Warships are becoming ever more complex and require comprehensive platform automation capabilities that allow them to achieve unprecedented levels of ship survivability and operational effectiveness while facilitating reduced manning on-board. L3 MAPPS pioneered the development of the Integrated Platform Management System (IPMS) to provide integrated monitoring and control of ship propulsion, electrical functions, auxiliaries and damage control machinery & systems.

In addition to the automation of these platform systems, the following features can be integrated in the IPMS:

- On-Board Training System (OBTS)
- Battle Damage Control System (BDCS)
- Personnel Location Monitoring System (PLMS)
- Digital Closed Circuit Television (CCTV) system
- Condition-Based Maintenance (CBM) systems

SYSTEM ARCHITECTURE

The IPMS is a distributed architecture real-time digital control system. This open architecture system comprises multifunction control consoles and 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 fiber optic databus. The L3 MAPPS reliable multicast approach ensures integrity of data communication on the bus, while minimizing the bus traffic and providing 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. It also permits the interface of the IPMS to other systems through fieldbus, serial links, and other interfaces.

HUMAN MACHINE INTERFACES (HMI)

The IPMS includes advanced HMI design that is consistent with its application in a sophisticated warship. The primary HMI is in the form of multifunction control consoles, typically located in the machinery control room and on the bridge. Wall-mountable consoles are typically provided in damage-control section bases and for local control in the engine rooms and other machinery spaces. Portable operating units support emergency control operations and troubleshooting using built-in test equipment and software.
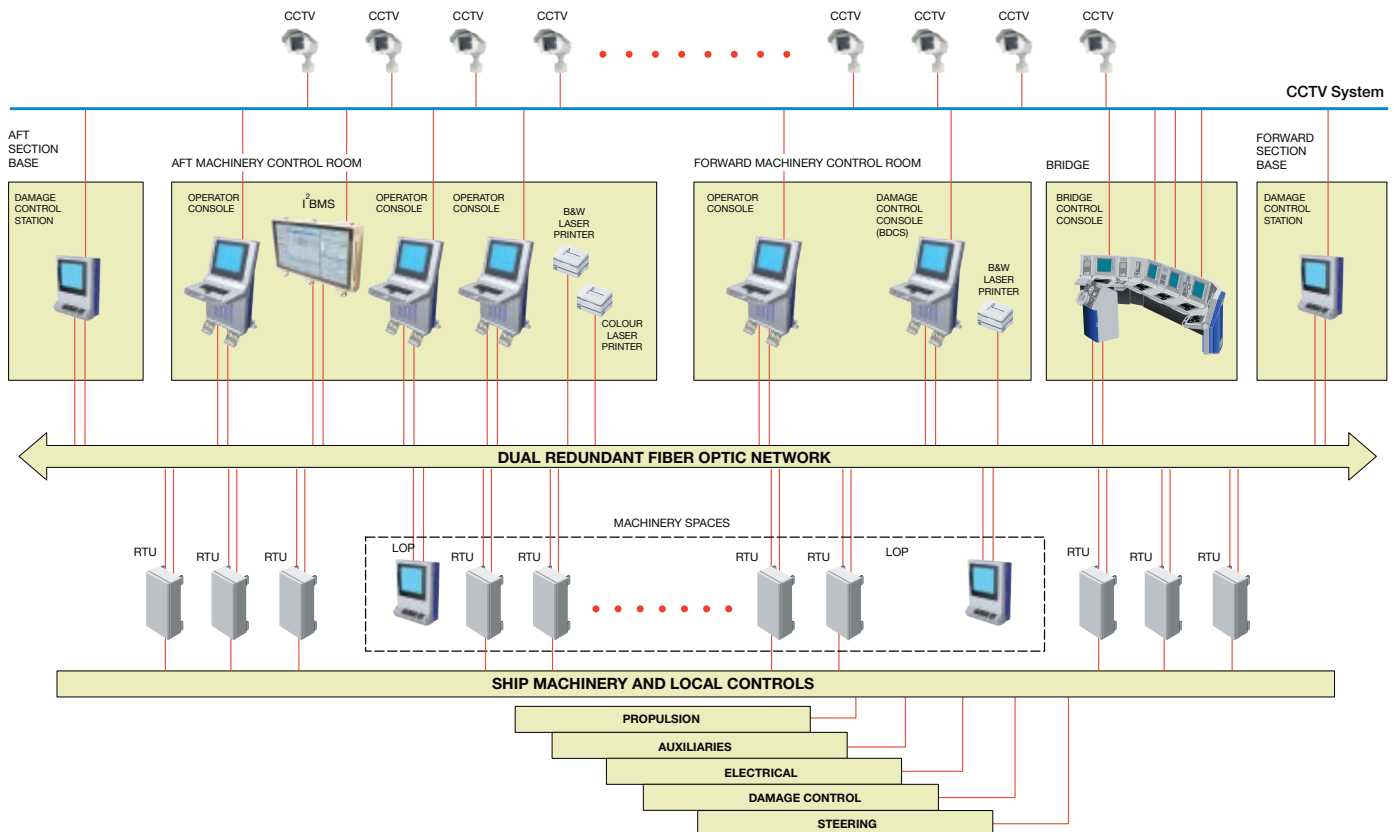

TYPICAL IPMS CONFIGURATION

Control and monitoring from consoles are performed through the use of integrated control panels and high-resolution colour monitors that display ergonomically designed graphical pages of the platform machinery and systems. Each console is multifunctional and can perform all functions of the IPMS, provided the appropriate password authorization is used and the control transfer protocols are respected.

This provides a very high level of survivability, because total platform control can be exercised from several widely separated locations on the ship.

L3 MAPPS pioneered the use of colour graphics-based machinery control for warships almost 30 years ago and has accumulated a significant amount of experience and expertise in the implementation of ergonomically designed colour graphics pages. L3 MAPPS prefers simple and well-researched symbology over the distracting effects of an extravagant use of colour and artistically rendered symbols. The screens are designed to provide the necessary information to the operator with special emphasis on emergency conditions.

The L3 MAPPS Tiled, Layered Graphics (TLG) approach facilitates the automatic decluttering of information at the various levels of zoom, ensuring easily readable displays at all times. TLG also provides a novel form of navigation through the ability to pan and zoom in a "world view" of the ship. Alternatively, a structured windows approach is used with four windows that can be displayed simultaneously on the screen, allowing the operator to manage several different systems at once.

While the colour screens make it possible to monitor and control every aspect of the platform, the IPMS can also include a limited amount of dedicated instrumentation for emergency control and monitoring from the control rooms. An engine order telegraph system can also be included to communicate propulsion orders to the control rooms from the bridge. This is backed up by an emergency telegraph system with repeaters located in the machinery spaces.
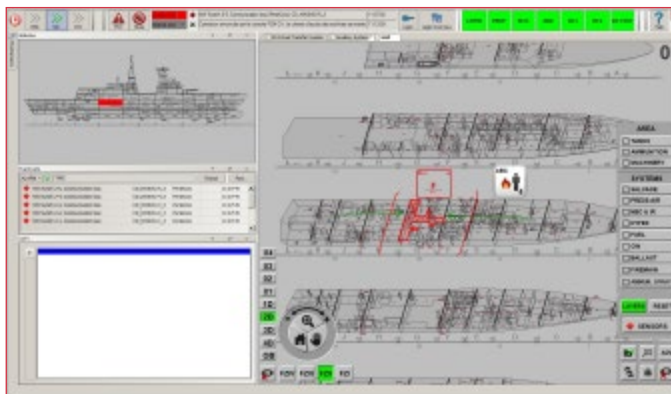
Several different types of pages are used to display plant overviews, machinery data, system schematics, trending displays, alarms, events, and fault messages. The IPMS features elaborate alarm processing techniques that reduce operator loading by filtering out nuisance alarms and providing context-sensitive displays based on the nature and severity of the alarm. This feature is vitally important in systems that have a large number of sensors because it helps to maintain operator effectiveness under both normal and emergency conditions.
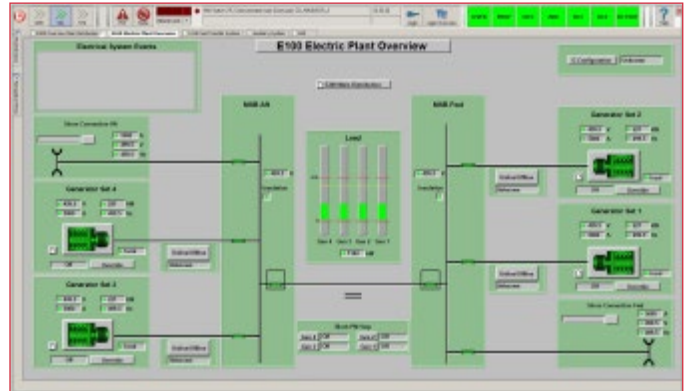
Audible and visual annunciation is used to alert the operator to the occurrence of alarms, warnings and faults. Acknowledgment of such annunciation is typically based on the function allocated to each position; that is, the Propulsion Operator (irrespective of his physical location in the ship) acknowledges propulsion alarms, warnings and faults.

DATA ACQUISITION AND CONTROL

From small training ships to the world's largest aircraft carriers, L3 MAPPS provides systems that can interface to as few as 100 signals and to a virtually infinite number of sensors and actuators. To manage this vast differential of signals across different ship types, the L3 MAPPS IPMS provides a flexible, modular and effective approach to data acquisition and control using variable density RTUs that are able to interface to a wide variety of sensors and actuators.

Such interfaces can be wired directly to the plant devices or can be provided through serial links and fieldbuses.

The RTUs are based on open architecture backplane electronic modules or fieldbus modules that integrate both signal conditioning and processing functions and provide optical isolation for field signals. The RTUs acquire plant sensor data, perform plausibility tests, check for limit violation, transmit the data to other IPMS subsystems as required, process automatic control sequences, output control signals to actuators, and perform online and offline built-in tests.

The automatic propulsion control and power management software reside in the RTUs together with control software for other platform machinery and systems. These units are ruggedized for installation in warship machinery spaces and can withstand the most stringent environmental conditions.

GAS TURBINE ENGINE CONTROLLERS

Using the same RTU hardware and software, MAPPS can also provide gas turbine engine controllers for a variety of gas

turbines used on modern warships. Maintaining commonality with the rest of the IPMS architecture has significantly reduced life cycle costs for many navies by supporting the Engine Control Module (ECM) with the same training, spare parts, and upgrades available for the entire control system. The HMI associated with the gas turbine local controller can also be used for shipwide control with all the capabilities of a console.
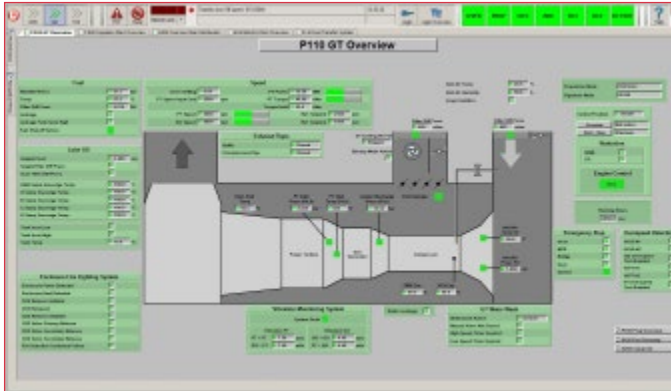
DATA LOGGING, TRENDING, AND REPORTING

The IPMS continuously records the changes in sensor data and the control commands together with the date and time stamps for each value. Short-term data storage, comprising the last 24 hours, is available at each console, whereas long-term data storage can be provided by removable media located inside specific consoles. The data from such removable media can be viewed on-board and can also be analyzed in shore-based facilities.

Sensor information and other system data can be selected by the operator to be stored and displayed graphically together with the relevant alarm and warning limit thresholds. Either black-and-white laser printers and/or colour printers can be provided to obtain hardcopy logs of events, alarms and the colour graphic screens for archival purposes.

ON-BOARD TRAINING SYSTEM (OBTS)

Starting in the late 1980s, L3 MAPPS used its extensive expertise in both high fidelity simulation and controls technologies to pioneer IPMS on-board training funtionality on warships. The IPMS can include an advanced OBTS capability whereby the operator consoles can also operate in training mode. All of the operator consoles (except one console to remain as station-in-control) can be placed in training mode to facilitate full-mission team training on board the ship. One of the consoles would be designated as the instruction facility while the other consoles are operated in training mode. If a console or group of consoles in control mode fails, the other consoles operating in training mode automatically revert to control mode.

The OBTS uses real-time high-fidelity simulation models of the ship's hull, platform machinery and systems and includes an emulation of RTU automation functionality. Previously

defined training scenarios can be performed or a new scenario created by the instructor on board the ship. Except for the use of training data generated by real-time high-fidelity simulation

techniques, the operator consoles behave exactly as they do during normal control mode operation using the same software. This ensures a very high level of training realism.

BATTLE DAMAGE CONTROL SYSTEM (BDCS)

Management of vessel safety systems is achieved by the BDCS function which provides early damage recognition and effective coordination of damage control actions. BDCS functionality can include any or all of the following features:

Damage plotting: A replacement of the traditional damage control reporting system that uses sound powered phones and laminated damage control diagram plates. These plates are replaced by full ship, colour diagrams with the ability to annotate standard damage control symbology. As damage information is acquired by the IPMS or entered at any console, all consoles are automatically updated. This provides the Commanding Officer, Engineering Officer, and the Damage Control Assistant with a real-time, complete, up-to-date picture of the damage situation giving them the information edge they need to effectively command the ship.
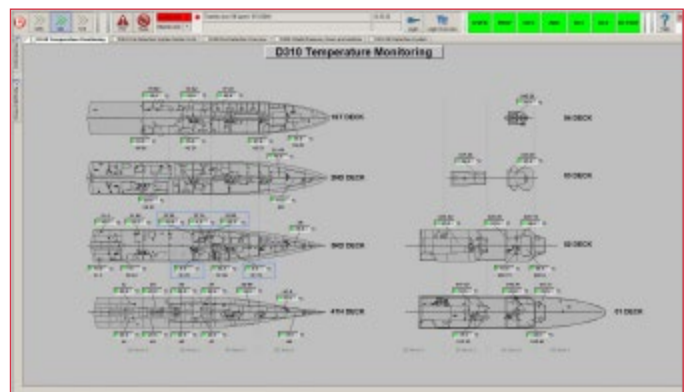
Kill Cards: Used to help the operator react quickly and correctly in the event of emergencies. Predefined automatic control sequences to respond to specific casualty conditions can be activated by the Kill Cards in addition to providing checklists for crew assignment and other damage management tasks.

Ship stability calculator: Provides online expert system advice to ship personnel. This system can either accept sensor values or manual input to determine stability in both intact and damaged vessel conditions. This function calculates weight and momentum, lifting arms, hydrostatic values, and vessel motion during swells. Recommendations for improving ship stability are also provided by the system.
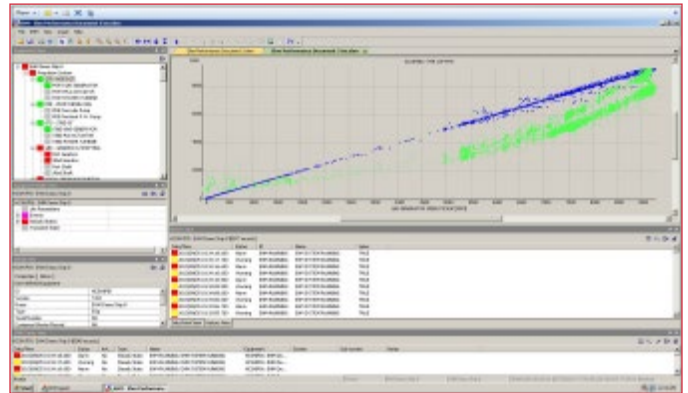
DIGITAL CCTV SYSTEM

To enhance the manpower reduction features of the IPMS, MAPPS has integrated a digital closed-circuit television system to provide video monitoring of the ship's machinery spaces and other locations. Colour CCD cameras can be connected to the IPMS consoles using the existing network to allow the console screens to display the video image in a screen window which can be maximized to use the full screen area. To provide the most flexibility, any camera can be selected for display on any console; however, fire alarms and flooding alarms will trigger the automatic display of the relevant camera images at specific consoles. The system also includes a very flexible record & play back capability.

CONDITION-BASED MAINTENANCE SYSTEM (CBM)

Vibration monitoring systems and other specialised equipment and sensors can be integrated with the IPMS to provide periodic monitoring of equipment health. To facilitate the predictive monitoring of the machinery plant, expert system software is provided to advise maintenance personnel concerning the need for machine maintenance. Maintenance based on equipment health as opposed to periodic scheduling of maintenance has provided significant reductions in life-cycle costs for ship owners.

The CBM system automatically monitors online accelerometers, tachometers, and displacement probes, and other sensors for critical machinery such as propulsion engines, shaft bearings, and generators. For less critical machinery, an offline portable vibration recorder with accelerometer can be used to transfer vibration data to the system.