SUMMARY OF REPORT

Embedded Diagnostics and Prognostics Synchronization (EDAPS) Transitioning to a Common Logistics Operating Environment

US Army Logistics Transformation Agency
Materiel Logistics Division
January 31, 2003

Abstract: This is a summary of a 2003 report by US Army Logistics Transformation Agency entitled "Embedded Diagnostics and Prognostics Synchronization (EDAPS) - Transitioning to a Common Logistics Operating Environment" that describes the vision and roadmap for creating a Common Logistics Operating Environment (CLOE), where embedded diagnostics and prognostics play a key role in the infrastructure for an Army-wide logistics environment. The summary is intended as a tool for ILS evaluators to use when participating in ASTs where logistics transformation plays a role. The EDAPS report is comprehensive, and lays out work necessary through 2015 in order to realize the vision. This summary is intended to give readers a broad perspective of the road map, but with enough detail to go deeper than an executive summary would. The time frame in this synopsis is as of the date of the report. Any update to information is clearly stated as that. Ongoing actions are embodied in a series of briefings provided on the CLOE web site, https://lta.army.mil/lta/ml_div.htm.

Prepared 10 November 2004
William P. Hannah
ILSED Support

Blank page

EDAPS OBJECTIVES

- Establish a common vision for logistics processes that are enabled by self-reporting platforms with Embedded Diagnostics/Embedded Prognostics (ED/EP).
- Include in the vision an end-to-end system throughout all levels of Army logistics support, from the platform through the wholesale logistics support processes.
- Build business cases and an operational architecture for these processes.
- Develop a "road map" for how and when to put the elements of these processes in place.
- Synchronize current efforts with the vision and the road map.
- Recommend policy and doctrine changes needed to implement the new business processes.
- Assure that training requirements are built into the affected programs of instruction (POI).
- Use the business case and implementation road map to assess related initiatives to support the implementation.
- Institutionalize the integration process through some kind of durable implementation structure.

FEATURES OF THE EDAPS VISION

- All primary ground, air, combat-support and combat-service-support platforms have embedded systems that continuously monitor the readiness status of the platform and report this information through command and control and logistics management information systems.
- The embedded systems monitor crew status, equipment health, and inventories of consumables and evaluate the current and projected mission capability of the platform.
- Embedded systems include diagnostic reasoners, built-in test equipment and test controllers that can isolate faults to a single line-replaceable unit (LRU) or line-replaceable module (LRM).
- Embedded prognostic systems predict the remaining useful life for mission-critical components that fail through wear-based degradation processes. These predictions permit replacement of components before failure to maximize platform availability and reduce maintenance costs.
- The embedded system determines what action is required to return the platform to full mission capability. If maintenance is required, the embedded system identifies the required maintenance procedure so that parts can be ordered and mechanics and special tools can be scheduled to make the repair.
- Near-real-time data on usage of consumables and repair parts flows from the platform to sustainment providers who use it to fill the supply chain with the right quantities of the right items and to deliver these items to the right place in the Area of Operations.
- The embedded systems collect detailed data on operating history, maintenance history and software and hardware configuration. This data is transferred from the platform into the enterprise data warehouse through the logistics management information system. This data is readily accessible to support fleet management and life cycle management activities.
- Detailed, timely and accurate data from the embedded systems enables the Army to operate a condition-based maintenance system. This allows platforms to be scheduled for restorative maintenance tasks before failures occur.
- All processes in the maintenance and logistics system are paperless and manual data entry is minimized.

EDAPS REPORT ORGANIZATION

The EDAPS report is organized into the following sections and appendices. This outline will be used to present the summary information.

1.0 Introduction

2.0 Approach

3.0 Vision for Objective Force Logistics Processes

4.0 Description of Legacy System

5.0 Description of Interim Force Logistics Processes

6.0 ED/EP-Related Requirements

Appendices

- A Background
- B Summary of EDAPS Activities (May 2001 – October 2002)
- C Policy of Doctrine Implications
- D The Embedded Diagnostic and Prognostic Event Horizon
- E ED/EP Definitions
- F Platform Data Categories
- G Formal Operational Requirements Document Reviews
- H Acronyms

1.0 INTRODUCTION

Definition of the EDAPS Initiative

The EDAPS process pulls together key players across the Army to define the end state, develop the business processes and lay out an implementation road map that integrates current initiatives and focuses resources on the process required to implement the ED/EP enabler.

Embedded diagnostic and embedded prognostic (ED/EP) capabilities have been designated by the Army Deputy Chief of Staff G-4 as a key enabler for the logistics transformation required to support the Army Transformation Campaign Plan. ED/EP is not a stand-alone enabler, and implementing it will require the integration and synchronization of a number of systems from the individual platform through the tactical and sustainment business systems.

G-4 directed the U.S Army Logistics Integration Agency (LIA) (now Logistics Transformation Agency - LTA) to lead a collaborative effort to synchronize implementation of ED/EP capabilities; the EDAPS process is in response to this directive. EDAPS is the basis for the Common Logistics Operating Environment (CLOE).

Several critical changes in classical logistics support systems are driven by EDAPS, including:

- Forecasting certain types of equipment degradation, and scheduling of maintenance interventions, before catastrophic failure. This is described as the heart of condition-based maintenance (CBM).
- Analyzing data from embedded sensors and test equipment to continuously assess the operational status of the platform.
- Coupling of ED/EP with automatic identification technology to allow far more precise configuration control and stockage of fewer variants of spare parts, and to maintain component history updates on the platform's knowledge base.

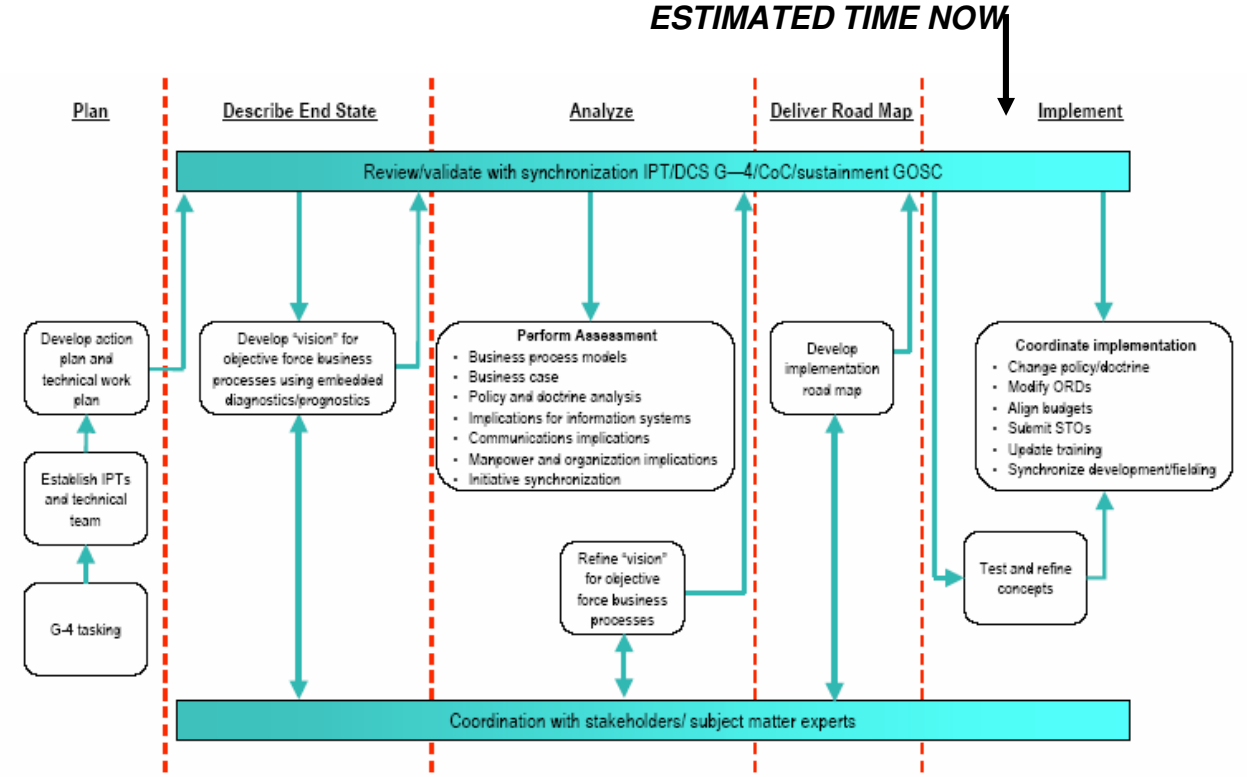
G-4 specific direction to LTA was to develop a process to:

- Pull the key players together from across the Army to define the end state,
- Design the necessary business processes,
- Develop an implementation roadmap that integrates ongoing initiatives and focuses resources on high-value programs,
- Write an action plan to accomplish the tasking, and
- Institutionalize the process.

EDAPS was recognized as a short-term effort to establish an initial synchronization process and make organizational recommendations for the ongoing development effort.

2.0 APPROACH

EDAPS is using an enterprise management framework[1] to enable leaders to manage the entire enterprise (rather than individual issues) and synchronize policy, procedures, operations, doctrine, training and automation requirements. The process is shown below. The EDAPS report is, in effect, the Road Map in the figure.



The plan provides for development of an Operational Architecture (OA) and Technical Architecture (TA).

Per recent briefings, LTA will be producing the OA and TA in December 04.

OA TO DESCRIBE

- Interim and objective force logistics processes
- Self-reporting platforms with ED/EP
- How ED/EP combines with other enablers
- Movement of platform info through tactical and logistics systems
- Info for use by tactical commanders, retail and wholesale log community

TA TO DESCRIBE

- Standards for incorporating ED/EP into platforms
- Standards to link ED/EP to log automation and C4ISR
- Data schema ED/EP info

The OA is to integrate information from other OAs being developed for various systems that must work together to implement ED/EP enabled business processes. CASCOM is projected to become the ultimate "owner" and maintainer of the overarching OA.

[1] An enterprise management framework encompasses all of the related functional activities, an operational architecture and associated metrics to define and synchronize necessary policy, doctrine, procedures, automation, and training changes to achieve the desired outcomes.

3.0 VISION FOR OBJECTIVE FORCE LOGISTICS PROCESSES

Vision responsibilities specified are:

- **TRADOC:** develops the operational and organizational concepts for the interim and objective forces.
- **CASCOM:** maintains the operational architecture for sustaining the interim and objective forces in tactical situations.
- **G-6:** Headquarters Army Chief Information Officer maintains the official systems architecture.
- **ALC:** Army Logistics Command maintains the sustainment level operating concepts, business processes and information systems.
- **PM TMDE:** coordinates efforts to implement ED/EP on platforms.

Three broad concepts as basis for the vision are:

- An essential "system-of-systems" view to integrate all the elements required for an effective logistics enterprise
- Implementation accomplished over time by adding incremental capabilities
- A system based on standardized information and communication protocols.

EDAPS recognizes that "look and feel" will be different on different platforms, but what must be standard on ED/EP applications is the data schema, the formats and interfaces that allow standardized information to be transmitted to standard management information systems over standard communications mechanisms and via standard portable maintenance aids of various kinds.

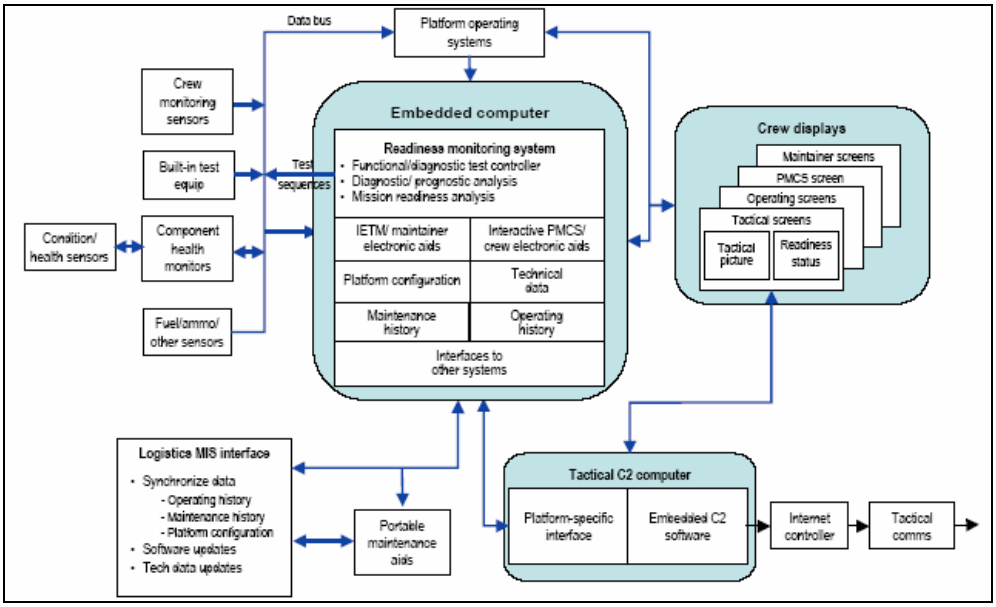
A high-level view of the ED/EP Operating Concept is presented, and details are discussed in four areas:

- The configuration of systems on the platform that generate, capture and transmit the data;
- The use of platform data in the tactical environment;
- The use of platform data in garrison; and
- Uses of the data in wholesale level sustainment and life cycle management processes.

Three overview architectures are presented for ED/EP and the on-board logistics system: 1) for a ground platform, 2) for an aviation platform, and 3) for movement of data in a garrison environment. A discussion is also presented for use of platform data in sustainment operations and life-cycle management. For example, the ground platform environment section includes a detailed three-page discussion on items such as a readiness monitoring system, fault detection and classification, trending algorithms and sophisticated decision-making routines for prognostics predictions, health monitoring, use of redundant circuitry, feeding of consumable information into the C2 system, and movement of a "rich data stream" into the logistics management information system.

Two of the overview architectures, for the ground platform and the garrison environment, are presented below with a brief discussion on data usage.

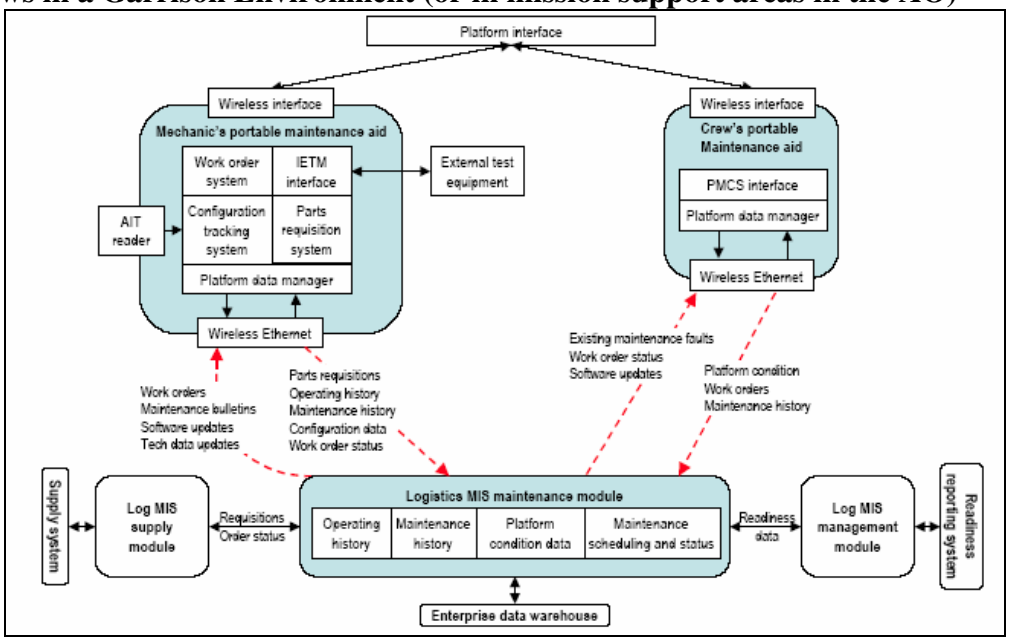
Overview of Platform-Level Architecture



Use of Platform Data in Tactical Operations

The logistics information enables the Army to conduct tactical logistics in ways that are much more responsive to the needs of the force. Tactical commanders use platform-based readiness data to make decisions about deploying combat assets to respond to changing conditions in the combat zone. The logistics staff in the unit of action (UA) and the supporting staff in the unit of employment (UE) use platform data to monitor the logistics status of combat units, track logistics assets and plan battlefield maintenance and resupply activities. Real-time readiness data from self-reporting platforms and supply points, along with asset visibility data, enable logistics decision makers to allocate assets to the highest priority needs and to *prevent* logistical problems through the application of proactive supply and maintenance support. The C2 system delivers messages directly to the Combat Repair Team (CRT) when maintenance assistance is needed. Emerging maintenance concepts rely on the crew to carry out most maintenance actions that require removal and replacement of an LRU. The embedded system helps the crew make the final diagnosis and give them access to technical data needed to complete the maintenance action. The readiness monitoring system reports the inventory of onboard spares along with reports on consumable status.

Data Flows in a Garrison Environment (or in mission support areas in the AO)



Use of Platform Data in Garrison/AO Operations

Platform data is transferred into the logistics MIS during maintenance actions. The maintenance supervisor uses the information generated by the embedded systems in the logistics MIS to order repair parts and schedule maintenance actions. Upper echelons can drill down through the reporting structure to examine the data in particular units. For example, when about to deploy, platform-based readiness data will provide an accurate picture of the status of a unit's equipment. Condition monitoring systems are part of the embedded systems on the platform. They monitor actual performance of the mission-critical LRUs as well as the usage and service conditions. This information is pulled during PMCS and other maintenance actions and processed into the logistics MIS used for maintenance management.

Note the use of an Enterprise Data Warehouse in the garrison/AO depiction. *Recent information indicates that such a warehouse is planned at two levels, one at the tactical level (probably Brigade/UA/UE), and another at the sustainment level.*

Use of Platform Data in Sustainment Operations and Life-Cycle Management

Once the information is moved off the platform into the enterprise data warehouse, life cycle managers use it to determine the root cause of excessive failures. Life cycle managers will also be better able to manage platform configuration. They will have access to LRU-level configuration information for each platform in the fleet. Materiel mangers can use information from embedded readiness monitoring systems to more accurately forecast future demand for repair parts. The National Maintenance Manager can use the prognostics information to more accurately predict sustainment level repair and overhaul requirements and more efficiently manage the workload of the sustainment maintenance provider.

4.0 Description of Legacy System

This section of the EDAPS report provides an excellent 22-page overview of the logistics process supporting legacy systems. The legacy force was chosen to provide the baseline from which to calculate costs and benefits. The legacy force includes the equipment, organizational structure, business systems, and business processes that were largely in place in the late 1990s, before the Army Transformation was initiated. Legacy forces are assumed to be a a mixture of "digitized" forces equipped with early versions of systems, such as the Army Battle Command System (ABCS), designed to implement information-centric warfare concepts under the Force XXI initiative and "analog" forces operating with Cold War era hardware and warfighting and logistics doctrine. At the time of the EDAPS report publication, the Business Process Redesign Laboratory at LIA was developing business process models to support the EDAPS business case analysis. *The current status of these modeling efforts is unknown.*

The section presents organizational roles and responsibilities, and discusses both the retail and the wholesale environments and the legacy system business processes for:

- Maintenance
- Supply
  - Repair parts
  - Ammunition
  - Bulk Fuel
- Life cycle management.

Command, Control, Communications and Information Systems are discussed, with their logistics reporting/management processes:

- C3, including ABCS, FBCB2, MCS, AFATDS, ……
- Logistics, including LOGSITREPSs; CSSCS; ULLS – G,A,S4; SAMS; SARSS – 1,2A, 2B, Gateway; SAAS.

The report points out that ED/EP and related technologies, such as interactive electronic technical manuals (IETMs), are just beginning to appear on legacy Army platforms. A few systems have embedded diagnostics. These capabilities have been retrofitted to selected platforms to reduce the requirement for external test equipment, to improve readiness, and to reduce maintenance cost. Built in tests and built-in-test equipment (BIT/BITE) is becoming more common, particularly on electronics and non-developmental items. No legacy Army platforms have embedded prognostics capabilities.

Virtually all Army systems and end items have electronic technical manuals (ETMs). The first generation ETMs only translated the hardcopy technical manuals into a "flat file" (PDF) format electronic form. The ETMs are gradually being replaced with interactive electronic technical manuals. Both ETMs and IETMs run on a portable maintenance computer, such as the Soldier's Portable On-System Repair Tool (SPORT). Embedded IETMs are being developed, but are not yet in the field.

Several aviation platforms are being equipped with health and usage monitoring systems (HUMS). Some HUMS can display critical health status information to the flight crew.

5.0 Description of Interim Force Logistics Processes

This section of the EDAPS report provides a 27-page description of the interim forces resulting from initiation in 1999 of the Army's transformation process anticipated to stretch over a 20 to 25-year period. The Stryker Brigade Combat Team (SBCT) is the foundation of the interim force. Emphasis in the section is on the logistics processes that are anticipated to support the ground portion of the interim force. The interim force is being fielded to:

- Meet near-term needs for flexible, rapidly deployable forces;
- Prove new operating and sustainment concepts; and
- Serve as a bridge to the objective force.

The logistics transformation expected in the interim force is detailed in the table below. Note the role of ED/AP as an enabling technology to shift the legacy characteristics to the future.

Existing Characteristic	Area of Change	Enabling Technology						Expected Result
		Enterprise interfaces	AIT	IETM	ED/EP	T/LDD	EC3	
4-level Maintenance	Organizational	X	X	X	X	X	X	2-level Maintenance
Manually generated and transmitted LOGSITREP	Platforms and processes	X			X	X		Embedded autonomous sustainment reporting by platform
Organizational maintenance on the platform	Organization and training			X	X	X	X	Use of combat maintainers Increased contractor support
Unit distribution	Processes, procedures, equipment	X			X		X	Platform specific and unit configured sets
Resupply on demand, large forward stodkpiles	Procedures, operating concepts	X			X		X	"Just enough" and infrequent
Repair forward	Organizational, systems	X	X	X	X	X		Replace forward, repair rear
Redundant capability in forward areas	Organizational, training, doctrine			X	X	X		Lean support, built-in robustness, triage until redeployed
Failure-oriented maintenance processes	National maintenance program	X			X	X		Condition-based maintenance
National Stock Numbers	Repair parts management	X	X					Automatic Identification Technology
Paper technical data	Data management	X		X		X		Electronic technical manuals
Legacy STAMIS	Information management	X	X	X	X	X	X	Enterprise management environment

AIT: Automatic Identification Technology
IETM: Interactive Electronic Technical Manual
ED/EP: Embedded Diagnostics/Embedded Prognostics
T/LDD: Tactical/Logistics Data Digitization
EC3: Embedded Command Control, and Communications

How ED/EP Fits in the Interim Force

Policy and doctrine for the interim force – SBCT – are described in detail, highlighting the differences from the legacy force to the interim force. The key areas presented are highlighted here:

- Supply doctrine – founded on distribution-based logistics
- Configured loads – key to distribution-based logistics
- Maintenance doctrine – replace forward, repair rear; field and sustainment maintenance
- Combat maintainer – crew/maintainer adds some corrective maintenance actions beyond traditional PMCS
- Contractor support – integral part of maintenance doctrine for SBCT
- Development approach – continuous evolution.

Opportunities where ED/EP (and CLOE essentially) fit within the interim force infrastructure are described; and some are extracted below as examples to indicate the level of detail planned at this stage [2003] of the process:

> The support concepts for the SBCT are based on a number of enablers including ED/EP, selfreporting platforms, near-real-time communication of logistics data, enterprise resource planning, automated data capture, automation of management and administrative tasks, operators trained to carry out some maintenance actions, TAV/ITV, and embedded interactive electronic technical manuals. These enablers are only partially implemented; "patches," in the form of temporary support processes, are being placed on the logistics system for the interim force to permit it to operate without these enablers. These patches invariably add to the logistics footprint and manpower.
>
> Future configurations of the SBCT will leverage ED/EP technologies to embed the DPMCS and logbook update functions on a computer on each vehicle platform. The crew will then access these applications through an onboard display, reducing the requirement to manually input data and exchange updates. Removable displays are being evaluated to replace the PDAs to permit the crew to use the applications as they move around the platform, performing checks and other maintenance actions. Data from the platform-based system would be exchanged with the ETM-I server through a wireless Ethernet connection, eliminating the current need to physically synchronize the PDAs with the platoon leader's laptop computer. The platoon leader would retain the ability to review the PMCS results on the server before they were released to other users.
>
> As ED/EP technologies are integrated on the platform and IETMs are enhanced, the IETM can be imbedded on the platform computer. This will then remove the IETM from the MSD and allow the IETM to communicate and interact autonomously with components on the platform. With such embedded systems, the mechanic could use an onboard display to access the troubleshooting sections of the IETM and perform many of his functions without the MSD.
>
> Additional enhancements that would specifically support the ED/EP operating concept are being considered for FBCB2. In mid-2002 USALIA funded a study to examine the interface between FBCB2 and embedded diagnostics systems. This activity developed a draft Interface Control Document for the software between the platform and the FBCB2. When fielded, this interface will allow health, fuel and ammunition status information to be automatically transferred from the embedded systems to FBCB2 to allow the transmission of the information from the platform; currently, the crew must enter this information manually, using readings from gauges, instruments and observations. This EDAPS task also developed and demonstrated proposed modifications to FBCB2 messages to permit information from ED/EP systems to move through FBCB2 to maintainers and logistics planners. Based on this work, PM FBCB2 will include these capabilities with future upgrades of FBCB2.

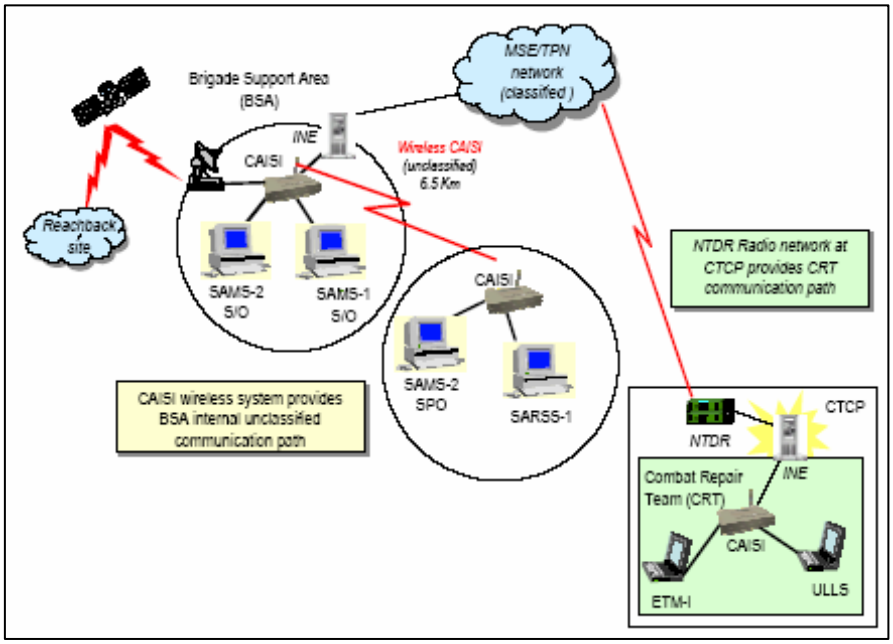
As of the EDAPS report publication, LTA has modeled and is continuing to refine business processes for the interim force to evaluate organizational design and processes. Models were developed with support and cooperation of the SBCT and TRADOC.

The business processes for the interim force are described in detail and include:

- Maintenance
  - Garrison
  - Tactical
  - Sustainment
- Supply (by class of supply)
- Life cycle management.

The communications infrastructure for the interim force is key to enabling ED/EP and the CLOE. The logistics communications architecture for the SBCT, as of January 2003, is below:

SBCT Interim Logistics Communications and Information Systems Architecture



In and near the BSA, the logistics staff will be linked through a wireless Ethernet provided by the CSS Automation Information System Interface (CAISI) wireless system. A satellite link will connect the CAISI network with logistics information systems and related resources in CONUS. The Combat Repair Teams will operate through the CAISI wireless network resources assigned to the CTCP to give them connectivity to the BSA.

The interim logistics communication architecture permits the SBCT to operate with currently available systems, but better solutions are needed for efficient operations. The SBCT is being fielded with legacy logistics information systems (ULLS-G, ULLS-S4, SARSS, SAMS-1, SAMS-2, SAAS ATP and SAAS BAO). The limitations of these systems are well known. Operating with this suite of systems will reduce the efficiency of most support functions. The limited capabilities of these systems make it necessary to develop "work-arounds" using

frequency modulated (FM) voice circuits and using "sneaker nets" to move information from the platform/near platform into the maintenance system. The PM overseeing Logistics Information Systems will initially upgrade and ultimately replace the legacy information systems, but this is not yet available.

Overall status of ED/EP in the Interim Forces

The EDAPS report recognizes that development of embedded diagnostics and prognostics for the SBCTs is evolving continually, using the Stryker vehicle as the base platform. The first and second brigades have some embedded diagnostics. SBCT brigades three and four are to be equipped with embedded health management systems using IETMs. The computers on these platforms will be linked through a LAN, but software changes have not yet been approved to permit vehicle status information to move automatically from the Embedded Diagnostics System of the vehicle into FBCB2 for transmission from the vehicle platform. Embedded prognostics are planned for Strykers of the fifth and sixth brigades.

Legacy platforms comprise two thirds of SBCT vehicles. These have limited embedded capabilities. All platforms have electronic technical manuals, but most do not yet have IETMs and none have embedded IETMs. Not having embedded diagnostics and IETMs makes the crew/maintainer concept difficult to implement.

Proof-of-concept demonstrations are planned that will ultimately be scaled up to a brigade-size experiment, and lessons learned and cost benefit information will help define the ultimate ED/EP configuration for incorporation into the FCS program for the objective force.

At this point, the integration of true prognostics systems into the interim force is deemed likely later in the decade. Once initial production is complete for Stryker brigades, it is reasonable to expect prognostic capabilities will be considered as follow-on modifications for the vehicles.

6.0 ED/EP-Related Requirements

The study recognizes the essential need of getting ED/EP-related requirements into operational requirements documents that drive the platform and infrastructure design to handle ED/EP and the CLOE.

This 20-page section of the EDAPS report presents an analysis of:

- User needs
- Platform requirements
- C2 systems requirements
- Logistics management information requirements
- Information exchange requirements
- Results of ORD reviews for ED/EP-related capabilities.

Platform data from the user perspective addressed:

- Who would use platform data?
- What functions would they perform using the data?
- What types of platform data would they need to carry out these functions?

User Needs

The user needs assessment in the EDAPS report is not intended to provide an exhaustive treatment of this topic, but to identify the major segments of platform data from the perspective of the potential users of that data. The purpose of this work was to support efforts by PM Logistics Information Systems (PM-LIS), PM TMDE, several platform PMs, and others to develop a data schema for GCSS-A/T and to develop a standardized interface between platforms with embedded diagnostics and embedded prognostics systems and GCSS-A/T. To that end, a detailed table of platform data needed was developed by 16 different user positions (e.g. tactical commander, logistical commander, life-cycle PM, etc.), and for each of these, specific functions and activities were identified, then mapped into specific platform data needed for those activities.

This preliminary user needs assessment demonstrates how timely data from self-reporting platforms is useful across a broad range of tactical and sustainment processes. The assessment resulted in the following characteristics of use:

- It provides tactical commanders and their logistics staff with critical information they need to plan and execute the battle and support the force.
- It provides staff in sustainment-focused organizations with the information they need to anticipate needs and put the right materiel in the pipeline to deployed forces.
- It removes the reporting burden from soldiers and unit commanders and greatly improves data quality.
- It removes the time lag from readiness reporting and enables commanders at all levels to use their available resources to maximize readiness.

- It provides life cycle managers with access to accurate and detailed information on what is happening on platforms so they can identify and eliminate readiness and cost drivers.
- It allows training program developers to identify training-related contributors to readiness problems and improve programs of instruction to reduce these impacts.
- It provides sustainment maintenance managers and providers with the information they need to plan and execute a cost-effective sustainment maintenance program.

Platform Requirements

This section of the EDAPS report provides an initial assessment of capabilities that would be needed on Army platforms to implement the ED/EP operating concept described in Section 3.0. These initial results are being used as a starting point for discussions with key stakeholders to develop recommended requirements for specific platforms. ORD terminology has been adopted in the descriptions, which include threshold and objective performance targets where they can be specified with available information. The capabilities/requirements are presented for each of the following areas:

- Embedded readiness monitoring system
- Embedded diagnostics
- Integration with component health monitoring systems
- Embedded prognostics
- Embedded IETM
- C2 system interface
- Data capture and storage
- Configuration data
- Interactive PMCS
- Portable aids
- Interface with logistics MIS
- Receive data from the logistics MIS.

Example: A platform configuration description will be captured and maintained to the LRU level. Hardware configuration should be maintained at the NSN and serial number level, and should include the installation date. Software configuration will be maintained by title, location and version number. The capture and storage of the configuration data will become an automated function. This automation will require implementation of other enablers such as the use of AIT technology to track LRUs and end items by serial number. A version of the configuration database will be kept on the platform for use by the mechanic, and configuration data will be transferred to the Logistics MIS for access by other users. The threshold requirement is a configuration description that covers components that are designated as cost or readiness drivers. The objective requirement is to maintain a platform-specific configuration description that covers all mission-critical hardware and software on the platform.

C2 Systems Requirements

This section discusses ED/EP-related requirements for command and control systems. The capabilities are not confined to logistics functions because many of the logistics sustainment processes also have command and control implications. The discussion focuses on platform-level C2 systems and the C2 systems that support tactical commanders and logistics staff at brigade or unit-of-action level and below. Requirements are discussed for:

- Platform interface
- Automate status reporting
- Readiness-based reporting
- Flexible reporting process
- Supply point status
- Use platform data in operational planning
- Use platform data to enhance situation awareness
- Use platform data in logistics C2
- Distribute and exchange data.

Example: The Tactical C2 System will have a hardware and software interface with the embedded health monitoring system on the platform. Platforms cannot be self-reporting without this interface. The embedded readiness monitoring system has the data necessary to automatically populate status reports and requests for logistics assistance. The C2 system can move the data off the platform to users in the tactical community. In the objective force, this interface will probably be standardized. In the interim force, a flexible approach is needed for the physical interface. Current platforms use or plan to use serial interfaces (RS232, RS422 and RS485), sensor link protocol, MIL-STD-1553, automotive data bus standards (CanBus, J1708, J1587), and Ethernet.

Logistics Management Information Systems Requirements

GCSS-A will be the primary logistics management information system using an enterprise resource planning system interface with the interim and objective forces. The sustainment- and tactical-level portions of GCCS-A will tie in through a commercial enterprise resource planning system as the "core" software. This will allow users across the Army to access a common set of logistics data in the "enterprise data warehouse." Although GCSS-A will use the core software provide by the enterprise vendor, it will also require development of specialized software applications to support Army-unique functions that use the data in the enterprise warehouse. EDAPS has conducted a preliminary assessment of the capabilities that will be required in GCSS-A to make the vision in Section 3.0 a reality. The GCCS-A capabilities and requirements for logistics management information systems are outlined in detail in the areas of:

- Platform interface
- Platform data warehouse
- Maintenance management
- Readiness management
- Crew or maintainer interface
- Mechanic/maintainer interface
- Technical data updates
- Data from other sources
- C2 system interface
- Life-cycle management
- Inventory management
- Sustainment maintenance management
- Rebuild or overhaul process support.

Example: GCSS-A will maintain the primary warehouse for data downloaded from embedded systems on platforms. This data is expected to conform to a data standard such as an updated version of MIL-STD-3008. The EDAPS objective is for all data to be XML compliant. Example data types include health status, platform configuration, sensor logs, event logs, operating hours, speed log, acceleration log, external environment, geographic location, operator ID, rounds fired, firing rate, fault codes, diagnostics session logs, maintenance action, date performed, time required, mechanic ID, components replaced by serial number, and software updates installed. The platform data warehouse will include the platform configuration database. GCSS-A will link the platform data warehouse to the Army's shared data environment. Through this link, any authorized user in the Army will have access to the platform data warehouse.

Information Exchange Requirements

EDAPS has developed a preliminary information exchange matrix for systems required to generate, capture, move, and use platform data. It is intended to illustrate the major types of data that move between the systems. The matrix specifies five systems, the other systems each interfaces with, what data it receives from the interfaced system, and what data it sends to the interfaced system. The five systems mapped are:

- System and Component Health Monitoring System
- Platform Readiness Monitoring System
- Tactical C2 System
- Logistics C2 System
- Tactical Logistics MIS.

ORD Reviews

EDAPS surveyed existing ORDs for major platforms and systems and provided inputs to the user based on their reviews. As of the 31 December 2002, 35 formal requirements reviews had been conducted.

APPENDIX SUMMARIES

APPENDIX A Background

The EDAPS effort is designed to pull the players and pieces together to rapidly and efficiently transition the Army to the Objective Force.

This appendix traces responsibilities as ED/EP became a logistics enabler. Primary responsibility for platform-level implementation of embedded diagnostics was focused in the Army Horizontal Technology Integration (HTI) initiative, called the Army Diagnostic Improvement Program (ADIP). The PM TMDE was directed to develop an Army-wide strategy for putting embedded diagnostics on legacy Army equipment. A memo dated 8 June 1998 from the Assistant Secretary of the Army for Research, Development and Acquisition directed all program executive officers (PEO) and reporting PMs to coordinate their embedded diagnostic programs through ADIP. Consequently, the current focus of ADIP is embedded diagnostics. ADIP has also provided limited prognostics capabilities are being provided through off-platform analysis.

Selected portions of today's legacy force are to be recapitalized through limited modernization in order to bridge the gap between today's Army and the Objective Force.

The DCS, G-4, of the Army put embedded diagnostics and prognostics and the associated interactive electronic technical manuals (IETMs) on the list of key logistics enablers for the Objective Force. Primary responsibility for platform-level implementation of embedded diagnostics has been focused in ADIP.

APPENDIX B Summary of EDAPS Activities

This summarizes planning and coordination activities conducted prior to the preparation of the EDAPS report.

APPENDIX C Policy and Doctrine Implications

The EDAPS study group conducted an in-depth review of 31 major policy and doctrine publications to identify relationships, gaps and required actions pertaining to ED/EP. The assessment determined whether generic or detailed ED/EP requirements were present in current policy and doctrine publications. The following actions were identified as being required to bring policy and doctrine in line with the use of ED/EP:

- Institutionalize standard ED/EP definitions.
- Update key acquisition policy and doctrine publications to reflect the formal recognition of ED/EP as a required enabler.
- Draft and implement new policy and doctrine.
- Draft and insert new ED/EP requirements in ORD reviews.

APPENDIX D The Embedded Diagnostic and Prognostic Event Horizon

Platforms will have a spectrum of capabilities as individual platforms are developed. This appendix recognizes there will be a spectrum of platform capabilities, and further that certain pace setters must be in place for platform capabilities to be fully usable. The pace setters for ED/EP capabilities are summarized below.

Platform Pace Setters	Sustainment System Pace Setters
• Sensors and electronic digital control systems for embedded diagnostics o Sensors for component anomaly or failure detection o Data bus for sensor signal path management • Platform health management software integrated with embedded diagnostics • Integrated health management and vehicle communication systems	• High bandwidth communication systems o Satellite o Radio • Enterprise resource planning (ERP) system technology and procedures o Support for condition-based maintenance - Procedures - Data Interfaces - Data Schema - Predictive Algorithms - Logistics Action Triggers o Sustainment support • System Integration o ERP o Communications systems o Networks

Three Stages of ED/EP Implementation

Three stages defined are summarized below:

1990 2005 Embedded Diagnostics Stage	2006 2010 Health Management Stage	2011 → Embedded Prognostics and Condition-based Maintenance Stage
Legacy equipment has spectrum of ED, from none to rudimentary Onboard diagnostics BIT not integrated with on-board cause-effect analysis	Automated logbook Sensor-coupled IETM AIT Health management software, but failure-event driven ED applications integrated with on-board comms/displays	Availability of high-bandwidth satellite and digital radio comms Fully functioning GCSS-A EFP software, modules, and interfaces
Stage began with Force XXI concepts	*Coincides with evolution of interim force*	*Total sustainment capability evolves – platform and networked "system of systems"*

APPENDIX E ED/EP Definitions

There have been no standard definitions adopted by the Army for embedded diagnostics or embedded prognostics. Definitions and/or descriptions in the appendix used by the EDAPS effort are presented for:

- Embedded instrumentation
- Embedded diagnostics
- Embedded prognostics
- Health management system
- Integrated vehicle health management system
- Condition-based maintenance system.

APPENDIX F Platform Data Categories

Sixteen data categories (such as platform health status, consumption data, sensor logs) for platform data are tabled, with definitions of each and sample data elements.

APPENDIX G Formal Operational Requirements Document Reviews

Thirty-five system ORDs are tabled that had a formal review by EDAPS through December 2002.

APPENDIX H Acronyms