RE-CONFIGURABLE LAND BASED TRAINING SIMULATOR

Mahesh Hegde, L-3 Communications, India

ABSTRACT

Navies all over the world are constantly looking out for efficient training solutions which require minimal effort, cost and resource for training their personnel on the operation and maintenance of Integrated Platform Management Systems (IPMS).

Duplication of valuable resources for the purpose of training the operators and maintainers on IPMS for different classes of ships is not a preferred approach for any Navy. This challenge calls for an innovative approach to training; a reconfigurable trainer which is readily capable of performing IPMS training for multiple classes of ships.

L-3 MAPPS has developed an open architecture Land Based Training Simulator (LBTS) which can be configured to provide both operator and maintainer training for the Indian Navy's modern stealth frigate and amphibious assault ship classes. The LBTS is capable of being reconfigured for these two unique classes of ships in less than an hour. The open architecture design supports the need to upgrade & include future classes of ships. Furthermore, the effort needed to upgrade is significantly less compared to building an entirely new trainer.

Navies can look forward to having a more Integrated Training Facility for multiple classes of ships using valuable common resources at a reduced overall in-service support cost.

KEY WORDS

1   Introduction

Many of the warships today are equipped with comprehensive platform automation capabilities provided by modern Integrated Platform Management System (IPMS). Operators & maintainers (end users) of IPMS require a detailed knowledge of the IPMS system and architecture before they can take on the responsibility of operating & maintaining IPMS as well as make full use of features provided by the IPMS system. A hands on approach to training is also a necessity for the end users to autonomously use and maintain IPMS.

Training on IPMS may be provided by means of classroom training sessions or hands on training using simulators which provide simulation and stimulation of the ship machinery and equipment. Training the end users on IPMS using simulators is a very effective means of imparting training on IPMS. However, the cost associated with building dedicated simulators for each class of ship can present aa limitation to the use of simulators for training.

The Re-configurable Land Based Training Simulator (LBTS) developed by L-3 MAPPS is an innovative approach to IPMS training using simulators. The feature to re-configure the LBTS for different class of ships will enable the Navies to have a more Integrated Training Facility for multiple classes of ships at a reduced overall investment and in-service support costs.

The objective of this paper is to describe the design of such a re-configurable LBTS,using the Land Based Training Simulator for the Indian Navy's modern stealth frigate and amphibious assault ship as an example.

This paper is organized as follows. Section 2.1 describes the generic architecture of the L-3 MAPPS IPMS. Section 2.2 describes the architecture of the Re-configurable LBTS designed for the Indian Navy's modern stealth frigate and amphibious assault ship classes. Section 2.3 explains the key features including the re-configurable aspects and the hardware and software changes required to reconfigure the simulator. Section 2.3.2 explains how the simulator can be upgraded for future projects. The last section concludes and highlights areas for future improvements.

2   Architecture & Features

The reconfigurable LBTS is built primarily on the open concepts and technology deployed by the L-3 MAPPS IPMS. In order to understand the re-configurable LBTS architecture, it is required to know the architecture of the IPMS. The following section describes the architecture of a typical L-3 MAPPS IPMS.

2.1   Architecture of L-3 MAPPS IPMS

The IPMS is a distributed architecture real-time digital control system. This open architecture system comprises **multifunction** control consoles and **reconfigurable** Remote Terminal Units (RTU). RTUs are used for process level data acquisition and control. The consoles provide the Human Machine Interfaces (HMI) for the operators at various shipboard locations. System-wide connectivity is provided by a redundant databus. The L-3 MAPPS reliable multicast (RMC) communication approach ensures integrity of data communication on the bus, while minimizing the bus traffic and maintaining very low data latency. Databus cables are strategically routed through the ship with adequate geographic separation to provide maximum system survivability. Open system architecture allows for the use of a variety of data networks in accordance with customer requirements. The open architecture also permits the interface of the IPMS to other systems through fieldbus, serial links, and other interfaces.

2.1.1   IPMS Hardware Architecture

Figure 1 shows a typical IPMS hardware architecture. The IPMS hardware architecture can be split into three layers as shown in Figure 2
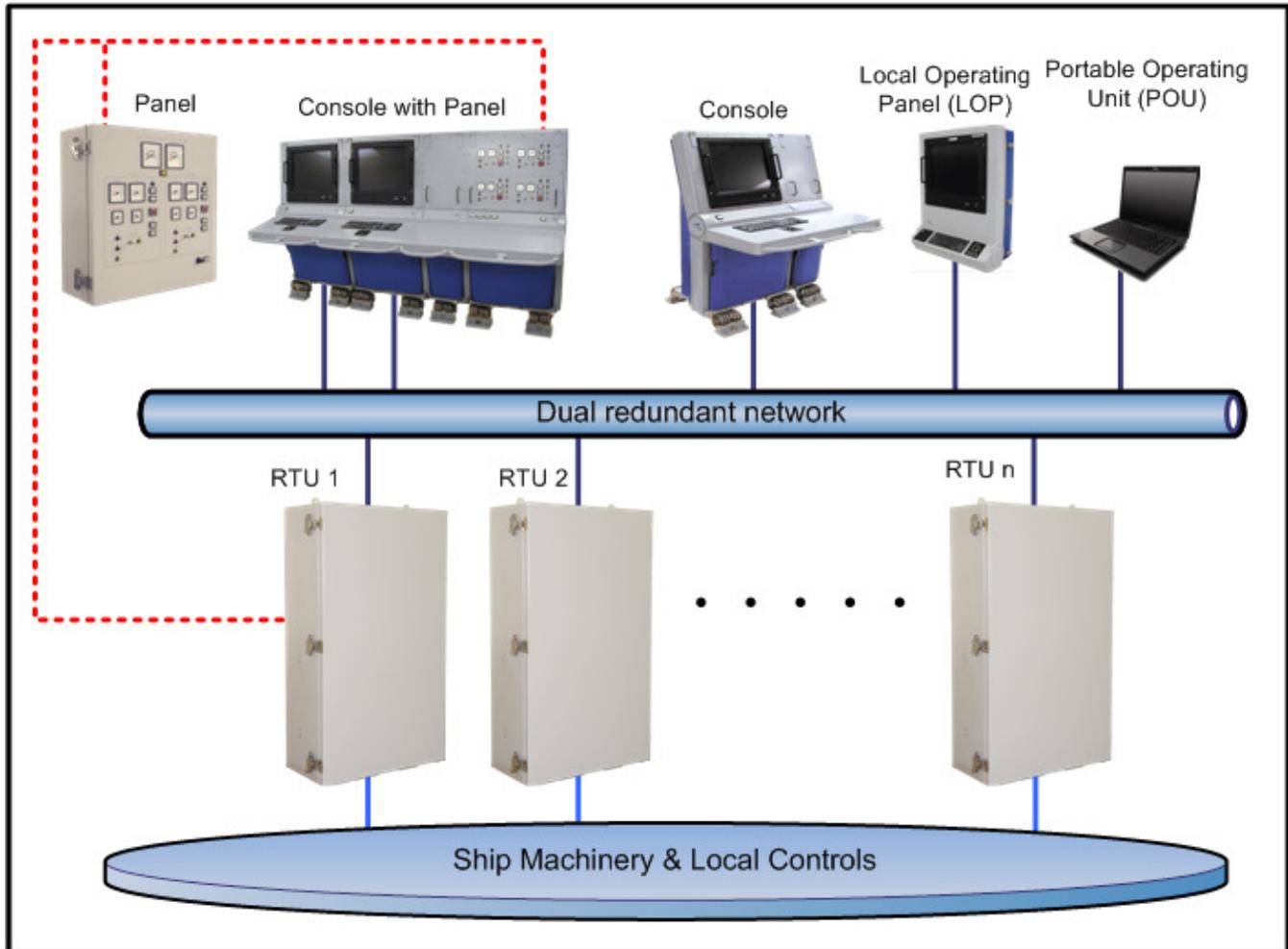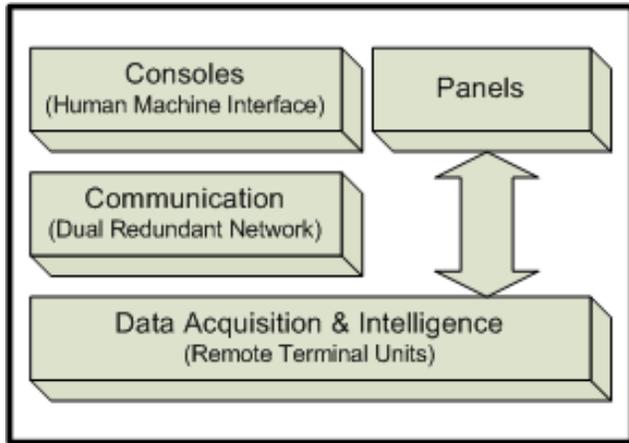

Figure 1 Typical IPMS hardware architecture

Figure 2 Block diagram of typical IPMS

The data acquisition layer interfaces with the actual machinery on-board the ship. The data acquisition layer consists of both inputs and outputs to the ship machinery and the interfaces may be in the form of Digital Input (DI), Digital Output (DO), Analog Input (AI) and Analog Output (AO). These signals may be either hard wired to the sensors or may be interfaced serially via standard communication protocols such, Fieldbus, Modbus or Profibus etc.,. The data acquisition layer resides in the RTU and also contains intelligence to control the equipment interfaced to the RTU. An RTU provides direct hardwired interface between the IMCS and the ship machinery sensors and actuators. The following are the main functions of the RTU:

1. Signal conditioning and data acquisition from the machinery sensors and actuators.
2. Communicate digitized data to the operator consoles and receive data from the consoles.
3. Convert digitized data from the operator consoles to discrete analogue or digital control signals for the machinery actuators.

The communication layer forms the backbone of the IPMS. All the Consoles and RTUs communicate via this layer and synchronize the data using the RMC protocol. The RMC protocol ensures data consistency and concurrency among all IPMS RTUs and Consoles

The layer that interfaces with the operators consists of consoles and panels. A console is usually provided with a display interface allowing the operator to control and monitor the connected ship systems. In addition, certain consoles have integrated hardware panels containing gauges and pushbuttons. These panels allow the control and monitoring of the ship systems the traditional way and also provide a back up control option.

2.1.2 IPMS Software Architecture

The consoles software usually operates on the Windows OS. The RTUs employ an embedded real time operating system. In general, the IPMS software contains the following components / modules:

1. Core SW
2. Control Application Software (CAPS)
3. Human Machine Interface (HMI) SW
4. On-Board Training System (OBTS) SW

Core SW is the nucleus of the IPMS. Core is present in all RTUs and consoles. Core SW provides data acquisition, monitoring and communication services.

HMI provides a graphical user interface through "pages" displayed on the display screen of the consoles. HMI SW also handles input devices such as keyboard, trackball, and mouse.

CAPS runs in RTUs to monitor and control ship machinery.

OBTS allows the user to train while at sea, without endangering the operation of the real machinery. In training / OBTS mode, the console connects the trainee's console to simulation software running in the instructor's console instead of the machinery.

2.1.3 IPMS Modes of operation

IPMS consoles can be operated in two modes: control mode and OBTS mode. In control mode, the consoles monitor & control the actual ship equipment. The user has a provision to switch the consoles to OBTS mode and get trained on IPMS by interacting with a ship simulation model (high fidelity mathematical model of the ship machinery) instead of the actual plant data.
It is possible to have group training in OBTS mode. This is achieved by running the simulation software in the instructor console. All the trainee consoles connect to the instructor consoles and synchronize in a group training scenario.

Figure 3 shows the location of the software modules in IPMS subsystems when running in different modes. The CORE software runs in all the subsystems. CAPS runs only in the RTUs. The consoles run the HMI software and CORE in both control and OBTS modes.
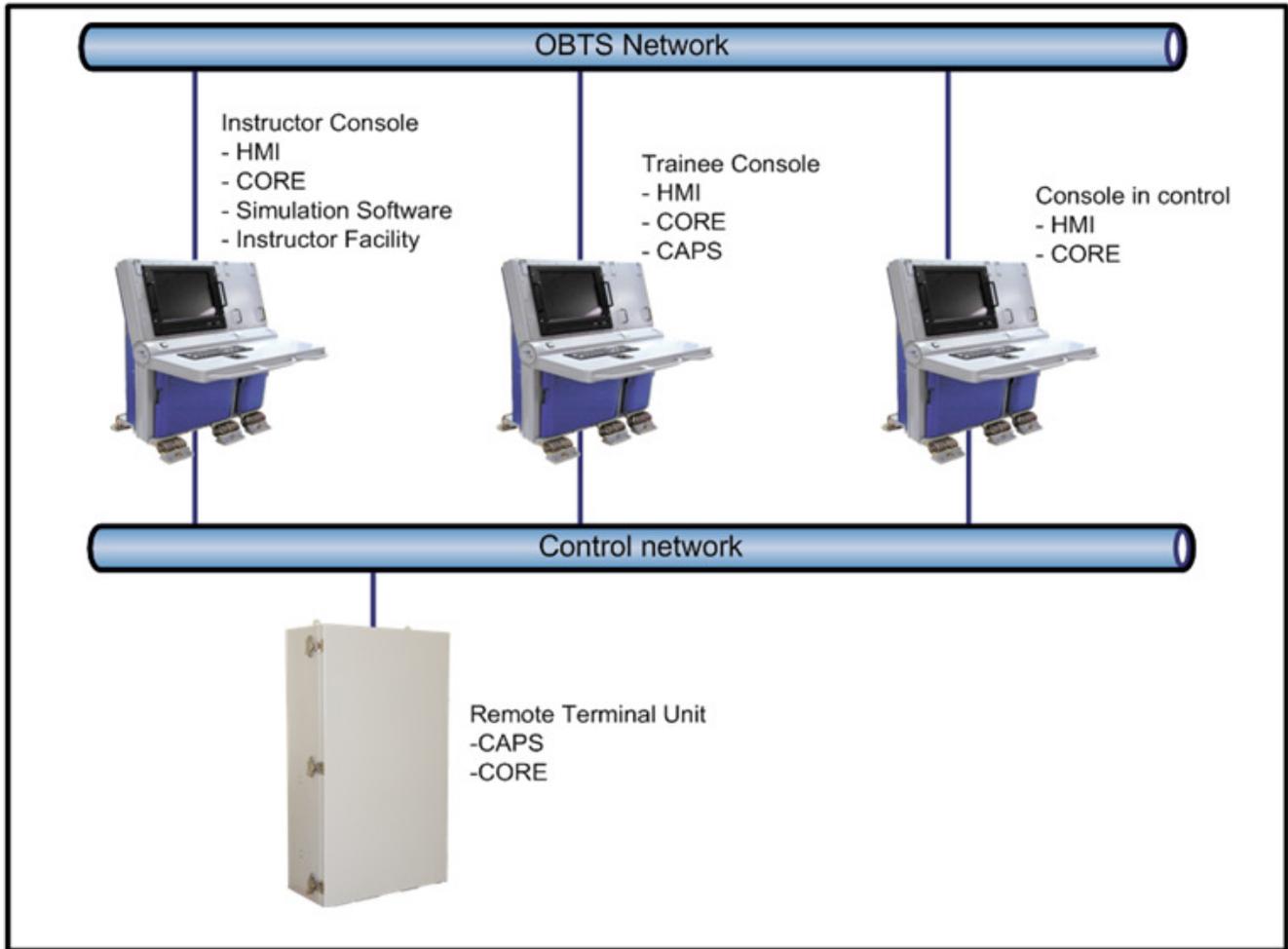
Figure 3 Location of software modules in different subsystems in IPMS

2.2   Architecture of the L-3 MAPPS Land Based Training Simulator

The following sections describe the hardware and software architecture of the LBTS designed for the Indian Navy's modern stealth frigates and amphibious assault ships..
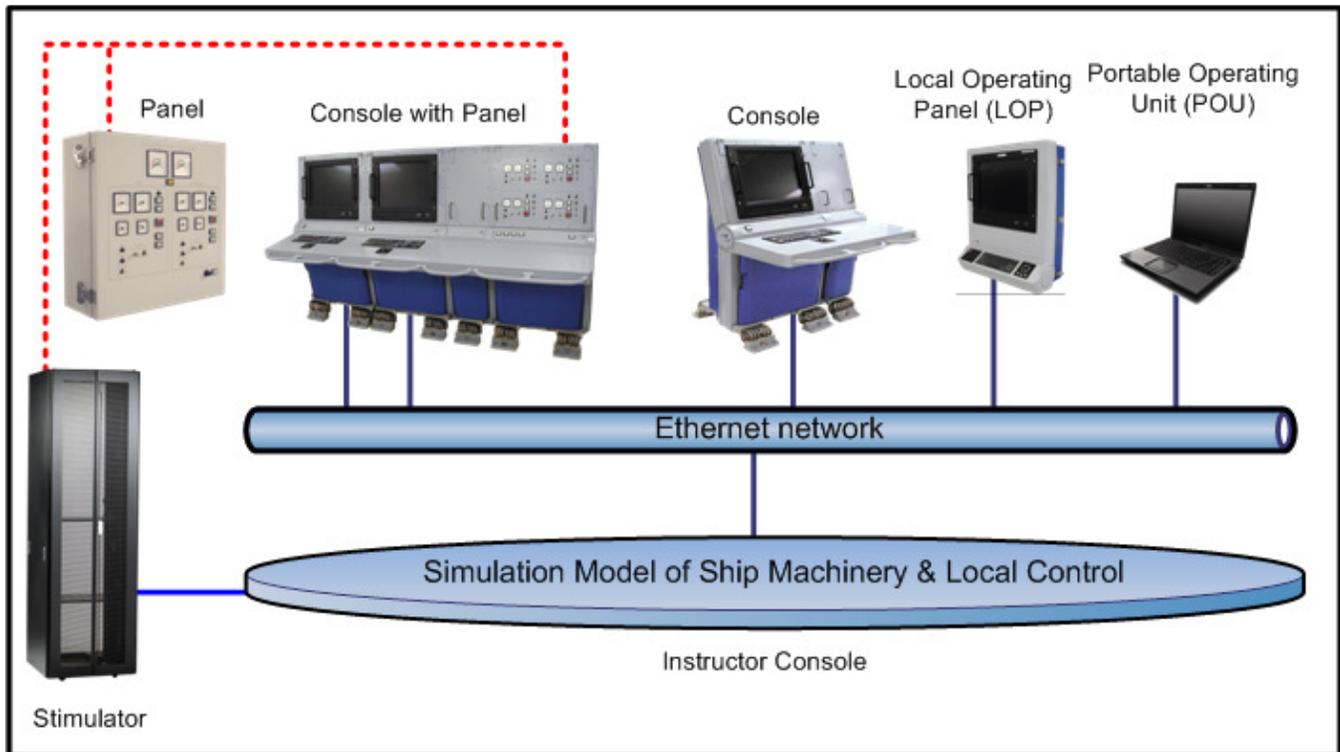
2.2.1   Hardware

The hardware architecture of the re-configurable LBTS is as shown in Figure 4. The hardware architecture of LBTS can be split into 3 layers as shown in Figure 5.

LBTS HMI layer is the same as the HMI layer of IPMS. The only major difference is that the hardware panels are driven from the Stimulator instead of the RTUs on the real ship.

The communications layer consists of an Ethernet switch instead of a dual redundant network. All the subsystems communicate on this network using the same RMC protocol.

The simulation model of the ship machinery and local controls execute in the Instructor Operating Station (IOS). The IPMS control Software (CAPs) also runs in the same console. In LBTS the consoles and panels interact with the simulation model instead of the actual ship equipment. All the signals to and from the hardware panels are connected to the Stimulator, which digitizes the signals and interfaces with the simulation model running in the IOS over Ethernet.

Figure 4 LBTS Hardware architecture
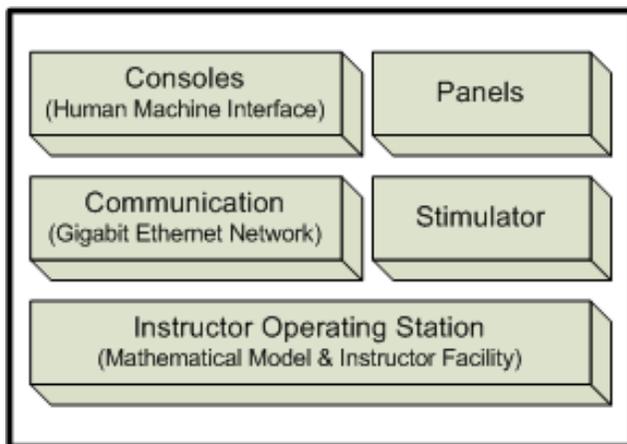
Figure 5 Block diagram of LBTS

Let us analyze an example of the flow of the commands from the HMI to understand how it propagates in the system.

1. The operator gives a command from the HMI to start a pump
2. Via the network the command propagates to the simulation model running in the IOS
3. The pump is started in the model and a running indication is generated

4. Running indication is propagated to the HMI & Stimulator through the network
5. On receipt of running indication from the model the HMI shows the change in status for the pump to "Running" completing the loop.
6. If there is a running indication lamp for the pump in the panel, it is turned on by the Stimulator to indicate the pump is running.

Above is a highly simplified example of how a command propagates in the LBTS. In the actual LBTS it is also possible to see the flow, pressure and temperature changes when related equipment is started.

The LBTS architecture is not specific to any particular class of ships. The only change that needs to be done to re-configure LBTS to a new class of ships is the addition of consoles and panels if any.

2.2.2 Software

All the software that runs in control mode also runs in LBTS. In addition, there is Instructor Facility (IF) and the Simulation model software that runs in the IOS.

IF allows the instructor to control and monitor the training environment. The IF functionality is by default assigned to IOS console, however it is not limited to the IOS. Any of the IPMS consoles may assume the Instructor status.

The IF is used to:

1. Modify local and instructor controls
2. Modify environmental parameters
3. Introduce malfunctions
4. Override signals
5. Store/Restore of Initial Conditions
6. Log events
7. Create and execute Lesson Plans

The simulation model is built using Real Time Object Oriented Simulation Environment The simulation model consists of high fidelity models of the different ship machinery including propulsion, auxiliaries, ancillaries and damage control systems. The simulation model is validated against the test results of the actual machinery to give the LBTS user a realistic feel of operating the ship.

Figure 6 shows the location of the software modules in LBTS subsystems when running in group training and standalone modes.
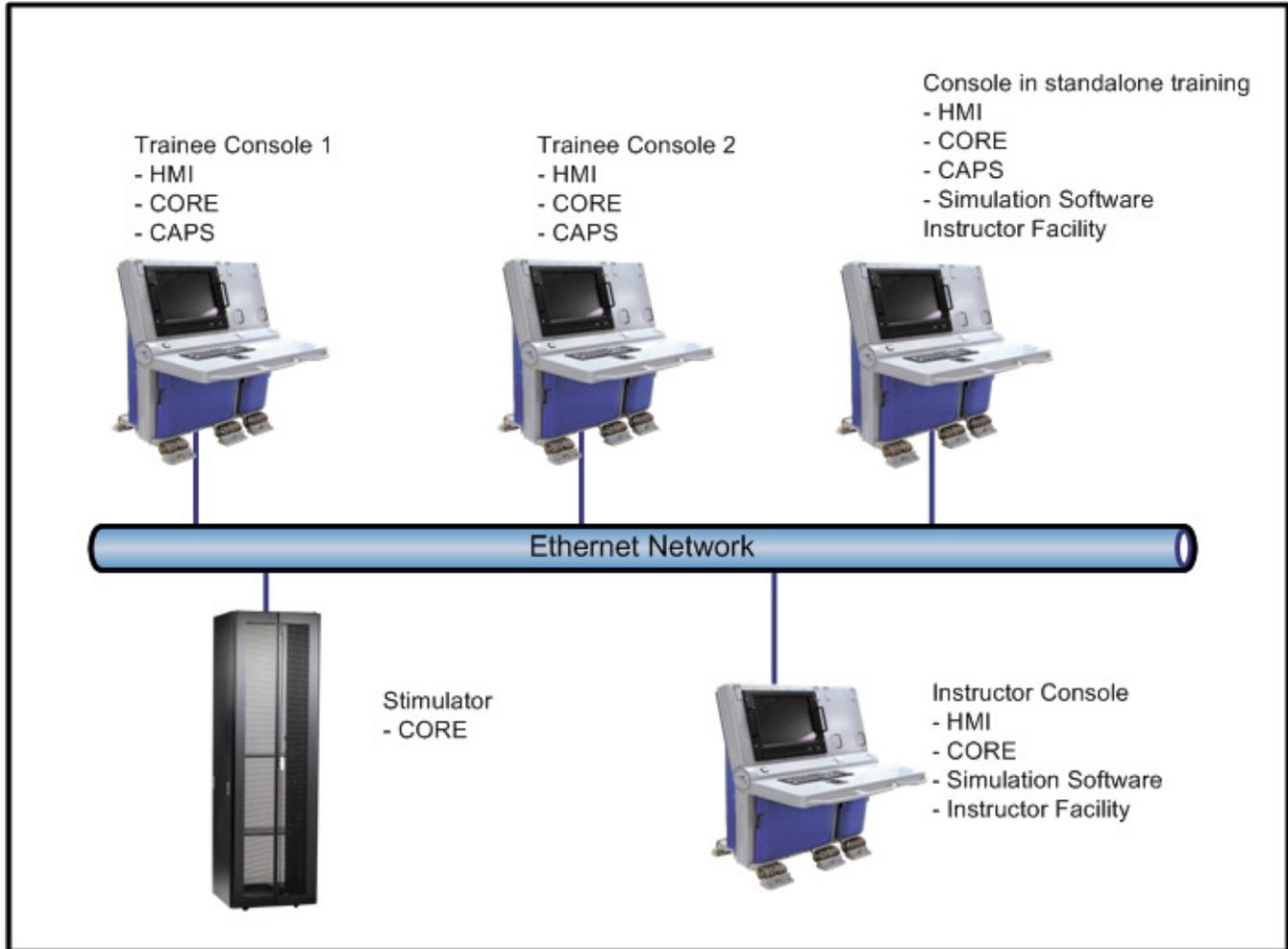

Figure 6 Location of software modules in different subsystems in LBTS

2.3 Key Features

The following sections describe the key features of LBTS

2.3.1 Re-configuring the LBTS

The main differences between the IPMS of different class of ships are the hardware panels, HMI pages & CAPS. In addition to the difference in the IPMS, the ship machinery is also different, so, there is a difference in the simulation

model. It is possible to re-configure the simulator for a different class of ships by changing the above mentioned hardware and software components. The following sections give the details of how the hardware and software modules are replaced.

2.3.1.1 Hardware reconfiguration

Hardwired panels are the only hardware that needs to be changed in order to re-configure the simulator for a different class of ships. The panels of the LBTS are designed to be modular, hence making it easy for the user to interchange them . The panels may be interchanged by removing screws which are accessible from the front of the panel as shown in Figure 7. Electrical connection of the panel is done using D type connectors as shown in Figure 8. The D type connectors can be easily removed and reconnected.
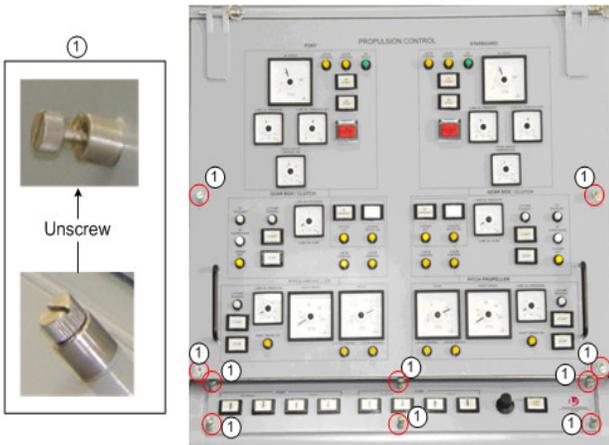

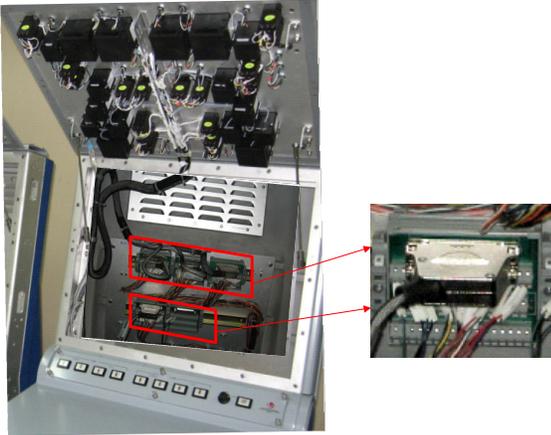**Figure 7 Screws used to remove hardware panel**

**Figure 8 D Type electrical connectors**

2.3.1.2 Software reconfiguration

The following software modules need to be changed in order to re-configure the simulator

1. HMI
2. CAPS
3. Simulation Model
4. Panel cross reference table

A cross reference table is created to drive panels from different class of ships. The table enables the same Stimulator and channels to be used to drive the panels of different ships. Stimulator uses the cross reference table to map to interface the panels.

The software switch is done by an executable script called as Project Switcher, which replaces the above software modules with the new ones. Downloading the new software to the Stimulator is also done by the script. All that the user needs to do is double click on the project switcher executable select the project and click on "Switch" button and the rest is taken care by the script. Figure 9 & Figure 10 show snapshots of the project switcher.
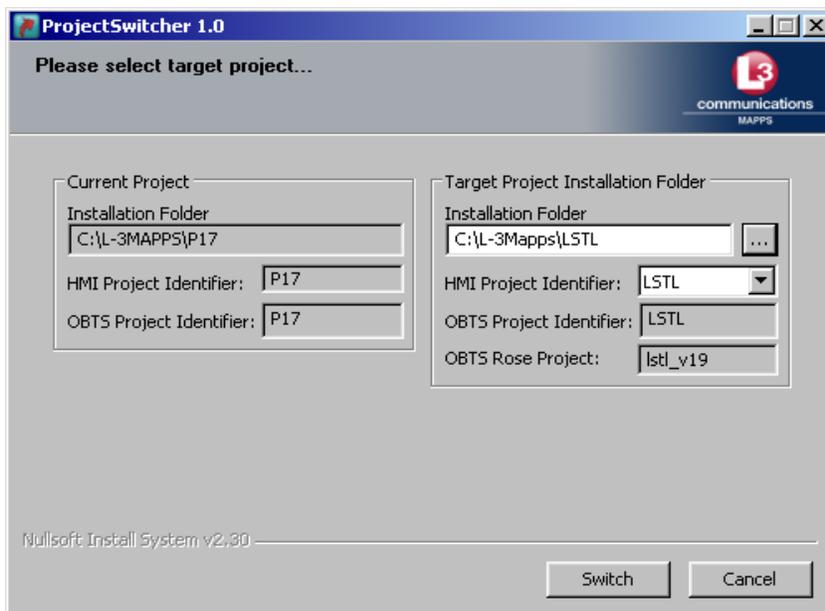
Figure 9 Current and target project selection in project switcher
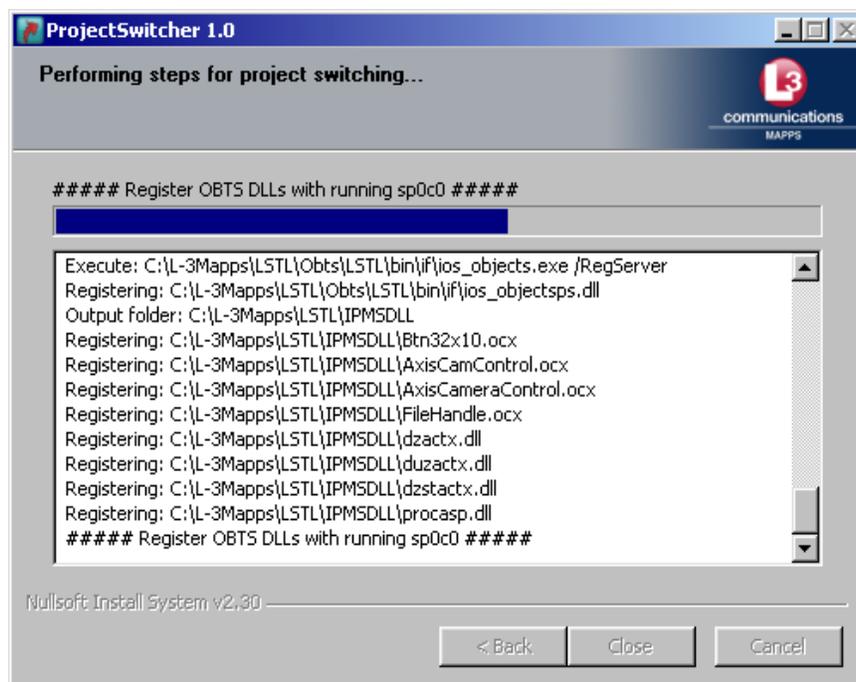
Figure 10 Project switcher in progress

2.3.2 How can the simulator be upgraded?

If it is required to upgrade the LBTS to accommodate additional class of ships, the only hardware change required to be done are the panels. It is also possible to increase the number of consoles and panels by having additional network points and adding channels in the Stimulator to accommodate the addition in hardware signals for the panels.

2.3.3 Group & Individual Training modes

Group training enables the trainers to conduct training sessions where students are assigned designated roles like on-board the ships. Usually each person is assigned the responsibility of operating only one set of equipment from the following category:

1. Propulsion
2. Electrical
3. Auxiliaries
4. Damage Control
5. Order
6. Thrust

In addition to the group training it is also possible to switch individual console of the LBTS into a standalone training mode. In this mode the Simulation model runs in the console itself instead of the IOS. This mode is useful if the students want to have a self learning session without affecting other students on the LBTS network.

2.3.4 Simulation of malfunctions (equipment casualties)

The Instructor has the ability to trigger equipment casualties also known as malfunctions of ship equipment. Students can be trained on handling crisis situations by using the malfunction feature. Some examples of malfunctions are valve failures, pump failure, governor failure for diesel engine, tank leaks, hull breach, filter clog.

2.3.5 Computer Based Training (CBT)

Students need to know some basic principles of IPMS before they take hands on training session on the LBTS. The Software User Manual (SUM) is an exhaustive document and it is difficult for the students to get a quick overview of IPMS operation from the SUM. Hence, a self-learning computer based training has been developed to give the LBTS students an understanding of the basic principles of IPMS operation before they take hands on training at the LBTS facility. The CBT has been developed based on the SUM incorporating the most commonly used features of IPMS.

2.3.6 3D Visualization

The ship crew can get a feel of the actual ship environment by taking a virtual tour of the machinery spaces onboard the ship using the 3D visualization utility. There are two modes to explore the virtual machinery spaces. In the guided tour mode, the student is guided through a pre-determined path to follow in the tour. In exploration mode the student is free to move around along any path he prefers. By identifying the important equipment of IPMS within the ship's machinery spaces, the ship crew is well prepared about the location of IPMS equipment. Figure 11
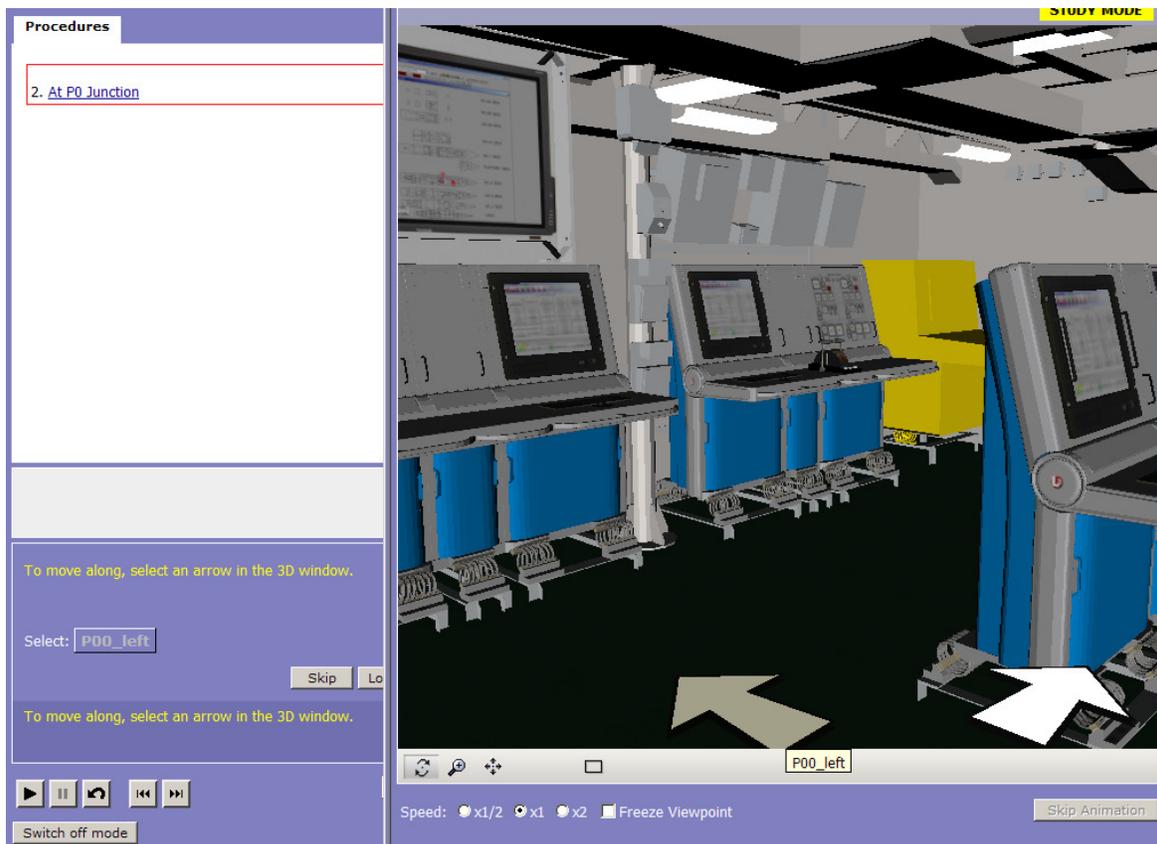

Figure 11 Students can have a virtual tour of ship compartments using the 3D visualization

3   Conclusion

The IPMS architecture is common across different class of ships. The main changes in the hardware are in the panels and the number of subsystems. The LBTS incorporates a three layer open architecture similar to that of IPMS enabling it to be re-configured and upgraded very easily. Project Switcher software utility helps the user to switch the software modules between different projects. Tools such as CBT and 3D Visualization supplement the LBTS facility and improve the preparedness of the IPMS users.

At present, LBTS is designed to be an IPMS trainer. In order to extend the LBTS to be used for training on ship systems the following features may be added. However, the necessity & feasibility of doing these need to be studied:

1.   Simulation of machinery sound
2.   Simulation of ship navigation using a 6 degree of freedom ship hull model
3.   Interface of 3D Visualization with the simulation model and the HMI

4   Acknowledgement

The author would like to thank all the people involved in the project at L-3 Communications MAPPS, Montreal, Canada and at L-3 Communications India Pvt. Ltd., Bangalore, India. A special thanks to the Indian Navy team at INS Shivaji, Lonavala where the IN LBTS is commissioned.

REFERENCES

[1]   IPMS Datasheet on L-3 MAPPS website http://www.mapps.l-3com.com/html/marine/ipms.html
[2]   OBTS datasheet on L-3 MAPPS website http://www.mapps.l-3com.com/html/marine/obts.html

BIOGRAPHY AND CONTACT INFORMATION

Mahesh Hegde is an engineer from Visveswariah Technological University. He graduated from Sri Jayachamarajendra College of Engineering, Mysore in 2003. He has been working with L-3 Communications India from 2004. Mahesh was awarded a Project Management Professional (PMP) certificate by the Project Management Institute in 2008. He has been working on simulation models for various projects of Indian Navy and Republic of Korea Navy (ROKN). Mahesh has worked on board the ROKN KDX-II destroyer class of ships where he has supported for commissioning of L-3 MAPPS IPMS. From 2008, Mahesh has been leading a marine and power plant simulation team in L-3 Communications India, Bangalore.

Mail: Mahesh.Hegde@L-3com.com
          hegdemahesh@yahoo.com

Phone: +91-80-67170223

Cell: +91-98455-09106