**DYNAMIC POSITIONING CONFERENCE**
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**Control Systems**

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# A Safer Ship to Ship DP Control Strategy

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# A SAFER SHIP TO SHIP DP CONTROL STRATEGY

Slides 2, 3 & 4

## The Problem:

For many years it has been common for dynamically positioned offshore vessels to manoeuvre and position themselves in the vicinity of other vessels.

A typical example of this is a supply vessel engaged in the transfer of fluids and solids to drillships, semi-submersibles, FPSOs etc.

A further example would be that of a shuttle tanker operating at the stern of an FPSO.

Slides 2, 3 & 4

I think that you will agree that operating in such close quarters, and doing so under DP control, demands that a safe and reliable DP control system is utilised and that suitable position measurement systems are interfaced to that DP control system.

The consequences of a DP problem in this situation can be immediate and severe.

Failure to properly control the DP vessel in the vicinity of other vessels and structures can lead to stresses on materials (for example hoses), stresses on personnel (including accountants) and could lead to collisions between vessels.

Such operations should NOT simply rely upon the classic “stay on spot” DP. Other factors must be considered and the DP control system must be tuned to respond to these factors.

In each example of operating scenarios that I have mentioned the DP vessel is required to position itself with respect to the other vessel and to respond by following the fore/aft and port/starboard movements of that other vessel.

The problem has always been that of following the rotational movement of that other vessel and of maintaining a position AND heading relative to it.

Slide 5

Slide 6

Some measurement systems exist which attempt to achieve this effect by placing GPS receivers on both vessels and interfacing them to gyrocompasses, delivering these measurements from ship to ship via radio data links and then performing comparisons between the position and heading of the two vessels.

Slide 7

These devices are widely used in the North Sea and other regions in connection with DP shuttle tanker/FPSO operations. When interfaced with a DP system and combined with other position reference systems they are widely accepted and used. Indeed they are considered to be “standard” equipment in these circumstances.

This solution is effective yet fairly complex, expensive and relies upon equipping both vessels with suitable electronics, power supplies etc., It also relies upon each vessel having suitable personnel to set up and maintain the equipment.

We believe that these are the reasons why this type of equipment has not been widely adopted for workboat style operations.

## The Solution:

Slides 8

ALSTOM has now developed a solution for this problem and it is available with the A Series DP control system. The solution can also be implemented in previous generation ALSTOM DP Systems such as the DPS 900 series.

The solution is in two parts:

1) The development of a suitable sensor which effectively, reliably and affordably measures the relative movement of the target vessel in three axes.

2) The development of a DP control mode which utilises these measurements and subsequently controls the DP vessel in response to the movement of the target vessel in three axes.

The “suitable sensor” involves the latest in position measurement technology. A laser measuring device known as CyScan has been developed.

A DP control mode known as “Ship Follow” is designed to enable the DP service vessel to simply and effectively follow the fore/aft, port/starboard AND rotational movement of the other floating vessel.

## CyScan:

The basic laser technology which lies behind CyScan has been developed for use in a variety of industrial applications over a period of many years. Alstom and its partners have extensive experience of these devices.

CyScan is based on a Class 1, eye safe laser. Its sensor element is a constantly rotating device and completes one scan of 360 degrees each second. The sensor element is mounted on a self levelling platform in order that it can maintain visual contact with the reflective targets despite the effects of pitch, roll and heave movements which are induced by environmental factors. This feature also permits reflective targets to remain in view even when draft changes to the target vessel and/or the DP vessel mean that the viewing angle between the CyScan sensor element and the reflective targets does not remain constant.

Slide 9

CyScan, is used to measure the position and relative orientation of a number (typically 3) of simple, passive (i.e. not requiring electrical power) reflective targets which are mounted on the target vessel.

Observations are taken from all available reflective targets during each rotation scan of the sensor head.

The reflective targets are passive (ie require no electrical supply), lightweight and easy to install.

Several types of target are available, these are typically simple reflective material mounted on either flat panels or tubes.

Slide 10

Slide 11

Slides 12, 13, 14, 15

By continuously monitoring the relative position and orientation of these targets CyScan can determine the position and heading of that target vessel relative to the DP service vessel.

It is CyScan's ability to "read" and internally process data from multiple targets which makes it suited to this task.

CyScan is reliable, fault tolerant and able to differentiate between good target reflections and false target reflections.

Whilst CyScan is also designed to operate in single target mode it should be noted that relative orientation of the two vessels (and hence difference in heading between the two vessels) can only be obtained when multiple targets are deployed.

Slide 16

The CyScan operator interface is a user friendly device which contains sufficient data relating to the relative position and heading of the target vessel to facilitate manual manoeuvres if required.

Slide 17

## DP Ship Follow Mode:

The DP Ship Follow mode is designed to provide an operator selectable option where the DP vessel can follow the position and heading of a target vessel provided by a CyScan measurement system.

Two sub-modes of Ship Follow are available:

- Pure mobile mode – the vessel immediately moves to follow each movement of the target vessel as defined by the CyScan.
- Mobile with fixed – a 'reaction circle' is given and the DP vessel will only move when the movement exceeds an operator pre-set maximum.

Each of these two sub-modes can operate either with or without heading follow. The heading follow element is operator selectable/de-selectable since it may be valid to undertake operations whereby the DP vessel does require to operate at a fixed heading.

Slide 18

In Ship Follow mode with heading follow selected the DP vessel can continue to follow the CyScan defined position fix as mentioned previously. In addition the DP vessel has to maintain the relative angle $\beta$ between the target vessel and the DP vessel.

Slide 19

To simplify matters it is instructive to consider what happens in the case where the target vessel is not moving in its fore/aft and port/starboard axes but its' heading is changing. It can be seen that the DP vessel cannot simply change its heading, as it would not maintain the same *relative vector* to the target vessel. Hence the DP system should maintain the same relative vector to the target vessel in the ship's frame of reference.

The dashed shapes show the new positions after a heading change of the target vessel. The heading change is exaggerated above for illustration - in real life conditions the incremental changes may not normally be so great.

However it is often NOT desired to continually attempt to follow minor changes and noise in the heading (and position) of the target vessel. The target vessels' heading will be monitored to ensure it stays within a permitted band of +/- 2 degrees. If the target vessel heading moves outside that band then the DP vessel's set heading will be adjusted by an amount equal to the band amplitude. The DP vessel will then use the normal DP heading change procedure to move towards the new set heading. This facility is designed to ensure that the DP Vessel does not respond to minor heading oscillations. Such minor oscillations would quickly become an irritant.

A similar facility also exists on the fore/aft and port/starboard position axes whereby the DP Operator may define a deadband.

The DP system will also compute a new destination for the control point based on the geometry similar to the above and the target will move towards the new destination.

On entering the Ship Follow mode a snapshot is taken of the vector in DP vessel co-ordinates. The DP operator can at any time alter the heading or position using the normal DP controls. This can be used to 'trim' the relative position and heading to the target vessel and will also alter the relative vector.

Users should be aware that the rate at which the vessel can follow is limited by the ramps as well as the velocities in the position and heading change code and by the size of the reaction radius and heading reaction band.

Throughout Ship Follow mode operations further position measurement systems may be available and selected for use by the DP control system. Typically one or more DGPS systems may be used. The DGPS is, in this instance, used to provide an *absolute* position measurement of the DP vessel (as opposed to the position of the DP vessel *relative* to the target vessel). In effect it is the CyScan which is used to provide an input to the DP system of a reference position and heading. The DGPS is used to control the position, the gyrocompass is used to control heading.

The DP system now has sufficient data to enable it to do the job and to significantly improve the safety and efficiency of ship to ship DP operations.

Slides 20 & 21

Slide 2 - Shuttle Tanker at Stern of FPSO

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# Slide 3 - PSV Offloading at a TLP

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# Slide 4 - PSV Approaching Semi-Sub

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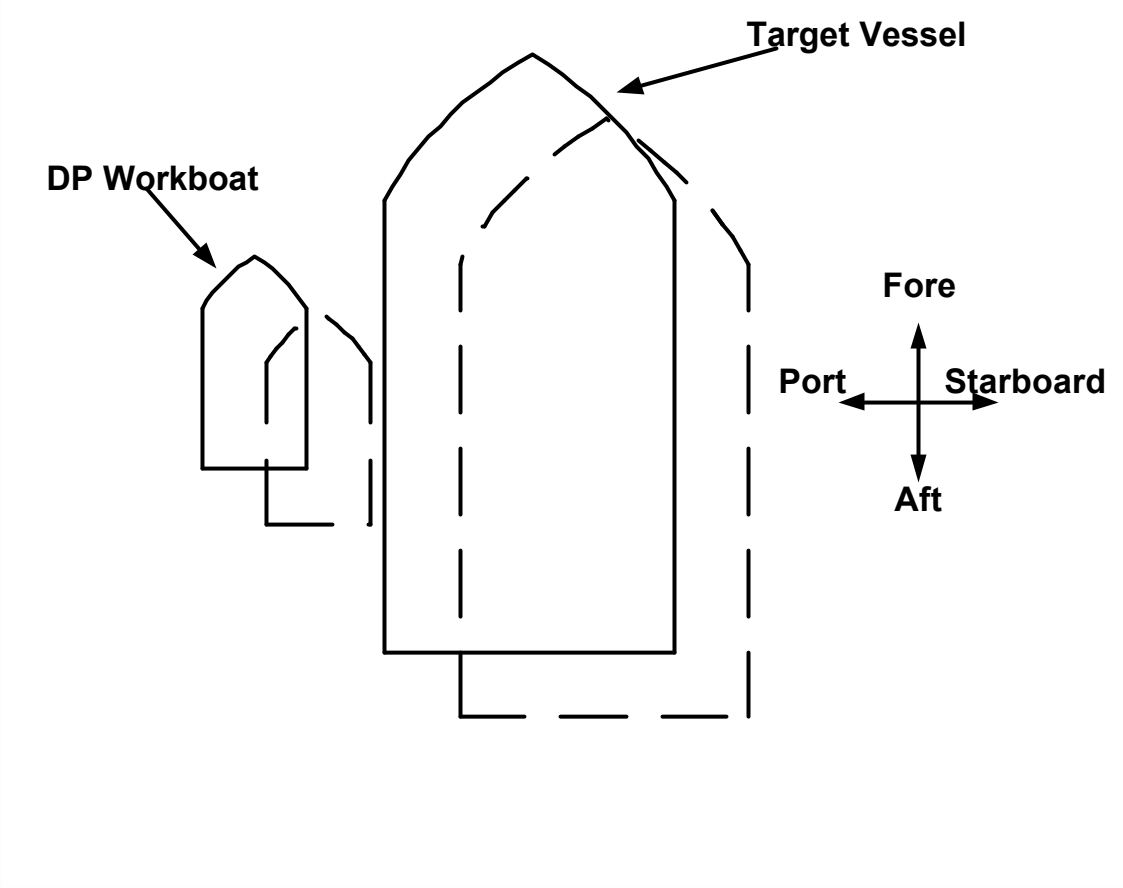


# Slide 5 - Workboat / Target Vessel Movement Relationship

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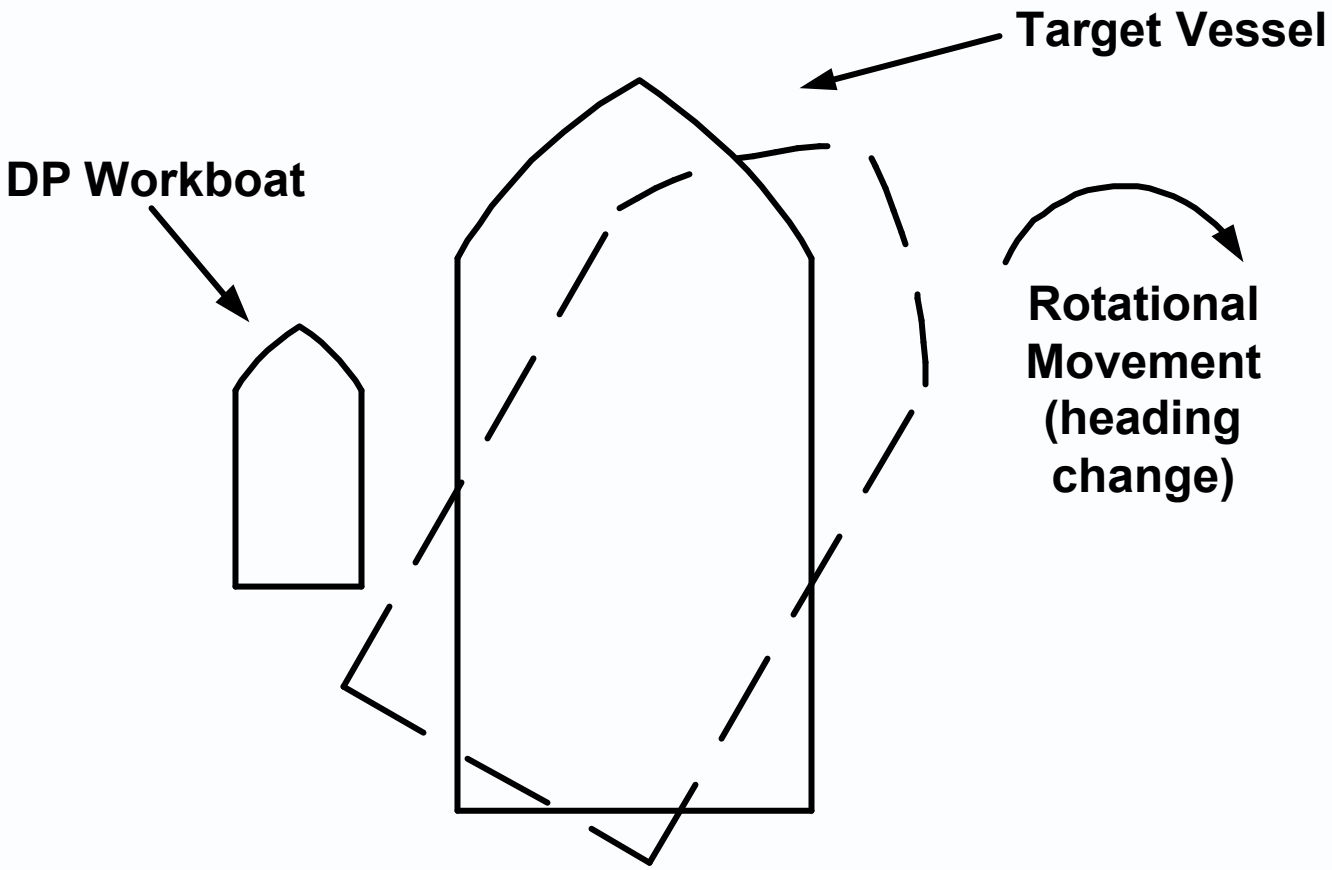


Slide 6 - Workboat / Target Vessel Heading Relationship

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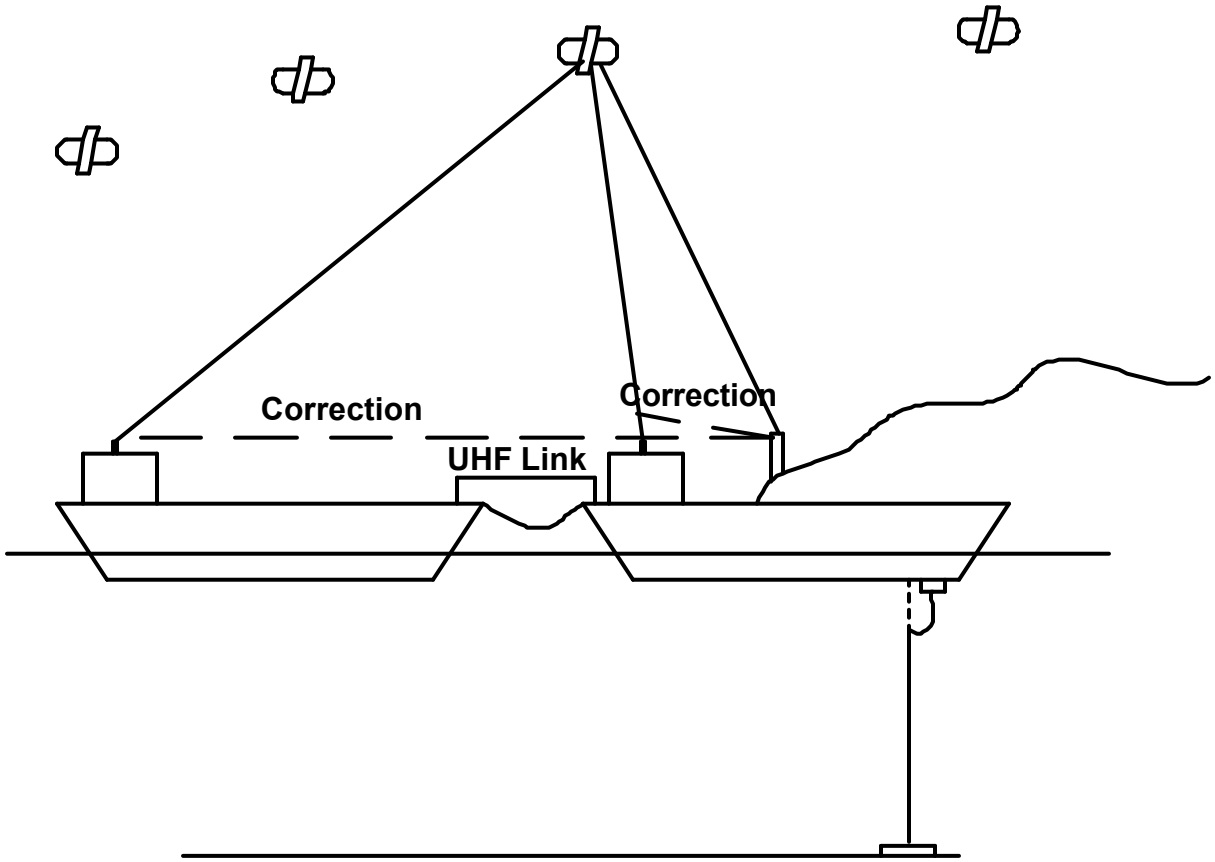


# Slide 7 - Relative GPS Operation

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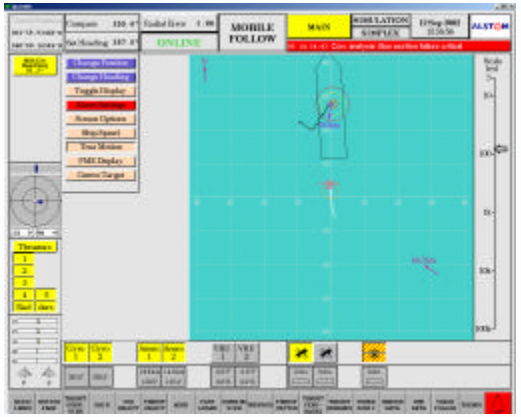
# Solution

- Suitable Position Reference Sensor

- DP Control Mode - Ship/Mobile Follow



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- Laser Beam Fanned in Two Axes

- Stabilized Levelling Platform for Wave Motion Compensation and Elevation Tracking

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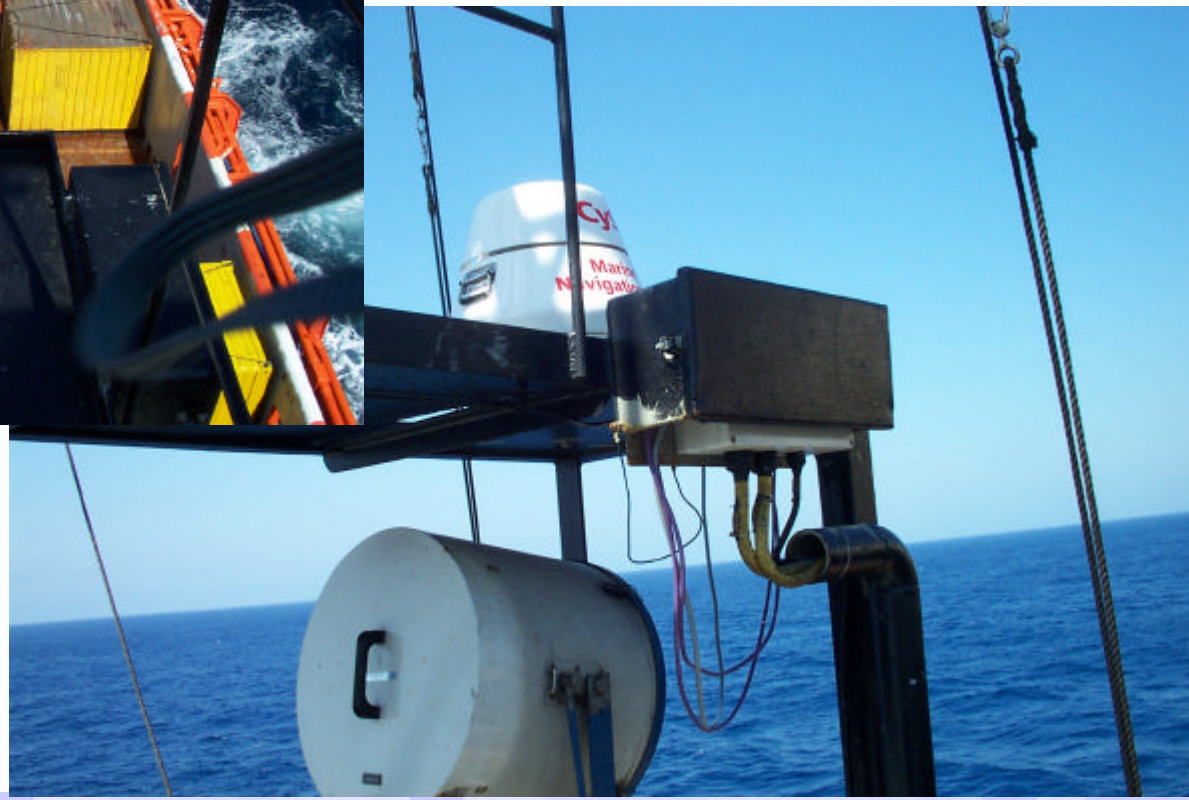

# Slide 10 - CyScan Located on PSV

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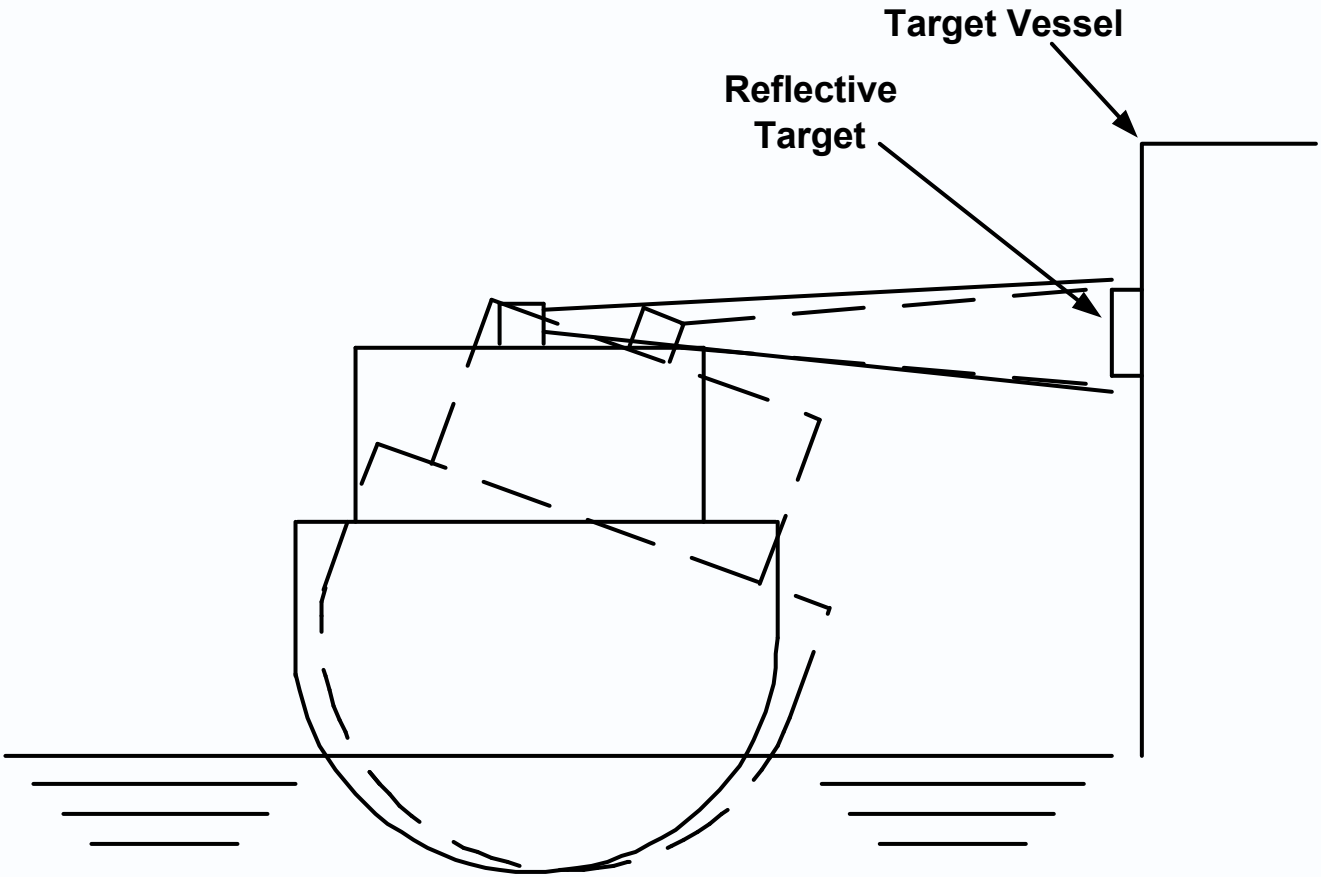


# Slide 11 - Effects of Leveller

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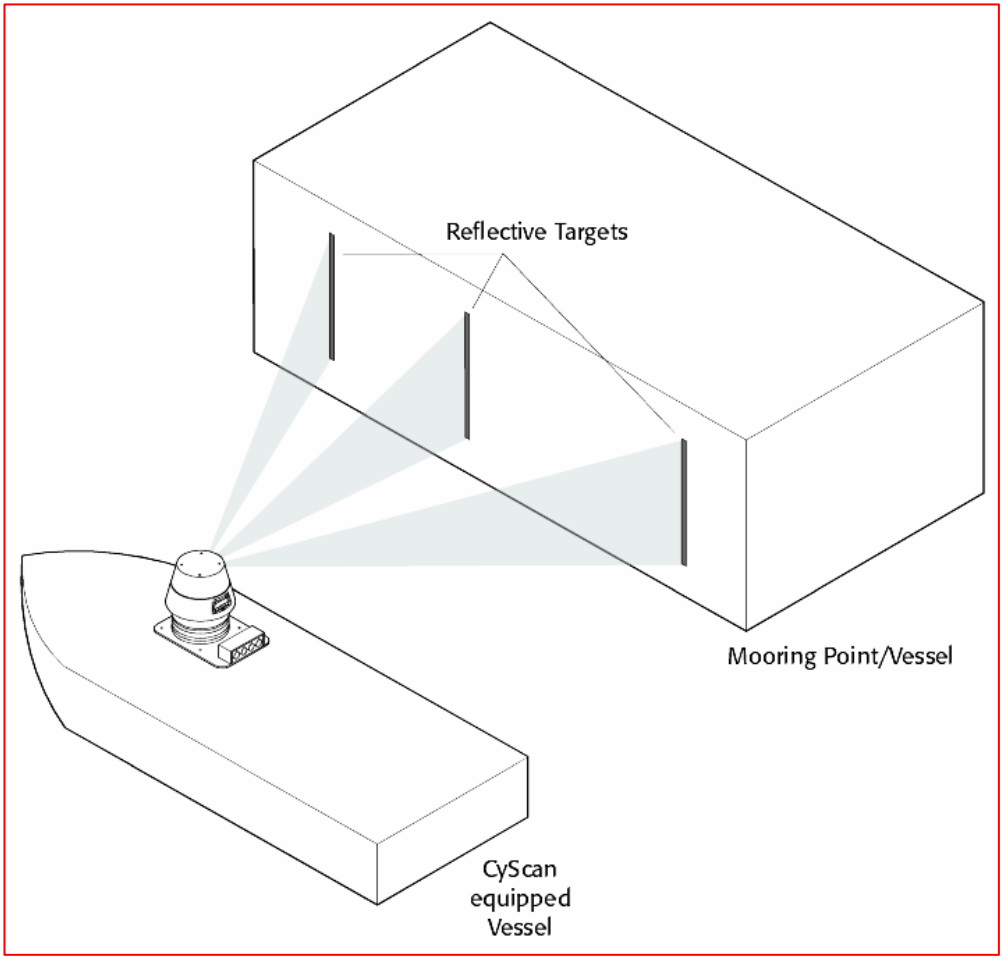


# Slide 12 - Typical Target Configuration

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# Slide 13 - North Sea - Targets on TLP

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# Slide 14 - North Sea - Targets on TLP

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# Slide 15 - Brazil - Targets on Semi-Sub

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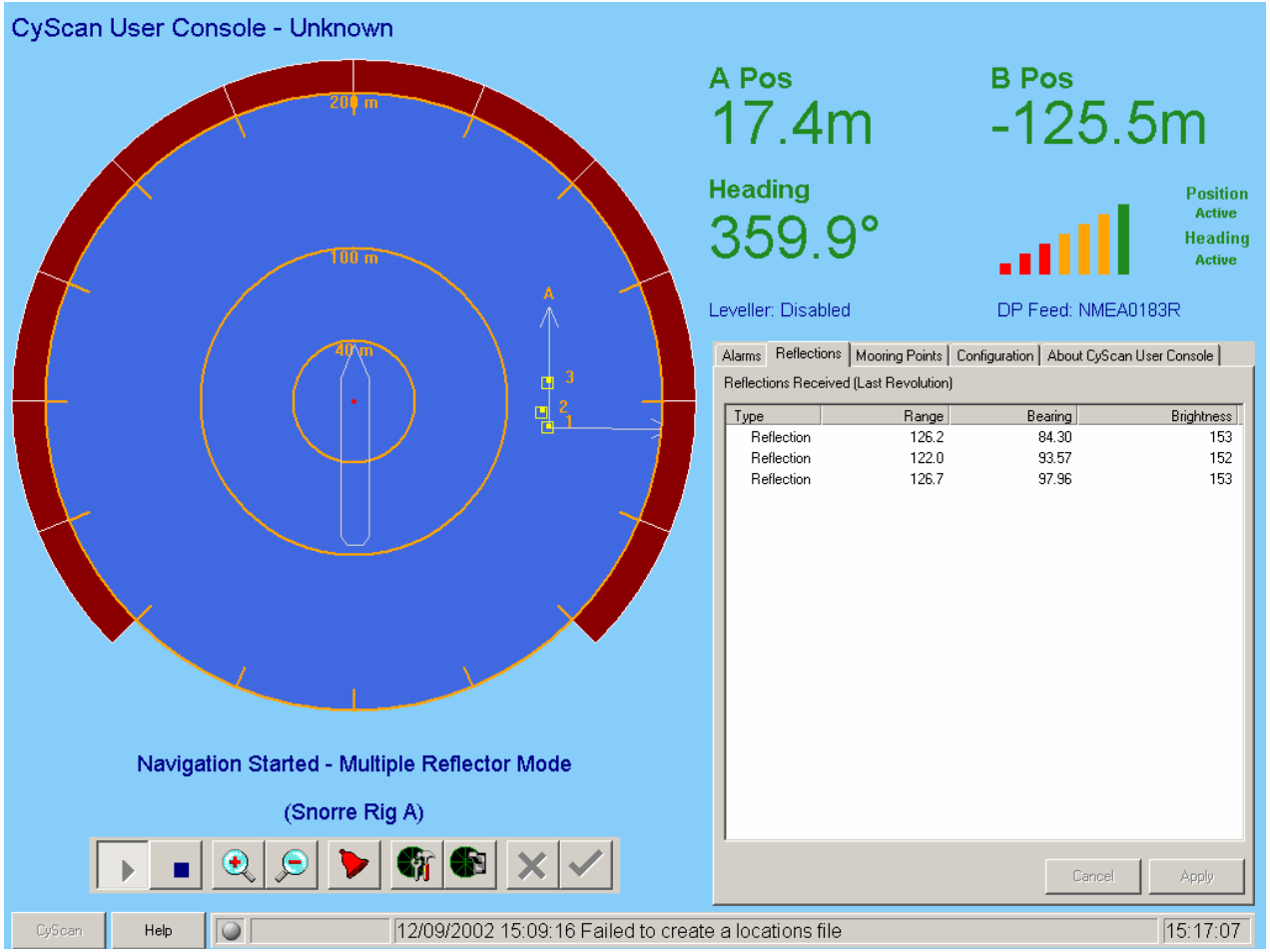


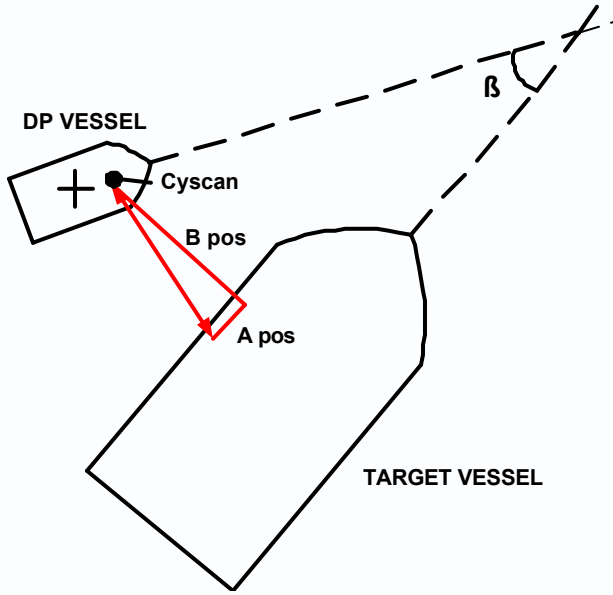


# Slide 16 - CyScan Operator Interface

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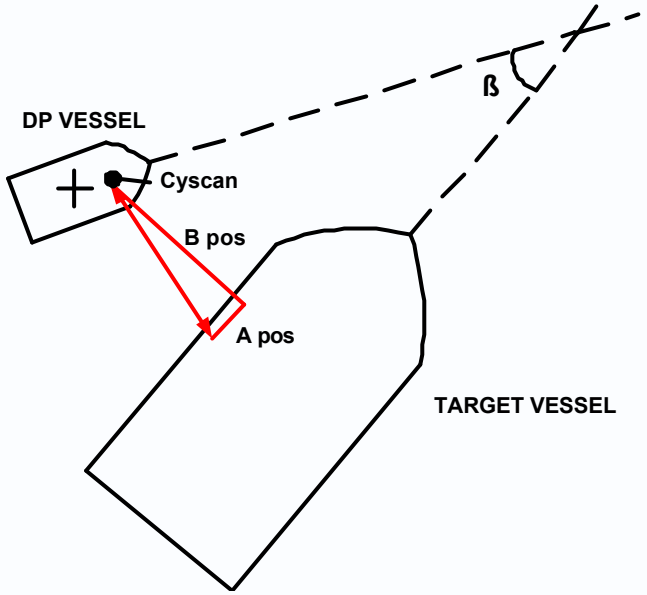
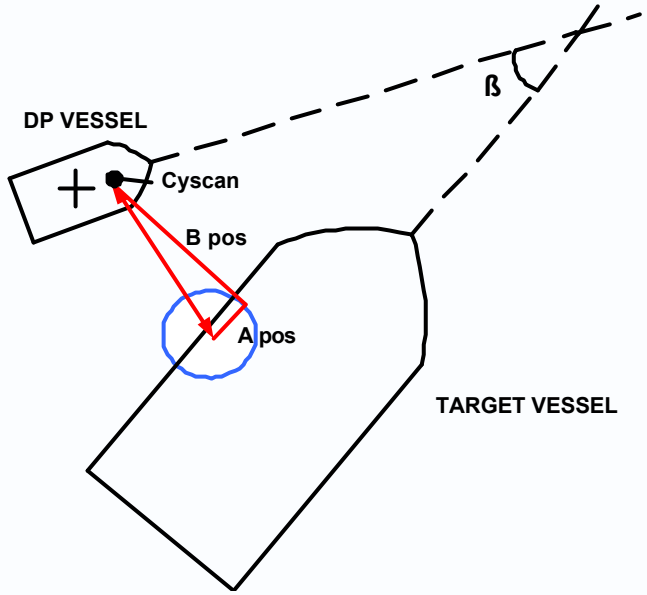
- Cyscan Main Features:-
  - Standalone System - providing relative position and heading information to the DP operator
  - Data base of all target vessels visited
  - Pitch and Roll Compensation
  - Manual/Automatic tracking of targets
  - Single target or multiple target tracking
  - Simple to use operator interface

- DP System Control Mode:-
  - Ship/Mobile Follow Mode

- Pure Ship/Mobile Mode
  - Ship/Mobile Follow with Laser System Only




- Ship/Mobile Mode with reaction circle
  - Ship/Mobile Follow with Laser System and DGPS system




# Slide 18 - Workboat / Target Vessel Relative Heading

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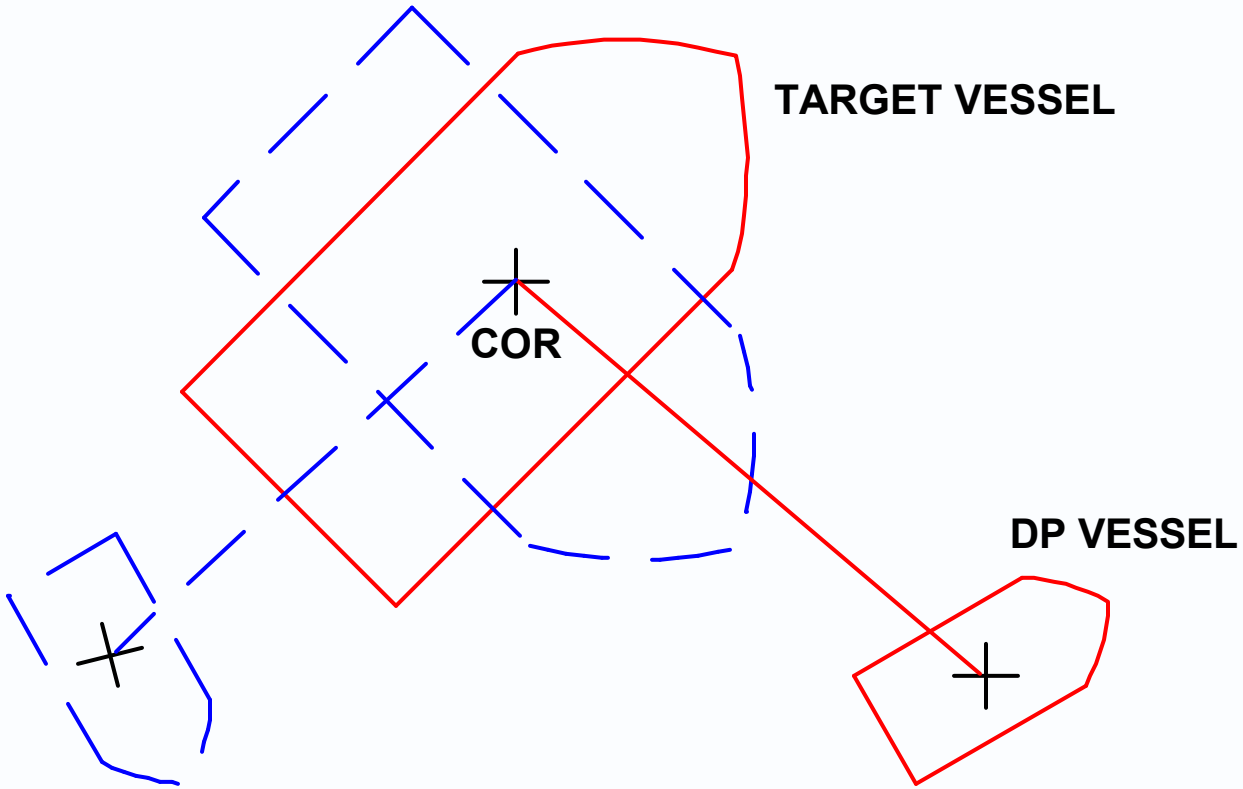


# Slide 19 - Workboat / Target Vessel Relative Heading Change

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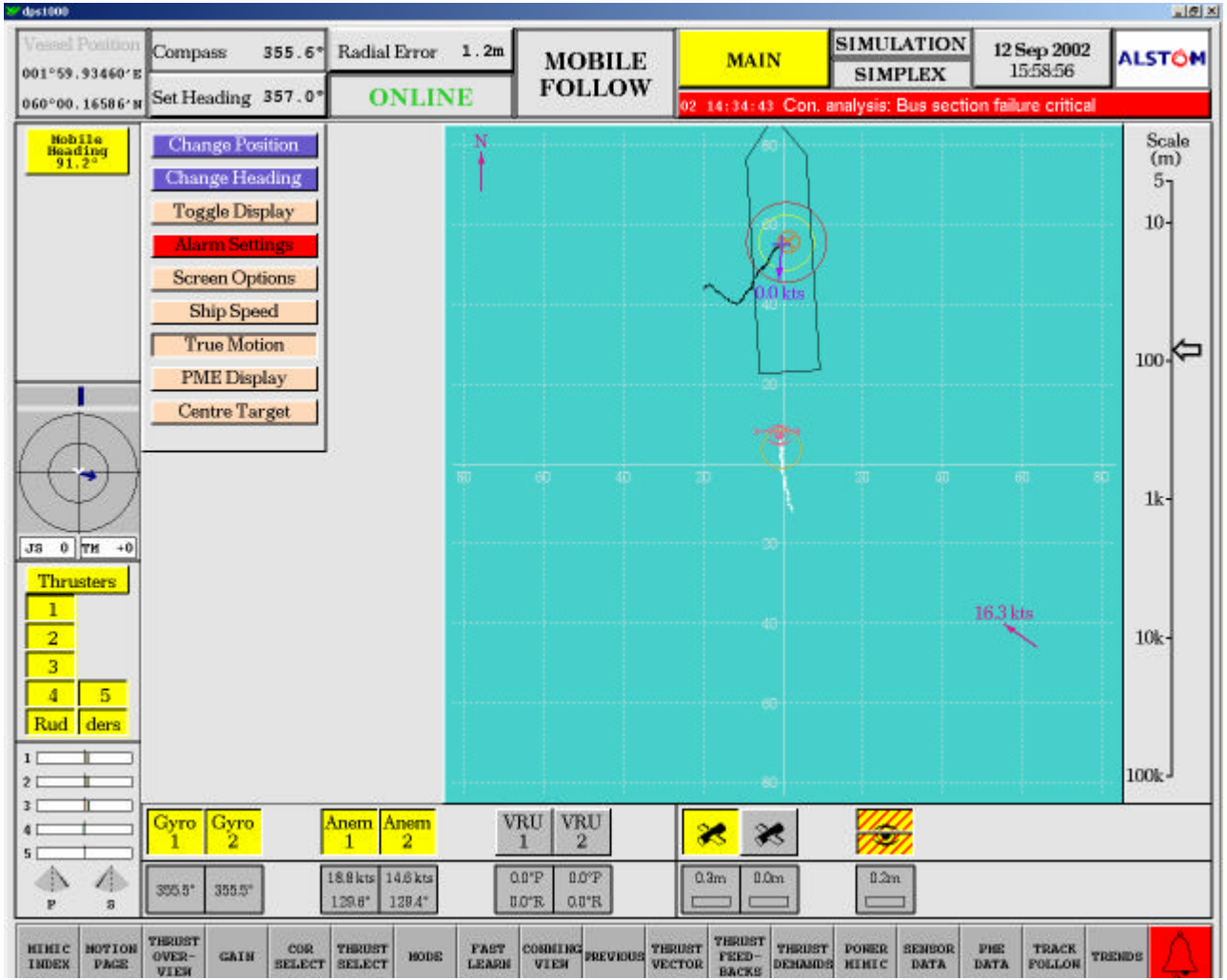
- Ship/Mobile Follow Mode features:-
  - Heading Deadband
  - Target Vessel Reaction Radius (operator selectable)
  - Target Vessel Heading Monitoring
  - Cyscan PME Icon (showing relative position and heading of target vessel)
  - Position and Heading changes (as per standard)
  - Operator selection of Target heading




# Slide 21 - Simple Simulation of Ship Follow

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