**U.S. ARMY AVIATION
AND MISSILE COMMAND**

ADVANCED MAINTENANCE AID CONCEPTS (AMAC)

Final Report
(CDRL A003)

BOEING
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Abstract

The Advanced Maintenance Aid Concepts (AMAC) Final Report summarizes the effort to analyze, design and prototype a next-generation portable maintenance aid for the CH-47 Chinook helicopter. The AMAC Demonstrator supports both the traditional phase maintenance system used today as well as multiple, flexible maintenance management schemes responsive to operation within a digital aviation logistics (DAL) environment.

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1.0 Introduction

Automated Electronic Maintenance Aids have been developed with objectives to increase maintenance efficiency, reduce maintenance costs and reduce training requirements. Unfortunately, efforts to date have been handicapped by requirements to imitate the paper environment they were intended to eliminate. As a result, each new automated initiative produces limited success when directly compared to predecessor paper based technical procedures. More importantly, each iterative advance with a new electronic device produces interface challenges resulting in limited use of the device; or stand-alone systems, which are reliant on paper and are of questionable utility due to the many software and man-machine interfaces, which are difficult or impossible to bridge in hindsight. Clearly, a soldier-friendly suite of flight line maintenance capabilities packaged into a portable hardware item that defines the interfaces and bridge the barriers of the current Army Aviation logistics environment is required.

2.0 Background

The Aviation logistics environment is a cost and asset constrained environment where aircraft, Unit and Theater level maintenance management information is critical to the field Commander and supporting Logisticians. Decisions made at each level rely heavily on reported and historical data which, is dramatically affected by the latency built into the information chain. The latency originates and ends in the unit environment. This is due, in part, to the lack of an intuitive and "hassle free" flight line data collection system and a simple interface for data entry into an electronic logistic system. As a result, at every level above Unit level, the data available to support day-to-day logistics decisions is not available, old or ancient, and cannot possibly reflect the actual status and situation in the unit today.

The data collection and entry issues are a result of a paper based collection and entry system which is executed via paper logbook and component management forms, which are usually completed after the maintenance is performed. Unfortunately, this logistics paper work is an "overhead" task, which is entered into the system after the maintenance action occurs. As a result, maintenance actions, cannibalization and other management decisions, which are forced by aircraft failures and/or hardware and repair parts shortages, are not visible at levels above the unit organization for several days or weeks. This lack of insight within the Unit and at levels above Unit makes maintenance workload difficult to manage as a result of the constant reshuffling of part requisitions from one tail number to another, and the tedious mix of human and paper input into the management system. Modern data input tools and devices have not been integrated to alleviate this problem and the current digitization initiatives do not address the basic problem. A flight line portable processor developed to enable simple, efficient and immediate input of this critical data while work is in progress could save significant non-productive man-hours and capitalize by providing real time data entry, transport and transfer capabilities through all levels of the system.

Other, very formidable, logistics requirements which drive aviation maintenance are the direct result of rigid maintenance schedules which do not account for utilization variables. Aircraft maintenance schedules are derived as a result of the aircraft design

process. Reliability and Logistics analysis determines scheduled maintenance inspection intervals parallel with system and sub-system design. These inspection intervals are based on predictions and a rigid scenario providing a pre-defined flying hour usage rate and scheduled maintenance program. This process forces all scheduled maintenance inspections to be "fitted" into a fixed maintenance schedule.

To complicate matters, maintenance schedules are not updated frequently to arrive at the best possible scheduled maintenance interval for two reasons. The first reason is the lack of timely, comprehensive and accurate historical maintenance data on which to base changes. Without good quality, fleet level data changes e.g. usage rates, are difficult or impossible to justify. The second reason is that the maintenance schedules were not developed in an architecture that acknowledges that maintenance credits could be "earned" through variable usage, environment, and other factors. For example: surge operations in high tempo operations could develop inspection "credits" for inspections fitted into the maintenance inspection schedule primarily because the usage model indicated that the aircraft would be inspected every two years based on the fixed usage rate assumed in development. In this case a maintenance inspection which was intended to be performed every two years (based on fixed assumptions) would, in fact, be performed more frequently (and unnecessarily) in a surge situation where very high flying hour usage is experienced. An emerging technical capability to collect and assimilate usage, on-aircraft in a dynamic, near real-time manner, could produce significant benefits in terms of eliminating unnecessary maintenance inspections and the development of a more flexible and managed approach to scheduled maintenance.

The presentation of technical support data remains one of the greatest challenges of the information age. Many new capabilities exist but few do much more than present the data in a mock paper format supplemented with animations and other graphic enhancements. These new products also incorporate new locating and navigation tools as part of the presentation package to provide the maintainer enhanced performance through simpler and less complex navigation. But none of these systems have yet explored the possibilities enabled by the introduction of full fidelity three-dimensional graphic models with which the human can interact in the same manner as an actual aircraft, in part because of specification issues and other regulatory issues related to IETM development.

To date, no military aircraft manufacturer has yet produced and fielded a full-up, specification compliant IETM. During the ten-plus years dedicated to develop the specifications, which govern military applications of these products, the computing capacity and graphics power of portable processors has increased to the point where a new era of graphics and interface capabilities are available for development. Industry, in general, and the military remain focused on developing and fielding a capability, compliant with current specifications that have not been able to "keep up" with growth in processors, which are antiquated and based on the "look and feel" of paper based products.

Two-dimensional data presentation dates back to aboriginal, communicative inscription in sand, stone, or later, paper. Three dimensional, interactive, solid, full fidelity models are the future of the human interface with real, complex objects. A capability to present

maintenance data in this new and revolutionary environment is explored and demonstrated as part of the AMAC program.

3.0 AMAC Demonstrator Objectives

The AMAC demonstrator addresses the digital maintenance environment and flight line data collection issues through a unique approach to human/hardware/software integration. The AMAC approach is driven by today's Army maintenance environment with the ultimate goal being to significantly improve combat readiness while providing the ability to save expenditures through usage "credits" which will enable maintenance cost avoidance.

The AMAC is not just another digital technical manual. The primary benefit of an AMAC can be realized through an "intelligent" maintenance and logistics management solution providing a significant soldier performance advantage over contemporary systems available today. The AMAC prototype demonstrates the primary functionality of an overall logistics management system that tests and develops the basis of a new era of managing and presenting critical maintenance data. The AMAC system provides unique tools, which not only improve individual soldier performance but enables maintenance managers to make critical decisions in a more flexible aircraft maintenance environment.

4.0 Requirements Analysis & Rapid Prototyping Approach

4.1 Phase and Preventive Maintenance System Analysis

The AMAC team performed an analysis of Chinook scheduled maintenance to include:
- Phase Maintenance Checklists
- Schedule Services
- Heavy Maintenance Areas
- Parts/consumable requirements

4.1.1 Phase Maintenance Checklists

The phase maintenance schedules for the CH-47D, MH-47E and a number of international Chinook schedules were evaluated. The US Army CH-47D is currently maintained on a 200 hour phase maintenance system. Other systems in operational use include a 300 hour Progressive Phase Maintenance system consisting of 15-20 hour packages, a 300 hour system with a 150 hour intermediate and an independently developed schedule.

The objective of this analysis was to determine the advantages and disadvantages of different methods of performing phase maintenance. The second objective was to arrive at a new, more efficient schedule for the CH-47 D which incorporated the best of all systems in use to maintain the aircraft. Examples of the number and types of phase maintenance schedules in use are contained in figure 4.1.1-1

OPERATOR	PHASE TYPE AND INTERVAL
US Army	200 HOUR
RNLAF	300 HOUR WITH 150 HOUR INTERMEDIATE
KOREAN ARMY	300 HOUR PPM - 15 EACH 20 HOUR
KOREAN AF	300 HOUR PPM - 15 EACH 20 HOUR
THAILAND	300 HOUR PPM - 15 EACH 20 HOUR
MINOS	200 HOUR
RAAF	200 HOUR
SPAIN	200 HOUR
GREECE	200 HOUR
RAF HcMkII	USER DEVELOPED PACKAGE

Figure 4.1.1-1 Example Phase Maintenance Schedules

The CH-47D Phase was decomposed as a baseline for comparative analysis for the AMAC. The team decomposed 385 phase maintenance checks into "card-like" inspections. This step was necessary to reconcile the inspection requirements in the phase books with its associated maintenance check(s). The initial prototype cards are rather primitive, in that they include only inspection, removal, reinstallation and other data from the maintenance manuals. A production version of the AMAC would require the creation of full set of electronic "cards" with all data collection capabilities, integrated into the AMAC scheduling system.

The number of inspections and areas evaluated in the phase maintenance inspection checklist for the U.S. Army CH-47 D follow.

Inspection Checklist Areas	# Inspections, Services, Tasks
Area 0 - Preparation	7
Area 1 - Nose	13
Area 2 - Left Fuselage	35
Area 3 - Right Fuselage	34
Area 4 - No. 1 Engine	36
Area 5 - No. 2 Engine	36
Area 6 - Aft Rotor and Pylon	33
Area 7 - Forward rotor, crown, and tunnel	37
Area 8 - Ramp	32
Area 9 - Cabin	23
Area 10- Cockpit	41
Power On Checks	56
Final Inspection	2

Table 4.1.1-2 Inspections by Area

4.1.2 Scheduled Services

Scheduled Services include all services performed on the aircraft during phase and during other intervals throughout the operational cycle of the aircraft. Some are due as a function of operation, flight time and/or calendar time. These traditionally Form 2408-18

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inspection items were also studies and were determined to be an integral part of the scheduled maintenance database to be incorporated into the AMAC.

Item to be inspected	Reference	Frequency
Ground Run	TM 55-1520-240-23-1	14 day
Inspection of all 3 hydraulic pumps	TM 55-1520-240-23-1	14 day /10hr
Abbreviated corrosion inspection	TM 55-1520-2240-23-2	90 day
DA For 365-4 Review (Wt&Bal)	AR 95-3	90 day
KY58 Battery Inspection	TM 11-5810-262-12	120day
In-depth corrosion inspection	TM 55-1520-240-23-2	180days
Corrosion Insp. under the cockpit, cabin and ramp flooring	TM 55-1520-240-23-1	180days
Aircraft Battery Inspection	TM 11-6140-204-12-2	25hr
Visual inspection of upper damper lugs bushings P/N 145R3116-10	TM 55-1520-240-23-1	25hr
Engine & Transmission oil samples	TB 43-0106	25hr
Visual Inspection of C-box Support fittings	TM 55-1520-240-23-1	50hr
Vibration Check	TM 55-1520-240-23-1	100hr
Fwd & aft droop stop retorque	TM 55-1520-240-23-1	100hr
Acft lube IAW lube chart	TM 55-1520-240-23-1	100hr
Combining Xmsn cooler fan tip rub insp.	TM 55-1520-240-23-1	100hr

Table 4.1.2-1 DA Form 2408 Inspection Item examples

4.1.3 Heavy Maintenance Items

The team compiled and analyzed the maintenance drivers on the Chinook. The table below breaks out the percentage (%) of maintenance actions by system. This was performed to determine the best possible candidate systems for the AMAC demonstration. The aft rotor was selected as the candidate system by mutual consensus of AATD and Boeing.

System	% of Actions		* Other Areas
Airframe	21.4%		
Rotor	13.6%		
Engine	10.3%		
Avionics	10.1%		
Electrical	7.7%		* Other Areas
Hydraulic	7.2%		Fuel
Instruments	6.6%		Utility
Drive	5.8%		Auto Pilot / Auxiliary Power
Flight Controls	3.9%		Environmental
Landing Gear	3.6%		Electronic Counter
Mission Equipment	1.8%		Emergency Equip
All other areas *	8.0%		Hoists and Winches

Table 4.1.3-1 Scheduled & Unscheduled Maintenance Actions
Percent of Actions in 178,244 flight hours

4.1.4 Parts/Consumables Usage

Parts and consumables usage was an identified study and analysis area. Unfortunately, data does not exist to determine the actual consumption of depot level repairables and other parts. As a result this area of analysis was not completed due to the lack of adequate information.

4.2 Field Visits

The AMAC team visited the 7th Battalion, 101st Airborne Division, at Ft. Campbell, KY to review current maintenance processes and to collect Phase maintenance records for two Chinooks. Over 3000 pages of data were collected including the historical records, weight & balance records, Logbook data, -1352 readiness data (monthly reports), Phase books, Phase records (2408-13-1, 13-2) and other miscellaneous forms and records. Data not available to the team included parts data, workorder information, and manhours utilized in the maintenance process. Forms and records were not indexed to enable tracking from inspection results to faults, which is consistent with the documentation methodology in use in the aviation environment today. The team recognized that the Ft. Campbell aircraft are not typical of the fielded CH-47 fleet due to the Army's excellent maintenance program and support capabilities at the unit.

4.3 Maintenance Management System Survey

The AMAC team reviewed four contemporary, military and "commercial-off-the-shelf" maintenance scheduling and management systems. The systems reviewed included:
- NALCOMIS Advanced Maintenance Architecture
- GDE Systems Maintenance Information and Diagnostic System (MIDS)
- Transportation Systems Consulting Corporation Aviation Management Information System 2000 (AMIS2000)
- TAMSCO Configuration Based Management System
- Anderson Consulting Company Integrated Maintenance Data System

The intent was to evaluate the level to which these systems could deliver the following functionality:
- Workload, planning, visualization tools
- Aircraft, fleet and multi-aircraft management
- Record Management
- Configuration Management
- Parts tracking management
- Personnel planning and integration
- Dynamic maintenance scheduling

The attributes of each system were reviewed and compared. Each system offered different levels of functionality and depth. None showed any form of management visualization tools nor fulfilled all requirements of the AMAC prototype.

4.4 AMAC Rapid Prototyping

The AMAC demonstrator was designed and built using the Rapid Prototyping process. The emphasis in Software Rapid Prototyping is the "evolutionary" development methodology illustrated in figure 4.4-1. The complex nature of army maintenance

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management created an equally complex software-requirements identification challenge which could not be addressed using traditional design, analysis and synthesis techniques. The reality is that some software has to be built and evaluated to gain the depth of understanding needed to produce a product that meets all of its requirements.
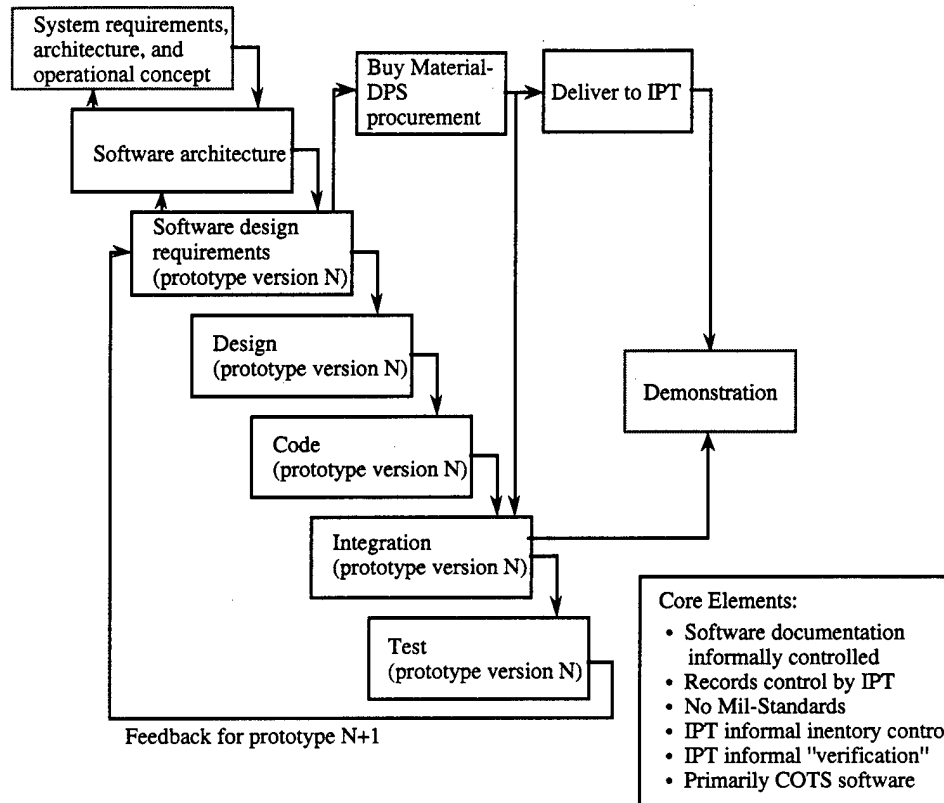
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┌─────────────────┐
│ System requirements,│        ┌──────────────┐   ┌──────────────┐
│ architecture, and │        │ Buy Material-│   │ Deliver to IPT│
│ operational concept│        │ DPS          │→  │              │
└─────────────────┘        │ procurement  │   └──────────────┘
    ┌──────────────────┐    └──────────────┘
    │ Software architecture│
    └──────────────────┘
       ┌──────────────────┐
       │ Software design    │                    ┌──────────────┐
       │ requirements       │                    │ Demonstration│
       │ (prototype version N)│                   └──────────────┘
       └──────────────────┘
          ┌──────────────────┐
          │ Design            │
          │ (prototype version N)│
          └──────────────────┘
             ┌──────────────────┐
             │ Code              │
             │ (prototype version N)│
             └──────────────────┘
                ┌──────────────────┐
                │ Integration        │
                │ (prototype version N)│
                └──────────────────┘
                   ┌──────────────────┐
                   │ Test              │
                   │ (prototype version N)│
                   └──────────────────┘
```

Feedback for prototype N+1

Core Elements:
- Software documentation informally controlled
- Records control by IPT
- No Mil-Standards
- IPT informal inentory control
- IPT informal "verification"
- Primarily COTS software

Figure 4.4-1 AMAC Rapid Prototyping Process

The evolutionary development approach applied to AMAC consists of building, testing, and evaluating several successive versions. Top-level requirements were addressed from the beginning of the development. To assure that each of the evolutionary versions converged toward the final product (and not simply a throw-away item), the first version implemented a design capable of accommodating all the different requirements to be included in the final product.

5.0 AMAC Demonstrator

The AMAC Team integrated existing and advanced technologies to produce a unique maintenance system, which will improve scheduled maintenance management and virtually eliminate the overhead involved in maintenance data input. The demonstration suite and applications of the AMAC system include hardware, software and maintenance information developed in support of the CH-47D aircraft as the proof of concept vehicle. The prototype system introduces a hybrid maintenance aid to demonstrate that the intelligent integration of advanced technology can significantly reduce the helicopter maintenance burden and reduce operational and support costs. The AMAC concept blends Army maintainer data input and information needs with state-of-the-art Portable Maintenance Aid (PMA) technologies. The AMAC demonstration represents a

significant advancement beyond recent efforts to emulate today's paper intensive maintenance environment.

The AMAC demonstrator is comprised of a combination of operating prototype hardware/software and PowerPoint™ briefings to demonstrate and communicate the AMAC concept. Important criteria for the demonstrator design was that it must:
- focus on fidelity and functionality judged important to future users
- be demonstrable by AATD personnel
- support 1-2 hour briefings
- operate independent of external systems

The AMAC team carefully selected the appropriate media for presenting AMAC concept and functionality. Some functions are represented with prototype hardware/software while others are represented as static PowerPoint™ briefing slides. The criteria used to select the appropriate media is described in the rules below:

Use the Prototype hardware/software when:
- functionality is compelling to future users
- operating hardware/software is needed to prove a concept
- demonstrating power of emerging information technology is important
- building blocks are required for future "production" system

Use PowerPoint™ capability when:
- presenting overview information
- Adequate source data is not available
- The concept is too complex to demonstrate
- Too costly to program within scope of this effort
- Requirements are too flexible

Figure 5.0-1 illustrates the media application to AMAC functions.

	At Aircraft	At Unit	At Fleet	Software	Slides
Electronic technical procedures					
Inspection procedures	━━━━━			X	
Fault corrective task	━━━━━			X	
A/C Logbook					
Operational information					
Fault list	━━━━━			X	
Fault and correcting information	━━━━━			X	
				X	
Maintenance Management information					
A/C information	━━━━━			X	
Unit Information		━━━━━			X
Readiness Information		━━━━━		X	X
Workorder Information	━━━	━━━━━		X	X
Historical Information		━━━━━			X
Phase and work management	━━━━━	━━━		X	X
HUMS Data					
Hums data transfer		━━━━━			X
HUMS file		━━━━━			X
Fleet Interface					
Data			━━━━━		X
IETM			━━━━━		X

Figure 5.0-1 Demonstrator Functionality Matrix

5.1 AMAC Demonstrator Theory of Operation

The AMAC Demonstrator operates as the unit and flight line element of a future maintenance management system where fleet-level management capabilities, that are task and inspection oriented are assumed to exist. The future system will at a minimum continually refine asset projections and inspection requirements. AMAC functionality focuses on the scheduled maintenance node of this future.

The AMAC Demonstrator supports phase maintenance as it is performed today, i.e. 300 hour with 3 phases per cycle. It can also support Flexible maintenance modes as described in section 5.1.1.

5.1.1 Flexible Maintenance

Flexible Maintenance scheduling may be performed in two ways, a Gated System and a Full Flex system. These two options, in concept, enable maintenance managers and commanders to select the program which best suits the unit, its mission, and the aviation maintenance support infrastructure.

The Gated System is a concept to provide opportunistic flexibility while retaining a defined and relatively fixed interval system. It enables commanders and maintenance officers to plan and forecast scheduled down time. Maintenance management information needs are minimized while the gates built into the system, provide a very visible and manageable structure. The system is in concept less intrusive than the present system, and can be user "toggled" based on need, assets available and tactical situation. In Gated Flex, inspections are performed in blocks or packets which are inter-changeable to a limited degree as illustrated in figure 5.1.1-1. The CH-47 would require an intermediate inspection.

Phase Maintenance								
Packet 1	Packet 2	Packet 3	Packet 4	I	Packet 5	Packet 6	Packet 7	Packet 8
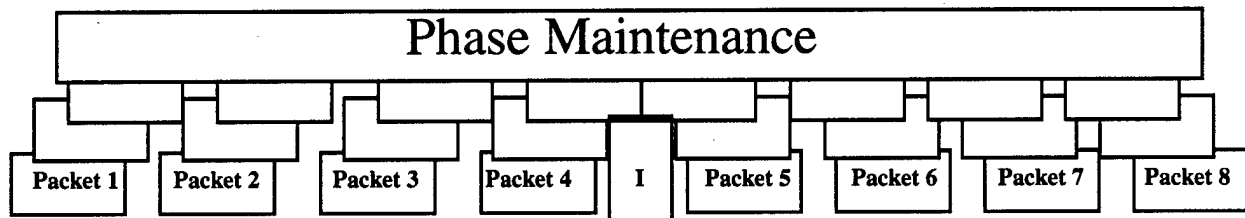
Figure 5.1.1-1 Gated Flex

The Full Flex Schedule is the second option that AMAC addresses. This concept requires high quality and accurate task metrics from a fleet level system. These key elements of information will enable maintenance managers the ability to accurately forecast all requirements associated with any area inspection in the full maintenance schedule.

The Full Flex package further breaks down gated flex packets into smaller incremental area inspections or modules as illustrated in figure 5.1.1-2. The modules are fully dynamic and arranged by the optimum due time. Rather than intervals or gates the system simply manages these inspections through the normal usage of the aircraft. Inspections can be pushed and pulled based on asset availability and operational tempo.
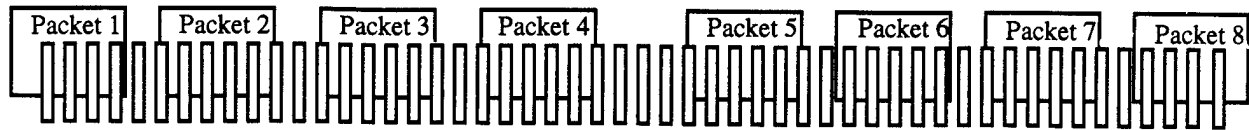
Figure 5.1.1-2 Full-flex

Under the flex system the maintenance manager would be able to accurately predict every requirement associated with an inspection, (from fleet level experience data), including the most probable conditions and faults that could be encountered. With this information the probability that the maintenance would progress without work stoppage for parts, etc. can be reduced to an insignificant level. Additional knowledge concerning the availability of probable assets which "could" become requirements once the inspection is initiated would round out the issue and enable full flex without concern for the unscheduled, work stoppage issues, of previous modular inspection programs.

5.1.2 AMAC Basic Functionality
The AMAC Demonstrator supports the following functionality:

a. Flight crew, time and environmental information to enable entry into conceptual GCSS-A interface consisting of an operational record which populates and updates aircraft time;

b. Dynamic aircraft status symbol changes based on faults and in-progress maintenance;

c. A fault and inspection file with a look-ahead capability;

d. Automated correcting information file displays and tracks tasks and reciprocal tasks in a GCSS-A like interface to enable task data collection, and correcting information to be displayed to the user (data entry);

e. Automated electronic maintenance procedures providing an intuitive human interface to tasks and steps for the maintainer;

f. Dynamic scheduled maintenance list incorporating scheduled maintenance inspection requirements, services, and component replacement times in a common database;

g. Work order file input and work order provision at fault and task level

h. Parts request file with the capability to order needed parts and data input;

i. Area trace of faults, parts, and work remaining;

j. Partial parts asset file;

k. Unit level maintenance management including the unit flow chart, drill down capability and various management views and reports;

l. Automatic readiness reporting;

m. Fleet level interface and sample of the type of task based information the system will provide including simulated tasks and task data availability.

n. Speech control of basic menu functions

o. Ability to view and manipulate 3-D aircraft system models.

5.2 AMAC Hardware

5.2.1 AMAC Computer

The Toshiba Tecra was selected as the portable laptop computer for the AMAC demonstrator. A Tecra 780CDM with 128mb RAM is used as the "at-aircraft" maintenance aid. A Tecra 750 CDM with 96mb RAM is used as the Unit/Fleet processor. The Tecra has a 266MHz Mobile Pentium II processor, a 20x max speed CD ROM and a 13.3" diagonal TFT active matrix color display with 1024 x 768 resolution. A K56flex internal modem provides DSVD voice/fax capability. The Tecra is expandable via PC Card slots, USB ports and a docking station. A digital camera is standard with this model.
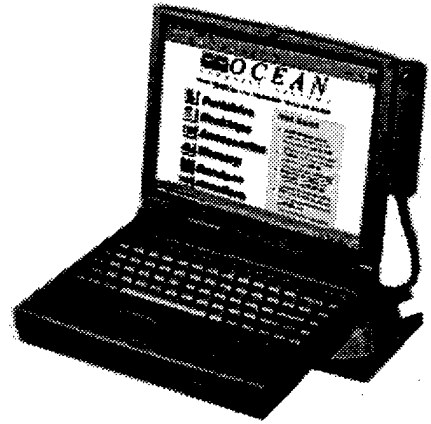
5.2.2 Electronic Torque Wrench

A Saltus-Werk DAZ-E Electronic Torque Wrench was selected to demonstrate a smart tools interface capability. The torque wrench has a data transfer capability via a serial interface.

5.3 Software

The AMAC was designed to use all commercial off-the-shelf software running on the MS Windows 98 operating system. The Java Development environment is Symantic Visual Café and Borland J Builder. Sybase is the database. Communications is via Laplink and Hummingbird. Web applications are Netscape and SGI Cosmo for VRML.

Refer to the companion AMAC Software Design Document (CDRL A005).

6.0 AMAC Operation
6.1 Top Level Interface

When the user starts the AMAC Application program the following window is displayed:
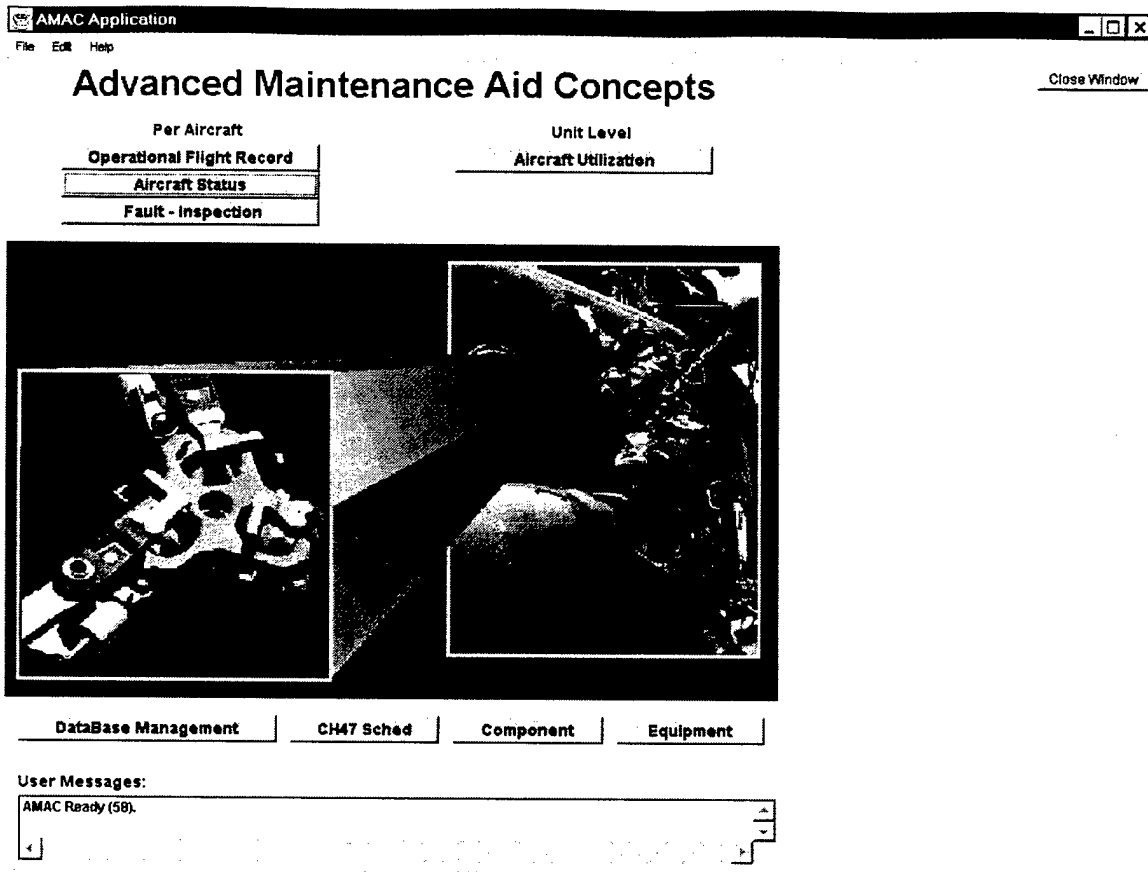
Figure 6.1 Top Level Interface

Purpose: This top-level interface window provides access to either at-aircraft or at-unit/fleet functions and provides access to AMAC databases.

Display:
Center Display: Static image of maintainer wearing next-generation portable maintenance aid.
User Messages: Provides user with application messages regarding successful software start-up.

Controls:
Per Aircraft –
a. Operational Flight Record: Opens window to record aircraft hours of flight operations consistent with DA form 2408-12.
b. Aircraft Status: Opens window to compute the current status of an aircraft, and perform look ahead function to determine inspection services and other scheduled maintenance required in the future.
c. Fault - Inspection: Opens window to list of scheduled inspections and identified faults.

Unit-Level –
a. Aircraft Utilization: Presents the unit maintenance display to show graph of aircraft hours remaining.

Database Management: (not used for demonstration – developmental)
a. CH-47 Schedule: Shows scheduled maintenance items.
b. Component: Shows components that are periodically inspected/replaced.
c. Equipment: Shows equipment that is periodically inspected/replaced.

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6.2 At-Aircraft Interface
6.2.1   Operational Flight Record

Figure 6.2.1 – Operational Flight Record

Purpose: This window provides direct access to historical flight records and provides a way to create new flight records.

Display:
Record #, and record state [existing, modified, etc.] are automatically assigned. Serial number, model, etc. is data that comes from the Aircraft Status window.

User Input:
Entering operational start (from) and stop (to) times result in fight hours calculation. Other data including personnel and servicing records can be entered.

Controls (and voice commands):
a. Previous: Shows the previous flight record in the database.
b. Next: Shows the next flight record in the database.
c. New Flight: Creates a new database record of flight activity.
d. Continuation Flight: (not implemented) would fill in a new flight record with as much data as appropriate to make this data entry task quick and easy.

6.2.2   Aircraft Status

Figure 6.2.2 Aircraft Status Record

Purpose: This window provides access to the overall status and information on the aircraft. Note, there is only one record of this type per aircraft.

Display:
The flight records since the date of last phase inspection are summarized. Today's flight hours are also summarized. Aircraft status is re-evaluated when this window is displayed, by looking at the highest status code of all the pending faults, tasks, and sub-steps.

User Input:
By entering a number in the "Look ahead flight hours" field, the user causes AMAC to select potential inspection/replacement tasks from the database. Selecting "Combat" check-box reduces the task / step selection to the only ones required in combat.

Controls (and voice commands):
a.   Close Window: For convenience, same as the top-right "X" window icon.

6.2.3   Fault / Inspection Due

Figure 6.2.3: Fault / Inspection Due

Purpose: This window shows all the scheduled inspections (selected with the "Look ahead" function), as well as any identified faults.

Display:
Fault status can be assigned initially, until task steps are performed, then this display "rolls-up" the highest task status associated with the fault. Scheduled tasks have a default initial status. In this example, System can indicate aircraft system (e.g. ROTOR), or scheduled maintenance (MAINT). The fault description, area, etc. are entered when describing a new fault.

User Input:
The user simply selects a fault or inspection due, then chooses to expand the associated task list, unit report, or fault detail record.

Controls:
a.   Refresh: Used after adding a new fault record, or executing the "Look ahead" function.
b.   Task List: Shows the list of maintenance tasks pending and completed.
c.   Unit Report: Shows summary of tasks, notes and parts ordered.
d.   Detail: Shows further definition of each fault.
e.   New Fault: Adds a new fault to this list. Note, same function is available on the "Procedure" window.

6.2.4 Fault / Inspection Due (showing look ahead to include components & equipment)

		Fault / Inspection Due						
	Refresh	Task List	Unit Report	Detail	New Fault			
Status	System	Fault / Inspection Due	Area	Panels	Date and Time	A/C Hrs	PID	
—	MAINT	Inspect Rotary-Wing Heads	6		1998-08-06 16:26 54.0	5395.0	jd6500	
■	COMP	Pitch housing	6		1998-08-06 16:26 58.0	5420.0	jd6500	
■	COMP	Pitch housing	6		1998-08-06 16:26 59.0	5420.0	jd6500	
■	COMP	Pitch housing	6		1998-08-06 16:26 59.0	5420.0	jd6500	
■	COMP	Pitch shaft, aft	6		1998-08-06 16:26 59.0	5420.0	jd6500	
■	COMP	Pitch shaft, aft	6		1998-08-06 16:27:00.0	5420.0	jd6500	
■	EQIP	Visual insp. of all 3 hyd. pumps for broken screws ...	"7,6,8"	"31,8,4"	1998-08-06 16:27:02.0	5420.0	jd6500	
■	EQIP	Acft battery insp. IAW TM 11-6140-204-14-2	2	68	1998-08-06 16:27:02.0	5435.0	jd6500	
■	EQIP	Visual insp. of EAPS (if installed) IAW TM 55-1520-...	"4,5"	0	1998-08-06 16:27:03.0	5435.0	jd6500	
■	EQIP	Transponder intermediate check IAW TM 11-5895-...	10	0	1998-08-06 16:27:03.0	5435.0	jd6500	
■	EQIP	Pitch link elastomeric bearings IAW TM 55-1520-2...	"6,7"	"5,47"	1998-08-06 16:27:04.0	5435.0	jd6500	
■	EQIP	Lag dampner elastomeric bearings IAW TM 55-15...	"6,8"	"5,48"	1998-08-06 16:27:04.0	5435.0	jd6500	
■	EQIP	#1 Eng. outboard shaft lugs and adapter lugs IAW ...	4	41	1998-08-06 16:27:04.0	5435.0	jd6500	
■	EQIP	#2 Eng. outboard shaft lugs and adapter lugs IAW ...	5	73	1998-08-06 16:27 05.0	5435.0	jd6500	
■	EQIP	Visual insp. of upper damper lug bushings P/N 14...	"6,8"	"5,48"	1998-08-06 16:27 05.0	5435.0	jd6500	
■	EQIP	#1 Eng. oil sample due LE-71322 IAW TB 43-0106	4	58	1998-08-06 16:27:06.0	5435.0	jd6500	
■	EQIP	#2 Eng. oil sample due LE-71368 IAW TB 43-0106	5	11	1998-08-06 16:27:06.0	5435.0	jd6500	
■	EQIP	#1 Eng. xmsn oil sample due AII-220 IAW TB 43-0...	4	42	1998-08-06 16:27 07.0	5435.0	jd6500	
■	EQIP	#2 Eng. xmsn oil sample due AII-119 IAW TB 43-0...	5	42	1998-08-06 16 27 07.0	5435.0	jd6500	
■	EQIP	Fwd xmsn oil sample due A7-396 IAW TB 43-0106	7	0	1998-08-06 16 27:08 0	5435.0	jd6500	
■	EQIP	C-Box oil sample due A8-410 IAW TB 43-0106	6	42	1998-08-06 16 27:08 0	5435.0	jd6500	

Figure 6.2.4.1: Fault / Inspection Due

Display:

System may also indicate aircraft system (e.g. ROTOR), or scheduled maintenance (MAINT), or component (COMP), or equipment (EQUIP). This example was generated using a 50 hour "Look ahead" function as described in the Aircraft Status Record.

6.2.5   Task List

Figure 6.2.5: Task List

Purpose: This window shows all the tasks associated with a particular fault. As follow-on tasks are selected with the "Procedure" window, these new tasks are added to the list.

Display:
The fault / inspection due is described in the title bar area. Task status displays a "rolls-up" of the highest maintenance step status. Scheduled tasks have a default initial status. System may indicate aircraft system (e.g. ROTOR), or scheduled maintenance (MAINT), or component (COMP), or equipment (EQUIP). The task description, area, etc. are predefined. Date, time and PID (personnel identifier) are determined at the time a task is selected. Note, the PID should be changed to reflect the person actually working the task based on available "Task Time" records. The "Minutes" is a summary of the "Task Time" records.

User Input:
The user simply selects a task, then chooses to expand the associated list of "Correcting Actions", "Step by Step" report, fleet data, parts order, work order, time records, or the maintenance procedure window.

Controls:
a.   Refresh: Used after adding a new task record, or updating step completion status.
b.   Correcting Actions: Shows the list of steps pending and completed.
c.   Step by Step: Shows correcting actions that have reciprocal (remove/replace) tasks.
d.   Fleet data: Shows typical numbers for fleet summary data of the task, for parts and people required.
e.   Parts: Shows list of parts ordered against this task.
f.   W/O: Shows list of work orders for this task.
g.   Time: Shows the time records for this task
h.   Procedure: Displays the maintenance procedure for this task.
i.   New (Task): Adds a new task to this list. Note, same as "Follow-on Task" function available on the "Procedure" window.

6.2.6 Correcting Actions – Steps in the maintenance procedure

Status	Task	Step	Correcting Action	PID	MMH	TI OK	TI PID	TI MMH	Signoff Date	Close Date
—	5-6	01	Check all surfaces of rotary-wing head	jd6500		☐				
—	5-6	02a	Check rotary-wing head for scores, nicks or gouges	jd6500		☐				
—	5-6	02b	Damage to six lugs, webs, and side surfaces shall not exceed 0.005-inch	jd6500		☐				
—	5-6	02c	Damage to hub oil tanks	jd6500		☐				
—	5-6	02d	Damage around aft droop stop lugs	jd6500		☐				
—	5-6	02e	Damage to horizontal pin caps	jd6500		☐				
—	5-6	02f	Damage to pitch shafts	jd6500		☐				
—	5-6	02g	Damage to edges of three pitch arms	jd6500		☐				
—	5-6	02h	Damage to edge of pitch arm	jd6500		☐				
—	5-6	02i	Damage to arm faces	jd6500		☐				
—	5-6	02j	Damage to remaining areas	jd6500		☐				
—	5-6	02k	Damage to six lugs	jd6500		☐				
—	5-6	02l	Damage to tanks	jd6500		☐				
—	5-6	02m	Damage to lugs	jd6500		☐				
—	5-6	02n	Damage to housing area	jd6500		☐				
—	5-6	03	Check outboard hub areas for scores	jd6500		☐				
—	5-6	04	Check outboard side of lugs for scores	jd6500		☐				

Figure 6.2.6: Correcting Actions – Steps in the maintenance procedure

Purpose: This window shows all the steps that require documentation associated with a particular task. As steps are marked "Completed" within the "Procedure" window, the status of each of these steps change.

Display:
The task name is described in the title bar area. Step status displays the current maintenance step status. Scheduled tasks have a default initial status. The step description is predefined, and it changes into wording as past-tense as the step is marked complete. Date, time and PID (personnel identifier) are determined at the time a task is selected. Note, the PID and MMH (maintenance man-hour) should be changed to reflect the person actually working the task based on available "Task Time" records.

User Input:
The user simply selects a step, then chooses "Show Procedure" to open the maintenance procedure window at the proper step. The "TI OK" (Technical Inspector OK) check box should be restricted by user id (function is not properly supported in this version of the ODBC database interface).TI PID, hours, and dates are input data fields in this implementation.

Controls:
a. Refresh: Used after updating step completion status.
b. Show Procedure: Opens the maintenance procedure window.
c. Statuses: May be used to manually set the given step status.

6.2.7 Side by Side Task Correcting Actions

Status	Task	Step	Removal	PID	MMH	Tas...	Step...	Desc Replace	PID ...	MM...	TI PID	TI M...	Sign...	Clo...
X	5-28	01	Removed lockwire from one filler/drain plu...	jd65...		5-29	19	Replace Lockwire plugs	jd65...					
X	5-28	02	Removed lockwire from one filler/drain plu...	jd65...		5-29	18	Install filler / drain plugs. Torque to 85 inc...	jd65 ...					
X	5-28	03	Removed lockwire, plug packings and 2 si...	jd65...		5-29	16	Install lockwire, plug packings and 2 sight ...	jd65 ...					
X	5-28	05	Removed lockwire between tank and man...	jd65...		5-29	19b	Replace Lockwire	jd65 .					
X	5-28	06	Oil Tank and packing removed	jd65...		5-29	14	Install Tank	jd65 ...					

Title bar: Fault: Oil Tank Cranked, Removal Task: 5-28 – Remove Vertical Hinge Pin Oil Tanks

Figure 6.2.7: Side by Side Task Correcting Actions

Purpose: The user can open this window by selecting the removal task in the task list, then choosing the "Side by Side" control button. This window only shows the steps that have associated reciprocal tasks.

Display:
The fault / inspection due is described in the title bar area. Step statuses are changed back by corresponding replacement task steps.

Controls:
a.   Close window "X"

6.2.8   Unit Report / Fault – Inspection Report

Figure 6.2.8 Unit Report / Fault – Inspection Report

<u>Purpose</u>: This window shows a summary report of all the tasks associated with a particular fault.

<u>Display</u>:
This window displays task number, actual task time (in minutes), PID, and "Sticky Notes" for each task. Also, any parts ordered.

<u>Controls</u>:
a.   Aircraft Data (2) Reports – Shows further aircraft data on the next pages.
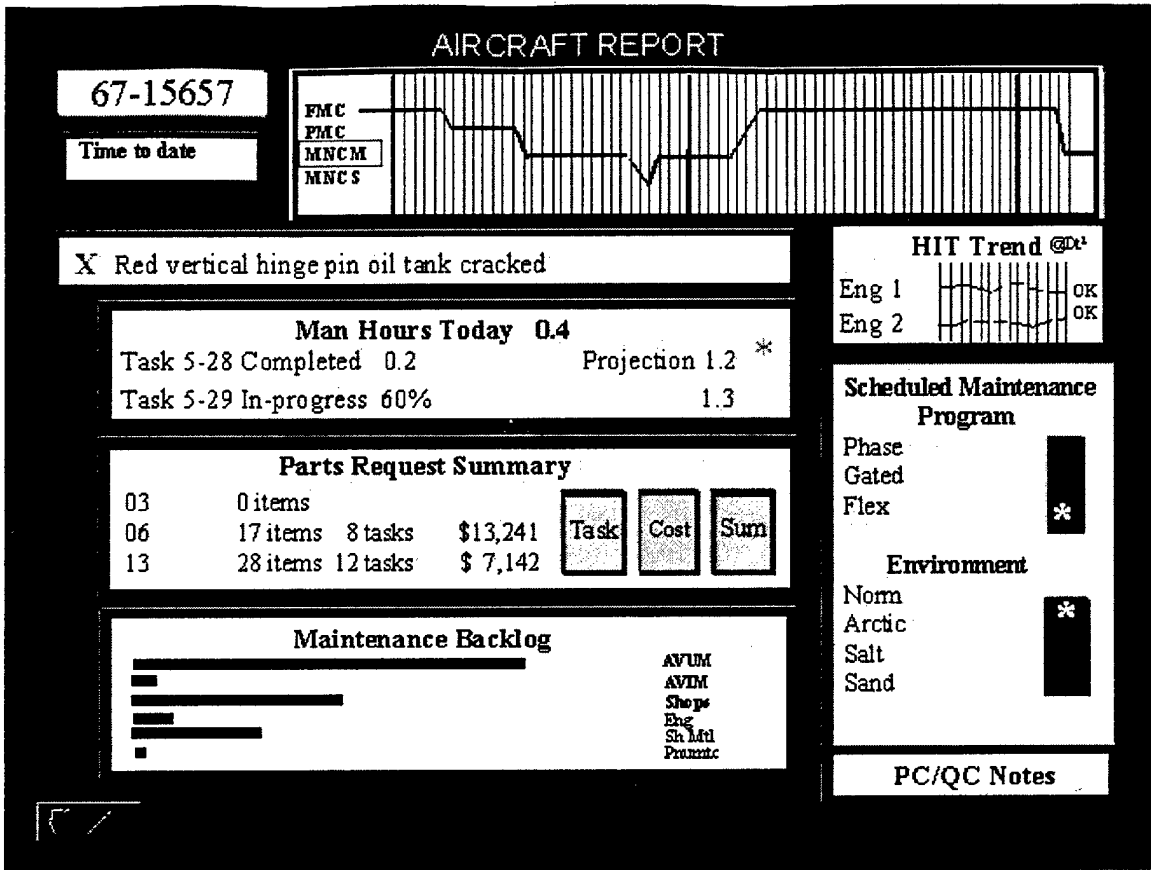
6.2.9   Aircraft Report 1

Figure 6.2.9 – Aircraft Report 1

Purpose: This window shows a high-level status report of the aircraft.

6.2.10   Aircraft Report 2 (Flexible Inspection Program)
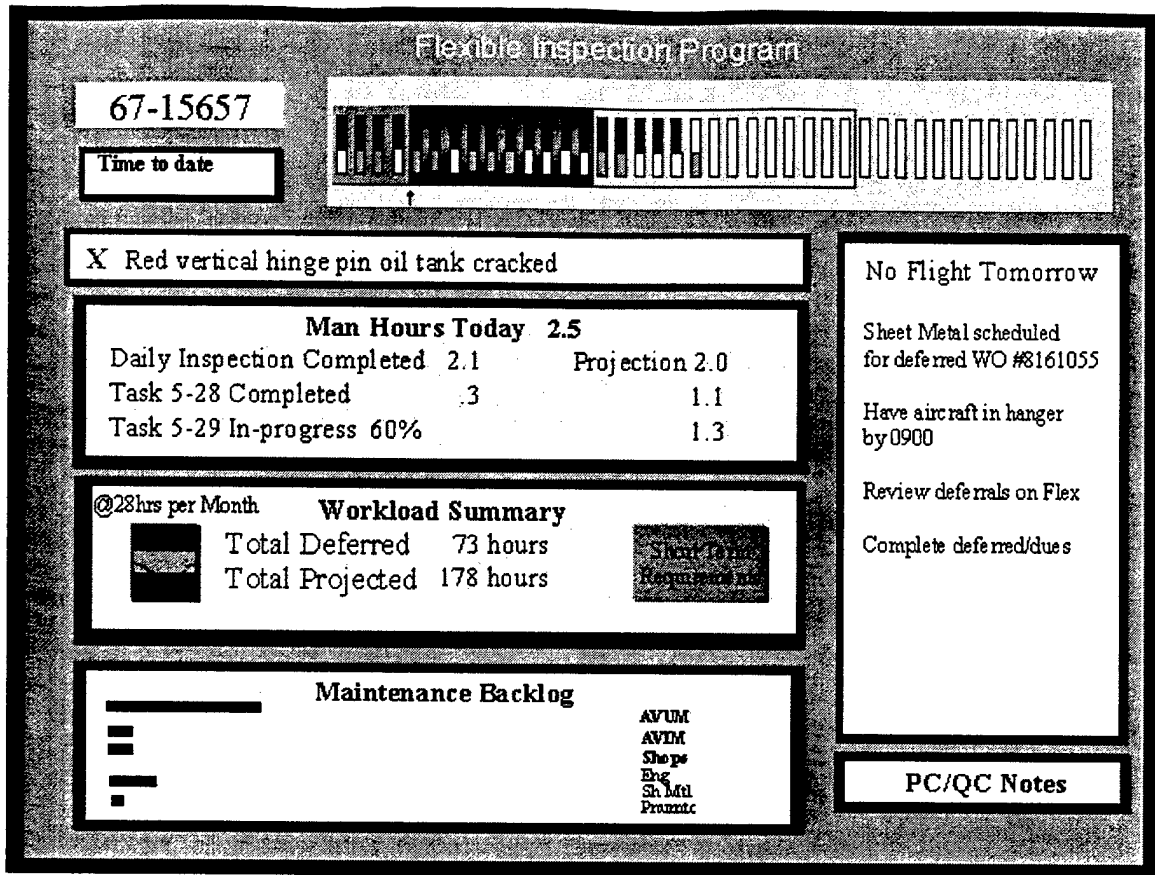
Figure 6.2.10 – Aircraft Report 2 (Flexible Inspection Program)

Purpose: This window shows a high-level status report of the aircraft.

6.2.11   Detail Record -- Fault / Inspection Due

Fault / Inspection Due

Serial Number	66-15374
Model	CH-47D
Fault Status	2
Fault System	MAINT
Fault Date & Time	98/08/20 05:38 PM
Task Number	5-6
Fault PID	jd6500
Fault / Insp. Due	Inspect Rotary-Wing Heads
Aircraft Hours	5395.0
How Recognized	
Start Time	
Stop Time	

Mal Eff	
WUC	
Work Order	
Req	
Other	
Record Number	903649120
Area on aircraft	6
How Discovered	
Due Date (calendar)	
Due Date A/C Hrs.	
Inspection Number	
State (started...completed)	0
Access Panels	

Figure 6.2.11 – Detail Record - Fault / Inspection Due

Purpose: This window shows a detailed report of a particular fault.

Display:
For a given aircraft serial number and model (defined in the aircraft status window), many supporting data fields are displayed.

User Input:
Any of the fields are currently editable. The "State" data field controls if the fault / inspection due record is removed (cleared) in the "Look ahead" processes of selecting inspection tasks. If the state=0 (not-started), the record will be cleared. If the state=1 (started), the record will be retained.

Controls:
a.   Close window "X" – Commits changes to the database.

6.2.12   Maintenance Procedure

Figure 6.2.12 – Maintenance Procedure

Purpose: This window describes each step of the maintenance procedure and automatically tracks the task time records. Here is where an IETM (Interactive Electronic Technical Manual) would be integrated with the AMAC Application.

Display:
Dialogs pop-up to enter start-stop times (at task-level). Display HTML pages for each task / step.

Controls:
a.   Close window "X".
b.   Start-Stop Timer: Example is shown
c.   Prev. Step / Next Step: For reviewing steps (browse mode)
d.   N/A and Completed: Advances the display to the next step and updates the Correcting Actions status field, and may update the aircraft status the next time the aircraft status window is opened.
e.   Follow-on Task: Selects one of the possible follow-on tasks to add to the list of tasks pending for this Fault or scheduled inspection
f.   Sticky Note: Task-level text area to annotate task.
g.   Fault Found: Same function as "New Fault" button on the fault list.
h.   Work Order: Same function as "W/O" button on the fault list.
i.   Order Parts: Displays parts diagram that the user may select parts to order.
j.   Fleet Data: Same function as "Fleet" button on the fault list.
k.   Fault – Insp. Due, Task List, Correcting Actions: Opens corresponding window.
l.   Camera On, Save Video: Take pictures of the current task and save.
m.   Show a Video or Tutorial: Used with tasks that have media content (should be part of HTML)
n.   Call the Expert: Dials the phone # (with video option) to maintenance support personnel.

6.2.13   Enter New Fault

Figure 6.2.13 – Enter New Fault

Purpose: This window allows the user to enter a new fault and select Area Diagrams and Access Panels.

Display:
Dialog to enter initial fault status, description, system and task number. The Aircraft Hours block is filled in from the current flight hours (on the aircraft status window).

Controls:
a.   Close window "X": Abort operation, no new fault.
b.   "OK": Add new fault to the fault list.
c.   Area, Access Panels: Opens diagrams for the user to select.

6.2.14   Sticky Note
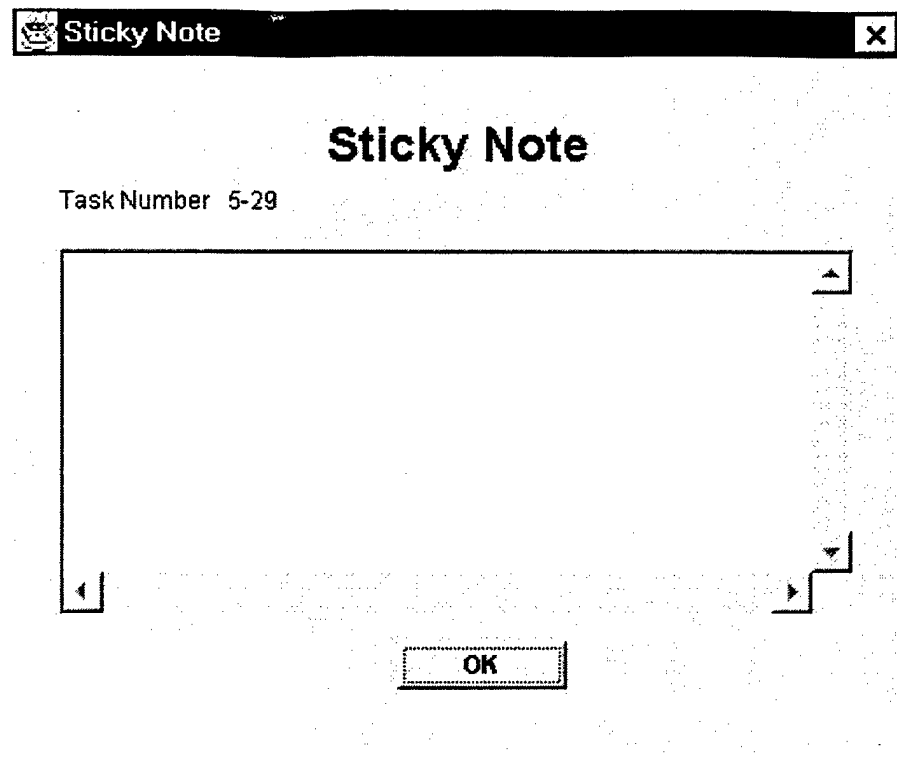
Figure 6.2.14 – Sticky Note

Purpose: This window allows the user to enter additional information regarding the task. These notes are collected and provide a forum for feedback on task description details.

Display:
Dialog has a large text area for the user type into.

Controls:
a.   Close window "X": Abort operation, no new note.
b.   "OK": Add note to this task.
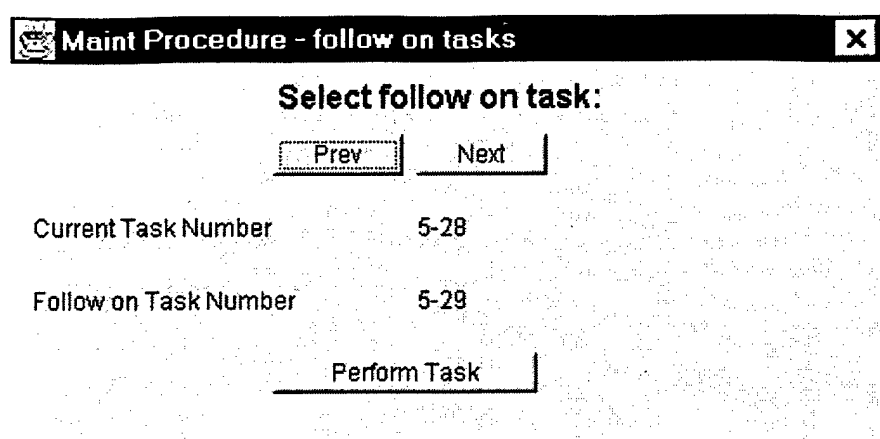c.   Scroll bars

6.2.15   Maintenance Procedure – Follow on Tasks

Figure 6.2.15 – Maintenance Procedure - Follow on Tasks

Purpose: This window allows the user to select a new task to add to the task list.

Display:
Current task number, and one of several possible follow on tasks.

Controls:
a.   Close window "X": Abort operation, no new task.
b.   "Perform Task": Add new task to the task list.
c.   Prev / Next: Select pre-defined follow on task.

6.2.16   Fleet Data / Parts Order

Fleet Data

Task 5-28 Remove-Vertical Hinge Pin Oil Tanks

Personnel Performing Task	Task Time	Follow on Task(s)
68D10	0.6 Hrs.	Task 5-29 Install Vertical Hinge Pin - Oil Tanks
68D20		Task Time 0.7 Hrs
67U10		
67U20		

Common Faults

Tank Leaking

Tank Cracked

Sight Glass Broken

Stripped Threads

Tank Scratched

Tank Gouged

Common Parts

Part Number		QTY	%	Order
P554B	INICATOR SIGHT	1	3%	☐
M8248/1-912	PACKING	4	100%	☑
M83248/1-908	PACKING	2	100%	☑
114R2252-1	NUT	2	5%	☐
MS24391D8L	PLUG & BLEEDER	1	2%	☐
145R2176-1	TANK, OIL LUBE	1	3%	☐
MS83248/1-260	PACKING	2	100%	☑
UR5005	RING RETAINER	1	8%	☐
114RS212-1	SEAL VERT HINGE PIN	1	92%	☐

Figure 6.2.16 – Fleet Data / Parts Order

Purpose:
This display provides a quick and easy way to order parts.

Display:
This window shows typical personnel requirements, task times, detected faults and part requirements.

Controls:
a.   Close window "X":
b.   "Order Parts": Add new parts to the parts order list.

6.2.17   Parts Selection
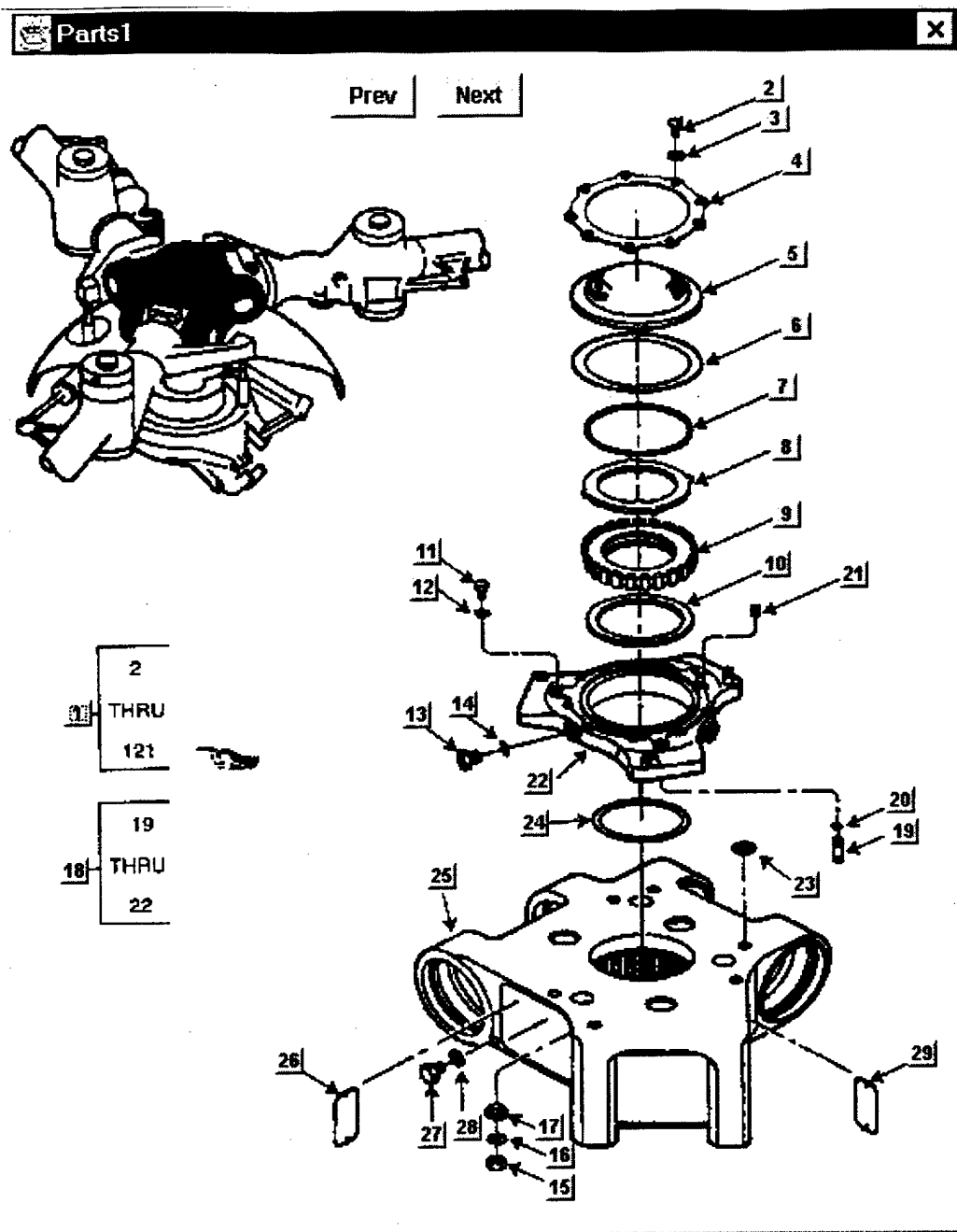6.2.17.1 Parts1 Screen

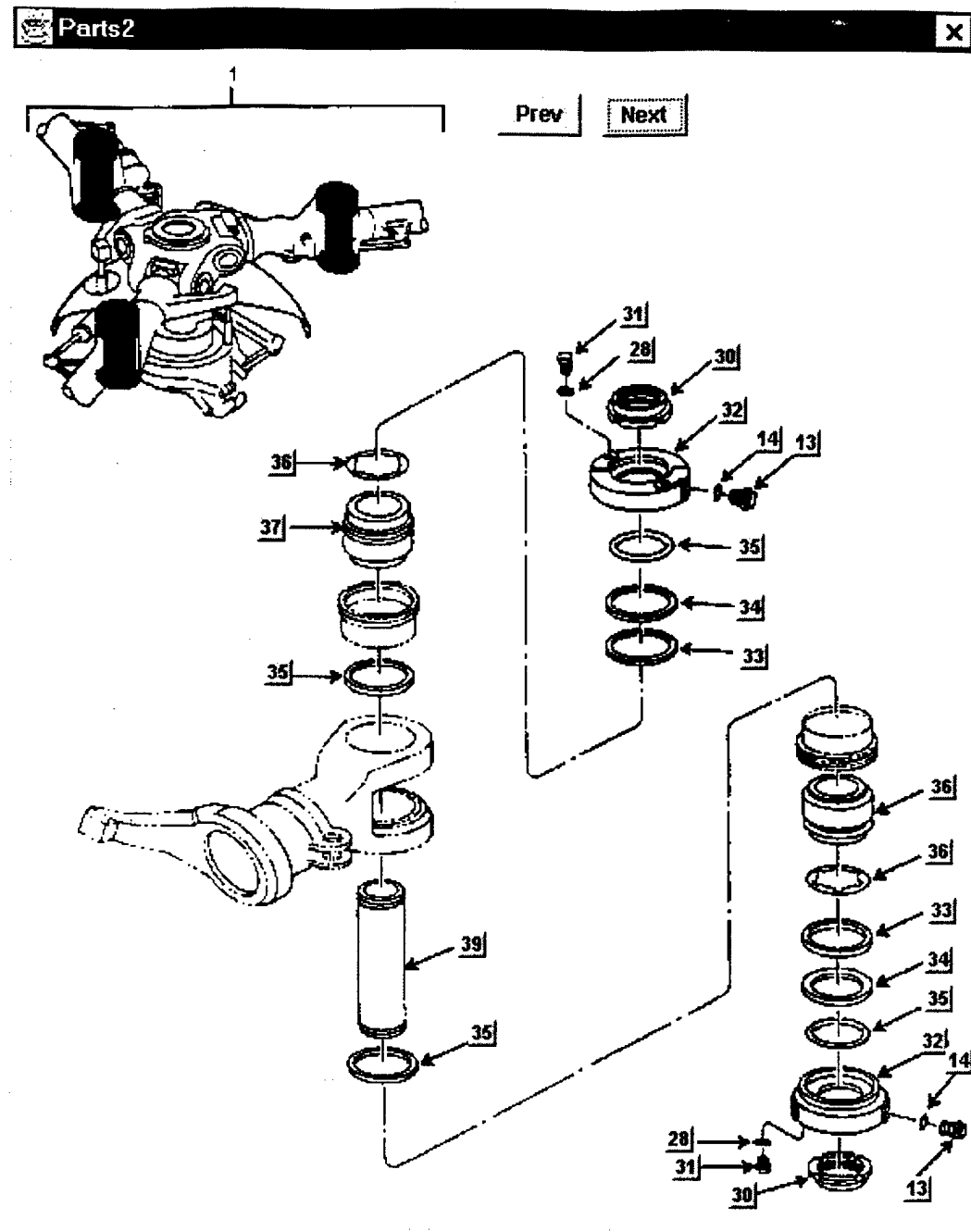Figure 6.2.17.1 – Parts Data

6.2.17.2 Parts2 Screen

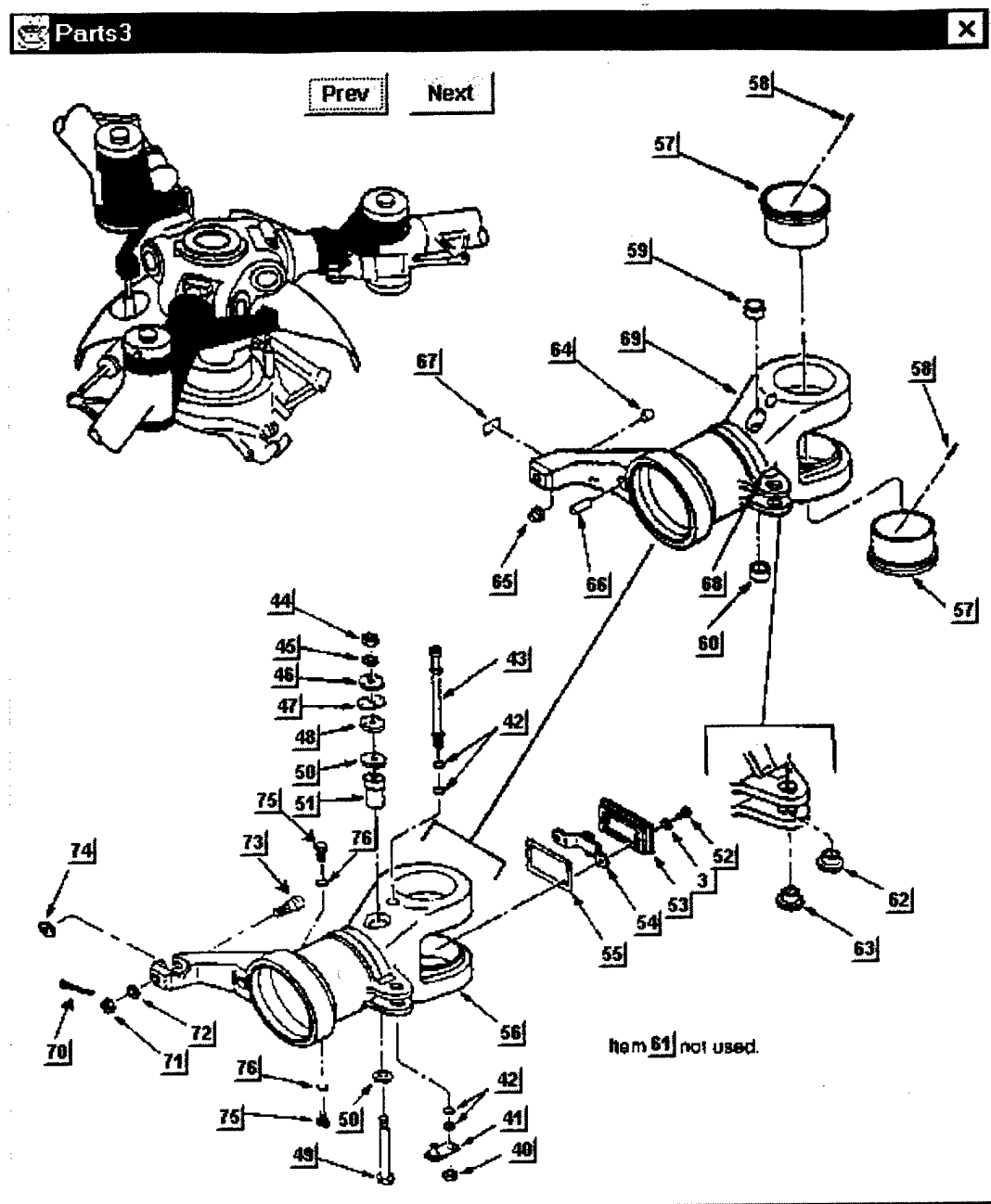Figure 6.2.17.2 – Parts Data

6.2.17.3 Parts3 Screen

Figure 6.2.17.3 – Parts Data

6.2.17.4 Parts List

Part	Description	Quantity
Fault: Oil Tank Cranked, Task: 5-28 – Remove Vertical Hinge Pin Oil Tanks		☒
New Part Order	Delete	
M8248/1-912	PACKING	4
M83248/1-908	PACKING	2
MS83248/1-260	PACKING	2

Figure 6.2.17.4 – Parts List

Purpose:
This shows what parts to order.

Display:
This window shows the fault, task, part numbers, descriptions, and quantity.

Controls:
a. Close window "X":
b. "New Part Order": Add new parts to the parts order list.
c. "Delete": Remove selected part from the parts order list.
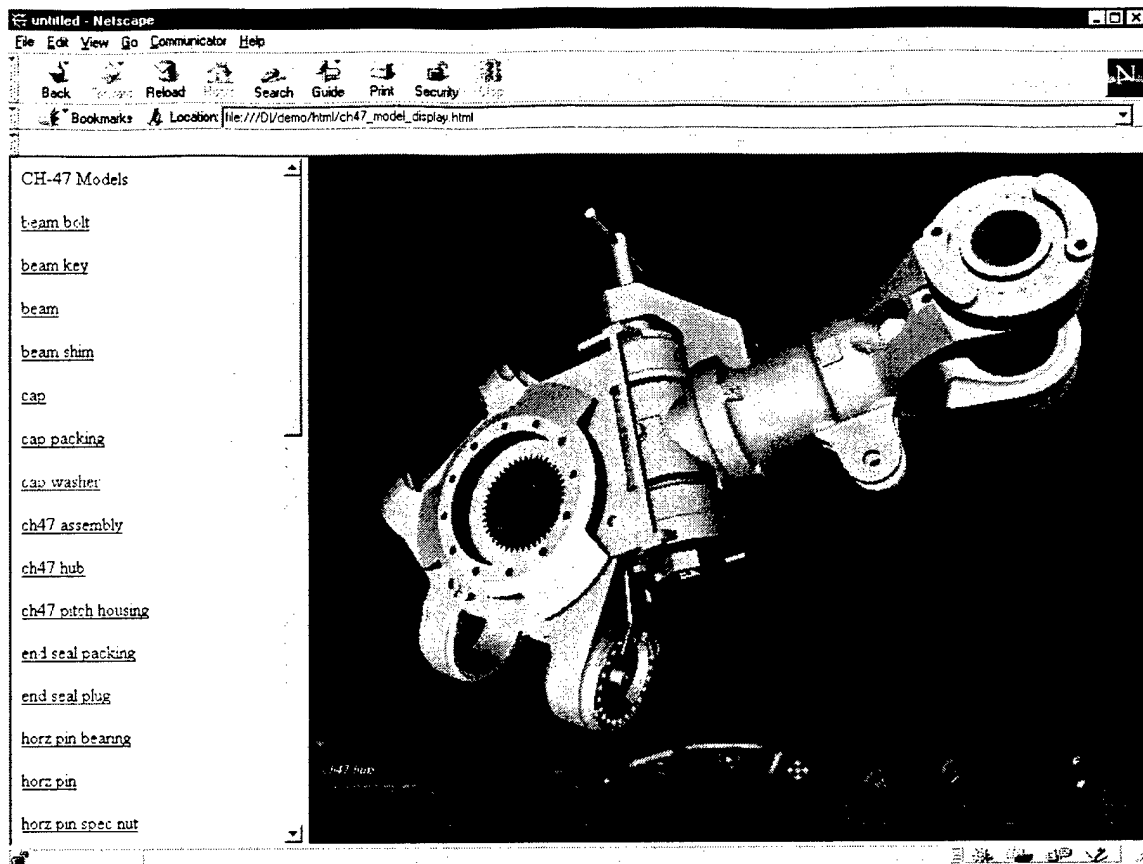
6.2.18 3D Model Display

Figure 6.2.18 -- 3D Model Display

Purpose:
This shows 3D view of parts in the maintenance procedure.

Display:
This Netscape window shows a list of assemblies that can be loaded into the Cosmo 3D viewer. Inside the 3D viewer a large number of pre-defined viewing angles are available, and the user may move a viewpoint anywhere.

Controls:
a.   Close window "X":
b.   Assemblies: Select and load a predefined assembly from the list.
c.   Viewpoints: Select and move to a predefined viewpoint from the list.
d.   Navigation controls to move around the 3D model.

6.3 Unit Level Interface
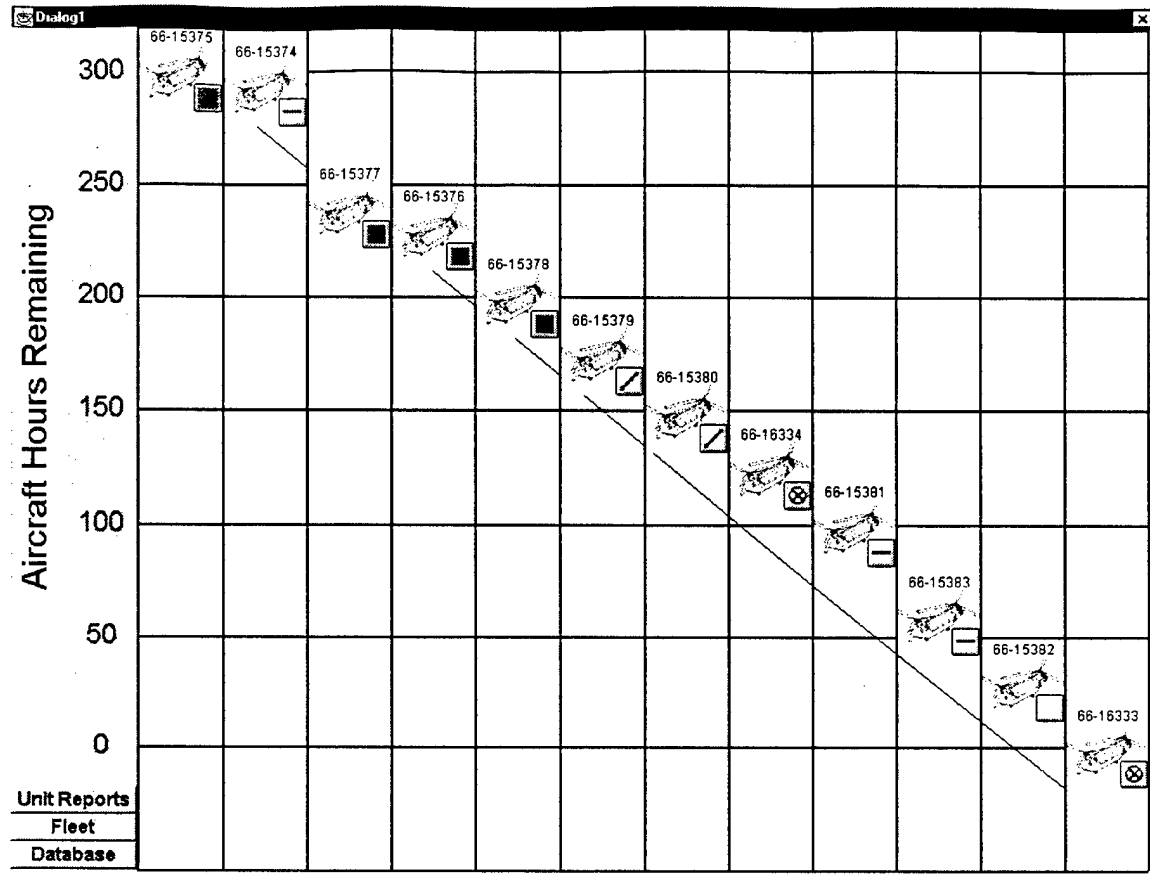### 6.3.1   Aircraft Utilization

Figure 6.3.1 – Aircraft Utilization

Purpose:

This window is a dynamic electronic representation of a unit flow chart. It shows all aircraft in the unit ranked by hours remaining until phase inspection and includes the current status of each aircraft. This display simulates a unit level display that will receive real-time updates from networked AMAC Applications. The concept demonstrator does support networking.

Display:

Aircraft serial number and status (as last computed in the aircraft status window), are arranged and sorted by aircraft flight hours remaining (also computed in the aircraft status window).

User Input:

By selecting the status buttons, the top-level AMAC Application window for that aircraft should be opened.

Controls:
a.   Close window "X".
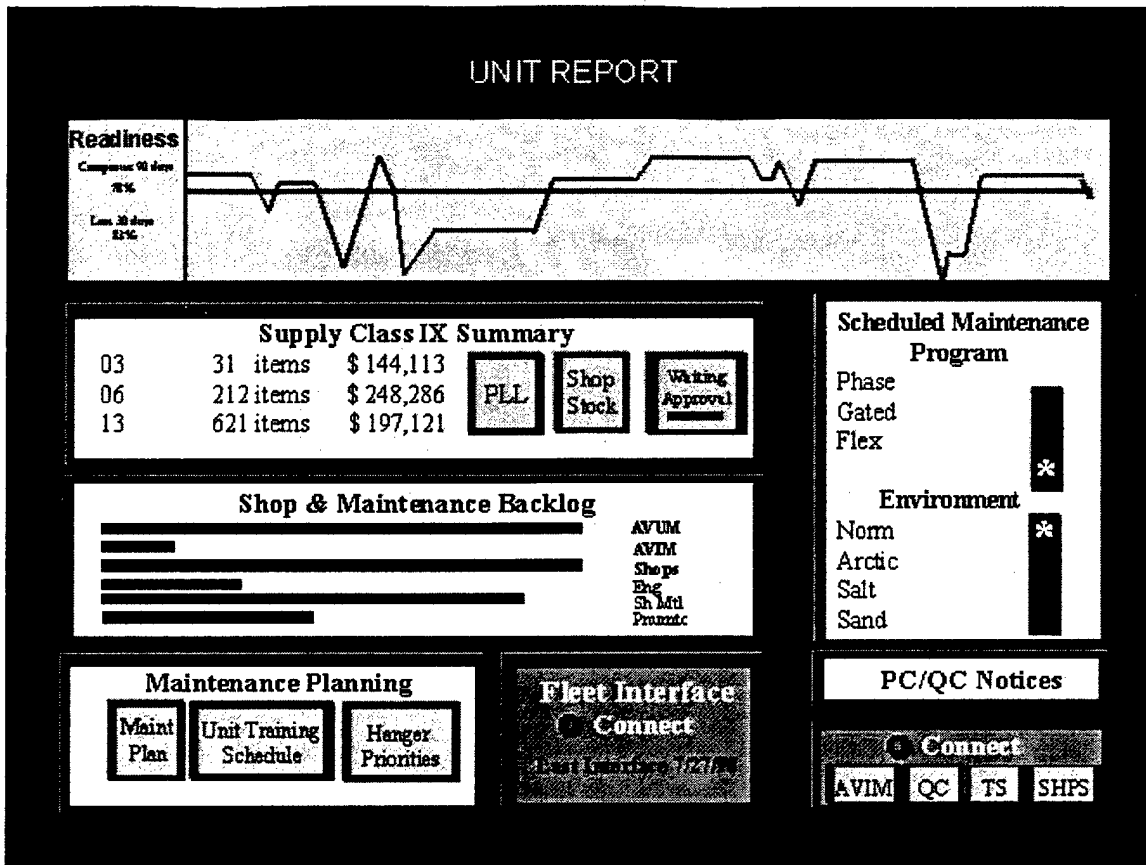
6.3.2 Unit Report

Figure 6.3.2 – Unit Report

Purpose:
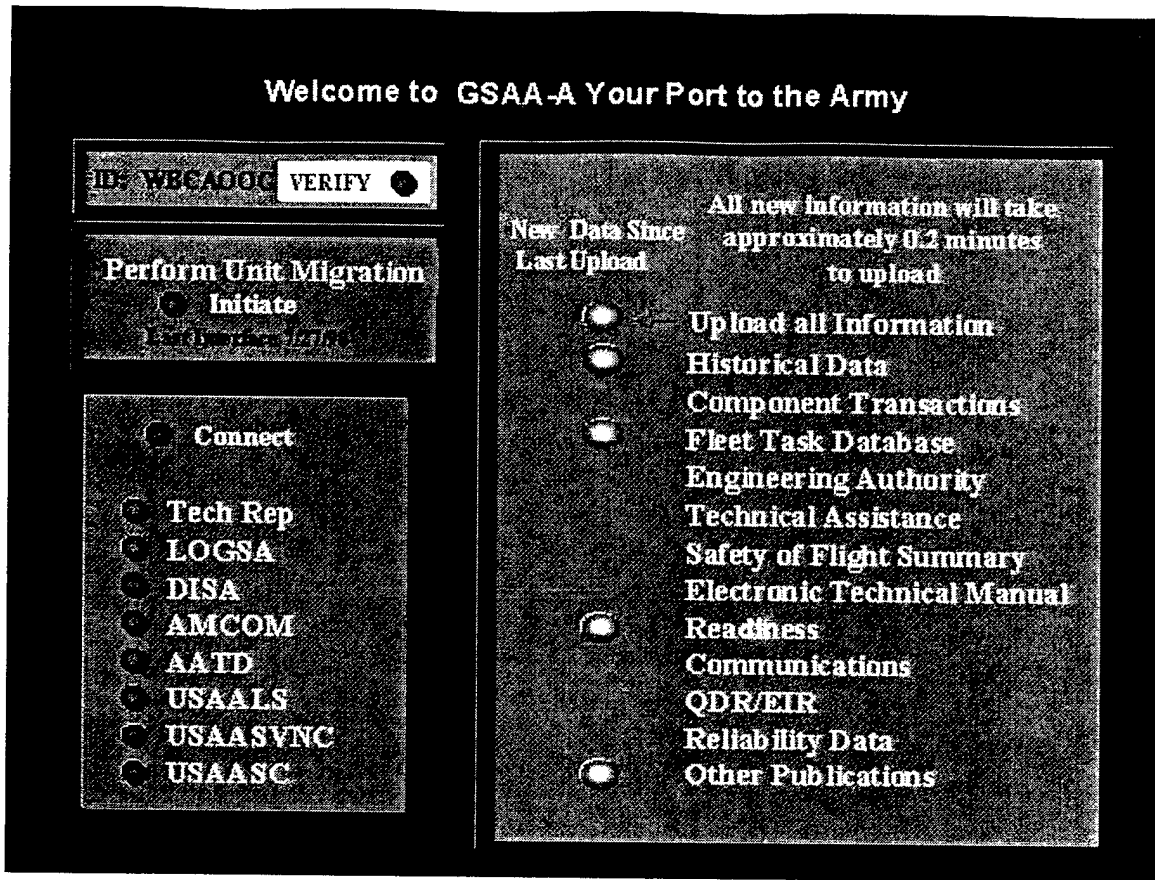This shows Unit Level Readiness and Planning.

6.3.3   Fleet Data

Figure 6.3.3 – Fleet Data

Purpose:
This shows an interface to GCSS-A.