

# Revolutionizing Maintenance Through Remote Monitoring via ICAS & Distance Support

Mike DiUlio, Brian Finley, Chris Savage, Ken Krooner  
NAVAL SEA SYSTEMS COMMAND (NAVSEA)

## ABSTRACT

Naval Sea System Command (NAVSEA) has developed, and is utilizing, a maintenance process that is changing maintenance practices and planning. This process began 5 years ago by equipping ships to continuously collect engineering plant performance data for use in a Condition-Based Maintenance environment. Today, shipboard digitized performance data is accessible on the world-wide-web and is enabling the U.S. Navy to obtain unprecedented health monitoring of their propulsion plants and auxiliary equipment. The quality and accessibility of this data is leading the way in improving current maintenance practices.

### Innovation

The innovation is to integrate existing systems and processes to revolutionize maintenance on U.S. Navy Vessels. This process will reduce Total Ownership Costs (TOC) and crew size while increasing mission readiness. This process will enable shore side subject matter experts to monitor operating shipboard equipment to allow for the optimal identification and scheduling of maintenance via an Enterprise Resource Planning (ERP) system.

Our vision is when a ship pulls into port, a maintenance package will be waiting. This package will include all necessary resources to accomplish the maintenance actions. These resources would include material, technical documentation, and if needed, personnel to execute the maintenance. This will occur with little to no ship's force intervention.

### Maintenance Effectiveness

Maintenance personnel are currently utilizing parts of these processes to remotely troubleshoot equipment problems for ships underway, minimizing equipment down-time and increasing mission readiness. By integrating these processes, the Navy will gain the full potential of remote monitoring.

### Transferability/Practicality

The Integrated Condition Assessment System (ICAS) is a Commercial Off the Shelf (COTS) software product developed by IDAX Inc., a subsidiary of GE Power Systems, for which the U.S. Navy holds Government

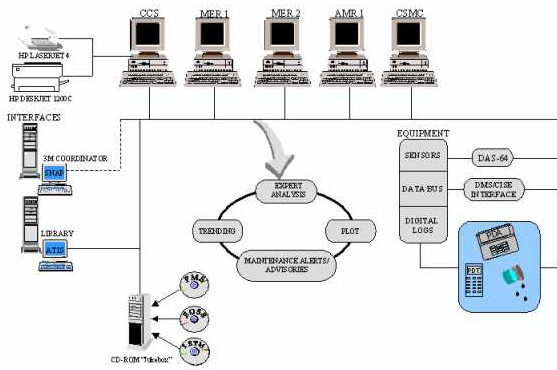
Purpose License Rights (GPLR). It is a configurable, shell type architecture to allow for varied implementation of machinery monitoring and condition based maintenance (CBM). The Boolean and Fuzzy Logic analysis engine makes it easily adaptable to most systems. Also, via an open architecture, the system can act as an infrastructure for other "bolt on" modules or systems ranging from logistical interfaces to prognostic modules. In addition to conventional Navy applications, it has been installed at nuclear test sites (Naval and commercial), various industrial sectors, and as a prototype on an Army ship. This demonstrates its transferability across various applications.

## INTRODUCTION

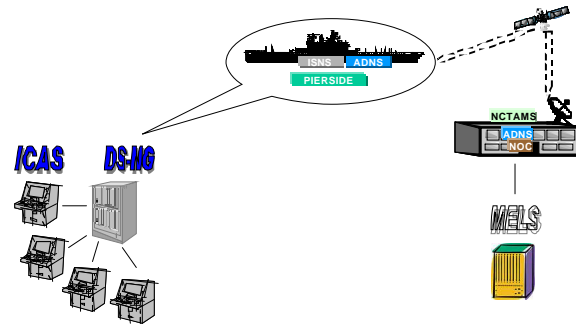
### Integrated Condition Assessment System

The Integrated Condition Assessment System (ICAS) is a Commercial Off the Shelf (COTS) software product developed by IDAX Inc., for which the U.S. Navy holds Government Purpose License Rights (GPLR). It is a configurable, shell type architecture to allow for varied implementation of machinery monitoring and condition based maintenance (CBM). Presently, ICAS is installed on over 100 U.S. Navy vessels and land based sites.

A typical U.S. Navy installation consists of four or five workstations, one in each major machinery compartment as depicted in Figure 1, connected by an active Local Area Network (LAN). Each workstation accommodates a unique Configuration Data Set (CDS), which contains the engineering information representing the equipment in that space. ICAS leverages existing ships' infrastructure by interfacing to machinery control systems to receive all pertinent information without duplicating sensor or processing hardware. For additional (non-automated) data points, ship's force utilizes a portable data collector to upload data, via a serial interface, to the workstations. This data is automatically trended, evaluated, and fused at the deck plate to allow for automated diagnostics.



**FIGURE 1. Typical CG-47 Class Installation**



**FIGURE 2. Moving Data Ashore Process**

ICAS also links to digital logistic products such as the Engineering Operational Sequencing System (EOSS), Planned Maintenance System (PMS), and Interactive Electronic Technical Manuals (IETMs). These links not only allow for browsing, but also for maintenance recommendations to be linked directly to the appropriate section or card.

Thousands of man-hours have been saved through the automation of data collection and performance monitoring. Recent efforts include data collection in a common database so that statistical analysis can be accomplished to further maintenance savings and to gain a better knowledge of equipment operation in its marine environment. As more data is gathered, the failure rates and causes are better understood. This knowledge will then be used to effect maintenance periodicities, design changes, and operational practices.

**REVOLUTIONIZING MAINTENANCE**

The maturity of ICAS in conjunction with Distance Support Capabilities have enabled the Navy engineering community to embark on a revolutionary maintenance process. This process will allow the Navy to optimally man ships as well as ensure that the proper maintenance is done at the appropriate time. The driving factor is the capability to remotely monitor the shipboard systems to identify optimal system alignments, assess machinery health and plant operations. The result is operational and maintenance cost reductions, while increasing mission readiness by eliminating unexpected failures.

Moving the Data Ashore

The data collected by the shipboard ICAS system will be seamlessly moved ashore via the Distance Support – Next Generation (DS-NG) server. At specified periods, data from the ICAS system will be “dumped” from the workstations to the DS-NG server for shipboard offload. Once shore side, the data will be routed to the Maintenance Engineering Library Server (MELS). Figure 2 represents the process of moving the data ashore.

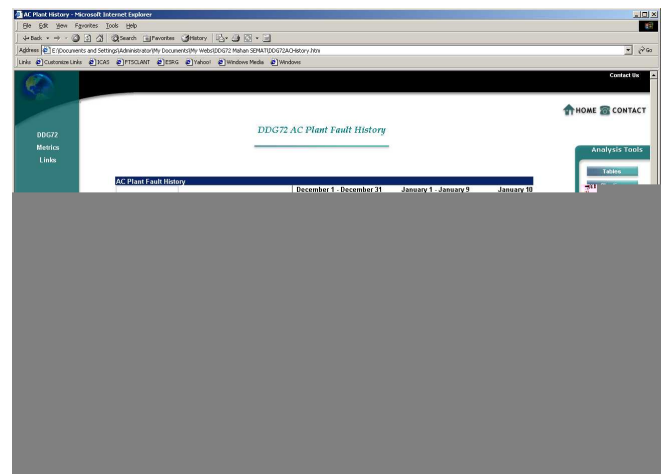
Maintenance Engineering Library Server (MELS)

MELS is a web based server which allowing access of shipboard operational data. The native ICAS data, which is ship specific, is imported into a COTS (Oracle) relational database. At that time the ICAS software is no longer needed to view the data since MELS is viewable through standard Internet browsers.

Data Analysis Screens (DAS)

Figure 3 represents a Data Analysis Screen from an ARLEIGH BURKE (DDG-51) Class ship’s Air Conditioning Plant. In addition to current fault status, the advisory actions are displayed for each fault, which allows ship’s crew, and Surface Engineering Maintenance Assessment Team (SEMAT) inspectors to communicate necessary preparations prior to a maintenance (or inspection) visit.

Additional analysis tools are available on the right. As details are needed, they can be accessed on the same summary page.



### FIGURE 3. ARLEIGH BURKE Class A/C Plant DAS

#### Engineering Performance Analysis Reports (EPARs)

From the Data Analysis Screens, subject matter experts can assess the equipment/system and generate an Engineering Performance Analysis Report (EPAR). The EPAR is the reporting mechanism in the process, containing the assessment and recommendation for the equipment/system. The report is available to all authorized individuals, including ship's force, via an Internet browser.

#### Operational Level (Shipboard)

The immediate impact of data utilization at the shipboard level is a result of ICAS' ability to provide ship's force with maintenance recommendations based on evidence of need. By changing the maintenance methodology from time based to condition based, unneeded time based maintenance will be prevented, "open and inspect" induced failures will be eliminated, and catastrophic failures will be avoided. The transition to condition based maintenance will reduce the number of man-hours spent on PMS (time-based) maintenance.

The avoidance of catastrophic failures will contribute significantly to the overall reduction of machinery repair costs and possibly defer the need for overhauls. The Kusek and Keenan, Center for Naval Analysis report (February 1998) <sup>1</sup> determined that the number of CASREPs are significantly reduced for ships with ICAS. In addition they found that the average duration of CASREP days for mission degrading CASREP's are reduced by over 30 percent.

Cost savings through

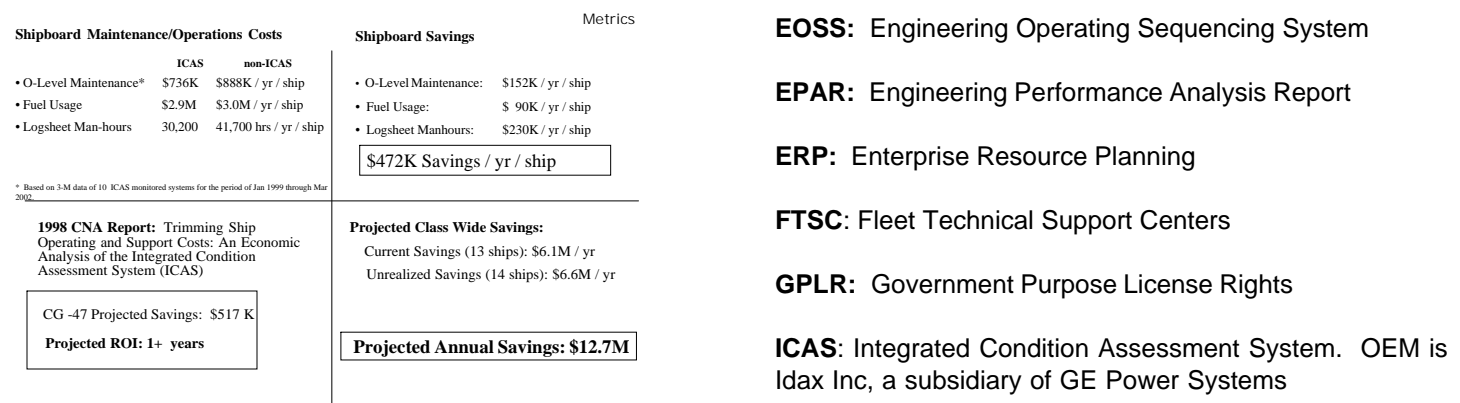
exploited by the ongoing Surface Maintenance Engineering Review (SURFMER) initiatives.

An additional ISE usage should be to assess the effect of machinery alterations. It is now possible for the operational data to be fed back to the appropriate subject matter expert to evaluate a design change.

Finally, in the spirit of continuous improvement, the data will be used to refine and optimize the shipboard condition based maintenance and monitoring system. This will lead to a continuous improvement of the ICAS Configuration Data Set (CDS), thus pushing lessons learned to the deck plate.

### Metrics

Figure 4 represents an O-Level Return on Investment (ROI) for the CG-47 Class. It utilized the CNA 1998 model to compare projected and actual savings (1999-2002). As illustrated, the projected (\$517K, lower left quad) and actual savings (\$472K, upper right quad) correlate.



**FIGURE 4. CG-47 Class ROI**

### CONCLUSION

In conclusion, the authors of this paper recognize and support the vision of revolutionizing maintenance and operations aboard U.S. Navy vessels. By integrating and leveraging existing Navy programs (ICAS, Distance Support, and MELs) this process will be realized. The process defined in this paper will enable the Navy to increase the ROI of these programs as an integrated product, as well increasing equipment and mission readiness thus preparing the Navy for the future challenges of reduced manning.

### ACKNOWLEDGMENTS

Frank Ferrese, NSWCCD-SSes 96

### REFERENCES

1. The Kusek and Keenan, Center for Naval Analysis report (February 1998)

### CONTACT

Mike DiUlio, NAVSEA 05Z53, diuliomr@navsea.navy.mil.

### DEFINITIONS, ACRONYMS, ABBREVIATIONS

**AEC:** Assessment of Equipment Condition

**CBM:** Condition Based Maintenance

**CDS:** Configuration Data Set is the engineering database used to configure the ICAS software shell

**COTS:** Commercial Off the Shelf

**DS-NG:** Distance Support – Next Generation, a program executed by NAVSEA 04L which enables engineering support to the deck plate sailor.

**EOSS:** Engineering Operating Sequencing System

**EPAR:** Engineering Performance Analysis Report

**ERP:** Enterprise Resource Planning

**FTSC:** Fleet Technical Support Centers

**GPLR:** Government Purpose License Rights

**ICAS:** Integrated Condition Assessment System. OEM is Idax Inc, a subsidiary of GE Power Systems

**IETM:** Interactive Electronic Technical Manual

**ISE:** In Service Engineer

**MELS:** Maintenance Engineering Library Server

**NAVSES:** Naval Ship Systems Engineering Station

**NAVSEA:** Naval Sea Systems Command

**NSWCCD:** Naval Surface Warfare Center Carderock Division

**PMS:** Planned Maintenance System

**RCM:** Reliability Centered Maintenance

**ROI:** Return On Investment

**SURFMER:** Surface Maintenance Engineering Review

**SEMAT:** Surface Engineering Maintenance Assessment  
Team

**TOC:** Total Ownership Cost