DIAGNOSTICS & PROGNOSTICS FOR A COLLECTIVE PROTECTION SHELTER SYSTEM

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ABSTRACT

Diagnostics and Prognostics (D&P) will be key to the usability and maintainability of future Collective Protection (COLPRO) systems. The introduction of a multiprocessor digital control subsystem into the Chemically and Biologically Protected Shelter System (CBPSS) allows for the first time the development and testing of a D&P architecture geared toward COLPRO. The proposed approach to D&P is a hierarchical, self-configuring, plug-and-play architecture which creates a generic solution that self-tailors to a shelter/mission platform. The overall concept removes the burden of diagnostics, maintenance and re-supply of such items as fuel, water, food, and residual filter life from the COLPRO commander. The status of the platform, to include its subsystem, is available at the platform as well as at a remote re-supply point. The various logistics and maintenance activities are provided individual portals into this information such that timely intervention maintains readiness at a continuously high level.

INTRODUCTION

A CBPSS is shown in Figure 1. Major subsystems include a dedicated M1113 HMMWV vehicle, a Lightweight Multipurpose Shelter (LMS) that is mounted on the back of the HMMWV, 300 ft^2 airbeam-supported soft shelter, a High Mobility Trailer with a 10 kW Tactical Quiet Generator (TQG). The HMMWV engine via a hydraulic pump subsystem, and the 10 kW TQG provides all needed power. The LMS contains a hydraulically powered environmental system to provide HVAC, airbeam inflation, and chemical/biological filtration. The CBPSS is designed so that multiple shelters can be connected as shown in Figure 2.

Figure 1. Chemical and Biologically Protected Shelter System (CBPSS).

Figure 2. Interconnected CBPSS.

Recent internal research and development work at EASI (Engineered Air Systems, Inc – a subsidiary of Engineered Support Systems, Inc) has developed a digital replacement for the analog control for a CBPSS. The control panel has been replaced with a programmable logic controller (PLC) and a microprocessor combination. This digital control system replaces hardwired, relay and control logic. The use of a PLC simplifies changes in systems operation, as well as system design. This new controller and interface are shown in Figure 3. The incorporation of the PLC, and microprocessor opens up the possibility of embedding diagnostics and prognostics into the future performance of the CBPSS.

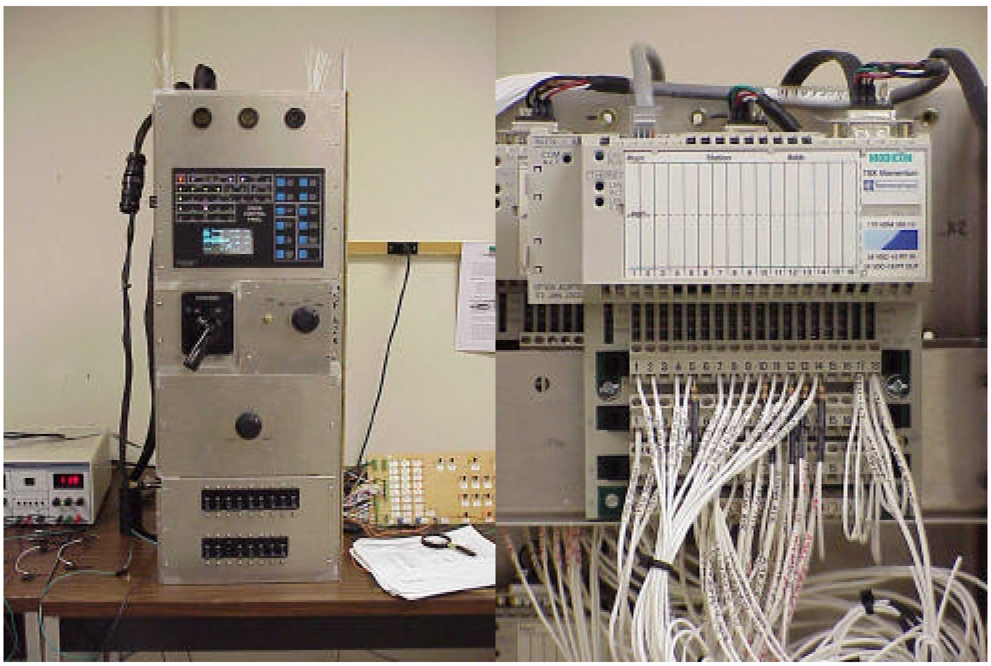

Figure 3. Digital Controller Replacement For CBPSS.

The CBPSS is but one example of a collective protective system. Other major systems include the Chemically Protected Deployable Medical System (CP DEPMEDS), the Chemically Hardened Air Transportable Hospital (CHATH), the Simplified Collective Protection Equipment (SCPE), and the future Joint Transportable Collective Protection System (JTCOPS). JTCOPS will be a modular approach that can be expanded to meet the current mission needs. JTCOPS will be able to provide protection for 30 days at a time. Lastly JTCOPS will be able to function in a stand-alone fashion or in conjunction with existing protective vehicles and shelters.

Using CBPSS and its new digital control capabilities as a model, and with an eye toward future JTCOPS, we are proposing diagnostics and prognostics architecture.

APPROACH

Current maintenance practices on collective protection center on time-based maintenance (TBM). Maintenance is performed at pre-defined intervals based on worst case analysis of equipment operation. Though this approach does not guarantee failure-free operation, without monitoring equipment it gives the largest safety margin. The cost of this approach is in unnecessary service and replacement of components. An alternative approach now being applied to aircraft, ships and tanks [3-10] is condition-based maintenance (CBM). CBM requires two things. The first, diagnostics, requires the continual monitoring of equipment to detect any anomalous conditions. Prognosis, the second, trends the gathered information to predict how much longer operational status can be maintained before servicing is required. Discussions of CBM being applied to aircraft, ships, tanks, etc can be found in references 2-10.

CBM and diagnostics and prognostics (D&P) require sensors to monitor equipment and the environment. Embedded and/or remote computing is needed to analyze data to diagnose fault conditions, to perform prognosis to predict future maintenance needs, and to provide interactive assistance to repair or maintain the system. Additionally algorithms must be tailored to trend the collected data, and search fault isolation trees. Additionally if logistics are to be included, remote communication capabilities must be available. Remote communication allows the logistics to be web based. This opens a whole new maintenance area with web based Interactive Electronic Technical Maintenance Manuals (IETMS) playing a major role in future D&P along with a consumable management system.

A CBPSS consists of a myriad of subsystems and components as illustrated in Figure 4. From an architecture standpoint, it is desirable that the D&P self-configure in a plug-and-play fashion when a new or different subsystem is loaded onto the platform, or when a new platform is integrated into a COLPRO configuration. The D&P modules in one shelter should communicate and coordinate when ganged with another shelter as shown in Figure 2. Plug and play would allow systems upgrades that allow improvements in both component capability, and D&P abilities, without affecting the architecture or D&P abilities of other components. Each subsystem should have its own embedded ability in diagnostics and prognostics as illustrated in the Figure 4.

The embedded diagnostics/prognostics plug and play into a Diagnostics/Prognostics and Consumable Executive. This executive would interpret the information for crew display and wireless transmission to a logistics portal gateway. A Windows NT Diagnostics/Prognostics and Consumable Management Graphical User Interface (GUI) would be available to the CBPS crew. The interface would display overall status information, interactive technical manuals, and stores levels such as fuel and life left on filters. Additionally the interface allows for manual entry of stores levels, such as food, water, and medical supplies.

The logistics portal has the ability to coordinate re-supply, maintenance, repair and electronic manual updates. By coordinating a data base of all diagnostics/prognostic events and conditions across fielded CBPS, updates and improvements could be made to trouble shooting and fault trees in the interactive technical manuals. Prognostics are more accurately predicted as information gathered, refining the ability to predict when preventive maintenance is required. Parts needed for depot level maintenance would be waiting and the CBPS automatically scheduled for service when needed, increasing system availability.

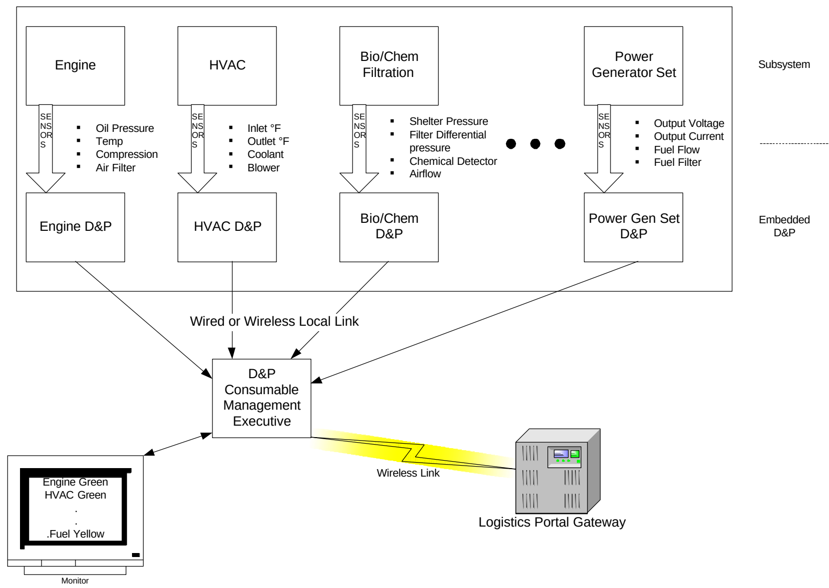

Figure 4. Diagnostic & Prognostics Architecture.

The concept for the Hierarchical Plug-and-Play DPCM architecture is illustrated in Figure 5. At the bottom level is the subsystem hardware. A protocol defines the interfaces that the embedded bottom level diagnostics and prognostics must satisfy to communicate status to the next level of abstraction (e.g., shelter and platform). Similarly the protocol for allowing consumable management is defined.

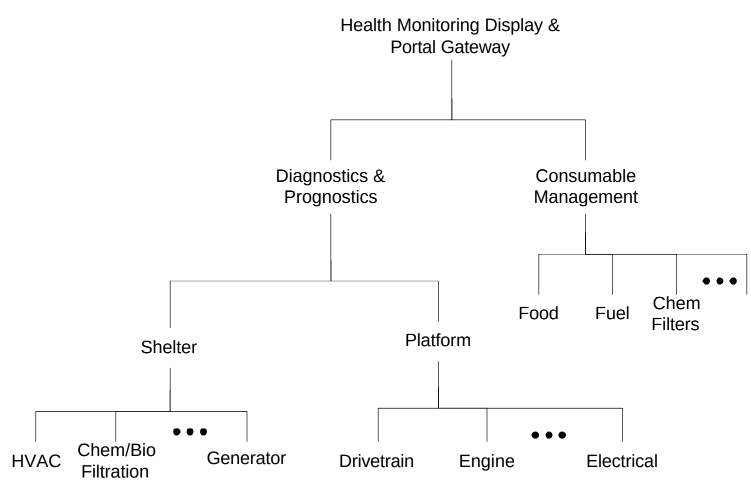

Figure 5. Hierarchical Plug & Play: Diagnostics, Prognostics, Consumables.

Development of the architecture determines the breakdown and abstraction of subsystems as shown in Figure 5. Though the actual sensor choices should be ultimately independent of the architecture, the type of information to be measured is defined. Additionally, the backbone used to plug an embedded diagnostics/prognostics subsystem into its abstraction layer will be determined (i.e., Bluetooth, fiber optic, coaxial). The choice evaluation will be on weight, performance, reliability, maintainability, technology readiness, and cost.

Methods of displaying and transmitting status information to the crew and to the portal are part of the D&P architecture development. Human factors will be used to define the form of the crew displays and how the displays will self-configure based on the plug-and-play subsystems discovered

The mix and type of information to be transmitted over the wireless link to the gateway of the logistics portal will be defined. This information will include field service requests, fuel, filter, rations, etc. Other information would be regularly scheduled maintenance, such as belt replacements, electronics calibrations, and engine overhauls.

CONCLUSION

The overall vision is the development of a hierarchical architecture that allows for diagnostics, prognostics and consumable management (DPCM) in a plug-and-play fashion, using the CBPSS as prototypical model that could be extended to smart COLPRO. A hierarchical and plug-and-play approach is desired so that the DPCM will automatically configure itself based upon both the platforms and shelter mix.

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