a curve with a non-zero speed selected. If the switching occurs on a straight segment, or if the operator-selected speed is zero, there would be no problem.

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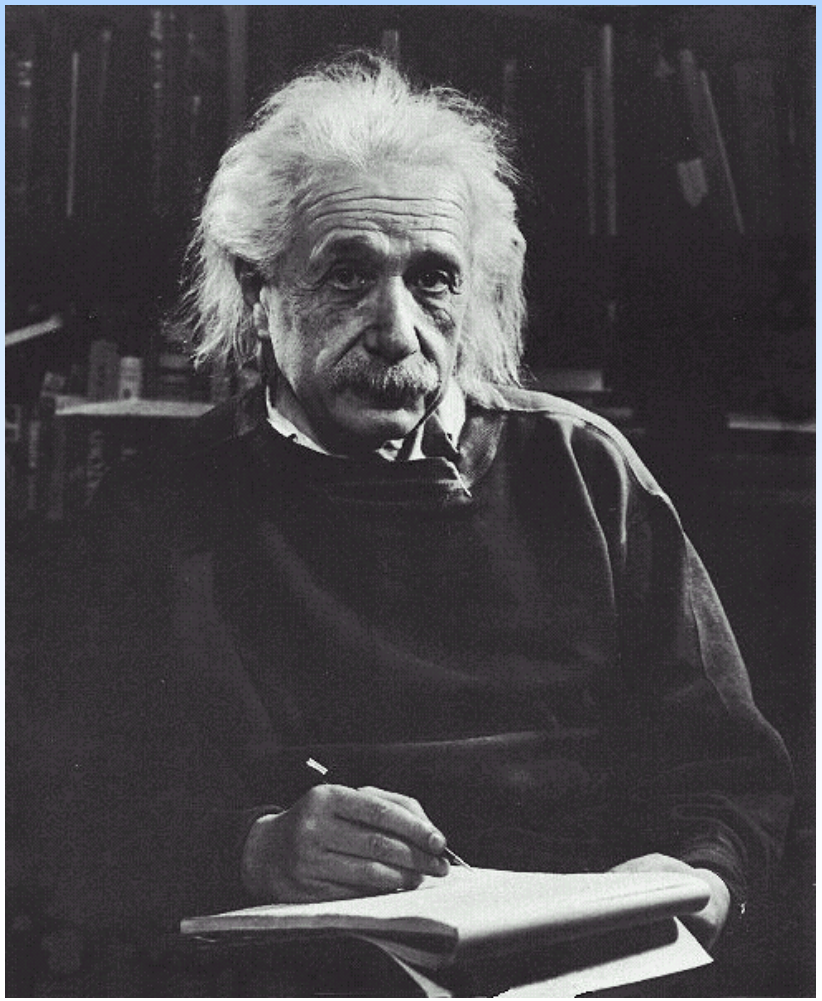
Software Engineers
(Self Image)



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Software Engineers

(As seen by the rest of the World)

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Sequence of Events to Cause Failure

- Vessel must be in a curve.
- Vessel must be moving.
- Control must transfer to backup controller.
- Control must then be transferred to original primary system.
- At the point where the curve ends, take a ride……

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Error Trap

- **Erroneous Setpoint Protection**. In the current software release there is a routine that constantly checks for “jumps” in the commanded position or heading setpoints. If a jump similar to the one that caused the excursion in question should ever happen again, this routine will make sure that track mode is cancelled, all position and heading setpoints from the previous control cycle will be re-instituted, and alarms will inform the operator of these event.

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Conclusion

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Gary Miller
Stolt Offshore

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The 'Problem'

- ABS required all 4 generators on line for DP-2 operation.
- The maximum current load of each bus exceeded the amp capacity of a single generator.
- The ship had no power management system installed.

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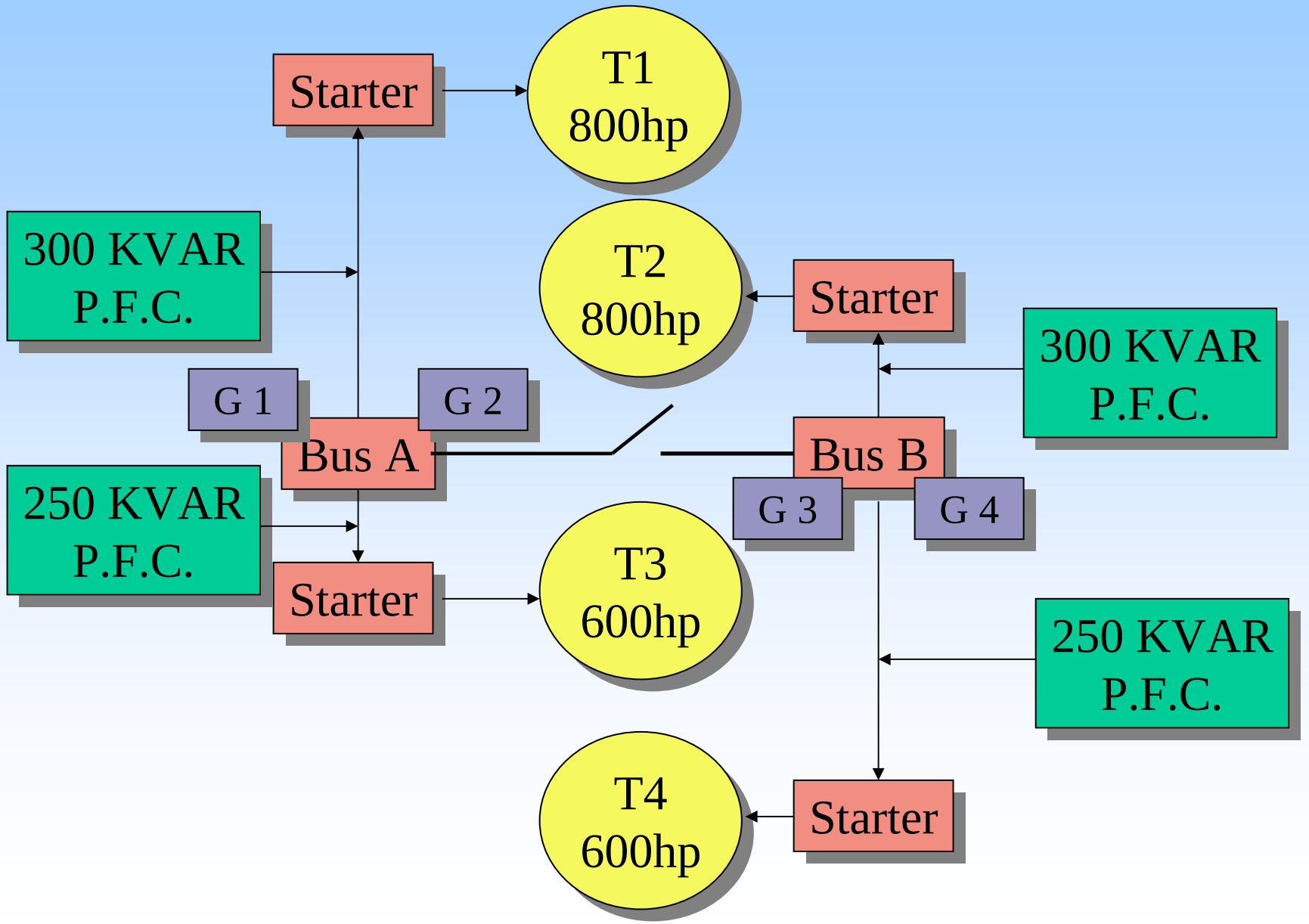
The Problem (cont.)

- Stolt proposed installation of an ABB Automatic Power Factor Correction Unit (PFC)
- ABS approved the PFC installation
- It was theoretically sound but they were not very sure that it would work.
- **But it did work!!** - here is the solution.

The Solution



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The Solution - Results

- Buss A - uncorrected - load 1768 Amps
- - corrected - load 1479 Amps
- - single gen capacity 1683 Amps
- - spare **204 Amps**

- Buss B - - uncorrected - load 1733 Amps
- - corrected - load 1448 Amps
- - single gen capacity 1683 Amps
- - spare **235 Amps**

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The Results

- **Installation of automatic PFCs resulted in a lower than calculated current at 100% thrust.**
- **Very soft starting of the thruster motors,**
- **A practical alternative to power management on a 20 plus year old ship**
- **A very simple system installed in days.**

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The Results (cont)

- The ship can operate in DP 2 mode with only two generators running.
- A generator can be down for service.
- A ‘normal’ power management would still have required all four to be available for DP 2 ops.
- The cost of the PFCs was less than a third of the lowest quote for any other system.

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Chuck Simms

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Whatever CAN go wrong…

This is the result of failure to plan for contingencies

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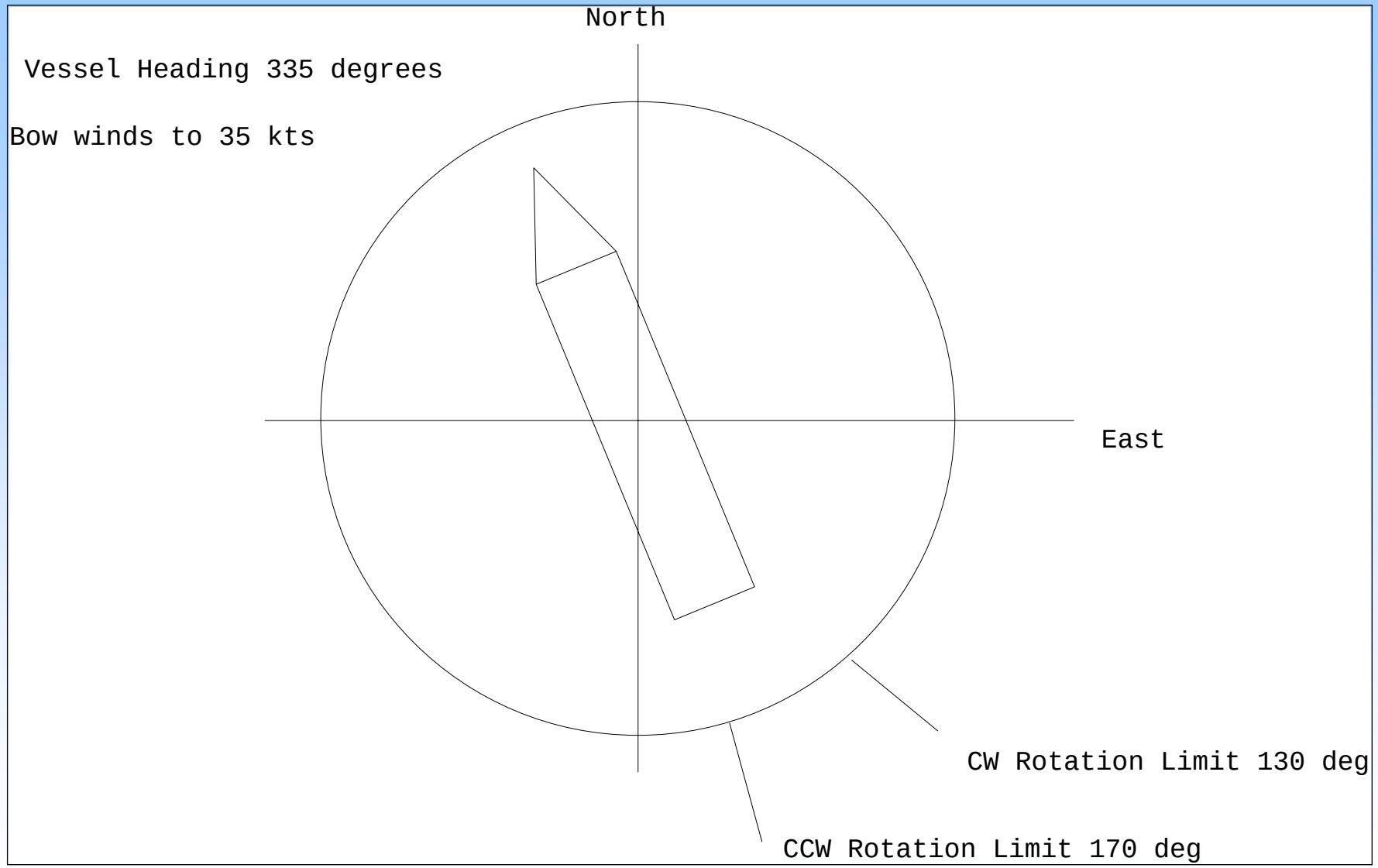

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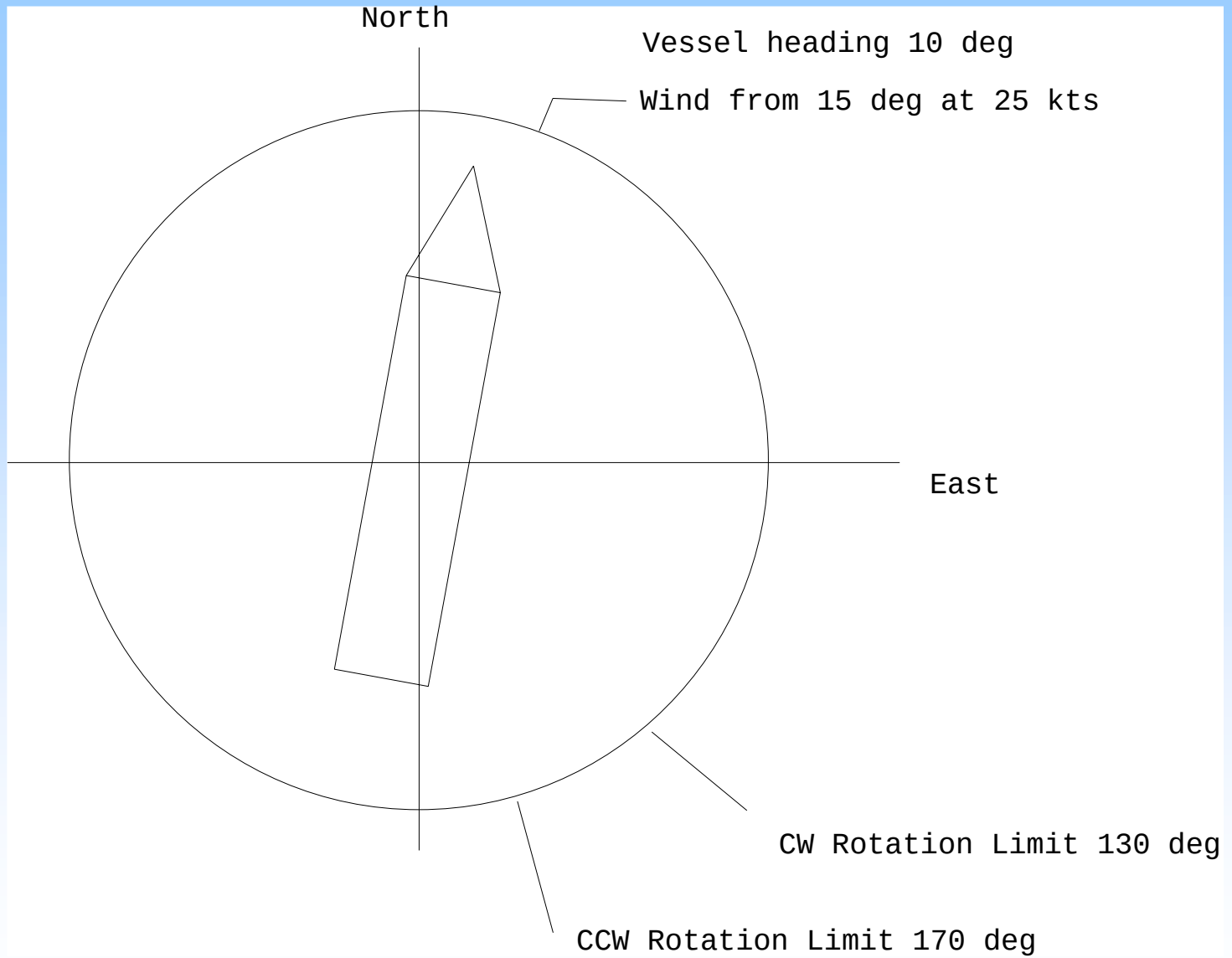

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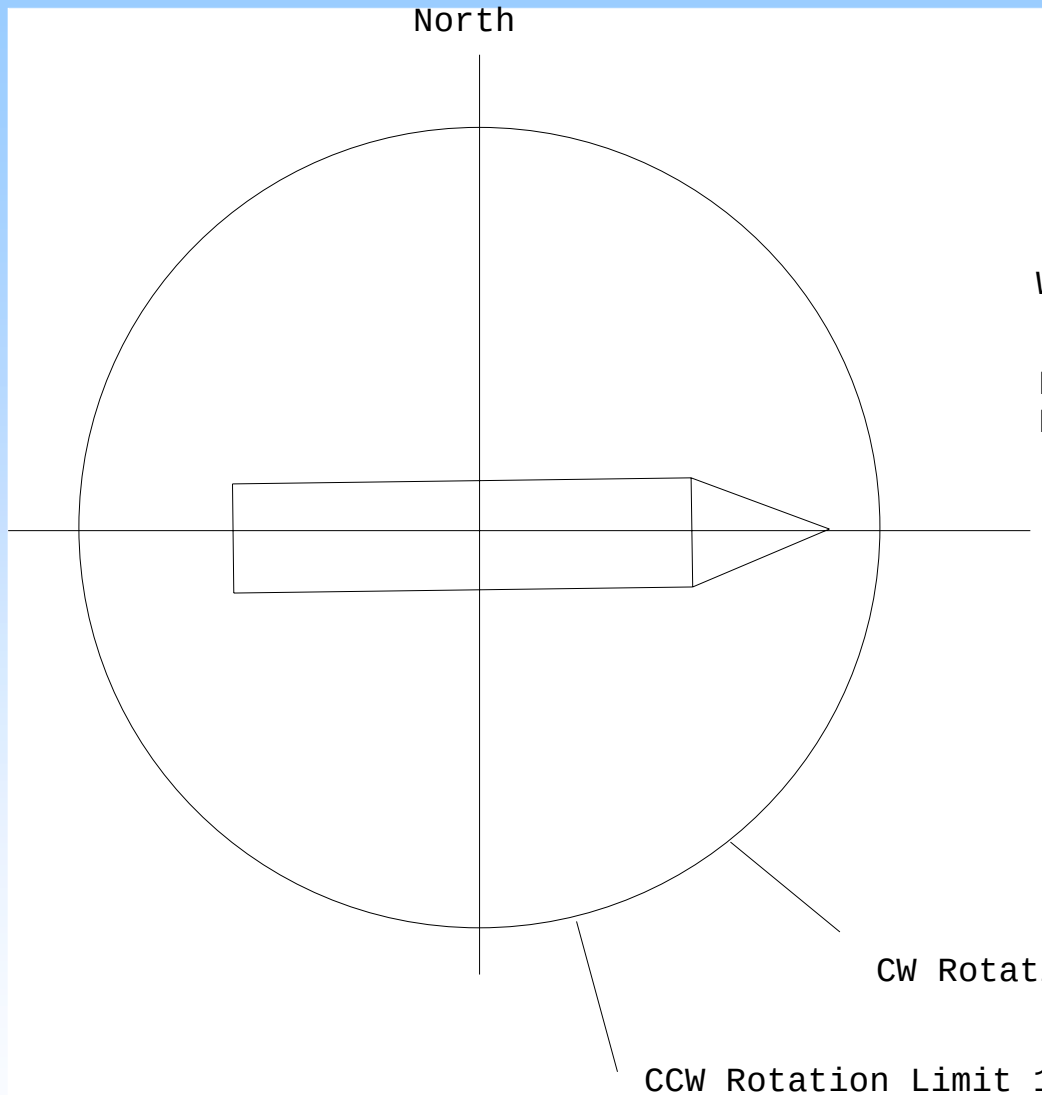

Winds variable 45 to 120 deg

Predicted to shift from SE to SW
Diminishing to 25 kts

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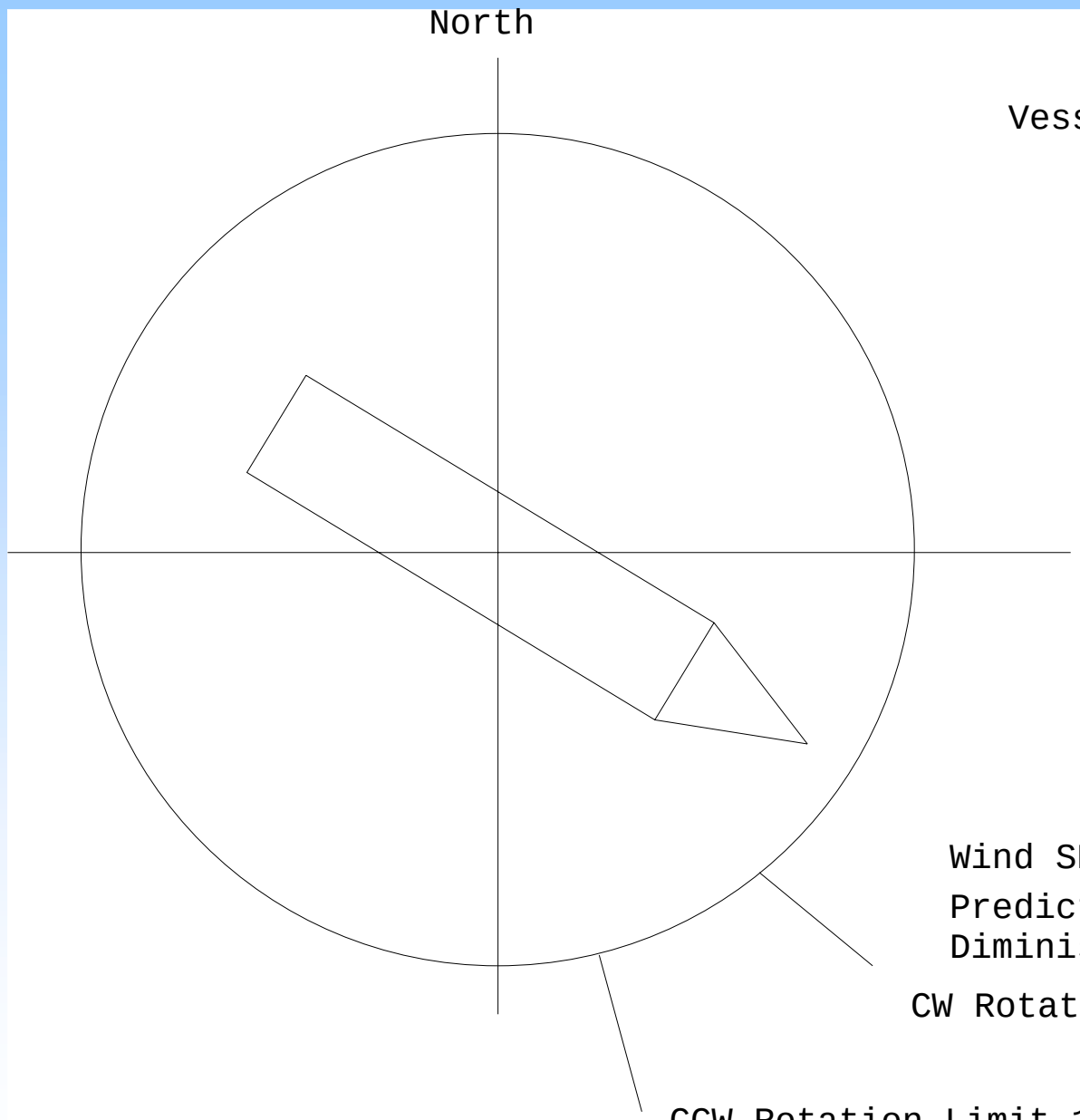

Vessel Heading 120 deg

Wind SE 40 kts

Predicted to shift from SE to SW
Diminishing to 25 kts

CW Rotation Limit 130 deg

CCW Rotation Limit 170 deg

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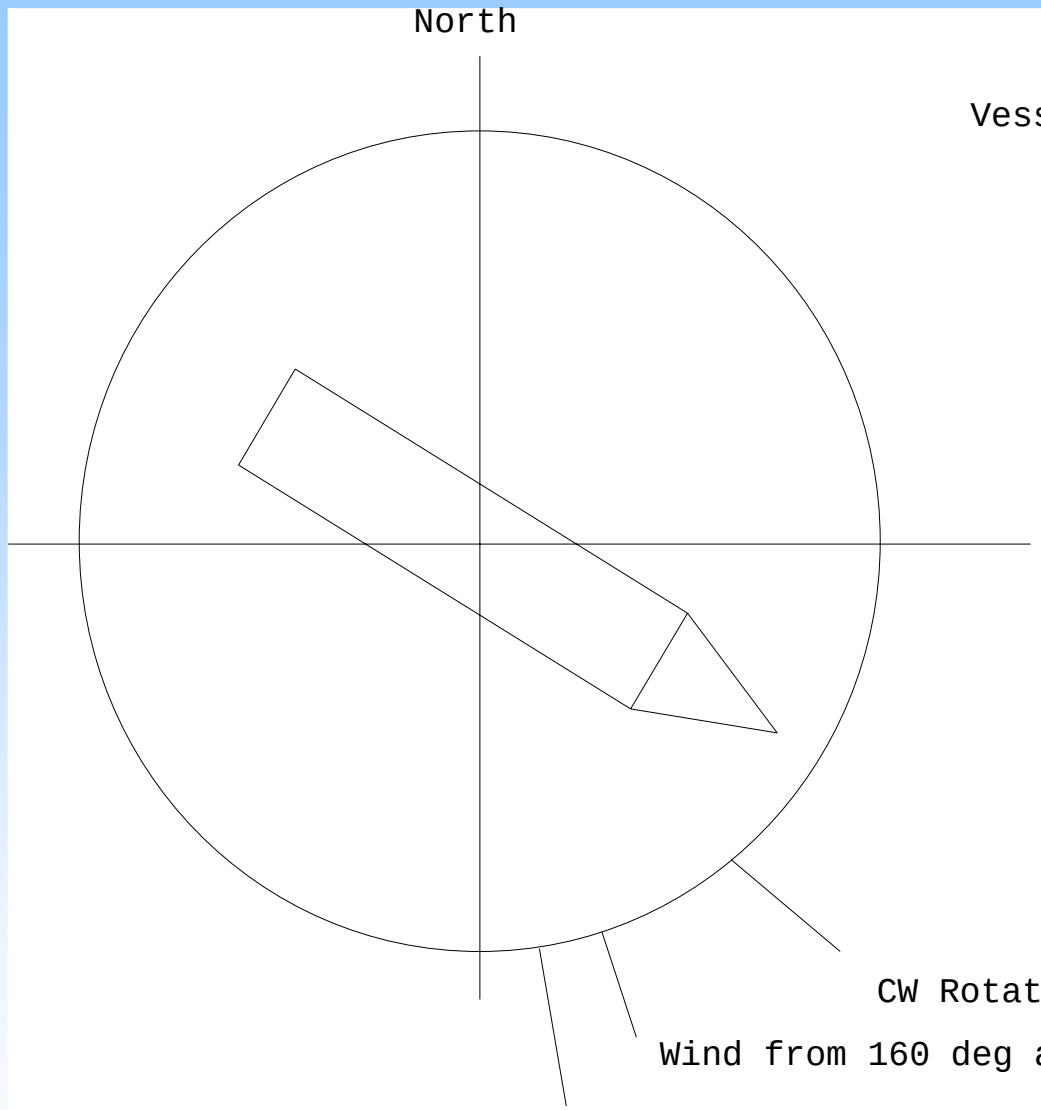


Vessel Heading 120 deg

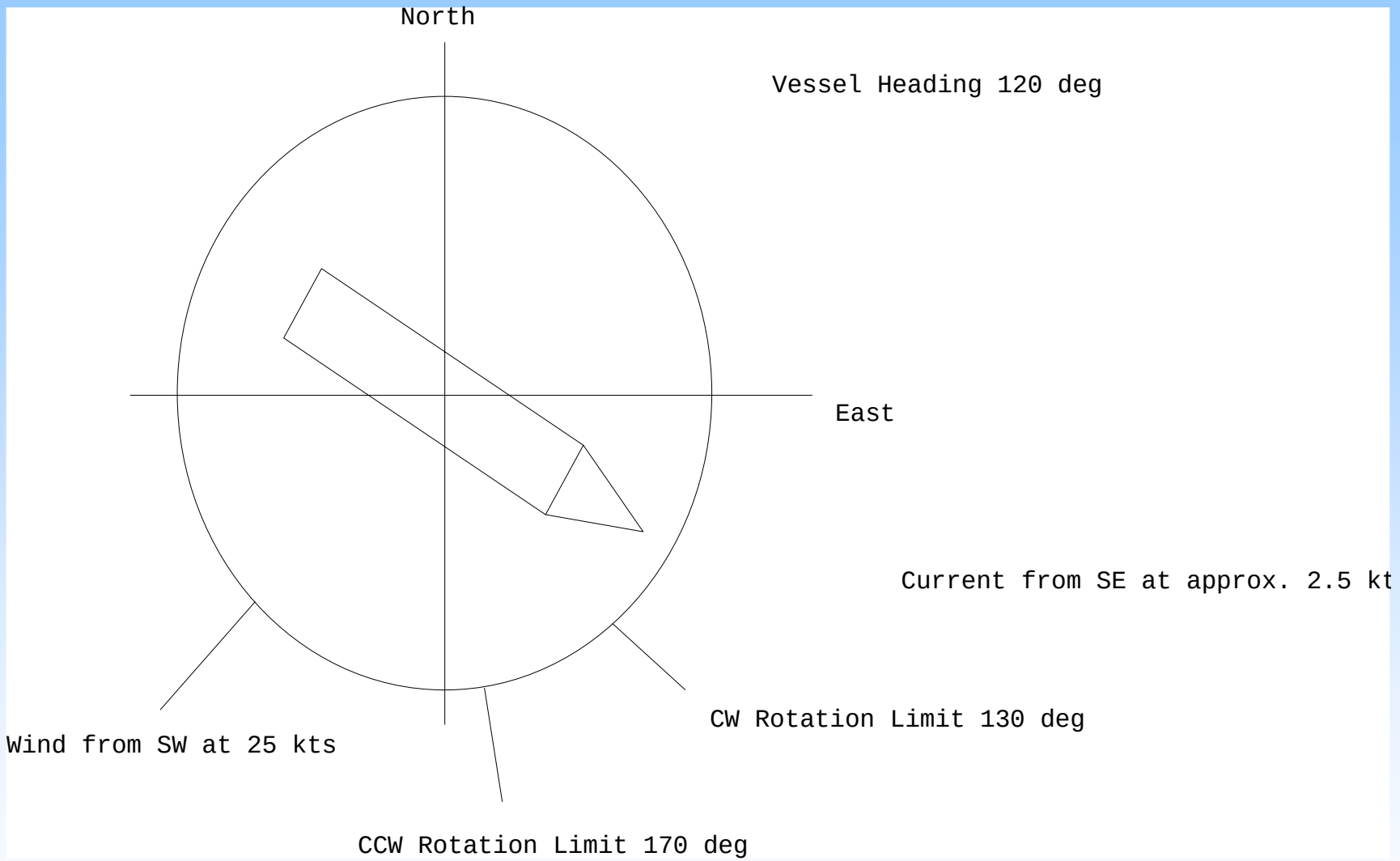
CW Rotation Limit 130 deg

Wind from 160 deg at 38 kts steady with higher gusts

Predicted to shift from SE to SW
Diminishing to 25 kts

CCW Rotation Limit 170 deg

Return to Session Directory



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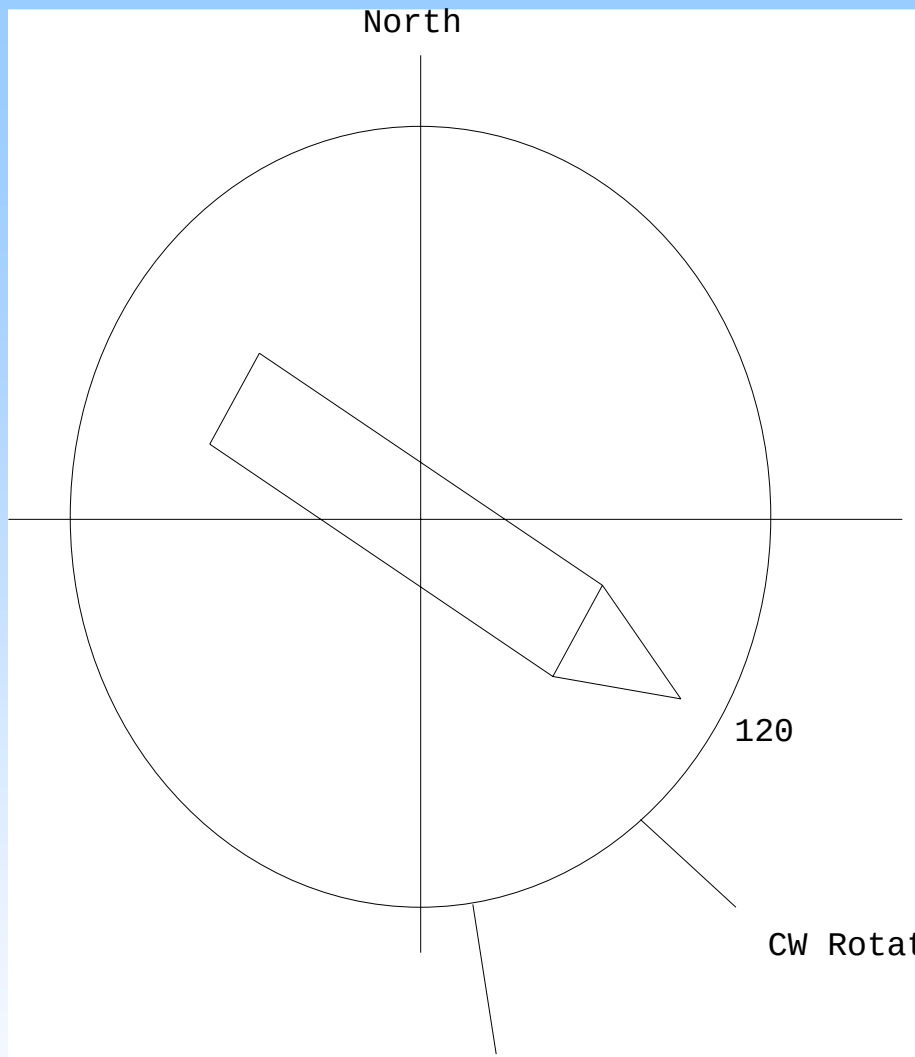

Current from SE at approx. 2.5 kts

Wind 40 kts from 160 deg. (40 deg off stbd b

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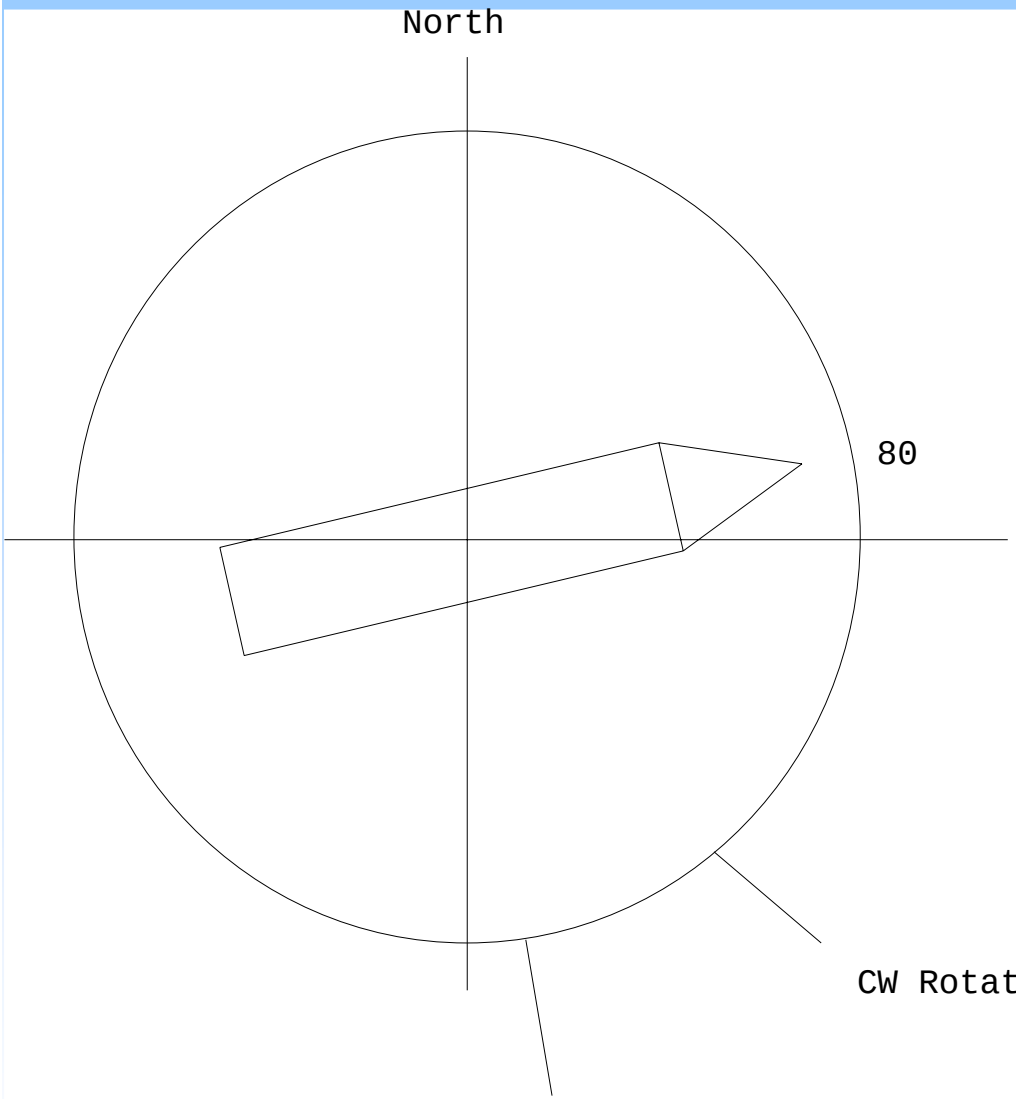
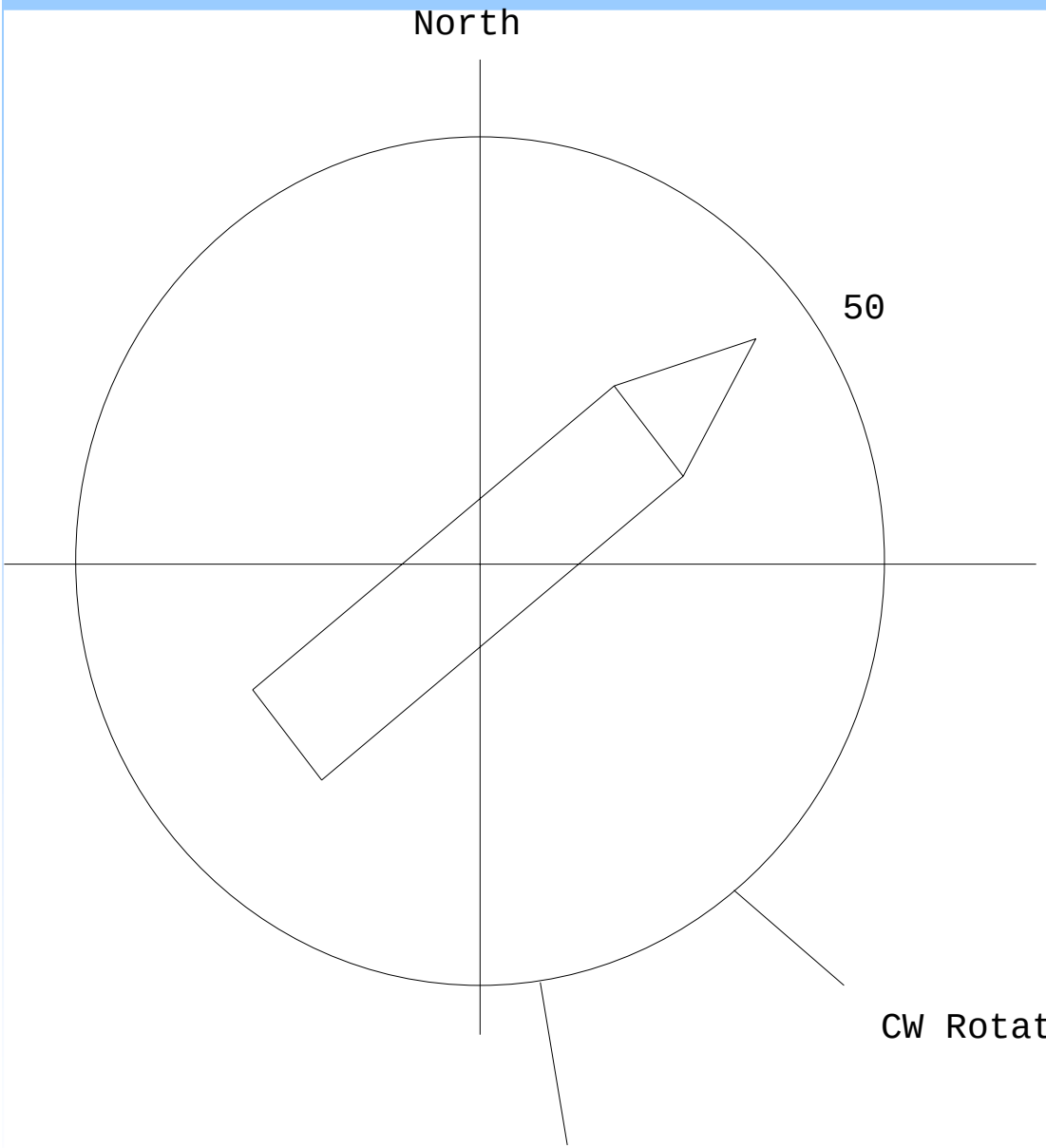


25 feet off location

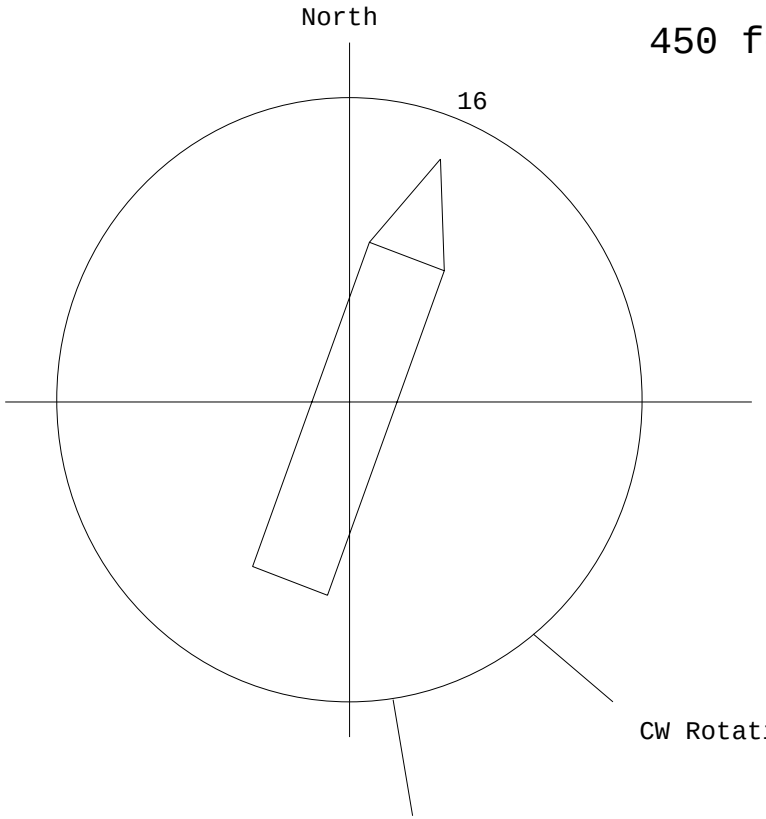
Current from SE at approx. 2.5 kts

Wind 40 kts from 155 deg (beam on)



164 feet off location

40 kt winds and 2.5 kt current
both beam on



450 feet off well center

40 kt winds and 2.5 kt current
both on stern quarter

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Oops!!!!

- Excessive confidence in weather predictions
- Automatically following wind
- Repeatedly modifying rate settings
- Changing position set point
- Consider heading limits

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It Can't Happen

- Three gyrocompasses all fail
- All three outputs freeze in place
  - Sperry Mod
  - Installation Mod
- After Mods
  - Outputs went to large negative value
  - Sperry S/W mods affected all gyrocompasses
- Redundancy may not protect against common programming errors or common design flaws.

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Looking for solutions

- GPS works great – mostly
- Two forward, two aft on drill ship
- Heading maneuvers, get intermittent dropouts of individual GPSs.
- Visits by vendors to no avail.
- Only solution so far – slow heading changes

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‘Continuous Obsolesence’

- DP/VMS/Drilling Systems computer related hardware, s/w development tools mostly commercially available products
- That means two years after its put in, replacements may be hard to find.
  - Driver software may no longer be compatible
  - Plug-n-play hardware may not be there
- Current review of all critical components to provide spares or time to develop needed mods
- Continuous review program needed to ensure no surprises.
- How are others dealing with the issue?

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Steve Savoy 1

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Power Transducer And Calculation Problems

kW and kVAR Transducers on the E7500 did not output the correct values at all power factors.

Values were correct for 0.7 power factor but a 5% error for every 0.1 of power factor.

First indication of a problem was that the full scale output could not be adjusted for 120% of full scale value.

Calibrated units with a three-phase injection test unit (Multi-amp EPOCH 10).

The following table and graph shows the differences between the calibration values of the two units.

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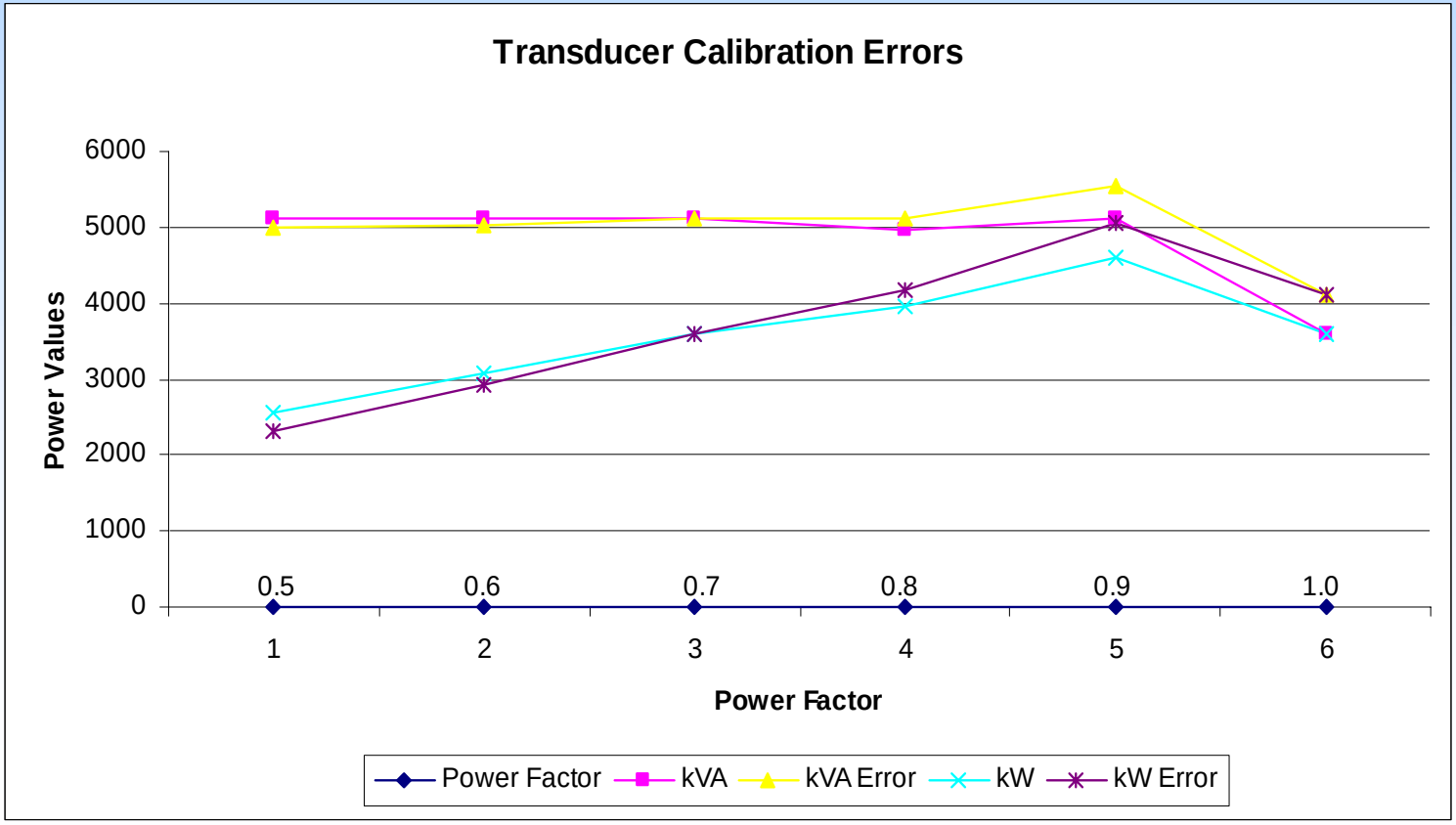
Calibration Data

Power Factor	KVA	KVA Error	KW	KW Error
0.5	5116	4993	2558	2302
0.6	5116	5025	3072	2918
0.7	5116	5116	3579	3579
0.8	4961	5121	3969	4167
0.9	5116	5534	4606	5066
1	3580	4117	3580	4117



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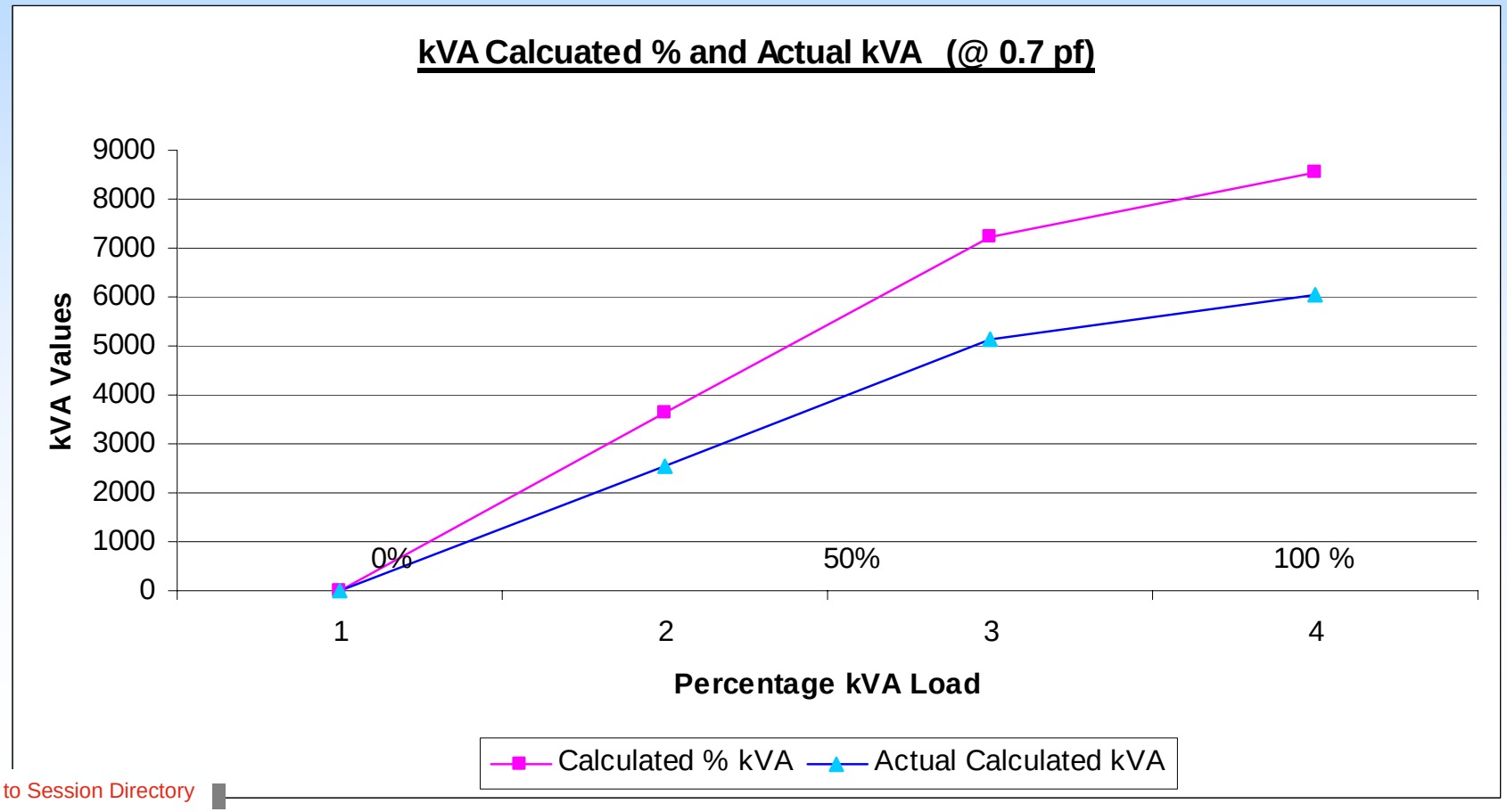
Software Calculation Errors

Using Percentages of kW and kVAR causes error in calculating kVA. The analog values for kW and kVAR are read by the control system. A percentage of full capacity is calculated then this value was used to calculate the kVA. This gives an incorrect result as shown in the graph below. The bottom line is the actual calculated kVA and the top line is the in correctly determined value.



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Problem Solution

- Use Three-Phase Test Equipment to verify all Calibrations and Calculations

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Pete Fougere 1

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Discoverer Seven Seas

DP Incident - 26 May 2002

- Trimble ProBeacon DGPS selected - rejected by DP System
- Configuration checked
- Trimble ProBeacon DGPS re-selected into DP System
- All 3 DP Computers slowed down so that a point where they were not responding
- Vessel drifted off
- Riser angle increased
- EDS actuated
- DP recovered after de-selecting faulty Trimble ProBeacon DGPS
- Vessel was positioned back over the well

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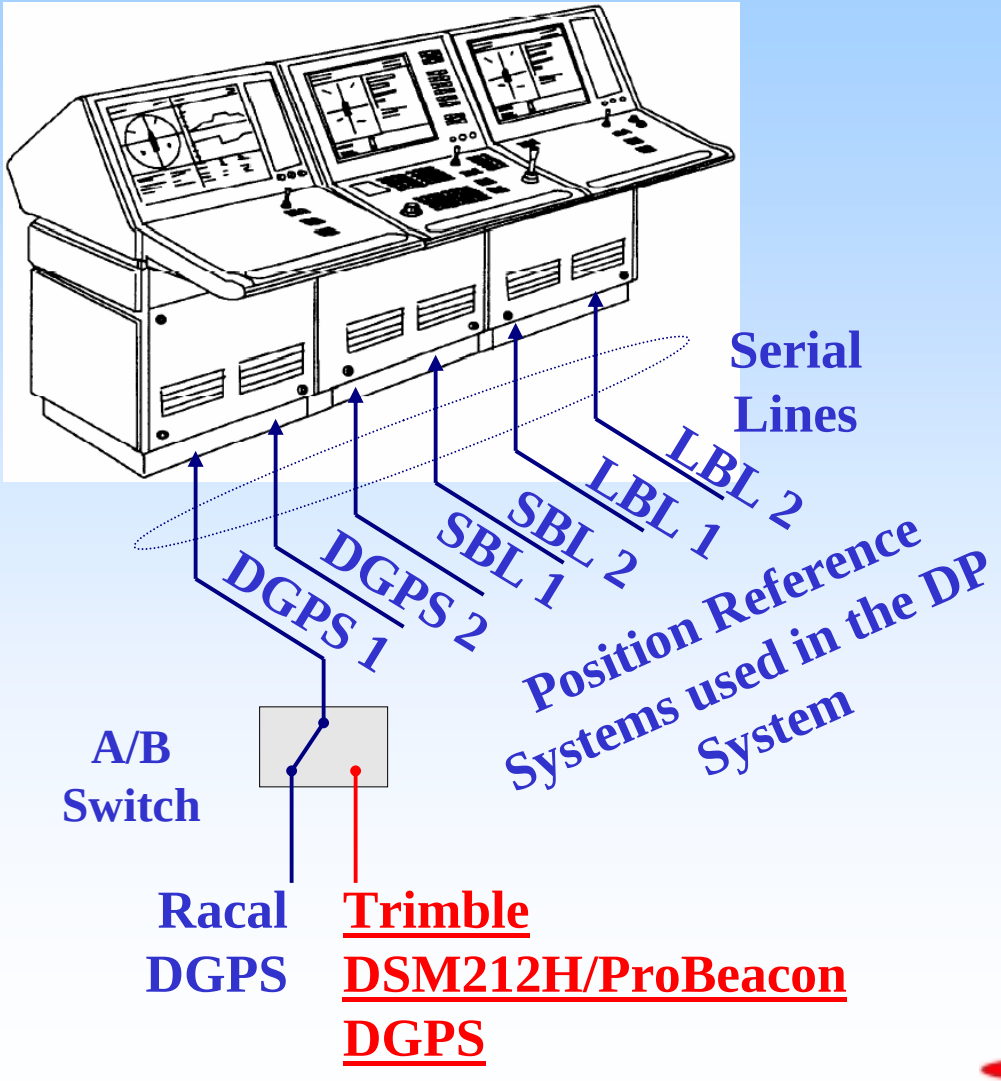
1. DP Incident: Root Cause and Events Analysis

1.1. Root Cause of DP Incident



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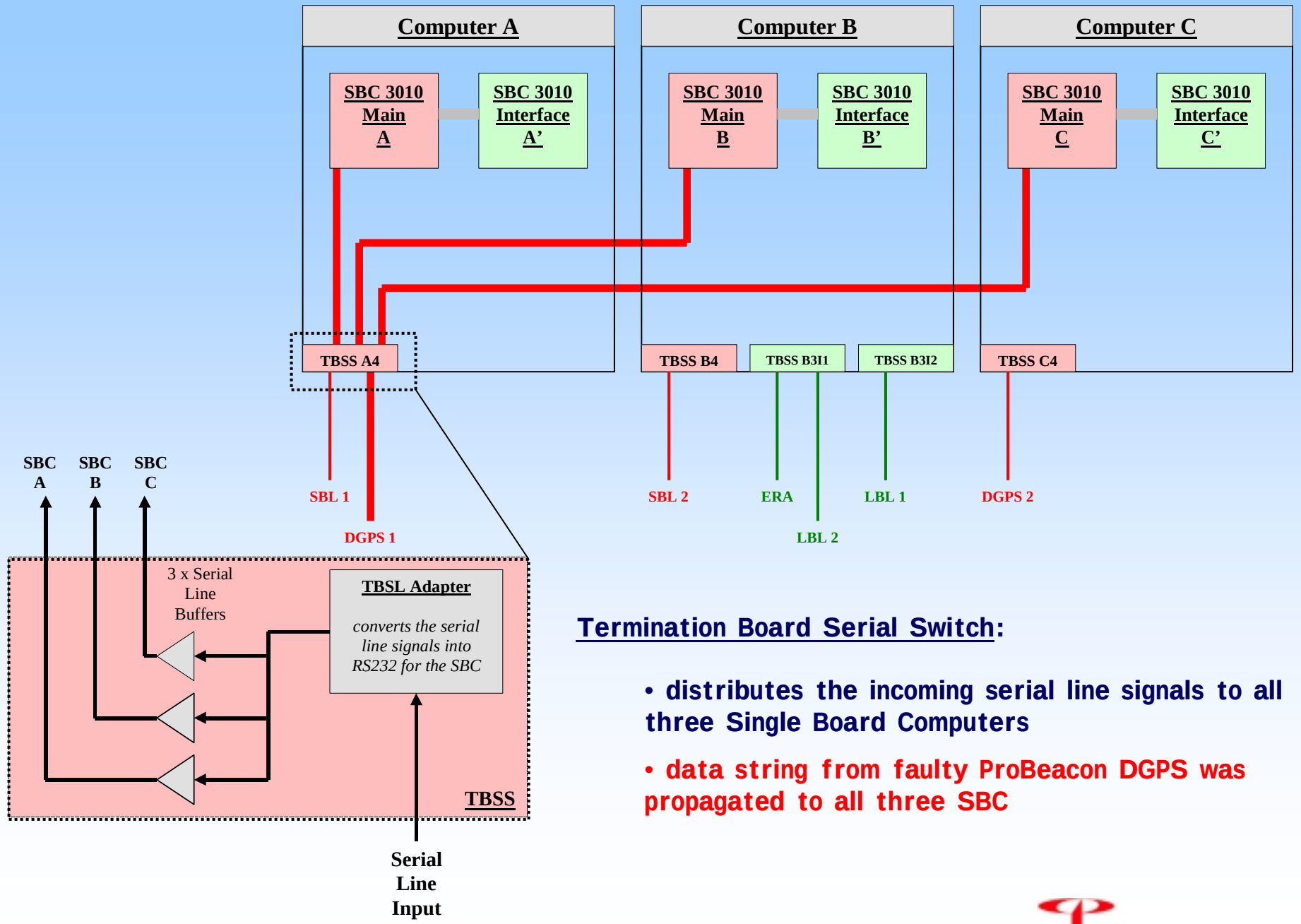
1. DP Incident: Root Cause and Events Analysis

1.1. Root Cause of DP Incident

Faulty Component:	***Trimble DSM212H/ProBeacon DGPS wrongly configured***
Fault Description:	***2 NMEA data strings sent continuously from the TX port***
Event triggered by:	***Selecting faulty DGPS with A/B Switch into DP System***
Event started at:	***8:11:56***
Event stopped at:	***8:21:45***
Stop triggered by:	***De-selecting DGPS with A/B Switch***
Consequence	***DP Computers overloaded A appeared less overloaded than Computers B & C***

Why did a fault on a serial line propagate to all DP Computers?



Termination Board Serial Switch:

- distributes the incoming serial line signals to all three Single Board Computers
- data string from faulty ProBeacon DGPS was propagated to all three SBC

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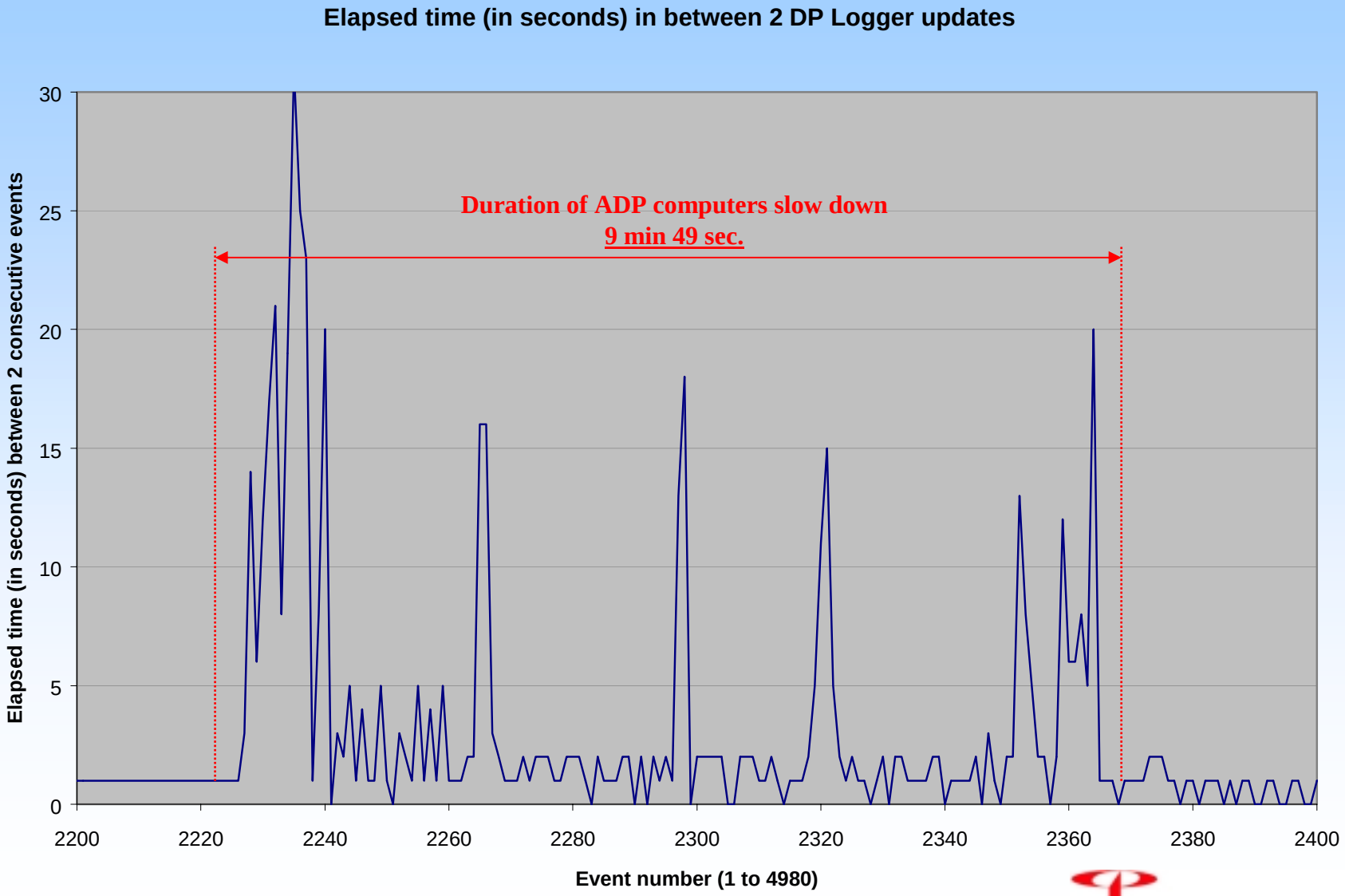
1. DP Incident: Root Cause and Events Analysis

1.2. Sequence of events following root cause



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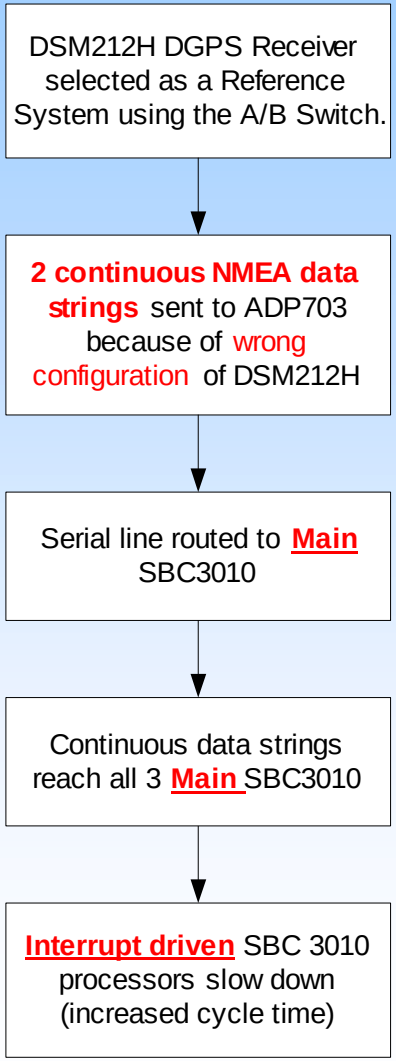
1. DP Incident: Root Cause and Events Analysis

1.2. Sequence of events following root cause



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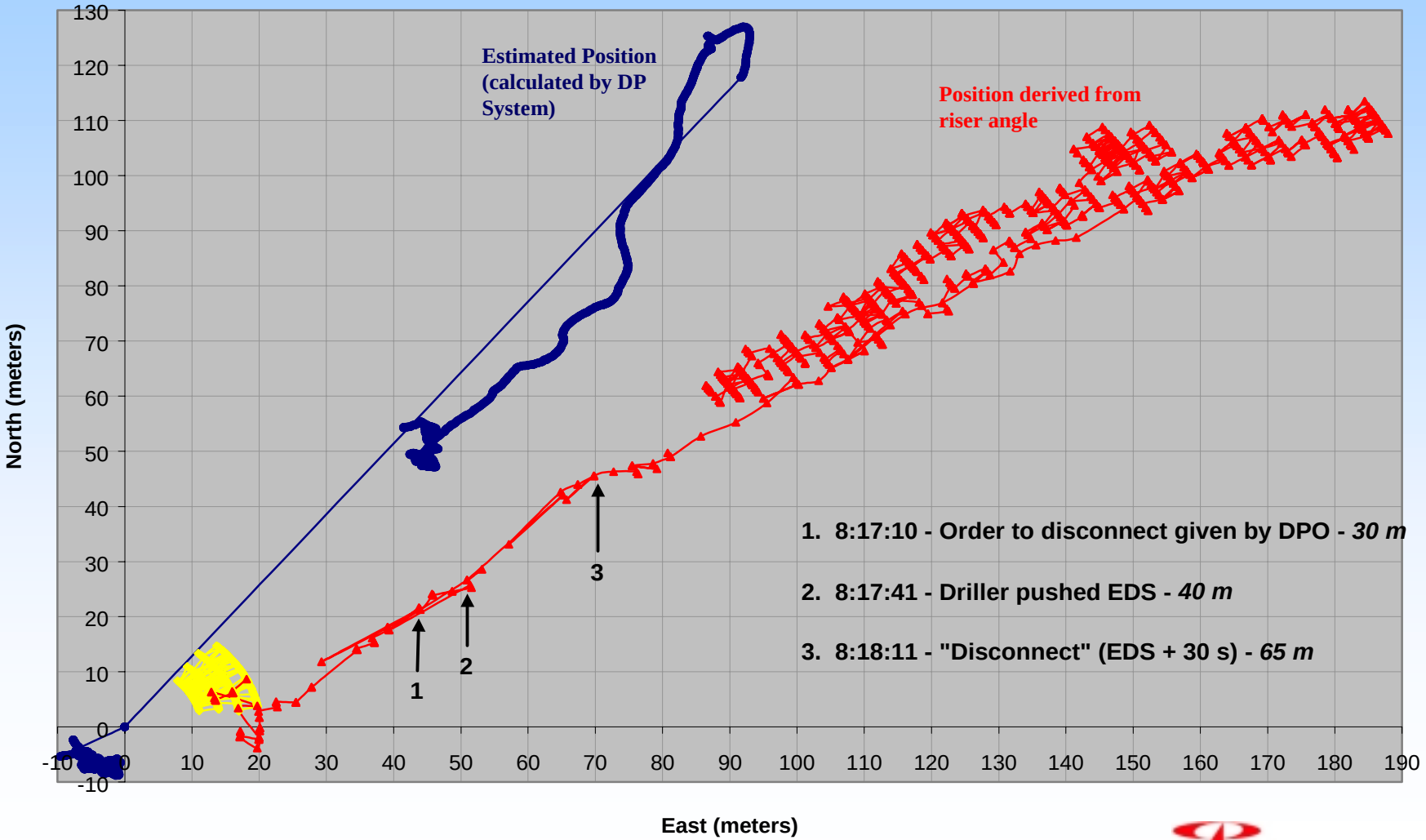
1. DP Incident: Root Cause and Events Analysis

1.2. Sequence of events following root cause

Vessel Position - estimated and derived from riser angle data



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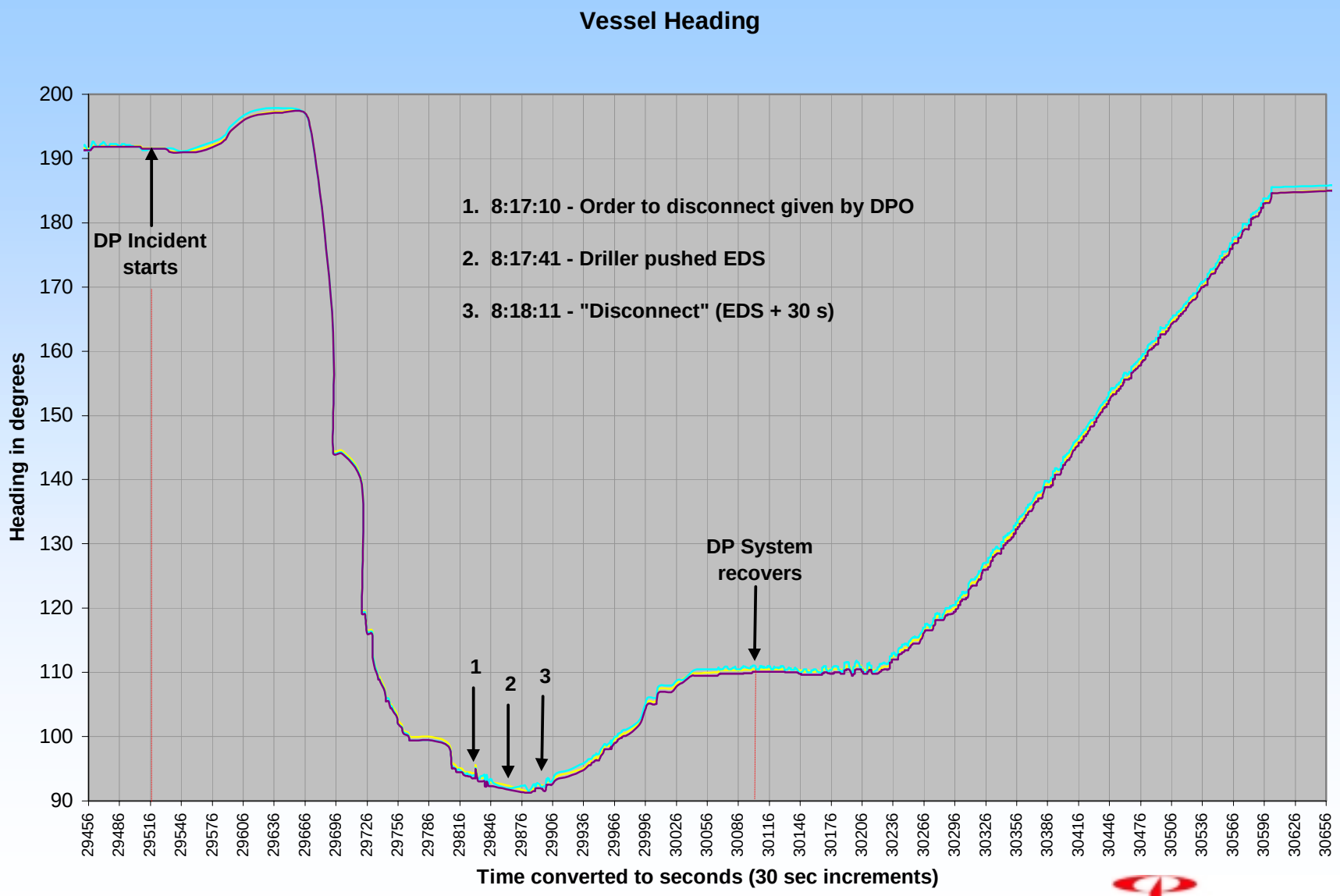
1. DP Incident: Root Cause and Events Analysis

1.2. Sequence of events following root cause



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2. Corrective Actions and Lessons Learned

2.1. Immediate and Medium Term Actions

Immediate Actions following DP Incident

- DGPS1 was switched back to RACAL DGPS ⇒ stabilized the DP system
- Trimble DSM212H/ProBeacon was completely disconnected from A/B switch
- DP Supplier informed.

Medium Term Actions

- OPDOC prepared to inform other vessels
- Investigation work on the vessel proved the Trimble DSM212H/ProBeacon to be the cause of the drift off (problem re-created).
- DP Supplier informed us of solution to prevent incident at their level - testing started

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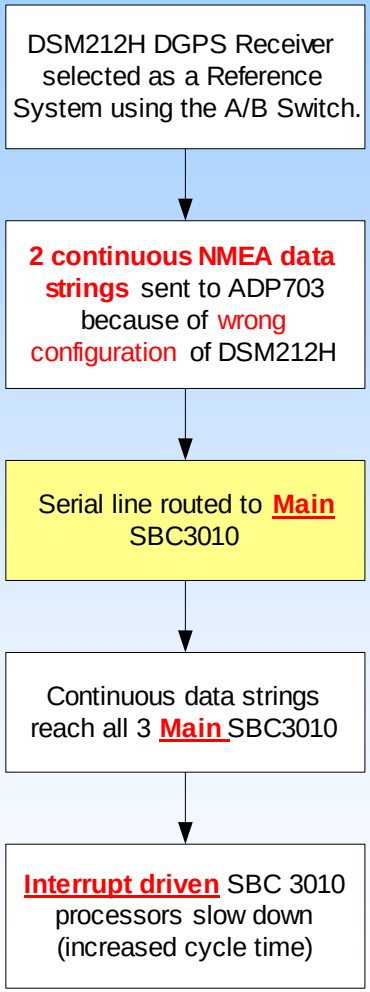
2. Corrective Actions and Lessons Learned

2.2. DP Supplier Solution



- **Solution:** reduce processor load on Main Single Board Computers.

- **Implementation:** dedicate the Interface SBC to handling serial line information. The main role of the Interface SBC will be pass on serial line information to the Main SBC at 1 Hz frequency.

  ⇒ Reduced main processor load

  ⇒ 1 Hz data transmission frequency guaranteed

2. Corrective Actions and Lessons Learned

2.3. Lessons Learned

- **Fault propagation in the DP system -** single fault might affect all 3 DP Computers.

- **Management of change -** exercise extreme caution when making changes to DP System (ex: unscheduled maintenance)

- **Data sent from reference systems to DP System -** difference between DESELECTING a reference system into the DP estimated solution and physically DISCONNECTING it.

- **SBC Processors are interrupt driven -** KS have started implementing "software" filters for SDP type systems.

- **Traffic indicators in serial lines and network**

Transocean

Chet Skowronski

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Offshore Brazil May 9th 2002 2.15 pm

- Rigging up wire line lubricator for down hole camera
- **Derrick struck by lightning!!!!!**
- Loss of both DGPS and all thrusters
- Except T3 and starboard shaft
- Loss of SPUs 2, 3, 4 and 6
- Vessel starts to lose station to N/E
- DPO goes into manual position and heading control

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Offshore Brazil – 2.19 pm

- DPO reconfigures SPUs
- OIM initiates a yellow alert

Offshore Brazil – 2.23 pm

- DPO regains control of the thrusters and propulsion
- Selects auto heading and position
- Maximum Excursion 14 meters
- Yellow alert cleared
- Back at original position 2.27

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Reasons

- Power surge through DGPS antennae
- (possibly wind sensor as well).
- Disabled DP system Data Highway communications.

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Corrective Actions

- Repair DGPS.
- Install lightning rods on derrick.
- Investigate possible surge protection for serial inputs from DGPS and wind sensors.

Return to Session Directory

Sean Hickey 2

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Long ago and far away in a parallel universe….

- Late 1977
- SEDCO 472
- Offshore Surinam
- Spudded in 3958 feet of water
- Riser and stack connected, drilling ahead
- Full power drive off

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Why our collective remaining hairs are gray….

- TAL commanded full power on lateral thrusters.
- DMS emergency started all skids.
- Operator initiated red light and began dropping thrusters offline.
- Emergency disconnect initiated
- Drill pipe broke did not shear, stretched until it.

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Computers at Stonehenge

- DP system - Honeywell ASK
- Based on Honeywell 316 computer, designed by GE in 1964
- 8 k core memory, 750 milli sec cycle time
- Parameters passed between systems via D/A to A/D link
- Calibration slightly off, zero set point error indicating slightly negative voltage.

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Math anyone?

- Binary A/D conversion
  - +1 = 000 000 000 001
  - -1 = 111 111 111 111

✓ Recognizing the sign bit, 111 111 111 111 is a very small negative number.

x Failing to recognize the sign bit, 111 111 111 111 is a very large positive number.

What happened????

- The primary system failed and passed control to the backup system.
- The backup system was reading a small negative voltage on the P/S error.
- The math did not recognize the sign bit and took the small negative number as a large positive number.
- The system commanded full power stbd.

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If you think that's silly...

- The BOP did not shear the pipe.
- The shear sequence time was determined to be 12 seconds.
- The emergency disconnect sequence had a 7-second delay programmed in.
- Therefore the shear rams grabbed the pipe and were in the process of shearing when the upper package lifted off……

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Why is software so bad?

Pete Fougere 2

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THRUSTER POWER

Power System Transients

- Single phase short circuit faults
- Three Phase short circuit faults

Common Mode Failure for Thruster Drives

- By malfunction of drive
- By action of drive protective devices

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POWER SYSTEM PROTECTION

- Comprehensive design of protection for power system
  - Short Circuit
  - Ground Fault
  - Differential

- Short Circuit Protection
  - Based on abnormal magnitude of current and may include intentional time delay before clearing fault
  - Short circuit fault at main bus level will cause voltage to drop on faulted phase(s) throughout the power system
  - Short circuit is an uncommon fault and it is difficult to test system under fault
- Not common to include internal drive protective design in design of power system protection

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EXAMPLE 1 - MALFUNCTION

- DP Vessel with SCR/DC thruster drives
- Normal operation, then a single phase fault occurs on a consumer connected to the main bus causing major voltage unbalance on main bus phases
- All the SCR's misfire is a result of the voltage unbalance
- This is a common mode failure for all the SCR drives because all experience the same voltage unbalance
- Manual reset of SCR protective device

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EXAMPLE 2 - PROTECTION

- DP Vessel with adjustable speed AC Thruster Drive
- AC → DC → AC
- Internal drive protection for incoming and motor
  - Voltage
  - Frequency
  - Load
  - Fault

EXAMPLE 2 (Cont) - PROTECTION

- For a short circuit fault on main bus, the drive controller incoming voltage protection can be tripped by low voltage -

Common mode fault all drives

- Manual reset
- Detailed design / settings of drive controller may also allow same fault as Example 1

LESSONS LEARNED

- - The characteristics and settings of the protective devices in the drive systems needs
- - to have design review
- - to be accounted for in vessel FMEA
- - to be considered in power system protective device coordination
- - Have a way to reset the drives from the DP Control Room

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Steve Savoy 2

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Boat Assist For Problems Due To Insufficient Thrust or Risk of Power Loss

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Situation 1
What happens when the Vessel Runs out of power in a high current?

- This situation applies to a DP barge in the process of laying pipe.
- While laying pipe the vessel cannot arbitrarily change heading.
- Current can increase to the point that its force exceeds the vessel thrust capability (mainly applies to small vessels).

Big Problem

The solution to this problem is to get additional help from a boat.

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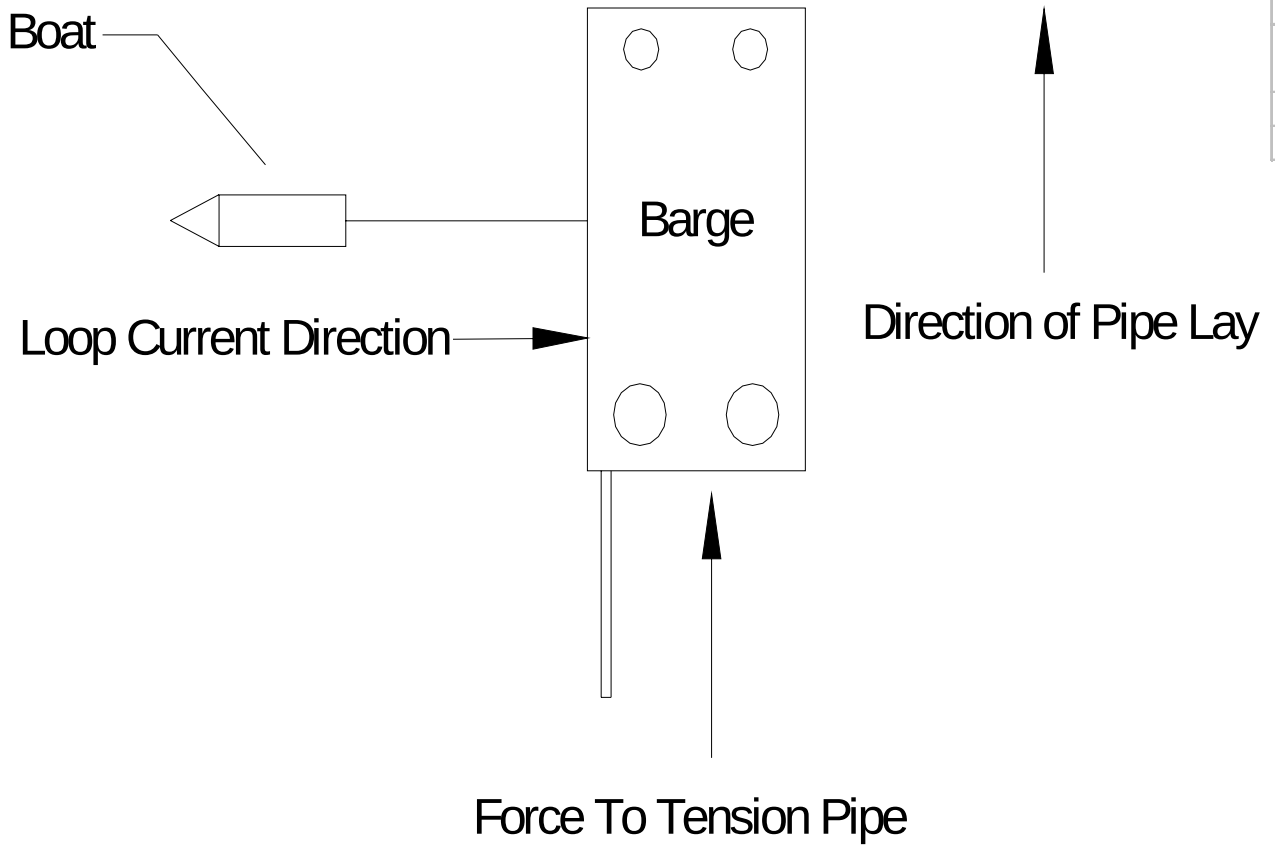
Lay Barge/Boat Configuration

	Force (lbs.)
Total Thrust Power	78,000
Power To Tension Pipe	20,000
Power To Position	58,000
Force Due To Current (3 knots)	67,000
Deficit of Power	9,000



Experience using a boat to assist the barge counteract the current force enabled the pipe lay operation to continue in high current situations.

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Rig and Boat Configuration for Safety Towing

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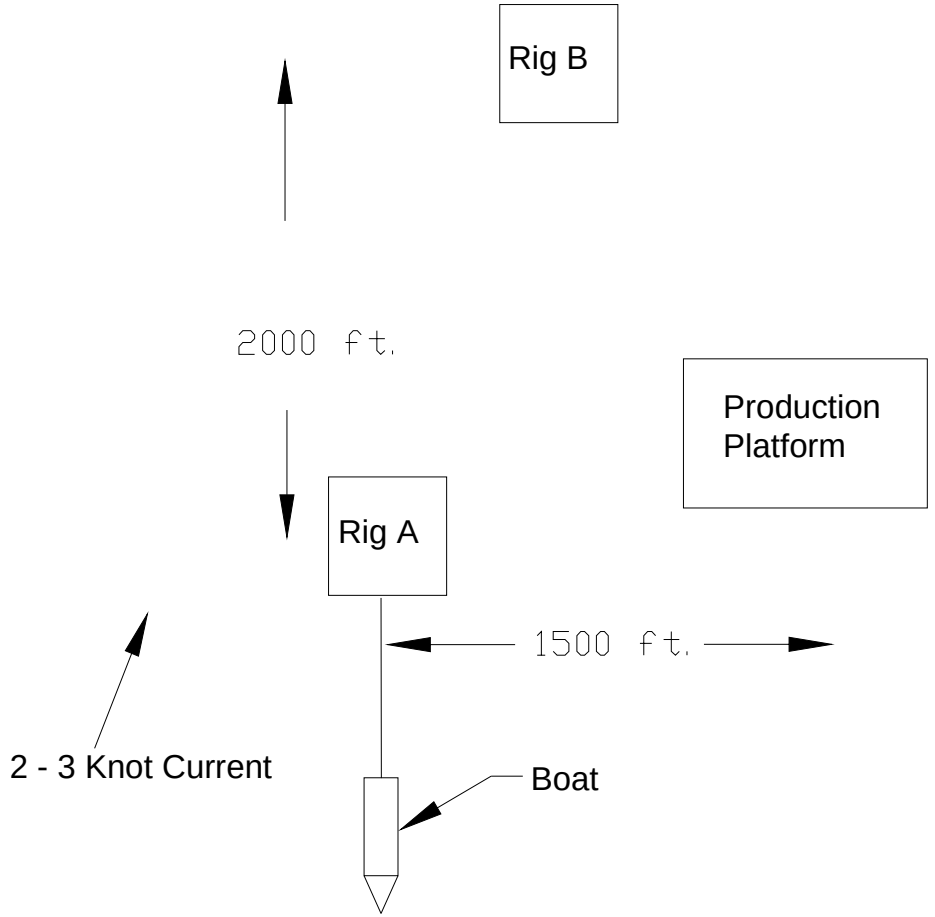
- Dynamically positioned Rig A is drilling 1500 feet from a Production Platform and 2000 feet from Rig B
- Both rigs are drilling relief well for blowout with platform on fire
- Current approximately 2 – 3 knots from the indicated direction
- In the event of a blackout the rig would rapidly drift into the rig and/or platform BIG PROBLEM
- Boat is attached with towing bridle to the rig so that in the event of a rig power loss it can tow the rig to a safe position.



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Issues Today?

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Chet Skowronski 2

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Flooding Incident

- Beforehand the incident a water tight door was left slightly open (1 or 2”)
- This was Between Stbd Pipe Tunnel and Aft Stbd Pump Room
- At 09.30 ET enter Stbd Pipe Tunnel from the Forward end
- Suspected lost Hydrophone head
- Inspect Stbd no 2 Hydrophone

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Flooding Incident

- Long Story short – pulled the hydrophone in past the packing
- Turns out that the ‘remaining shaft was 7’ 8’’ not 10 feet plus
- Pipe tunnel starts to flood – estimated later at 850 m3 per hour
- ET escapes through frwd door and closes it

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Flooding Incident

- Calls control room from elevator
- Meanwhile at 9.55 control room operator had a bilge alarm – just before ET's phone call
- At 9.58 high bilge alarms
- Could not close the door to the aft pump room – now flooding

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Flooding Incident

- Shortening the event
- Trying to control ballast and pump out spaces
- Lost seawater water pressure at 10.27 – recovered
- Lost thruster cooling water motors
- 10.35 Emergency closure of all vents and water tight doors

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Flooding Incident

- Poss. shutdown - thrusters 5 & 8
- 10.41 Red alert discussed but not initiated
- But all to muster stations
- 10.43 thruster cooling motors failed
- Other water tight doors leaking
- Bilge alarms on thrusters 6 & 3

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Flooding Incident

- 11.04 tree clear of well
- 11.40 LMRP disconnected and clear
- 14.30 muster stood down.

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Some of the Lessons Learned

- ✓ Water tight doors must be properly dogged
- ✓ Status of the doors should not be ignored by operator
- ✓ The hydrophone should have been inspected using ROV
- ✓ Control of flooding should have been much better

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Some of the Lessons Learned

- ✓ Permit to work for entering pipe tunnel
- ✓ Ballast damage training
- ✓ Hydraulic Doors rather than manual
- ✓ Suspect stalks should be jettisoned not withdrawn

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Issues Today?

1. People
2. Complication
3. Position Sensors

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People

- Qualifications
- Training
- Competence
- Experience
- Technical Understanding

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Complication

- Inadequate Testing of VMS, PMS, and Networks
- 'State of the art' –false sense of security - testing
- Too much automation
- Man machinery interface ('stupefying')
- One stop shop – DP and power
- Obsolescence
- Systematic Failures
- FMEA not adequate ('naive faith')

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Position Sensors

- Reliability
- Insufficient suite
- Dependence on multiple identical references

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Questions and Conclusions

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