DYNAMIC POSITIONING CONFERENCE
November 15-16, 2005

Operations I

Electronic Strip Charts – Following the Trend

Steve Jasper

Transocean

Return to Session Directory

ABSTRACT

Electronic Strip Charts, following the trend.

Author: Steve Jasper
Company: Transocean
Contact: Steve@jasperinspain.com.
+34 965973589

Early dynamic positioning (DP) systems were fitted with pen recorder strip charts, which were the best existing technology but were functionally limited and difficult to read.

As DP equipment became more sophisticated and the “pos plot” graphical display developed, the strip chart was judged to be obsolete and if fitted at all it appeared on a single “page” as an afterthought that was awkward to configure and limited in functionality.

More recently, a resurgence of the strip chart has occurred, as PC-based, digital versions became available to replace the old pen recorders and system operators and fleet superintendents convinced their employing companies of the advantages of observing a trend, rather than just a ship shape hopping around on a screen.

Then, system manufacturers seemed to notice the increased use of strip charts and started to supply integrated DP / logger / strip chart systems in a format that the system designers decided that operators needed.

This paper describes, with examples, some of the advantages to DP operators of a strip chart trend used in conjunction with a DP system to assist and improve safe operation, predicting and preventing potential problems, fault diagnosis and incident investigation.

The paper also sets forth the need for system suppliers to liaise with actual system users. Such dialogue can ensure that the supplied equipment is user friendly and consequently is actively used operationally to predict and prevent incidents or at least reduce their impact. In addition, it will provide a diagnostic tool for data recording and shore-based incident investigation, after the event.

Electronic Strip charts; Following the Trend

Introduction

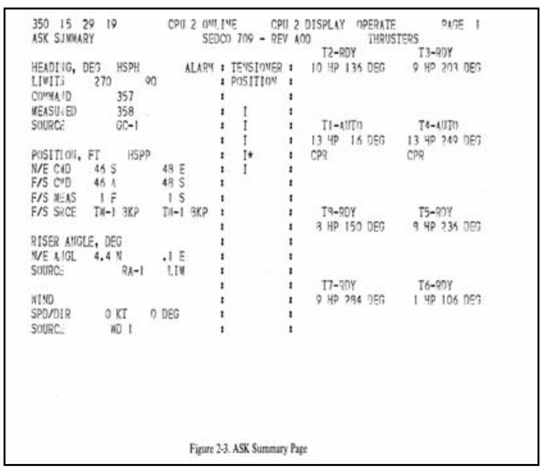
My name is Steve Jasper; I am currently a senior DPO (Dynamic Positioning Operator) on a semi-submersible drilling rig.

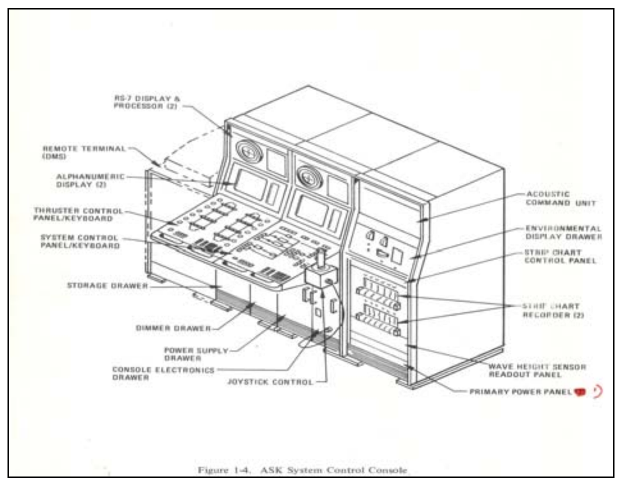
I began my career at sea in 1980 on tankers and was employed on a variety of vessels from gas, chemical and petroleum tankers to general cargo vessels before moving into the offshore industry in 1989.

I worked as mate on AHTS vessels before moving to DP vessels in late 1990.

Since then, I have been employed on a variety of vessels ranging from small survey / rov support to drilling semi-submersibles including pipe-lay and construction barges and larger dive support vessels.

Over time, I have become convinced that the original system designers had it right when they included trend recorders in their systems. The computers existing at the time of the early systems were not capable of the sophisticated graphics displays we expect today, so we were given the real time data on an alphanumeric CRT display and a trend on one or more pen recorders.





Alphanumeric display from Honeywell 316 ASK. Outline of Honeywell 316, with twin strip charts in the lower right console

As the computing capability / graphic displays improved, we progressed to a ship shape display on a grid, the pos plot display, and thruster output was represented by bars that lengthened and shortened depending on power level. At about this time, the pen recorder disappeared or became a “cost option,” as all the data could now be displayed in an easy-to-read graphical format. The difficulty of this format, however, is that it requires changing pages to access different data and it doesn’t facilitate comparison of present performance with recent history. On the other hand, with a pen recorder you can instantly scroll back minutes, hours, or days.

As DP systems were upgraded, many experienced operators noticed the impact of the loss of the information provided by the trends and where possible they instigated a digital replacement.

The result was a generation of DP systems designed and provided without a strip chart. Many, however, had a variety of user-installed equipment to provide trending capability.

The next stage was for system designers to include basic strip chart functions within the DP system itself. They are not as functional as dedicated displays and an even greater downside is that if a DP system display page is left on a trend display, it is likely that some other similarly important display is sacrificed.

In many cases, vessels continued to use third-party charting software often as part of a third-party data logging system. These systems worked quite well, as equipment and software was purchased on merit and the software developed over time, with input from and sometimes by the operators themselves.

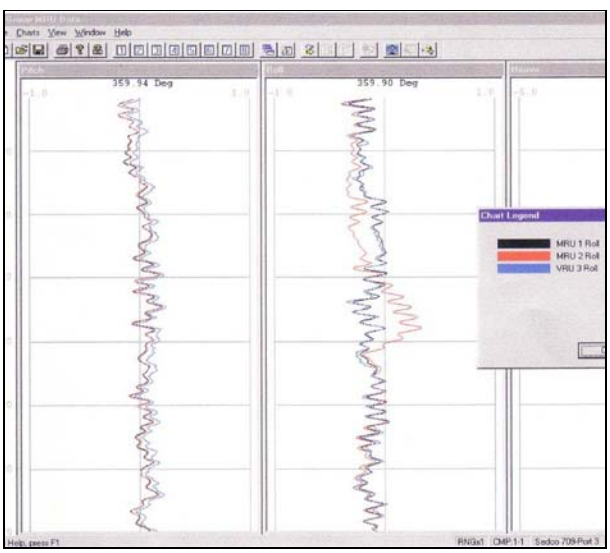
In other cases, data logging systems were provided by DP system vendors and focused more on data logging than data presentation. These systems, typical of data logging systems supplied by DP vendors, are quite powerful overall, but provide minimal operational support to the DPO.

More recently, the use of third-party equipment has decreased as more and more logging oriented systems are supplied by DP equipment vendors, effectively removing a very useful tool from the operator.

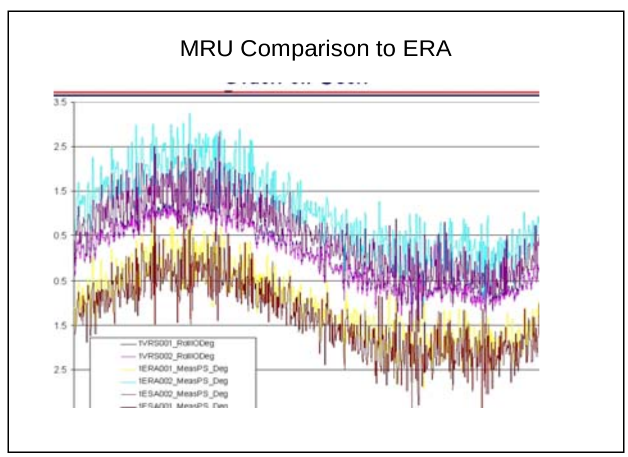
Use of strip chart trends prior to commencing operations.

A trend allows us to check various equipment even before we bring it in to operation.

The expanding use and reliability on DGPS and acoustic systems coupled with the increasing operational water depth requiring careful monitoring of riser angle has meant that the importance of the MRU or VRU has increased significantly. The height of the antenna for a DGPS system is normally considerable and slight errors in the MRU could have a significant effect on position accuracy and repeatability. By using the trends, we can easily check the MRU before commencing operations. If we list the vessel and check the trends of all MRU units, they can easily be compared to both each other and more traditional roll and pitch indicators. This ensures faulty or erratic units can be isolated before problems develop. At the same time, we can set a chart to compare the various deployed reference systems to ensure effect of list and trim are compensated for and position deviation is minimal. And, assuming the BOP stack is on the beams ready to run, we can compare the electronic riser angle sensor output to the MRU output to confirm correct operation.

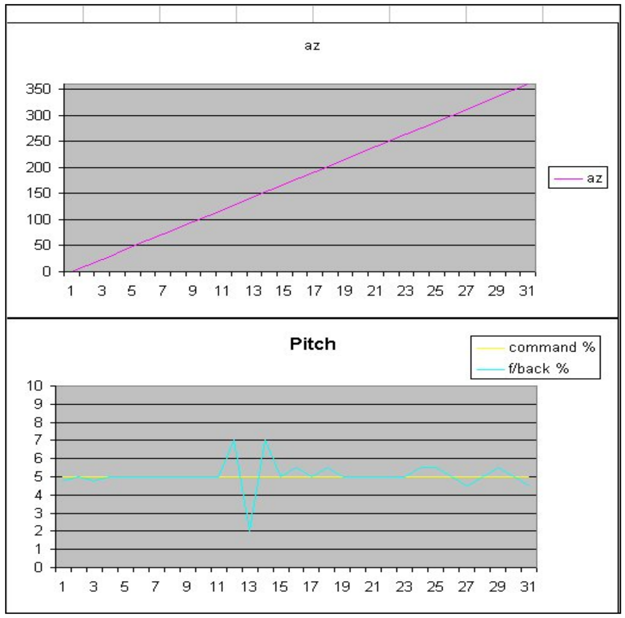


The error on MRU 2 roll (red centre trace) can be seen



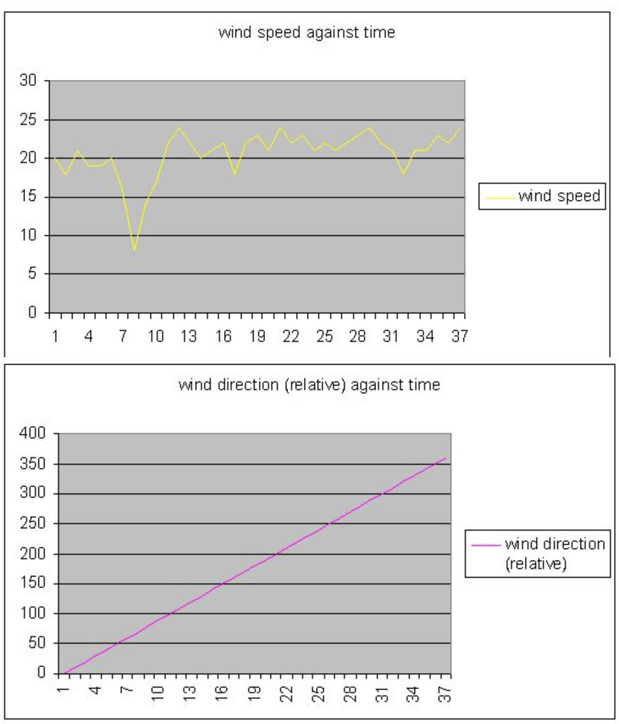
Comparison of VRS sensors to riser angle sensors

Another simple check is to compare the measured thruster azimuth with the commanded thruster azimuth for a 360-degree rotation. If a small amount of pitch is applied during this test, it can show dead spots on slip rings indicating on which azimuth if any, the thrusters may have problems with pitch feedback signals.

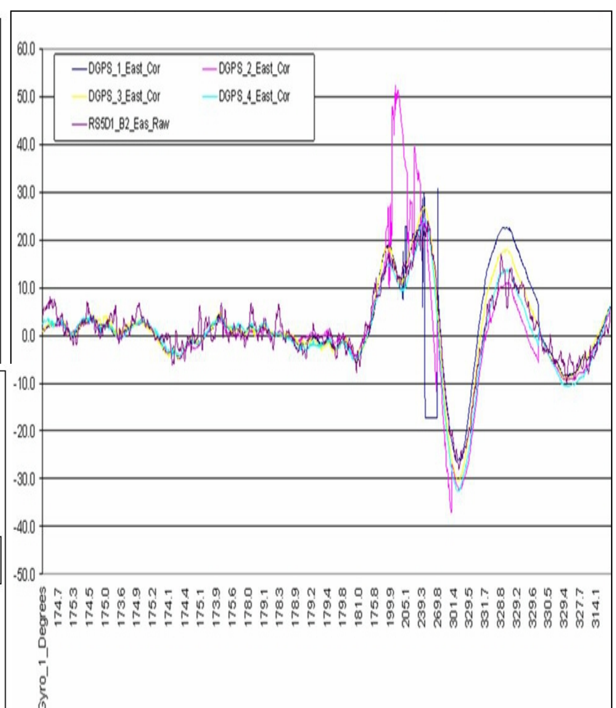


Pitch feedback (blue) is intermittent between 12 and 15 minutes, corresponding to 130 to 160 degrees relative azimuth

The last example of the simple checks involves wind sensor blind sectors. If the vessel is rotated through 360 degrees and the wind sensors are monitored for both relative azimuth and speed, areas where each wind sensor is shielded from the wind are immediately apparent. We could also graph DGPS data and note any differential antenna blind spots or other problem areas that may be heading related.



Wind sensor is shadowed between 50 and 70 degrees



Problem with DGPS 2 East (pink trace) commencing about 200 degrees

Many other options for checking equipment are available and providing the charting software is easy to set up and configure, they can be performed on arrival in the field without adding to the time spent on routine arrival checks.

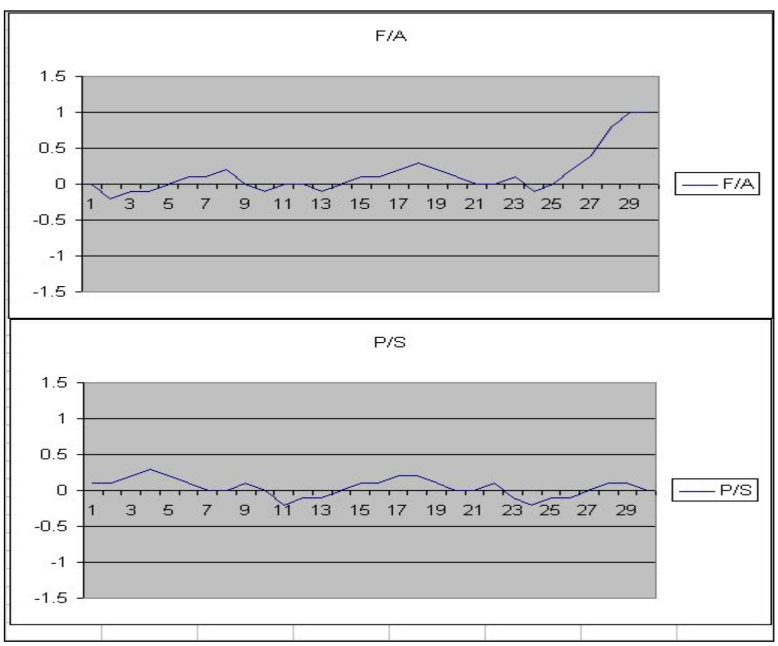
Generally, the operations required are already being done as part of field arrival; listing is a consequence of using the crane to pick up equipment from supply vessels, rotating the rig will occur during hydrophone calibration, each azimuth thruster is checked though 360 rotation for correct operation, etc. So, using a strip chart to graphically compare data that is already available should be second nature. However, anecdotal evidence from professionals, including many in more senior positions to my own (the majority outside the drilling industry), shows that this does not appear to be the case. I believe that many of the minor, unreported mishaps and perhaps some of the more serious upsets could be prevented, by using simple checks similar to those mentioned.

Use of strip chart trends to aid routine watch keeping.

The immediate advantages of a graphical trend display are more apparent to a DP operator on a vessel in open water than to a support vessel crew working next to a structure.

Most dive-boat-trained DP operators say that one of the first things they do after settling down on location is to select various transits on the adjacent structure to monitor position visually, without needing to rely on the DP screens. If possible, these transits will indicate when the vessel is in position and the normal limits of oscillation. In open water this is not possible. On a drilling unit, even if the DP operator actually has an external view, one bit of sea generally looks pretty much the same as the next bit so the operator is totally reliant on the information provided by the DP and associated subsystems.

To perform his function properly, the DP operator needs to observe and process a large amount of information continuously over a long period of time. In general, we are looking for a change, be it in thruster output, wind direction, position or heading etc. If we can put the information in the form of a graph where the central or mid point y-axis is normal, it would be easy to observe a change, and thus investigate the cause and instigate whatever corrective action (if any) is needed.



Trend highlights position deviation exceeding normal oscillation

On a generic dual computer system there will be either 2 or 4 display pages visible at any one time. One page is dedicated to the ship / grid graphic of pos plot display. Another will be left on thruster output, one perhaps on a summary page and a fourth available for weather or power use or details of reference system performance.

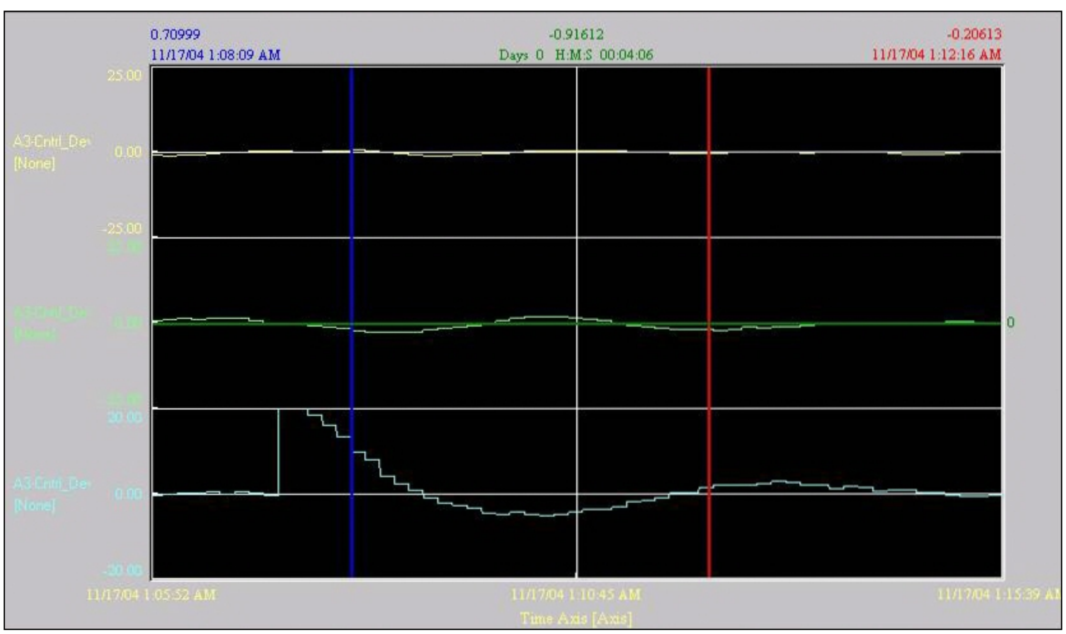
The operator routinely scans these pages and on occasion or when something causes concern will check other pages. It is easily possible for some information to be missed or not interpreted correctly during these brief scans of the data.

The strip-chart allows more information to be displayed and compared in an easy to interpret format. Anything that is either above or below the normal is immediately apparent.

Under routine watch-keeping situations, we normally have a display showing heading and position deviation, and rate of change in surge and sway axis, switching to a display showing DGPS, acoustic and riser angle periodically to check reference sensor trends and the performance of the riser angle PME. Different displays are pre-configured to be selected as required.

One of the routine uses of trends for me is setting and adjusting the system gain and thruster bias levels. By watching the trend of rate of change of position as well as position deviation and thruster activity, gain and bias settings can be adjusted to give an optimum balance of minimum rate of change, allowable position deviation and minimum change in thruster activity, thus reducing mechanical wear and tear while maintaining station within required limits.

A related benefit is that this serves as a quick and easy aid to technicians when performing and evaluating the stability margin tests while setting the system gain range in the DP software.



During stability margin test, inject 20-meter position error in sway, rig gracefully recovers position in sway axis with little impact on yaw or surge. Gain settings are good.

Having correct gain settings can, of course, significantly enhance performance of the system and reduce breakdown maintenance on equipment.

Another simple watch-keeping use is to configure a chart to graph thruster allocation logic (TAL) resultant and position deviation outputs from all system computers. Doing so can provide early warnings of potential computer difference problems, etc., or very quick confirmation of problems, allowing the erroneous computer to be removed or re-initialized before any serious impact on station keeping occurs.

Use operationally

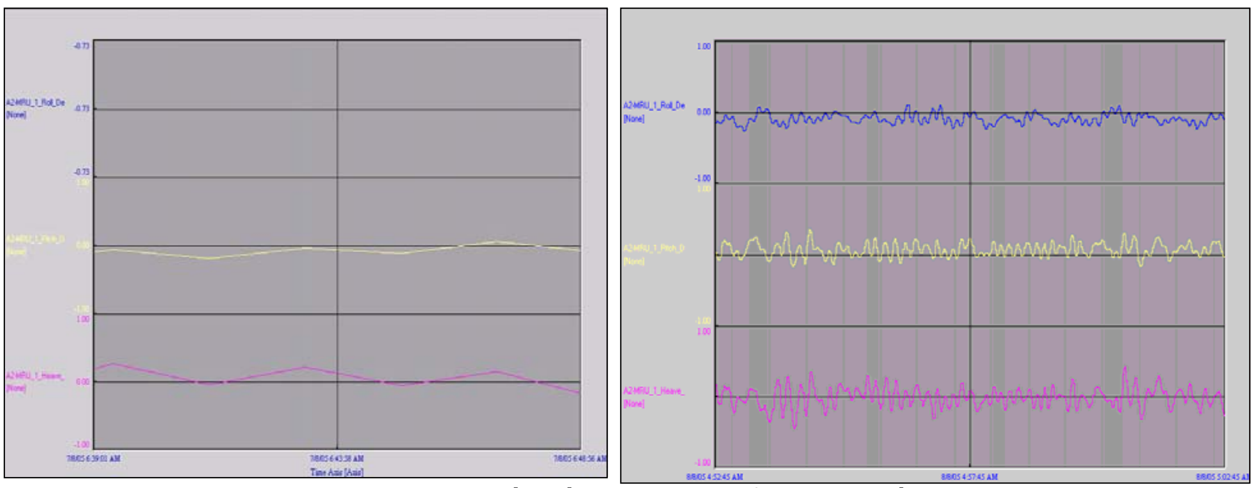
One of the operations on a drilling unit where there is a high potential for damage to occur is when landing equipment on a wellhead. The forces involved are significant, and the degree of control is limited.

Equipment is suspended from the rig on the drill string or riser and positioned above the wellhead. The rig is maneuvered on DP using the ROV camera display to line up the equipment over the wellhead and the equipment is then lowered in to position on the wellhead.

Obviously, with the pendulum effect, time lag between rig movement, suspended equipment movement and the normal oscillation of DP, careful planning and patience are required.

Heave is a major consideration during these types of operation.

It is often seen that swell, and consequentially heave, comes in cycles, but the cycle is difficult to predict by watching numerical motion reference unit data. However if we graph the data over a period of time, the swell cycle becomes apparent. Heave is indicated on the lower axis, in purple

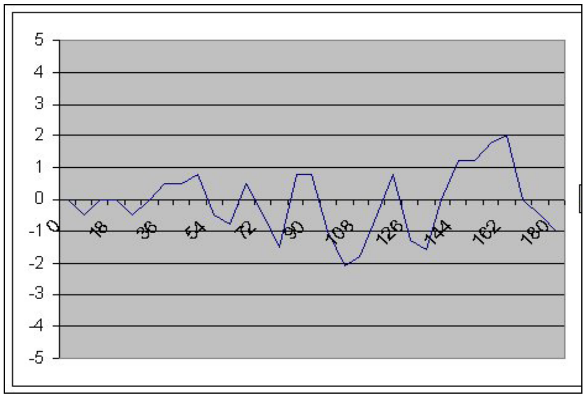


Heave cycle on lower axis over a 10-minute period

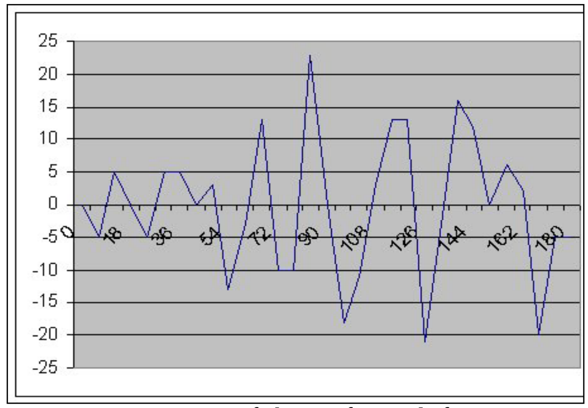
These measurements are very useful when conducting subsea land out operations. Once the swell cycle is seen, the rig can be positioned in one period of low swell, and then the equipment lowered and landed in the next period.

Use of trends to predict and prevent problems.

Trends and graphical representation can provide easy to recognize symptoms of potential problems earlier than numerical data. Shown below left, a graph of vessel position F/A over 3 minutes of time. There appears to be little if anything wrong initially, and the pos plot and numeric displays would be unlikely to prompt action until about 100 seconds with a position deviation approaching 2 meters.



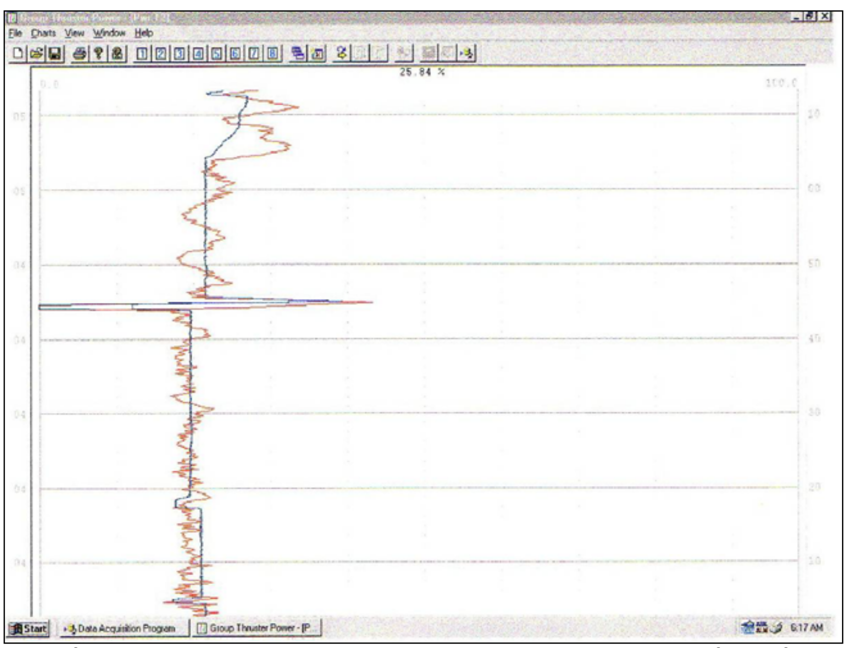
Position error fore and aft axis



Rate of change, fore and aft axis

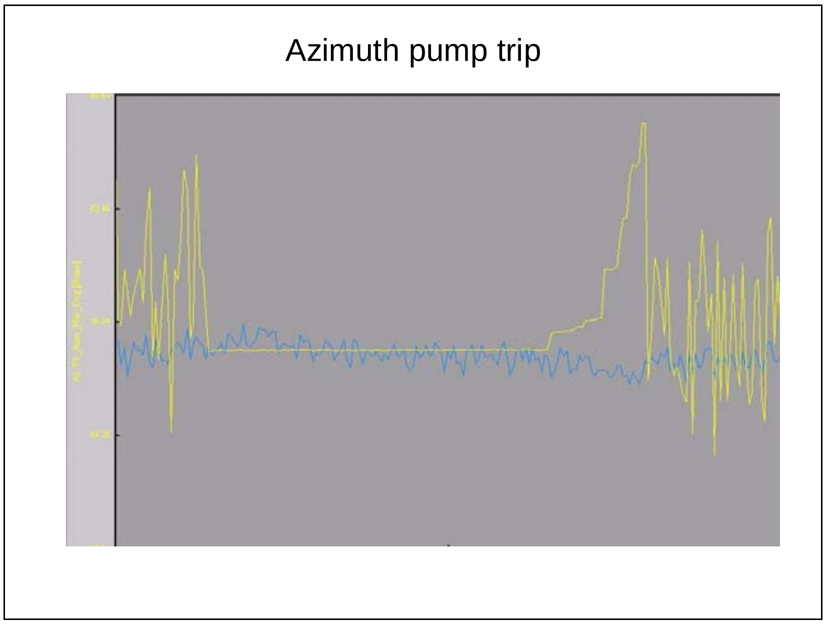
Using the position trend alone, the operator would investigate at around 75 seconds due to a change in position trend. Adding the rate of change of position trend, enables even earlier recognition of a performance problem.

Sometimes thrusters develop hard-to-spot problems, such as slow reaction time. A serious problem may be indicated, so early action is desired. It may be difficult to spot the problem from the thrusters display on a DP system, but, it is easily noticed on a strip chart, which allows action to be taken prior to it causing a problem.



Thruster command in red with feedback in blue, slow response indicating possible hardware or software fault (this was in fact the dead-band being set too high)

It is common practice on vessels with multiple azimuth thrusters to bias these thrusters opposing each other, especially in low-environment conditions. This gives a better holding envelope and reduces azimuth activity as the rig can maintain position using mainly changes in pitch command, as opposed to rotating the thrusters. We have an intermittent fault that causes one of the azimuth pumps to trip off without generating an alarm and requires a breaker to be reset by the electrician. In fact, the first alarm that is generated is the azimuth command / feedback compare alarm set at 10 degrees. Due to thruster dead-band settings and thruster biasing, it is not unusual for some thrusters to remain within a 10-degree band for several hours, so we periodically check the thruster azimuth trend to ensure the feedback is not constant, indicating that the azimuth pump has tripped.



Here yellow is feedback and blue is the command. The vertical scale is from 62 to 90 degrees. If a sudden environment change were to take place while the azimuth pump is inoperative, a positioning problem could occur prior to the pump being restarted and the thruster becoming fully operational

Using Trends during incidents.

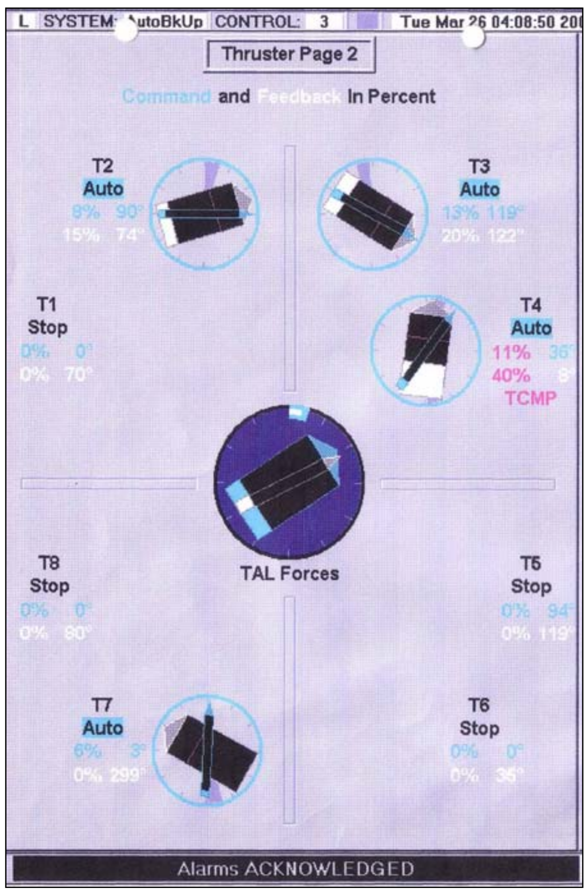
Until now, we have looked at the information we can obtain to improve our interpretation of data to increase system performance and pre-empt major problems.

Now, we will look at using a trend / chart to help decide on a course of action once an incident begins.

In this case, the vessel is on DP running one azimuth thruster port fwd, two stbd fwd and one port aft, with the thrusters biased fore and aft by 383 kW, (383 kW of power are distributed among the on line thrusters to point them towards each, other causing a known artificial environment which improves holding envelope), and has been stable for several hours using this configuration.

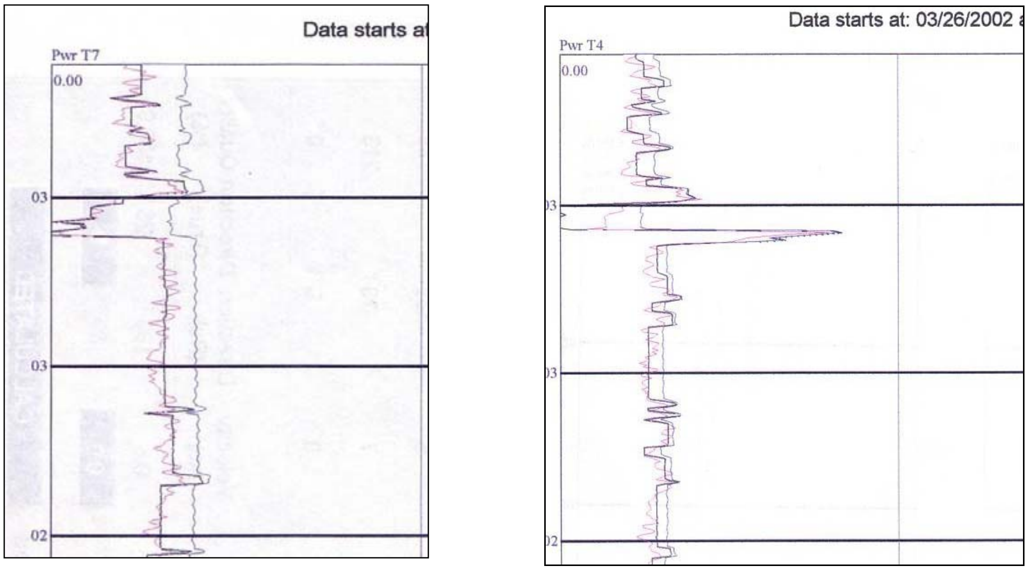
The indicated DP current is from 71 degs on stbd bow.

A power compare alarm was generated at 04:08 08, and the thruster page gives the information as per the diagram, which was captured very shortly after the alarm. The blue arrows at the centre of each thruster are commands, and the larger yellow arrows are feedback

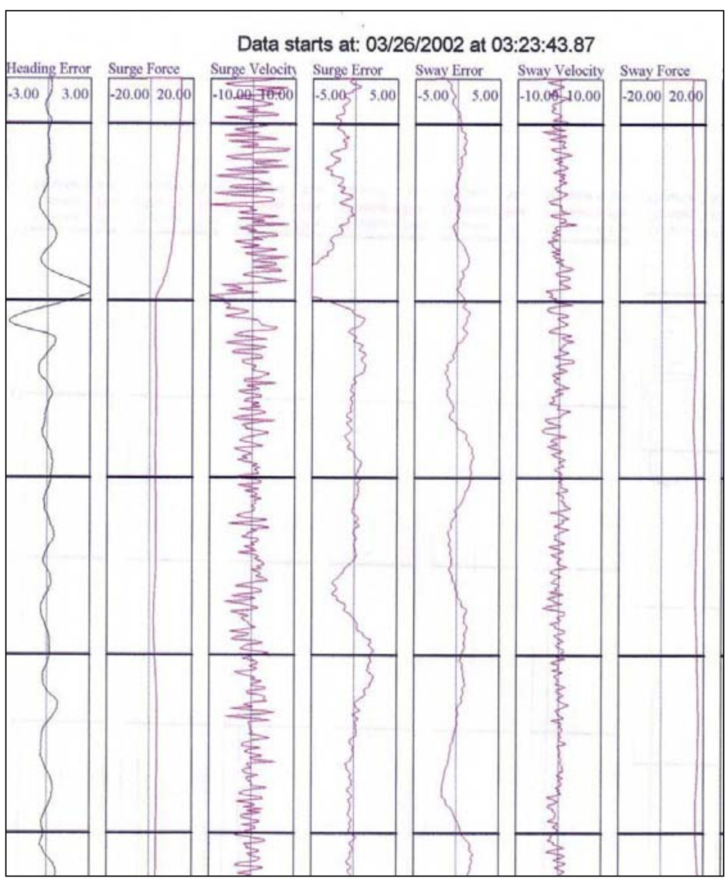


The first reaction may be to decide T4 has a fault and take it off line or even emergency stop it, however, the question must be raised that as the thruster has jammed at 40 %, it is likely to have had a command to go there before jamming, either a faulty command or a true command. Normal thrusters operating levels were 20 to 30 % or lower.

Checking first the thrusters strip chart and then the control parameters chart :



Section of T7 trend and T4 trend charts, time is offset by -1 hour from ASK time
Time scale between grid lines is 10 minutes, when in use the scale is usually 1 minute between grid lines



Control Parameters Trend

It was apparent that:

1) The thrusters were receiving commands to the levels displayed by the feedback on the DP thruster's page,
2) The rig was losing heading to port but it had been stable prior to the change in thrusters output.

All DP computers where displaying similar information on the thruster's page, Until now, there have been no alarms on the alarm printer related to this incident.

The next action was to remove the manual bias to change commands to all thrusters to point freely in the direction which thrust was required, and to increase the system gains to encourage a speedy response to the expected move off location as the thrusters changed configuration and heading was recovered. Monitoring the thruster strip chart page and the control parameters page in conjunction with the DP screens, it was apparent that the thrusters were pitching as commanded, the commands were correct and the rig was coming back under full control.

Without the trend capability, it would have been difficult and taken longer to ascertain if the thrusters were following commands, that the thrusters were causing the loss of heading, not responding to it, and that zeroing the manual bias would be the best solution. The software bug in the biasing routine of the software has since been traced and removed by the vendor.

Incidents such as this are naturally investigated to identify cause and possibly find improvements to the corrective actions. The data obtained from the data logger is invaluable for this usage and nearly all the data is examined as a graph. Hard copies are filed to allow the information to be available to all DP-related personnel in an easy to interpret format. A written description of events would be difficult, both to compile and to digest. The strip chart graphs on the other hand show all the relevant information easily and very little text is needed.

In addition to assisting the duty DPO in deciding the nature of a fault and the best response, a strip chart is invaluable to someone called to the bridge to assist during a problem. Observing the relevant charts can quickly provide sufficient information to ascertain what is occurring, the seriousness of the problem and possible causes, thus saving time before action is taken. Often, an experienced operator's interpretation of the trend data will supply sufficient extra information to allow the problem to be identified and the correct action instigated.

Using strip chart trends to confirm software bugs.

Obviously, the ability to compare data graphically can be used to correlate cause and effect. The following is a simple example to illustrate the concept.

The rig was experiencing a larger-than-normal station keeping envelope with the DP current coming from right ahead. The current quality was oscillating from zero to 100 % and the DP stopped using current rate and direction in the TAL solution once the quality dropped below 50 %. The poor station keeping was obviously linked to the poor current calculation, but why did the current quality vary so markedly?

By comparing the trends of relative current direction, current quality and rig heading, we could see that as the direction crossed 360 degrees relative it dropped to zero, built back up to 100 % then dropped to zero as it crossed 360 relative again. This was causing the rig to oscillate, which increased the frequency of the current relative direction changing.

Apparently the change of direction from 359 to 001 degrees relative was seen as a 358 degree current shift, not 2 degrees, hence the drop in quality.

Once identified, the bug was quickly rectified by the vendor and applied in the next software upgrade. Meanwhile the rig endeavored to avoid having the DP current from right ahead.

Requirements for the equipment

It can be seen that there are certain core requirements from a strip chart software package, if it is to be used as discussed above.

Primarily:

1. The data recording frequency must be suitable for the data being recorded;
2. It must be stable and reliable;
3. It must be easy to operate;
4. It must be easy to select data for display;
5. There needs to be the option of saving chart layouts;
6. It must be easy to switch between chart displays;
7. There needs to be an industry standard data export format;
8. There needs to be a simple page capture and print facility.

Taking them in order;

To monitor data that is being updated every second, the recording frequency also needs to be every second, or data-points will be missed. Reference system and power spikes may have an impact on DP performance, but if an appropriate data-recording frequency is not selected these spikes may not be recorded and data analysis may not produce desired results.

If software is not stable and is prone to hanging, conflict or crashing, it probably will not be operational when it is needed most.

If software is not reliable, meaning that it does not provide consistent accurate results then it is unlikely to be used. The amount of work invested in learning new software is directly proportional to the quality of the results obtained and the perceived benefit.

It needs to be easy and straight forward to set the displays up. If the initial results are good, more displays will be configured. The more relevant data that is available to the operator, the better. However, there is no point in pre-configuring charts if they cannot be saved.

Neither is there value in having several quality pre-configured displays available if it is complicated and time consuming to switch between them. Each pre-configured display set, should have an optional hotkey assignment, and there should be a single key selection of any single chart on the display and single key return to full display. We should also be able to easily increase and decrease the scale of the display, in both amplitude, and time to facilitate observing and comparing short and long-term trends. All of this should be available without having to stop the display.

Incident investigation will require close examination of the all the data available. The quickest way to disseminate this data is electronically, so the data needs to be made available in a common, standard format with the data units for each channel clearly identified.

It is also desirable to be able to save charts of various events on the vessel, both electronically and as hard copy. While it is easier to store data on a computer, hence the need for a screen capture facility, people are more likely to browse through a folder of hard copy data than browse through a series of computer files.

Of the various different types of charting software I have used offshore, only one design had any direct input from the final user. This was by far the most superior, and consequently the most used. It has helped prevent several potentially awkward situations, and has been used to demonstrate and diagnose faults.

This in itself should be proof enough that when a manufacturer is asked to provide software for a purpose, or requires that software be changed to conform to equipment upgrades, then the operators should have a direct input. Failure to design software to meet the needs of the final users will produce a “dull tool” which in turn will result in the software being shunned, criticized, and in the worst case ignored.

Ideally, a knowledgeable, professional body such as the MTS DP committee, with significant participation by the end users, should investigate the use and requirements of strip chart and trending software with the aim of compiling a standard set of features and operability to aid manufacturers and developers to provide useful equipment. This in turn will aid the DP operators to spot problems early, and decide on a correct course of action before the DP problem becomes a DP incident.