Marine Technology Society

Dynamic Positioning Conference

21 - 22 October, 1997

Session 9:

Control Systems

Number and Location of Computer and Control Stations, Class 1,2,3.

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NUMBER & LOCATION OF COMPUTERS AND CONTROL STATIONS, CLASS 1, 2 3

In summary the IMO DP class notations are :

- **Class 1**

The slide shows the configuration of a typical Simplex DP control system which meets the criteria of an IMO Class 1 notation.

For equipment Class 1 the computer and control station need not be redundant.

You should note that the sensors such as gyrocompasses, VRUs and wind sensors are not required to be duplicated.

IMO Class 1 does not require that Position Measuring Equipment (PME) be duplicated. In practice most DP systems are manufactured with the capability for multiple PME interfaces and for operational reasons it is fairly unusual to rely on a single PME.

It is also interesting to note that the major classification societies have rules which in broad terms at least are the parallel to IMO Class 1, all of these specify the minimum number of PMEs as two.

The equivalents are :

- ABS - DPS 1
- Lloyds - DP (AM)
- DnV - AUT

The Computers/control station is normally located on the bridge in a position which suits the operational requirements of the vessel. General rules of visibility should be applied.

- **Class 2**

The slide shows the configuration of a typical Duplex DP control system which meets the criteria of an IMO Class 2 notation.

The DP control system is made up of two independent computers/control stations.

Common facilities such as interfaces, self testing/checking routines, data transfers etc should not be capable of causing failures on both control systems.

The philosophy behind this configuration is that one of the computers is selected as the online system. It has control of the thrusters.

The second computer is designated as standby. It is connected to all plant items, PMEs and sensors. It is also connected to the online computer and is constantly being updated with status information from that online computer. In other words the standby computer ‘tracks’ the online computer.

In the event of a failure in the online computer there is an automatic changeover which moves command from the online to the standby computer. This changeover is bumpless and is designed to ensure that no disturbance to the positioning operation is experienced.

Wind sensors and VRUs are duplicated, gyrocompasses are triplicated.

PMEs are also triplicated. It is not permitted (neither is it good practice) to meet this requirement with three PMEs based on the same operating principle e.g three DGPSs.

It is normal practice to mount both computers/control stations on the bridge.

Again, the chosen location for the control position should be chosen with the operational role of the vessel as the primary consideration e.g a crane barge would sensibly site the DP control location at the aft end of the bridge such that the DP operator is facing aft looking out towards the ‘business end’ of the operation.

As for IMO Class 1 we can draw broad parallels with the requirements of the major classification societies :

- ABS - DPS 2
- Lloyds - DP (AA)
- DnV - AUTR

Minor differences do exist between these various notations and advice should be sought before assumptions are made.

- **Class 3**

The slide shows the configuration of a typical DP control system which meets the criteria of an IMO Class 3 notation.

The DP control system is made up of a Duplex DP control system plus the addition of one back up simplex DP control system.

Under normal conditions the Duplex system is the one which is used. It behaves exactly like the Duplex previously required for Class 2.

The additional back up system is supplied with its own sensors and PME.

The switching from the Duplex to the back up Simplex is initiated manually. The switching is initiated at the back up location. A bumpless changeover from Duplex to back up is required.

The underlying philosophy of IMO Class 3 is that positioning can be maintained following and single fault including complete loss of a compartment due to fire or flood.

This clearly imposes some influence on the siting of computers and control stations (and sensors, PMEs, switchboards, prime movers etc., etc.).

The main control position at which the Duplex is sited should be chosen in exactly the same way as the Class 2 system described previously.

The back up system should not be in the same room as the main Duplex. It is required that the back up system is separated from the Duplex system by A60 class division.

It makes a great deal of sense to site the back up location within easy reach of the main Duplex location. A DP operator should be able to move between the two locations quickly and easily. Remember, he may eventually be asked to make the move between the two control locations under emergency conditions.

The requirements for the back up location are difficult (often impossible) to meet when considering conversions and upgrades of existing vessels. Clearly it makes little sense to site the main Duplex in the same location as the back up system. As Class 3 does not permit such an arrangement it is assumed that such an arrangement would only be considered by those who seek additional redundancy than that offered by a DP system which is configured to meet the minimum requirements of Class 2. Under such circumstances it is possible that a Triple Voting system should be considered as an alternative.

Again we can draw broad parallels with the requirements of the major classification societies :

- ABS - DPS 3
- Lloyds - DP (AAA)
- DnV - AUTRO

- **TRIPLE VOTING SYSTEMS**

A brief mention should be given to Triple Voting DP control systems.

These systems do not feature specifically in the guidelines of IMO or any of the leading classification societies. Such systems do meet the requirements of IMO Class 2, in fact these requirements are exceeded.

Triple voting DP systems do offer a number of benefits.

The slide shows a typical arrangement of a Triple Voting system.

All computers/control stations are sited together in a single location.

The benefits of such a system are :

- Redundancy in excess of the minimum required for Class 2. In theory a Class 2 operation may continue despite the loss of a single complete control system.
- Voting if performed on the incoming sensor values thus increasing validity of the values used by the control system.
- Voting is performed on thruster output signals.

Triple Voting systems are worthy of consideration.

SENSOR DATA REJECTION VOTING PROS & CONS

Sensor data rejection is very important part of the DP system integrity preventing dangerous situations from occurring.

Sensor data includes vessel sensors like vertical reference units, gyrocompasses, anemometers and position sensors like DGPS, Artemis, Acoustics and so on which are considered today but any sensor associated with the DP system should be checked for validity, sensor failures should be detected as early as possible and not cause dangerous situations.

Sensor systems have changed considerably over the last few years from analogue and simple serial protocols, to virtually all serial communications, NMEA messages being the trend and the future. With serial communications, more and more manufacturers of positioning systems, gyro's, anemometers etc. are moving to supplying standard NMEA messages. All of us here, think great, a NMEA message but how many manufacturers actually sit back and start thinking about the consequences of wrong data to a DP system, how stringent are there checks they make and who regulates the sensor manufacturers. Typically, action is only taken when the DP system suffers an incident due to a sensor failure. The outcome usually requires further checks in the DP or the sensor system, to overcome this particular scenario.

As sensor systems seem to grow in complexity, so the need for protecting the DP system from the unforeseen circumstances grow.

Typically in the past, sensors would be treated independently and rely on the operator to follow procedures before entering the sensor. (ie. visual checks of sensor, standard deviation's, numeric data etc) Today, there is a need to start checking between sensors of different manufacturers but with the same measurement principle, for example Artemis and Fanbeam (range and bearing systems) . The need to warn operators and protect the DP system is ever more important, this applies to DP and Sensor manufacturer's.

The following areas will look at how sensors are treated in the DP system:

- Availability and Rejection Criteria
- Voting
- Use of Operator Displays

Availability and Rejection Criteria

Availability and rejection criteria go hand in hand, prevention against making a sensor available for use is just as important as the rejection of an already selected sensor.

Sensors are available to the operator when the following checks are healthy:

- Basic checks are made in the sensor system itself and communicated to the DP system. This check relies heavily on status information from the sensor. So the understanding of that status with respect to sensor degradation is VERY IMPORTANT and should be made clear to DP manufacturer's.

  For example:DGPS system status/quality indicator, transponder timeout, tautwire pressure fault etc. conditions that are clearly and readily diagnosed as faults.

- Interface tests, generally time out checks on serial links and signal integrity tests on analogue signals (eg. 4-20mA continuity tests).

- Maximum rate of change checks.

  This checks that the measurement has not jumped by more than a credible amount since the last reading.

- Minimum rate of change or data frozen checks.

  This checks the measurement has at least moved a little since the last measurement. (ie. not frozen)

- Delays

  Time delays are included on all the above checks, this means the DP system will not make the sensor available until a period of healthy readings have been validated.

  The normal procedure is that a sensor has to fail a check for some time, say 10 to 15 secs, before being permanently deselected. During and after this time it is excluded from the DP system. If during the rejection period the sensor has valid checks the sensor will be introduced back into the DP system.

With one or two sensor systems, rejections are based on failing one of the checks above. With two sensor systems the operator should be informed of mismatches between the same sensors (eg. gyro, vertical reference units, anemometers). It is then upto the operator to decide which sensor is incorrect.

With three or more sensors (ie. 3 gyro's, 3 VRU's, 3 position reference systems etc.) voting techniques are employed providing further protection.

Voting

DP vessels will often use three or more sensors whenever possible or if class requirement.

This provides the facility for the DP control system to vote on the systems: typically this will involve taking the median value, the median being the middle value of three values. The median is not the average. The median value of 1, 5 and 94 is 5, the average is 33.

This provides a powerful technique for identifying a faulty signal, as all can be checked against the median. If one exceeds a preset difference from the median then it is deselected and the system reverts to the average of the remaining two. This should not result in a significant shift in the value used by the DP system. The maximum shift will be about half the median test.

This check will also reject a stationary value.

This voting system can be fooled by two perfect sensors eg. two DGPS systems using identical hardware suffered a loss of differential corrections without informing the DP system, the net effect the DP system followed the DGPS and the only good sensor was rejected. Different sensors for position measurement are always advised, where possible.

Displays

Most operators are more intelligent than the software, this ability can only be utilised if the operator has good data. The operator needs to be intelligent, alert, well informed and not confused. Good displays are very important.

The criteria for selecting any position sensor into the DP system should be made on the basis of what information is displayed, this should include local indication where applicable:-

- Check raw data
- Check standard deviation on sensor for a time period
- Check visually on motion page error/physical position if possible
- On selection check no substantial thrust demands

The criteria for selecting other sensors into the DP system should be:-

- Check raw data
- Check data against same type sensors

- On selection check no substantial thrust demands

The following DP mimics help in the selection and rejection process.

Early warnings of a bad sensor using information shown on displays:-

- Sensor dropping out on fleeting failures indicated by flashing selection buttons on screen
- Standard Deviation degrading indicated on Position Fix Repeatability page
- Visual display of jumping position on a motion page
- Data trends
- Position sensor weighting page - a shift in the weighting
- Alarms - mismatch, frequent failures

Conclusions

For the future DP and sensor manufacturer's need to look at the total integration of complex systems tied together by two wires. Information is the key, the DP system needs to know that the sensor is healthy, if a sensor degrades but not to the extent of giving bad readings, the DP system/operator MUST be informed.

DP manufacturers are forever increasing the number of checks to protect the integrity of the DP system, maybe hiding potentially lethal situations within the associated sensor systems. In the ideal world three sensors of the same measuring type allow clever deductions to be made with respect to automatic rejection BUT this type of configuration is costly, more complex and majority of the time not needed.

So it is perhaps upto sensor manufacturer's to supply systems which keep system integrity and the operator well informed, at the end of the day HE's THE BOSS, so let's help him and ourselves.

OPERATOR INTERFACE, COMPUTER ADVICE TO AVIOD ERRORS

Operator Interfaces have come a long way over the lifetime of DP technology i.e. around 30 years or a little over.

Some of you may recall DP systems with banks of moving coil meters, thumbwheel switches and, perhaps, green screen CRTs with very limited display capability.

The DP control system of today presents a very different interface to the operator.

Windows based operating systems, track balls, touch screens etc. are all available.

These new technologies have led to many advantages and to some disadvantages:

- MAIN ADVANTAGE

  Operators can be presented with an ever increasing quantity of data in an increasingly sophisticated way.

- MAIN DISDVANTAGE

  Operators can be presented with an ever increasing quantity of data in an increasingly sophisticated way.

What we mean is that DP manufactuers have to exercise great caution when designing operator interfaces. We must ensure that they are straightforward, easy to use, clear and, most importantly, safe.

One common technique which is employed on CRT displays is the use of contrasting colours to indicate the status. For example, everybody would recognise red as an Alarm indication.

Different colours are commonly used to convey the status of various component parts of the DP system. Steady state/flashing coloured icons can also be used to indicate equipment status.

The attached slide is a typical example of a screen display for a DP system.

The following colour codes are used:-

- Grey - not selected and not available
- Blue - Available but not selected
- Yellow - Selected and available
- Yellow Flashing - Selected but not available
- Red - Alarm

So, the first theme is to make the operator interfaces clear and to use contrasting colours to convey data..

But what else can be done to prevent inadvertent operator action.

The simplest of these concerns the interlocking of pushbuttons and other control input devices. Many DP systems require that ‘significant’ commands which are initiated via hardwired pushbuttons require two handed action. One hand to press the command button, the other hand pressing an ‘enable’ button. Simple but effective.

The screen equivalent of this is the ‘two click’ approach. Windows based systems can have commands initiated via, for example, a track ball with ‘click’ buttons. For ‘significant’ commands this first click causes a ‘confirmation’ window to appear. A second click is required to either cancel or confirm the command.

This procedure may seem a little extended, particularly if the operator is working under the stress of an emergency situation. However, it is in precisely these circumstances where most consideration should be given to prevent inadvertent operations. In any case, in order to save time, when the confirmation window appears on the screen the cursor now automatically ‘jumps’ into the confirmation window to save the time it would take an operator to manually move that cursor arrow. Even now the cursor arrow jumps to the safest position, the ‘Cancel’ position.

Conventions for data display and for control interaction are useful provided they are clear and consistently applied.

However, it is also the case that different individuals have the varying capacities for interpreting the data which is presented. Again the clarity for data presentation is vital, this clarity must survive all circumstances from sheer boredom to the stress of an emergency.

One further technique is to present operator data in a variety of formats and to leave individual operators to decide to make their own choice on selecting their preferred view. For example, thruster data could be presented in a dynamic graphical format using colour aspects as previously discussed, alternatively the same information could be presented in a data table.

Which technique is clearest ? I know my opinion but I do not know the opinion of every individual DP operator.

The key to this philosophy is not to present every operator with more data, rather it is to allow the operator the opportunity to choose a display presentation technique which he as an individual finds to be the most effective means of assimilating the data.

The slides demonstrate this technique when applied to the presentation of data concerning the ‘fixes’ and the ‘errors’ according to each PME.

SIMULATORS FOR TRAINING

Training in the use of DP control systems is clearly a very important topic.

Inadequately trained DP operators (DPO's) can lead to risk of injury, loss of life, equipment damage and major financial loss.

Training simulation packages are an invaluable means of conducting DP training.

Simulations permit basic training of unqualified operators seeking certification for the first time, at land based training establishments. They also allow refresher training for experienced operators and, when installed on the vessel, permit operators to become familiar with their installation prior to live operation.

This discussion aims to focus on Training College simulation facilities (Extended Simulation) although onboard training simulators (Simple Simulation) are also discussed here.

SIMPLE SIMULATION

Simple simulators are an integral module of the DP control system. They require no additional hardware and are delivered as a standard feature of many manufacturer's DP systems.

This slide shows the operator interface for simple simulations.

The main facilities available can be seen on this slide:

- Position Measurement Equipment (PME) Deployment/Recovery
- PME Low/High Noise selection
- Wind magnitude and direction setup
- Motion page for simulation setup

This relatively simple setup allows the DP system to be used for operator training and scenario testing.

It should be remembered that a DP system which is in simulation mode is not an active, online DP system. It can be used in this way when the vessel is tied up, in transit or in other circumstances where the DP system is not in active use.

Such simple simulation facilities are also an extremely useful tool which enables DP manufacturers to :

- Test the functionality of a DP system and the vessel model under known conditions prior to delivery of DP software.
- ‘Replaying’ fault situations enabling investigation of problems reported by customers.
- Demonstrating equipment at events such as this one.

EXTENDED SIMULATION

The extended simulation scenario is normally associated with land based training facilities. Several training establishments exist worldwide, all use some form of extended simulation facility.

Some DP users have installed such simulation facilities onboard.

When delivered to DP vessels extended simulators are constructed from additional hardware, and run sophisticated training scenario's based on a wide number of user settable parameters.

It's worth noting that the additional hardware which is required can be configured from the DP system spares. Thus little or no additional cost is incurred and two useful spin offs are gained:

- DP spare are kept 'hot'
- The simulator can also act as a test bed for suspect DP hardware modules

These extended simulators are connected to a DP control system via a control data network. The simulator is therefore used to exercise the DP control system and the DP operator, this commonly means that it can only be used when the vessel is not actively engaged in live DP operations.

Many training college simulators have the capacity to simulate any one of a number of different vessels types and configuration.

The training instructor establishes an Initialisation Plan (see slide), these may be stored and retrieved or created on line.

The Initialisation Plan defines the starting conditions for the simulation and it covers the following parameters :

- Enviromental (Wind, Waves, Current)
- Sensors
- PMEs
- Thrusters
- Power System
- Vessel position
- Vessel heading
- Water depth
- Vessel draft
- PME noise levels

The instructor then prepares training scenario's which run sequentially in real time and moves from the ***Initial Conditions*** through an ***Events Programme*** which may contain up to 200 instructions.**.**

The ***Events*** are strung together with varying time intervals between them. Training sessions can be constructed to last for a few minutes or for several hours. Situations which have occurred in real life can be re-created on the simulator.

The ***Events*** which can be controlled by the instructor cover and therefore introduced into the training session include (typically) :

- Environmental (Magnitude/Direction/Rate of change of Wind, Wave and Current)
- Sensors :
    - Compass (OK/Freeze/Drift/Offset)
    - VRU (OK/Fail/Freeze/Offset)
    - Wind sensor (OK/Fail/Lee/Offset)
- PME (OK/Fail/Offset/Error/Noise level 0 - 9)
- Thrusters (OK/Freeze/Fail to zero/fail to full)
- Power System (OK/Freeze/Fail of Generators)

The instructor monitors the reactions/responses of the trainee to these training scenarios.

The Events Programmes may be stored on floppy disc. In this way consistent training is achieved and instructors are able to monitor the progress of operators to familiar incidents.

CONCLUSIONS

Simulation is undoubtedly a valuable contribution to the training of DP operators.

Many training establishments offer training at a professional level.

Simple simulation packages are installed on the vast majority of DP vessels. Extended simulators are fitted on only a small minority of DP vessels.

When used effectively realistic training scenario's can be prepared and the trainee can be exposed to a variety of environmental conditions and equipment failures.

However, safe DP operations rely on a combination of different formats and simulation should not be relied on as the only training tool. Who would volunteer to fly with a 747 pilot whose only training was a number of hours on a flight simulator?