DYNAMIC POSITIONING CONFERENCE
October 14-15, 2014

DESIGN AND CONTROL SESSION

Approach for Advanced Testing of DP Control System

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Abstract

Modern DP control system is a complex HW/SW product interfaced with number of other systems through different types of interfaces. In most cases such systems are made by different manufacturers.
Because of fact that whole DP system and its integral parts can be tested only on-board the vessel its operational stability potentially reduced. Moreover depth of such on-board testing is not deep enough to provide required systems functional and operational stability.
Using of a complex Ship motion and Data simulators for factory testing of DP Control System is one of approaches to improve situation. Wide ability for simulation of dataflow, interfaces, faults, errors and malfunctions provide this approach huge potential for advanced testing of DP control system.
Such testing includes not only hardware (interface signals type and protocols) but also functional tests of built-in software, performance and failure handling ability.
Navis Engineering OY is a developer and manufacturer of Dynamic Control systems since early 2000.
This paper represents experience and approach of the company in design of Ship motion and Data simulator for factory acceptance and internal testing of own developed DP control systems.

Introduction

Recent years DP systems become more and more demanded by the marine industry. Initially mostly used for offshore oil and gas sector now it's applied for many marine applications and different types of vessels, even for passenger ferries. Day rate of modern DP vessel costs high enough and every day of demurrage leads loss of investments and operational efficiency, that's why all processes needs to be optimized starting from design and continue when vessel starts to operate.
Growing demands in combination with requirements for fast system delivery leads to lack of time and tough schedule for design, production, testing and commissioning of DP control system.
This challenge actual for any manufacturer: - how to get reliable, robust, stable and high quality product in limited time frame. Specific thing of DP control system is that it is a "heart" of whole vessels DP system interfaced with number of sub-systems (e.g. thruster, power system) which add complexity to this challenge.
Another task is supporting of already delivered system. They are living and time to time require upgrades (up to higher class), refits, updates and 24/7/365 service, indeed.
That means before delivery of the system/upgrade/update it should be prepared as good as possible for further "plug-n-play" operations.
Mentioned issues can be at least partly resolved using extended simulation tools for DP control system pre-testing, verification and debugging.
In the nowadays there is no any standards of the DP system testing or test –bench designated for such purposes. One of approaches is HIL (Hardware-In-the-Loop) widely used as DP system testing, it allows system verification by the 3rd party before\after its delivery.
But for some purposes it difficult to be applied (e.g SW\HW verification during all project lifecycle, pre-calibration, adjustments and after delivery troubleshooting). The alternative wider and beneficial approach for these purposes - using of custom DP simulator for DP control system during its design and commissioning, starting from the very beginning of the project.

Problem statement

Following IMO MSC\Circ.645:
DP system means the complete installation necessary for dynamically positioning a vessel comprising the following sub-systems:

- Power system;
- Thruster system;
- DP-control system;

DP-control system means all components and systems, hardware and software necessary to dynamically positioning of the vessel. The DP-control system consists of the following:

- Computer system\ joystick system;
- Sensor system;
- Display system (operator panels);
- Position reference system;
- Associated cabling and cable routing;

There are three IMO DP classes: Class 1/ Class 2/ Class 3.

Except of IMO\CS classification there is a number non-classified system (e.g DP-0, extended DP-1 and DP-2).

Practically, minimal supply of DP control system consists of the following HW, SW and set of documentation:

- PC's with installed SW (core SW and customized vessel configuration data);
- Control panels with firmware/ software;
- Controllers (PLC) with installed SW (core SW and vessel specifics configuration);
- Interface boxes;
- Set of installation\operation and user documentation;

During the vessels lifecycle the following changes can be implemented to initially delivered configuration:

- SW update;
- SW upgrade;
- HW\SW upgrade;

All of those configurations have to be properly tested and debugged prior to delivery and commissioning.

Because of specifics, different kind of configurations requires different test-benches: - "new-build" DP control system has to be tested on a full HW\SW test-bench replicating real vessels DP system configuration (including electrical connections) and simulating hydro\aerodynamic of this vessel (mathematical model of specific vessel) while upgrades can be tested with SW test-bench only (without all equipment available for testing).

Every SW developer knows that quality of the final product depends to considerable degree on the test tools.

This approach requires classification of the test benches and their purposes.

Applied methods and test-bench family

Software lifecycle within the particular project includes two testing levels- DP software version release testing and DP configuration testing. Both levels applied for QA verification of every delivery and include number of stages:

DP software release:

- Internal testing of core SW (SW debugging verification and tests of custom protocols);
- Internal testing of documentation;

DP configuration:

- Review and approval of the project documentation by Classification society;
- Internal testing of every HW component of the system (including internal wiring)
- Internal testing of algorithms and customized vessel configuration data;
- Factory acceptance testing;
- Dock and sea trials;

Most of steps optimized with using different type of test-benches.

Based on the practice test-benches divided into three types (so-called **S**mall, **M**edium and **L**arge) depending on the complexity of the tested system and goal of testing.

Type **S:**

Simulator SW and SW for testing installed at common PC communicating via virtual interfaces.

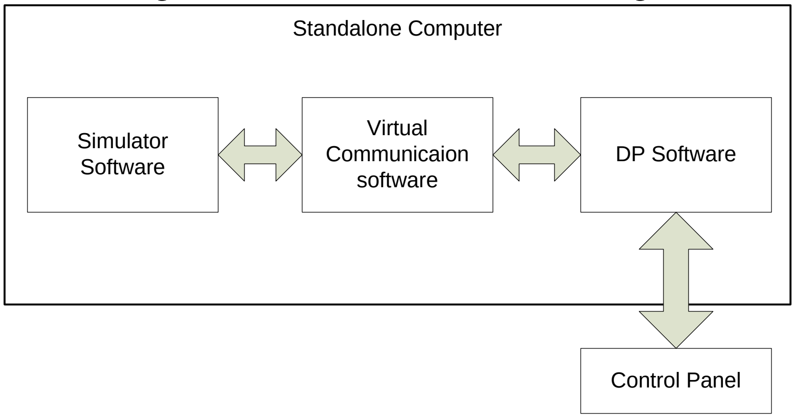


Figure.1

Type **M:**

Simulator SW installed at standalone PC, SW for testing installed at dedicated PC's, communicate via Ethernet. PLC is used for testing of embedded SW.

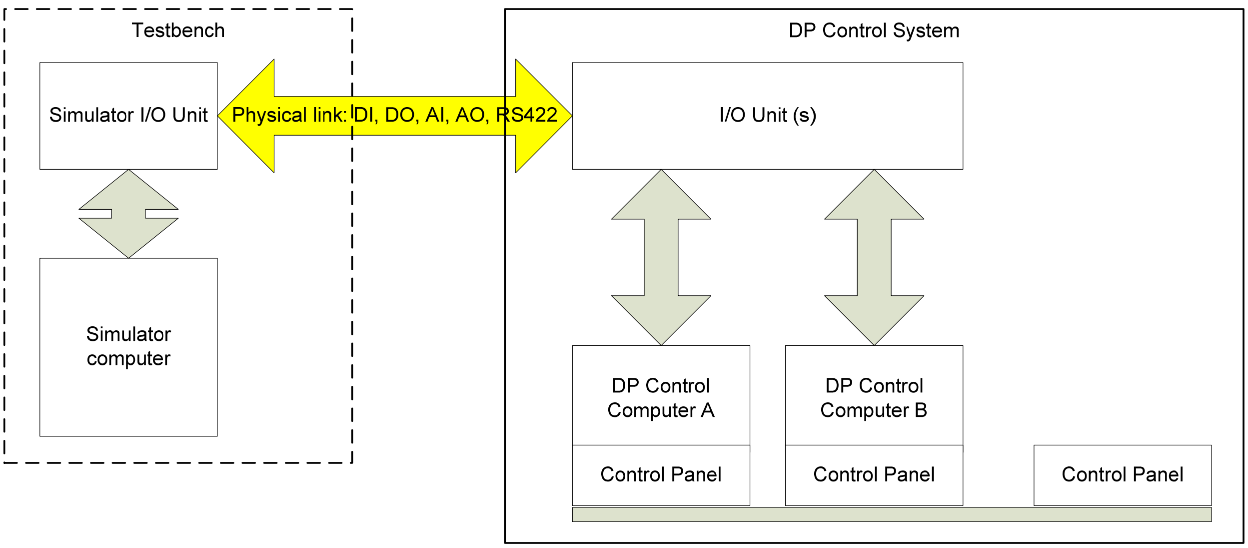


Figure.2

Type **L:**

"Full mission" test-bench. Simulator SW installed at standalone PC connected to Model I\O unit via Ethernet. Model I\O unit is intended for simulation of external systems data flow via real interfaces. Model I\O unit connected to real DP control system via Ethernet.

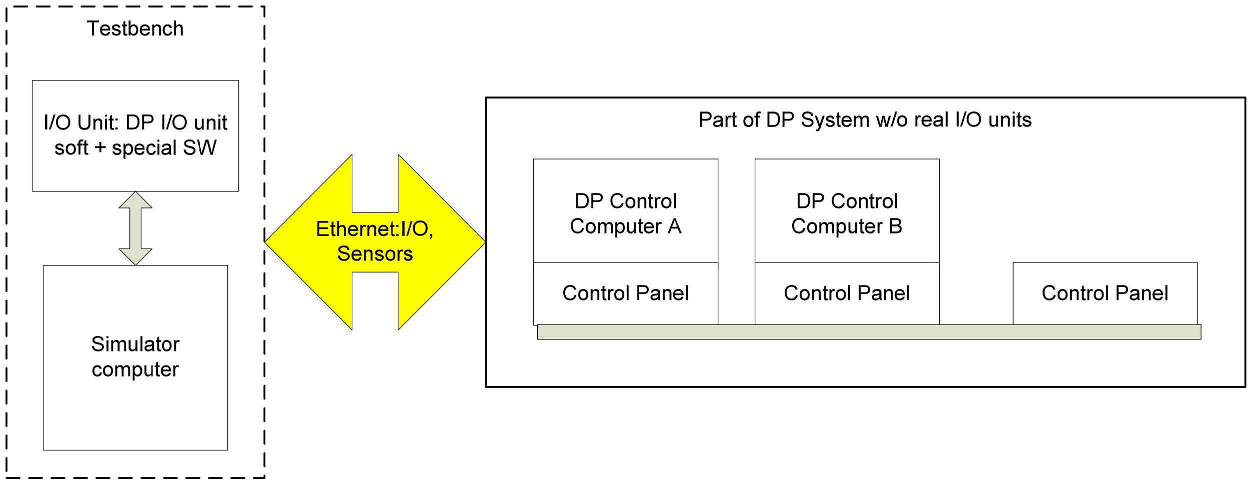

Testbench
I/O Unit: DP I/O unit soft + special SW
Simulator computer
Ethernet:I/O, Sensors
Part of DP System w/o real I/O units
DP Control Computer A
DP Control Computer B
Control Panel
Control Panel
Control Panel

Figure.3

DP-2 test-bench connection

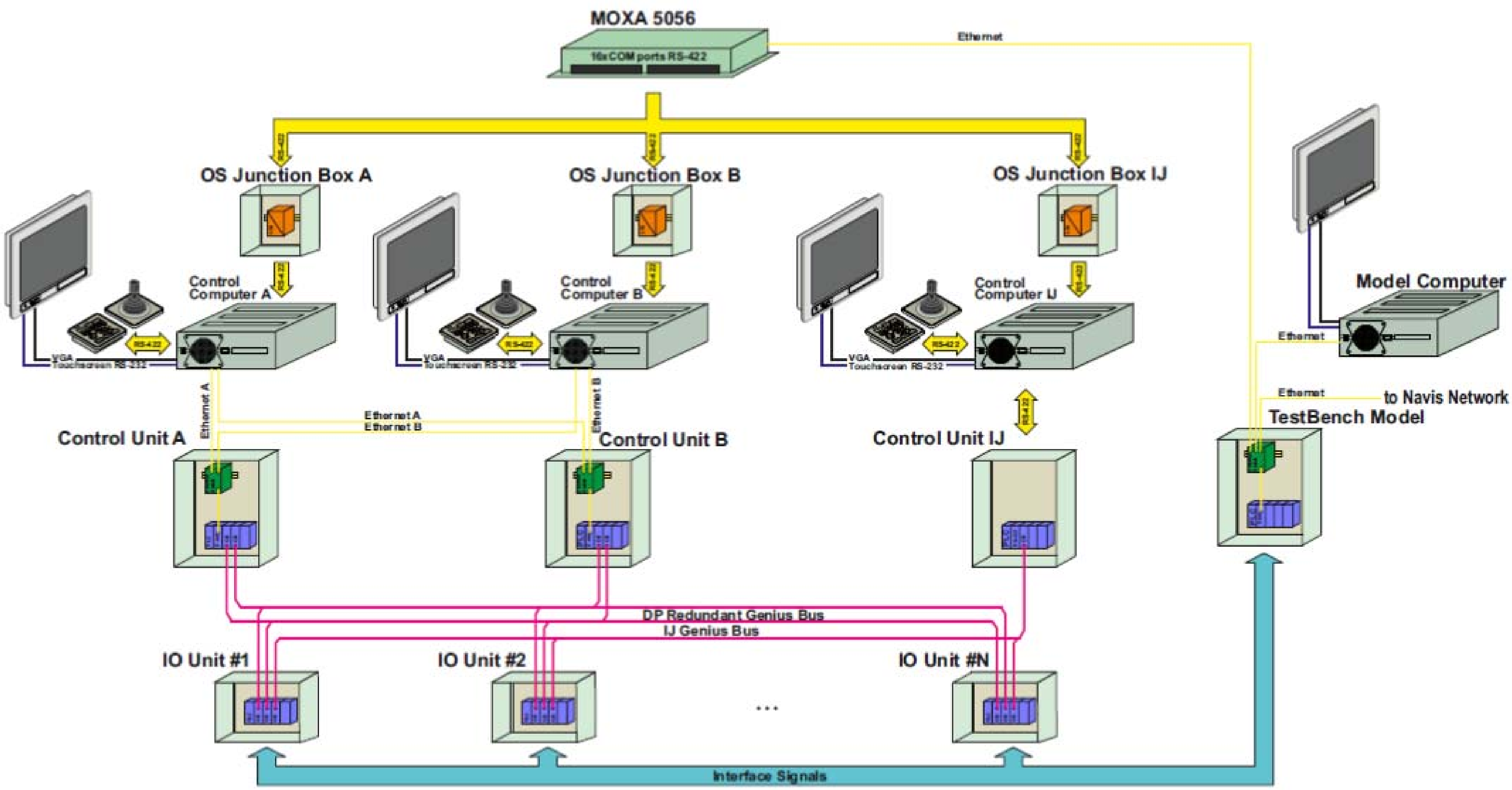


Figure.4

Every type of test-bench can be used for different purposes but generally sorted as:

Task	S	M	L
SW development	+	+	+
SW version stabilization\release	+		+
Release documentation check	+		+
FAT of class\non-class system			+
FAT of upgrades	+	+	
Debugging	+	+	+
Troubleshooting	+	+	

Pros and contras of test-bench types:

Type	S	M	L
Description	Vessel model and simulation SW (simulator) run on the same computer.	• Vessel model and simulation SW (simulator) run on standalone PC's. • PLC with embedded SW • Ethernet virtual ports for data communication between PC's.	• Vessel model and simulation SW (simulator) run on standalone PC's. • PLC with embedded SW and analog I/O for simulation of signals handshaking (command/feedbacks) • HW for simulation of custom interfaces (e.g EPP Modbus\Profibus interface) • RS 232\422 COM-ports for sensors data simulation.
Purpose	• Testing of core SW functionality; • Testing of algorithms and configuration data; • Troubleshooting;	• Testing of core SW functionality; • Testing of PLC HW\SW component; • Testing of algorithms and configuration data; • Testing of SW upgrades;	• Testing of core SW functionality; • Testing of all HW\SW components of the system (including internal wiring) • Factory acceptance testing • DP familiarization and maintenance trainings
Wiring	Virtual interfaces(PC memory)	Ethernet connection;	Wiring reproduce real vessels configuration;
Pro	• Available for any specific vessel and configuration. • Fast ready to use.	Ample opportunities for configuration;	Close to real system testing;
Contra	• Impossible to test PLC SW; • HW faults emulated with the simulator SW;	Not all functions and parts able to be verified.	• Requires all HW components available. Limited in configuration. • Difficult in connection. • Time consuming for up and running

Simulator software overview

Every type of applied test-benches includes simulator software. This SW customizes for every particular project and includes vessels mathematical model associated thrusters, sensors, power station etc. This is additional complexity for implementation but as a final benefit this model can be used for DP control system built-in trainer.

Following requirements applied for every simulators SW mathematical model:

Ship motion

- Realistic vessels dynamic;
- 6 DOF (including roll and pitch);
- Ship displacement\draft (constant or variable);
- Proper thrusters forces in bollard-pull and free-run (for AP);
- Realistic environmental disturbance – wind, wave, current;

Thrusters

- Proper dynamic;

Local control

- Faults simulation: control failure, noise in feedback, dead-band, low speed, feedback loss, time-delay, etc;

Power Station

- Circuit breakers control connect/disconnect;
- Load sharing between buses;
- Additional load on buses (external consumers);
- Faults of breakers (signals), generators;
- Specific interface, if necessary;

Sensors, PRS's

- Real model of measurements;
- PRS antenna position depending on roll, pitch;
- Roll\pitch sensor;
- Gyro\Magnetic compass with deviation model;
- Hydroacoustic system and associated beacons;
- Laser\ microwave radar with associated reflectors;
- Configurable data output – NMEA, or other format
- Faults simulation: data drift, data jump, data noise, data corruption, no data, etc

Hardware (for test-bench without real hardware)

- For test-bench without real hardware – emulation of HW faults (PLC, etc)

Software: CotMACS-JDP

OS: Win XP\ Win 7

Main Simulator window (project "oblique icebreaker" Baltika)

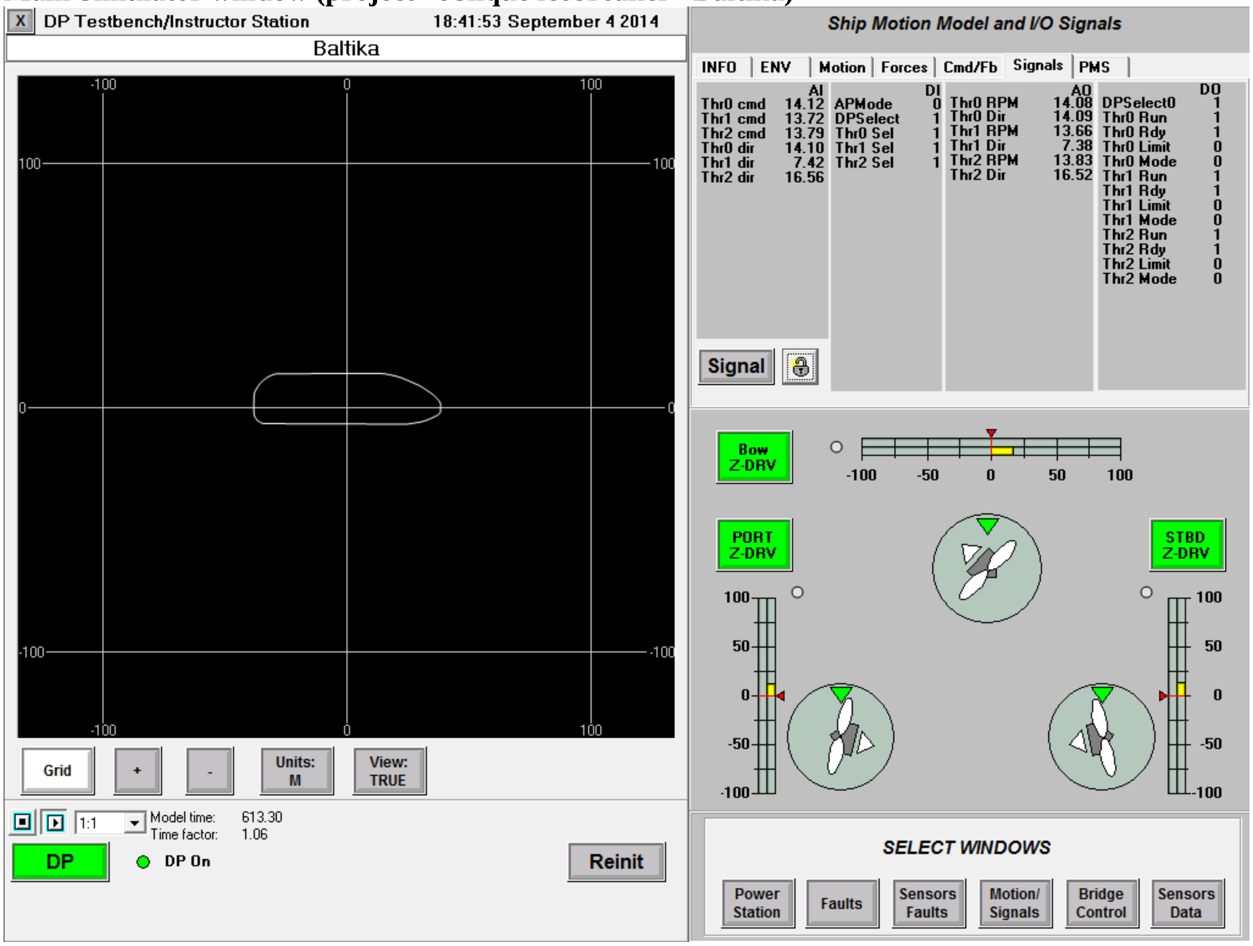


Figure.5

Practical examples

Wire broken\ signal faults and other tests are doing during the FAT program, software and configuration tests

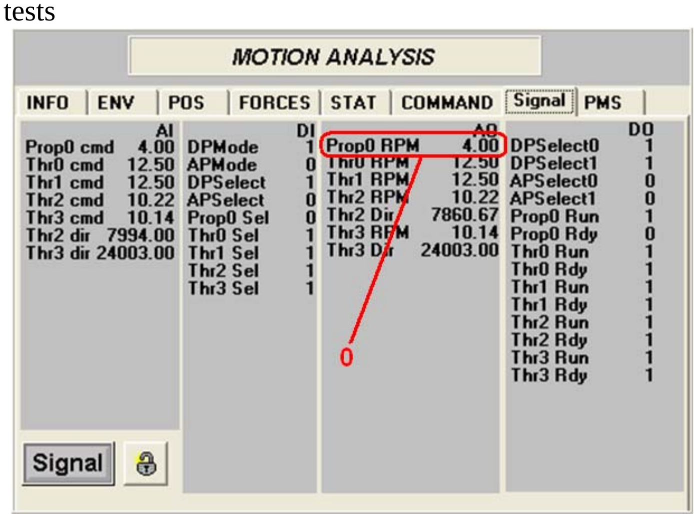


Figure.6

Signal monitor function constantly checking availability and health of data flow establishing auxiliary ethernet communication between DP and Simulator Computer.

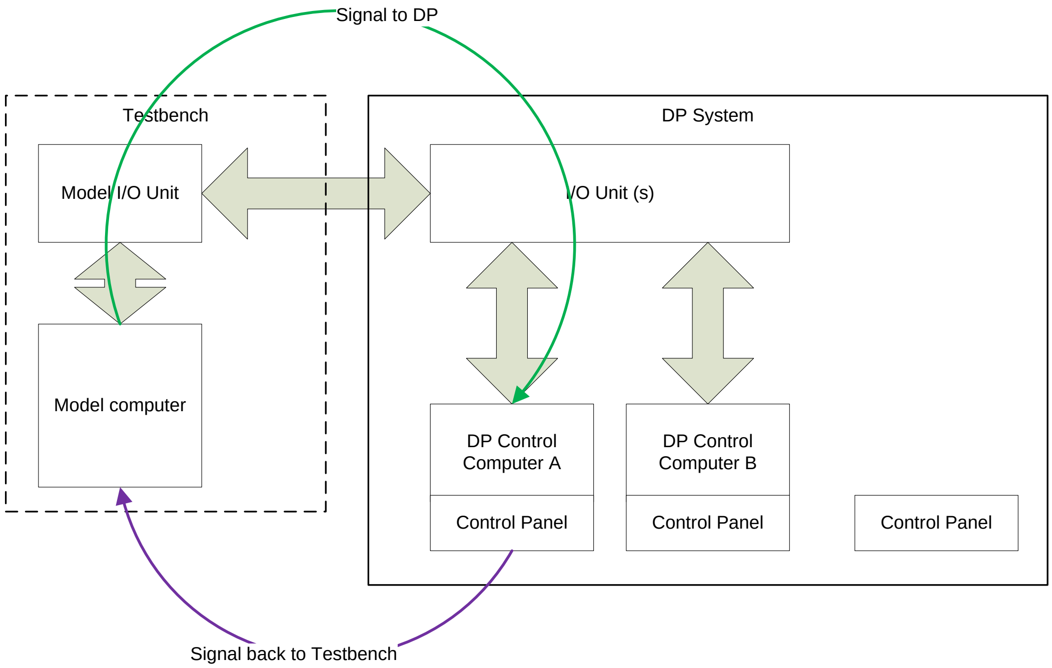


Figure.7

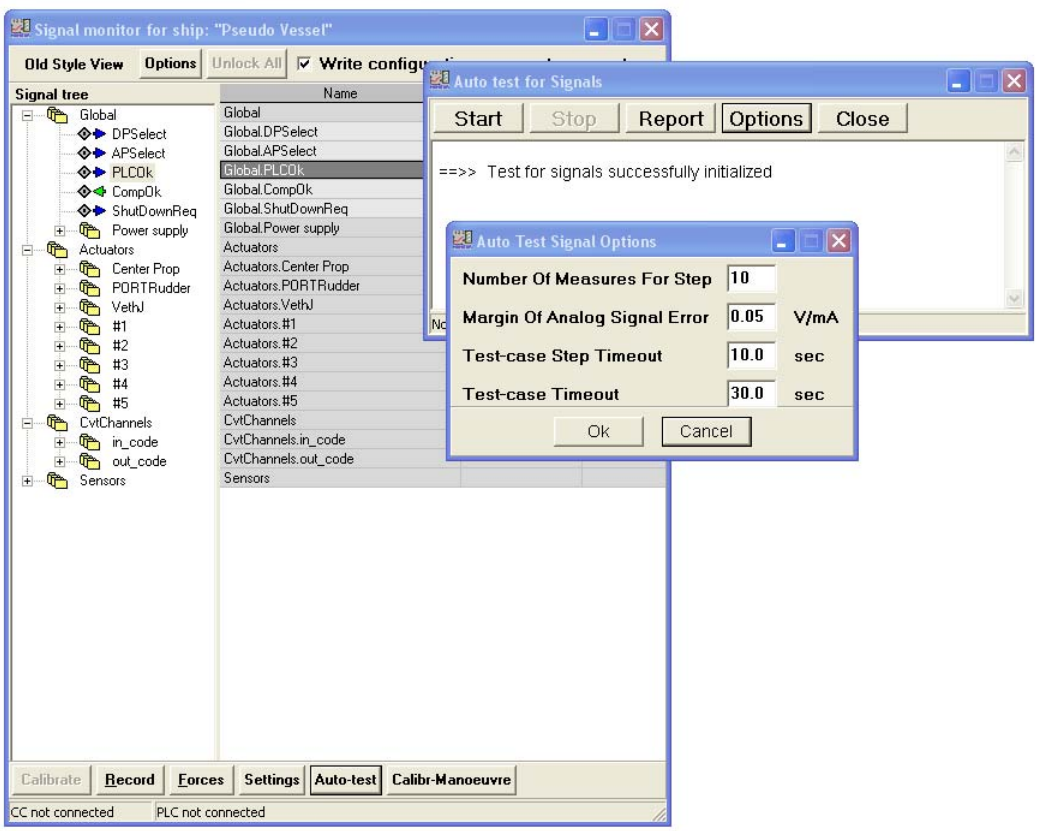


Figure.8

Parameters of outputted sensors data are widely configurable right in online.

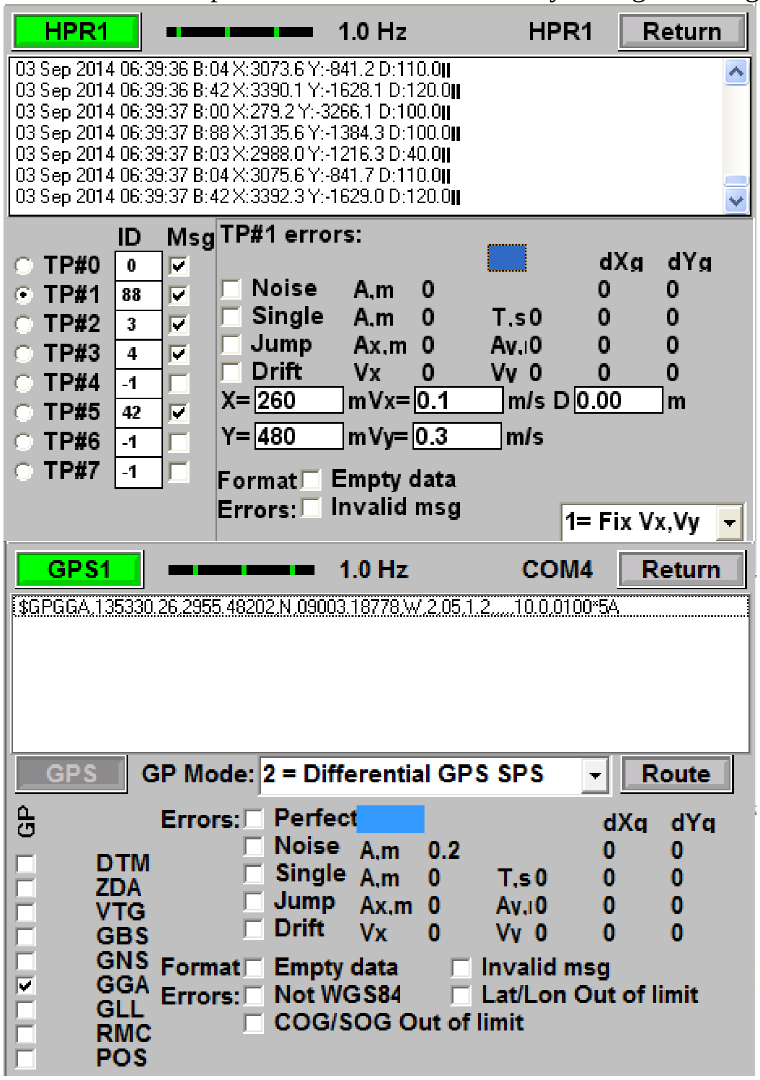


Figure.9

Simulation of GPS signal noise can be customized.

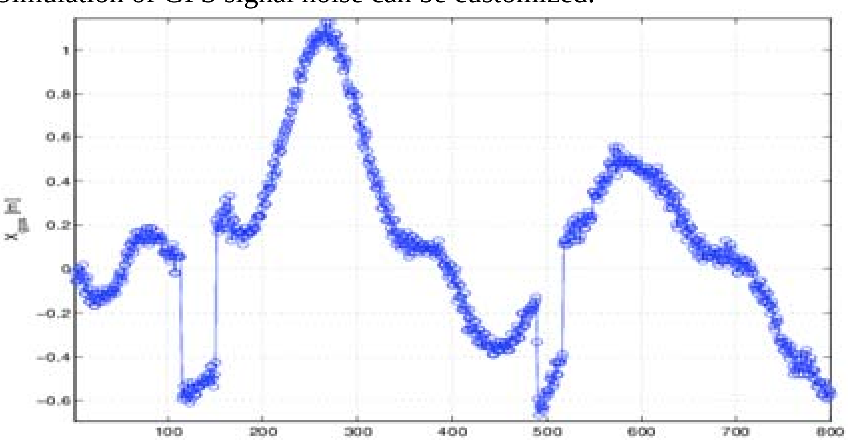
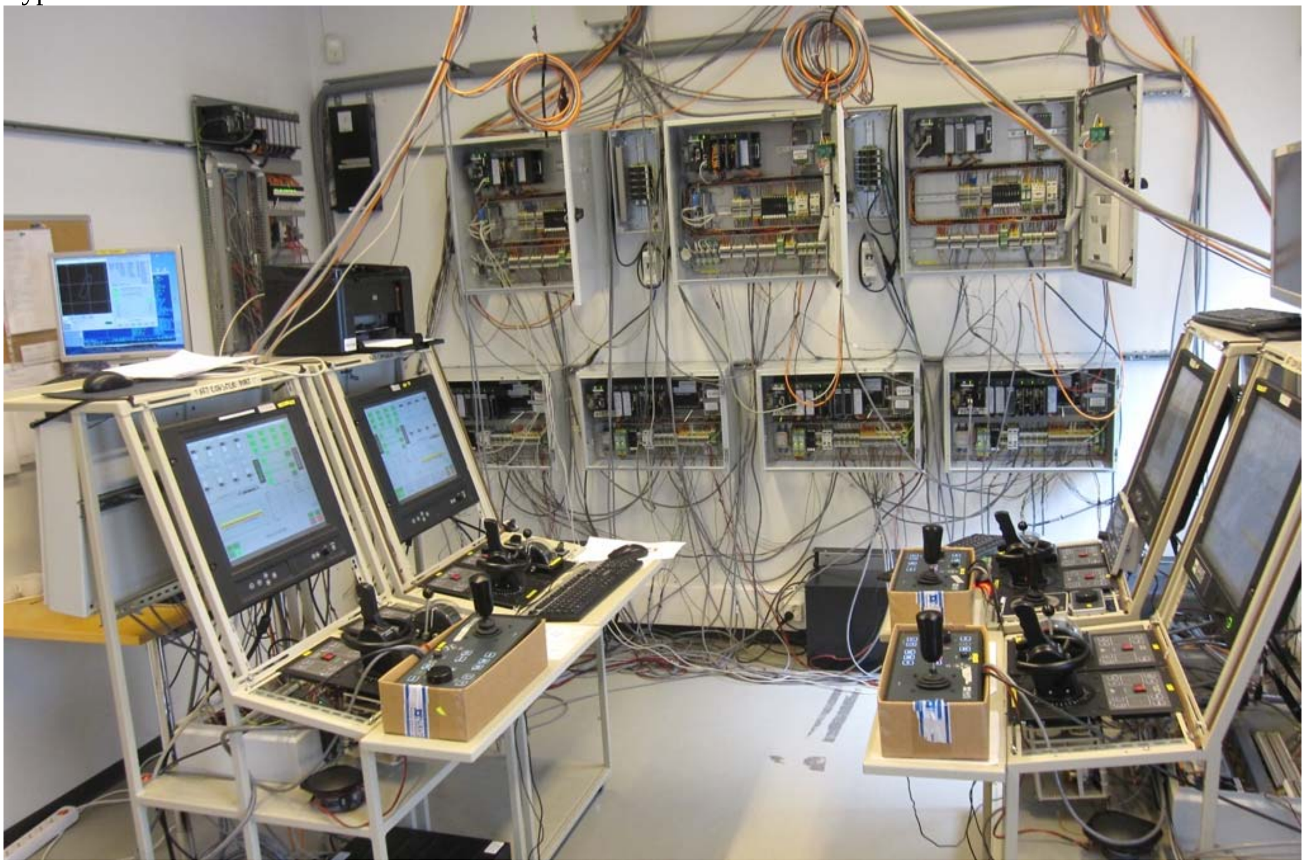


Figure.11

Type **L** test-bench



Conclusion

Practically, implementation of mentioned test-bench family for QA control, verification and troubleshooting allows to significantly reduce:

- Time for troubleshooting and fault finding (up to couple of minutes);
- On-board time for system commissioning (up to couple of hours);
- Service calls in regard to DP control system;

Based on real experience we can state that using of advanced simulation test-bench can save time for initial system commissioning and further service and support. Finally it brings huge benefits for both parties- vendor and customer helping them to optimize their costs.

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