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CONCEPT FORMULATION STUDY FOR AUTOMATIC INSPECTION, DIAGNOSTIC AND PROGNOSTIC SYSTEMS (AIDAPS)

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13. ABSTRACT

This document represents the second interim report prepared as part of the concept formulation study for Automatic Inspection, Diagnostic and Prognostic Systems (AIDAPS) for Army aircraft. The principal objective of this Phase B effort is the identification of AIDAPS technical approaches and concepts that fall within the engineering feasibility limitations established in Phase A.

Section 2.0 of this document consists of a detail rationale for selecting the indicated number of AIDAP Systems for trade-off in Phase C. Concept approach elements, system sophistication considerations, and the aircraft interfaces are dealt with at length to present a comprehensive evaluation of proper AIDAPS/aircraft relationships. Section 3.0 presents the impact of hardware design and mechanization considerations of the adopted system concepts. Section 4.0 presents an evaluation of the impact of AIDAPS on Army maintenance to include potential alterations in the Maintenance Allocation Chart (MAC) and Army computer systems interfaces with AIDAPS. Section 5.0 presents an examination of Army maintenance activities related to AIDAPS implementation. Section 6.0 is a summary of the work accomplished during the second reporting period.

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SECTION 1

1.0 INTRODUCTION

This report represents the second interim report prepared as part of the concept formulation study for Automatic Inspection, Diagnostic and Prognostic Systems (AIDAPS) for Army aircraft. It documents the basic results of the phase B effort. The principal objective of this phase, in addition to providing a detail plan of analysis under separate cover, is the identification of AIDAPS technical approaches and concepts that fall within the engineering feasibility limitations established in phase A. These systems are defined in sufficient detail to enable the tradeoffs and tasks of phase C to proceed.

The four principal areas of discussion, as outlined by the statement of work, include (1) a review and evaluation of the Army maintenance and logistic environment, (2) a review and evaluation of aircraft malfunction data for impact on AIDAPS design, (3) an analysis and identification of practical system concepts, and (4) an identification of AIDAPS hardware considerations. However, the primary emphasis of this phase has been oriented toward items 3 and 4 due to their importance on future study activities.

Section 2.0 of this document includes a detail rationale for selecting the indicated number of AIDAP Systems for tradeoff in phase C. Concept approach elements, system sophistication considerations, and the aircraft interfaces are dealt with at length to present a comprehensive evaluation of proper AIDAPS/aircraft relationships. The impact of hardware design and mechanization consideration of the adopted system concepts are presented in section 3.0. Section 4.0 presents an evaluation of the impact of AIDAPS on Army maintenance. It discusses such items as potential alterations in the Maintenance Allocation Chart (MAC) and Army computer systems interfaces with AIDAPS. Section 5.0 presents a very brief examination of Army maintenance activities related to AIDAPS implementation. The result of this evaluation of aircraft data has its impact more noticeably demonstrated in the plan of analysis. The last section, section 6.0, is a summary of the work accomplished during the second reporting period.

SECTION 2

2.0 ANALYSIS OF SYSTEM CONCEPTS

The objective of this section is to define practical system candidates for a detailed tradeoff analysis in phase C. When considering eight existing aircraft and two future aircraft in conjunction with several combinations of airborne and ground based system concepts and various levels of sophistication, an overwhelming number of possible systems can be postulated. The goal is to reduce these to a reasonable number of system conceptual approaches which include the optimum solutions. Impractical systems were eliminated in this phase of the study such that only practical systems will be subjected to the full cost/effectiveness model analysis in Phase C.

When developing practical system approaches many factors must be considered, such as the operational environment, the impact of retrofit, and the human skills necessary for use and interpretation of the data acquired. To successfully yield a useful and cogent development plan for defining the envelope of system configurations to be evaluated, a broad spectrum of potential systems and their applicability to Army aviation must be considered, and the areas of technical tradeoffs identified. While systematic cost/effectiveness techniques and analysis will be exercised directly in phase C, the fundamental constraints are developed and applied in this phase to distill the innumerable variables to practical dimensions.

The impact and interface of an Automatic Inspection, Diagnostic and Prognostic System (AIDAPS) on the Army aviation logistical structure was evaluated with continual consideration given to the worldwide environmental and operational extremes encountered by units of the Army-in-the-field. The bulk of Army aircraft, when engaged in combat, are located and employed alongside the field soldier. An AIDAP system must live, function reliably, and provide significant assistance in the reduction of maintenance and supply problems if it is to prove its worth and be accepted by the field soldier.

The methodology employed to eliminate systems which will not be evaluated in Phase C is the application of a series of constraints developed from a careful review of the Army logistic structure and the objectives of AIDAPS. A comprehensive list of criteria has been established and applied to formulate a logical systems analysis approach. Criteria common to all vehicles and criteria which are unique to a specific aircraft type are identified and applied independently.

2.1 GENERAL SYSTEM APPROACH

This section defines the basic system structures which are considered in the tradeoffs of this phase. The AIDAP system was divided into four functional blocks and the alternatives within each of these functional blocks defined. Considerations are identified and constraints established for evaluation of alternatives.

2.1.1 System Functional Blocks

Based on the functions that AIDAPS must perform, and review of historical systems designed to perform similar functions, the basic AIDAP system was divided into four basic functions of sensing, collection, analysis, and display/record. These functional divisions are the basic building blocks for any AIDAP system. This is a logical division since each functional block performs a separate and distinct operation related to the overall objective of AIDAPS.

2.1.1.1 Sensing

The sensing function includes all wiring from the sensors to the collection interface and any additional transducers which must be added to monitor parameters that are not instrumented.

The function of sensing is defined herein as the act of detecting an electrical or physical unit of measure; i.e., parameter, by means of a device referred to as a sensor or transducer. For the purpose of this study signal amplifiers, normally considered as transducers in engineering texts, will be categorized under the function of collection and/or acquisition. The sensing function will be identified by the symbol (I) in the discussions which follow.

2.1.1.2 Collection

Data collection includes the acquisition of the analog or discrete signals from the sensors, all multiplexing prior to and subsequent to signal conditioning, analog-to-digital conversion, primary editing, and digital data formating necessary to arrange the data in the best form for analysis.

The collection function will identified by the symbol (C').

2.1.1.3 Analysis

The analysis is the operations performed on the data to obtain useful information. This includes secondary level data editing and compression, threshold detection, parameter cross correlation, trend analysis, signature comparisons, and the control of data transmission, which are necessary to achieve the objectives of fault detection, fault isolation, and fault prediction.

Processing will include the means to determine if monitoring conditions are valid relative to the determination of maintenance items. As an example, the conditions of fuel demand by the engine must be known for the determination of satisfactory fuel flow rate.

Consideration must be given to techniques which allow for spurious or short term "invalid" inputs from signal conditioning. These spurious inputs can be caused by sensor transients or external electrical influences and should not indicate maintenance items. Methods of confirmation or time dependence should be evaluated in relation to the elimination of incorrect or superfluous data.

The symbol (A) is assigned to the analysis function.

2.1.1.4 Display/Record

The display is defined as the presentation of the information resulting from AIDAPS implementation to the Army maintenance or flight personnel, i.e., the link between man and machine.

Display techniques and components utilized for presentation must be optimized in relation to their ability to meet presentation requirements and their suitability in adopting outputs from processing circuits. Existing aircraft display equipments relevant to inflight safety will be utilized in lieu of additional display equipments.

Presentation of maintenance items should be as simple as possible and compatible with the maintenance concept.

Information to be displayed/analysis on the ground must be recorded in such a manner that ground display is possible with an airborne data acquisition systems.

The symbol (D) is used to identify the display function.

2.1.1.5 Functional Block Operator Notation

The total System (S) including Sensing (I), Collection (C'), Analysis (A), and Display (D) can be designated as:

$$S = (I) \bullet (C') \bullet (A) \bullet (D)$$

where the "•" operator signifies the "AND" operation.

2.1.2 Airborne/Ground Based/Hybrid Configurations

The Automatic Inspection, Diagnosis and Prognosis System (AIDAPS) is designed to monitor, analyze, isolate, display, record, report and present information relative to the aircraft and its systems, to the air crew and/or the ground crew, as appropriate. Numerous mechanizations of AIDAPS may be configured to satisfy these requirements.

There are three basic types of systems; airborne, ground based, and a combination of both, herein referred to as hybrid. Essentially, each type involves equipment in either the aircraft or on the ground, configured and proportioned as implied in the name. Each type of system has certain inherent advantages and disadvantages. Considerations have been applied to compare the relative merits and applicability of each approach to all 10 Army aircraft both individually and collectively.

Evaluation criteria for these three basic systems, airborne, ground based, and hybrid, for future aircraft, UTTAS and HLH, could be somewhat different than for existing aircraft, since cabling, baseline sensors, and BITE could be established in the original aircraft design, however, the "independent considerations" apply regardless of aircraft type. The tradeoffs involved are compounded by the Army's wide range of aircraft type, model and series comprised of fixed wing and helicopters. However, the fundamental disparity between the airborne and ground based concepts is the question of the capability of a ground-based system to adequately diagnose a vehicle's condition when it is on the ground, in contrast to an airborne system which can continuously monitor the vehicle in all modes of flight. Since the ground-based data collection systems assume an umbilical cable to couple the aircraft to a ground-based console, it is apparent that fixed wing versus helicopter operation would present a different set of constraints. Within the limits of flight safety, it can be assumed that the helicopter could operate in a hover mode in addition to normal ground operation, whereas fixed wing aircraft would be limited to only an engine runup on the ground. The basic advantage of the ground-based system, with its need to have only sensors on board the aircraft, is that the signal conditioning and processing equipment can be shared by several aircraft and therefore overall equipment costs can be reduced. There are other aspects of the ground-based versus the airborne data collection systems which will be presented subsequently in this report.

The four basic functional blocks are considered with respect to an airborne, ground or hybrid application because each of the functions could be accomplished in the air or on the ground.

There are numerous variations of these fundamental approaches. To be objective, the criteria for selection must be only what is required to perform the function in the most reliable, useful and cost-effective manner which is compatible with the aircraft mission and related operational constraints.

2.1.2.1 Airborne Definitions

An airborne system has all the elements located in and flown as part of the aircraft. An airborne system has many more possible configurations than the ground system due to the ability to perform both data analysis and data presentation functions in the air. Some on-board analysis systems compare the conditioned data with known signature values or curves and only when there is an exceedance is it displayed, as opposed to systems which record data for subsequent ground analysis and display.

The principal advantage of an airborne acquisition system over a ground-based system is its ability to monitor the aircraft in all modes of operation. Intermittent or transient problems which are not necessarily repeated in a ground runup and hover, can be detected and identified. Another advantage is the potential to increase real-time inflight safety by alerting the pilot to an adverse condition which is not readily identifiable via the cockpit instruments.

The obvious disadvantages are the decrease in aircraft payload, and the increase in the cost of providing one AIDAPS for each aircraft as opposed to a ground system which can be used to service several aircraft.

The symbol A/B will be used to identify an airborne function.

2.1.2.1.1 Airborne Sensing

Sensing will be considered airborne if the sensors are permanently installed in the aircraft. Airborne sensing is symbolically represented by A/B(I).

2.1.2.1.2 Airborne Collection

Collection will be considered airborne when the hardware is an integral part of the aircraft and is flown on the aircraft during all normal flight operations. Airborne collection will be identified as A/B(C').

2.1.2.1.3 Airborne Analysis

Analysis will be considered airborne if performed in real time while the aircraft is in flight and the hardware is installed in the aircraft during all flight modes. Airborne analysis is represented by A/B(A).

2.1.2.1.4 Airborne Display

The display equipment must be flown with the aircraft during all modes of flight to be considered airborne. A display which is connected directly to the aircraft after it has landed, then removed prior to normal flight will not be considered airborne display. Airborne display is identified by the notation A/B(D).

2.1.2.2 Ground Based Definitions

A ground based system has none of its components permanently installed in the aircraft. Any component temporarily installed to take readings, then removed before normal flight operations is considered as ground based.

The ground based system may monitor the existing and added sensors through an umbilical cable to the aircraft. The sensor outputs are the result of operating the vehicle in a limited regime to simulate flight conditions. These signals are collected, conditioned, analyzed, displayed, and stored. Ground based is symbolized by the notation G/B.

2.1.2.2.1 Ground Based Sensing

Sensing will be considered ground based if the sensors are installed on the ground to take data, then removed again for flight. This is not practicable for full AIDAPS implementation and will probably not be incorporated. The notation for ground based sensing is G/B(I).

2.1.2.2.2 Ground Based Collection

Ground based data collection hardware is not normally flown as part of the aircraft. For example, a unit designed to condition and digitize the signals from the sensors for data transmission to ground analysis equipment, and then removed after collection has taken place would be considered ground based. The ground based collection notation is G/B(C').

2.1.2.2.3 Ground Based Analysis

The test of whether analysis is airborne or ground based is dependent upon the location of the analysis equipment. Therefore, analysis performed on the ground, while the aircraft is in the hover mode, is ground based. The symbol G/B(A) represents ground based analysis.

2.1.2.2.4 Ground Based Display

The display is ground based if it does not remain on board the aircraft during normal flight operations. A display unit put aboard the aircraft temporarily for a go/no-go indication then removed is a ground based display. The notation for ground based display is G/B(D).

2.1.2.3 Hybrid Definition

A hybrid system has part of each function performed in the air and on the ground, excluding sensors. The sensors are considered an integral part of the aircraft. Many variations of a hybrid system are possible. One alternative is inflight data collection, ground analysis, and ground display. There are many versions that perform some on-board analysis and some ground analysis. Once the data has been analyzed, either in the air or on the ground, it is then displayed. The display can be in flight, or stored and then displayed on the ground, or combinations of each. The displays can take the form of lights, flags, analog traces, numerical printout, code printout, CRT displays, voice warning messages, or combinations thereof. If the data are to be presented on the ground, either all or in part, some form of data storage is required. This data storage can be accomplished by various recorder types. Examples are shown in Table 2.1-1 to illustrate two possible hybrid system configurations.

TABLE 2.1-1 EXAMPLE HYBRID SYSTEMS

SYSTEM	AIRBORNE EQUIPMENT	GROUND EQUIPMENT
A	Sensors: (1) Existing (2) New Signal Conditioning Recording	Data Transfer Analysis Display
B	Sensors: (1) Existing (2) New Signal Conditioning Partial Analysis Recording Partial Display	Data Transfer Partial Analysis Display

Concept Type A is categorized as a flight data system in which all data is acquired, conditioned and recorded in flight for complete computerized data processing on the ground. This approach is characterized as a recording system rather than an analytical system. In essence, it approximates the traditional mechanizations that have been used for several decades for flight test programs. Extensive analysis on the ground is required to separate the pertinent information from the mass of data collected. Any delay in maintenance data analysis following landing may be incompatible with the QMR and practical application.

Type B recognizes the limitations of Type A above and performs partial airborne computation with subsequent ground computation. While superior to Type A, with respect to providing some data that can be displayed during flight, this system is more complex than Type A; Type B involves data acquisition, recording and inflight computation for the specific aircraft. Because the computation is done in the air, inflight real time display is feasible. Such systems are particularly suited for multi-crew aircraft which includes a crew chief to read special displays and performance maintenance-oriented functions. This concept has the dual capability to present inflight critical information in real time and pertinent information after landing in minimal time with ground recovery equipment. The data recovery equipment permits review of the information on the flight line by maintenance personnel.

The hybrid symbolic representation for each of the functional blocks are H/B(I) for Hybrid Sensing, H/B(C') for Hybrid Collection, H/B(A) for Hybrid Analysis and H/B(D) for Hybrid Display.

2.1.2.4 Total Variations of Airborne/Ground Based/Hybrid

A total of 81 possible systems can be derived from airborne, ground, and hybrid combinations related to each functional block. Many of these systems can be eliminated by deductive reasoning because the configuration is not logically feasible. For example, when considering ground collection, all system configurations which do not have a ground analysis and display can be eliminated, because data collected on the ground would have to be taken in the air to be analyzed and displayed.

The system possibilities related to A/B, G/B or H/B can be represented symbolically by the following expression:

$$S = (I)\ (A/B + G/B + H/B) \bullet (C')\ (A/B + G/B + H/B) \bullet (A)\ (A/B + G/B + H/B) \bullet (D)\ (A/B + G/B + H/B)$$

where "+" indicates the "OR" operator and "•", as before, indicates the "AND" operator.

2.1.3 Levels of Sophistication

A generic consideration to be evaluated is the level of sophistication applied within each functional block of the system. As a guide to eventual cost/effective tradeoffs, some relatively simple method for categorizing the levels of sophistication and capability of alternate AIDAP systems and concepts is necessary. Using three levels of sophistication of Simple (S), Medium (M), and Complex (C), criteria were established for each level within each functional block. A rational scheme of considering each level of sophistication against each functional block has been developed in order to be able to compare AIDAP system concepts by means of these criteria.

Each level of sophistication for sensing, collection, analysis, and display is defined in the following paragraphs.

These levels of sophistication will be correlated for all functions for the 10 aircraft. The level of sensor sophistication is dependent on aircraft type, and therefore the alternatives will be correlated to special aircraft discussed in Section 2.5.

2.1.3.1 Sensing Sophistication Definitions

The sensing sophistication is derived in detail in Section 2.4.3. The results of this analysis are based on the number and type of parameters monitored to arrive at a "Weighted Sensor Count" (WSC) which is more meaningful than just presenting the number of parameters independent of type. The results are categorized into three levels of sophistication as follows:

Simple	-	$WSC < 200$
Medium	-	$200 \le WSC < 400$
Complex	-	$WSC \ge 400$

The notation for describing sensor sophistication is as follows:

$$(I) = (S + M + C)$$

2.1.3.2 Collection Sophistication Definitions

There are three basic modes of collection sophistication which readily describe the sophistication in terms of S, M, or C. These modes are "Continuous Analog Processing," "Time Shared Analog-to-Digital Processing," and "Digital Data Compression with Process Control." The foregoing elements are related to S, M, and C as:

$$S = a$$
$$M = \Sigma\ a,b$$
$$C = \Sigma\ a,b,c$$

where:

a = continuous analog signal processing
b = time-shared analog-to-digital processing
c = digital data compression and process control

The symbolic representation of the three levels of sophistication as related to collection is described by

$$(C') = (S + M + C)$$

2.1.3.3 Analysis Sophistication Definitions

The three levels of sophistication as related to the analysis function as defined by the following statements.

$$S = a$$
$$M = \Sigma\ a,b$$
$$C = \Sigma\ a,b,c,$$

where:

a = comparison to simple fixed limits
b = comparison to interrelated limits and logical situations with coded signal output
c = recognition of failure signatures and trend analysis.

The expression to describe the levels of sophistication as related to analysis is:

(A) = (S + M + C)

2.1.3.4 Display Sophistication Definitions

The sophistication levels of display are defined as follows:

Simple - Single purpose display with fixed visual presentation; i.e., a light or flag indicator in conjunction with data storage.

Medium - Single purpose displays with multiple presentations; i.e., lights, flags, audible, and printer records with semi-automatic/automatic selection in conjunction with data storage.

Complex - Multiple purpose displays with multiple presentations, e.g., lights, flags, audible, hardcopy printer or x-y plotter records, and special use optical presentations, such as cathode ray oscillographs, pattern recognition arrays, etc., with automatic selection and reset in conjunction with data storage.

The notation for defining the levels of sophistication is as follows:

(D) = (S + M + C)

2.1.3.5 Total Variations of Sophistication Levels

A total of 81 system combinations can be postulated when considering three levels of sophistication associated with each function block; sensing, collection, analysis, and display. Many of these configurations can be eliminated by logical considerations, while others can be eliminated by evaluation of the AIDAPS objectives and the QMR.

All possible system configurations related to the levels of sophistication can be symbolically represented by the following expression:

S = (I) (S + M + C) • (C') (S + M + C) • (A) (S + M + C) • (D) (S + M + C)

2.1.4 Combined System Alternatives

Considering all possible combinations as associated with each of the 10 aircraft results in an overwhelming number of possibilities. Condensing the alternatives to reasonable numbers cannot be an intuitive elimination of configurations. Objective constraints have been established to eliminate impractical approaches. The constraints developed and the application of these constraints are discussed in Sections 2.2 and 2.3.

All of these concepts are evaluated in light of the Army's mode of operation, environment, maintenance personnel skills, and aircraft type. A brief exposition of some of the principal considerations that will be employed in AIDAPS concept formulation follows:

a) Maintenance Environment - The conditions for organizational, direct support, and even general support maintenance in the field are usually austere. Facilities are often very limited. ARADMAC, Fort Rucker, and Hunter AAF, to name a few, are not representative of a typical Army aviation combat operations in a forward area in which maintenance of the aircraft must be performed. The effect of combat operations as well as deployment within the CONUS must be fully considered.

b) Ground Crew Skill Level - Personnel available for recovery, interpretation, and analysis of automated data for maintenance may have limited experience, and are on short tours of duty with frequent reassignment. This is true of all levels of maintenance excluding depot.

c) Aircraft Operational Environment - Typical Army aircraft utilization involves multiple flights in a single day, usually with alternating air crews and only a few minutes permitted between missions for refueling, rearmament, and inspection. It is unlikely that this operational environment will change significantly in the future.

d) Aircraft Space, Weight, and Power Limitations - The majority of the existing Army aircraft are characterized as lightweight, high-utility vehicles in which payloads have been increased to the design limits to satisfy military mission demands. For these and similar vehicles there are severe limitations to additional weight, space, and power for nontactical equipment.

e) Scope of Instrumentation - Existing on-board sensors must be used to the maximum extent practical. The selection of additional signal sources must be kept at a level commensurate with the acquisition of information that significantly reduces maintenance costs. In the case of future vehicles, incorporation of needed sensors in the original vehicle design phase will substantially reduce instrumentation costs.

f) Reliability - The reliability of the AIDAPS must be better than the systems monitored to gain acceptance as an effective adjunct to the aircraft. Because of its importance, the high reliability goal must not be compromised. The individual functions assigned to AIDAPS must be weighed in terms of the relative complexity in mechanization.

g) Allocation of the Maintenance Problem - The engine(s) and power train have been identified as the most frequent items of material failure and require the most significant percentage of maintenance manhours (MMH). Since engines are the most costly single item of equipment as well as the most critical from the flight safety viewpoint, a correspondingly high allocation of AIDAPS capacity to the engine/power train is well justified. In monitoring engines, study and experience indicate that a relatively few properly selected parameters provide a disproportionately high effectiveness in identifying key incipient failures and furnish data for detecting small gradients of performance degradation for prognosis/trending analysis. As an example, a Northrop study for a similar application revealed that 120 parameters provided 92% of the possible maintenance action; 265 additional items related to the remaining 8% of the potential maintenance. In contrast, a very substantial number of new sensors may be required to identify lesser important secondary items. The usefulness of the data must be rigorously screened for effectiveness.

h) Economics - Cost-effectiveness tradeoffs and the optimum point for scope of implementation of AIDAPS must be determined. The most yield per unit cost must be thoroughly explored and validated by experienced judgment as well as theoretical analysis. The concept formulation is properly oriented toward analytical economic tradeoffs. However, care and discipline must be exercised to insure that the analytical results do not depart from practical fact.

The following paragraphs of this section present the process of analysis and application of the resultant criteria to establish alternate practical AIDAP system concepts for the 10 U.S. Army aircraft under study.

There are 6561 system possibilities for each aircraft when considering all the combinations of Airborne, Ground Based, and Hybrid, and Simple, Medium, and Complex sophistication levels as related to the four functional system blocks. All these system configurations can be represented in logical notation by the following expression:

$$S = (I)\left|(S + M + C) \bullet (A/B + G/B + H/B)\right| \bullet (C)\left|(S + M + C) \bullet (A/B + G/B + H/B)\right|$$

$$\bullet (A)\left|(S + M + C) \bullet (A/B + G/B + H/B)\right| \bullet (D)\left|(S + M + C) \bullet (A/B + G/B + H/B)\right|$$

2.2 CONSIDERATIONS OF ALTERNATE AIDAP APPROACH CONCEPTS

The considerations for alternate AIDAP approaches were grouped into two basic categories identified as aircraft (A/C) "Dependent Considerations" and AIDAP generic considerations common to all aircraft referred to as "Independent Considerations."

Although the generic considerations are in fact closely related to the A/C requirements, related AIDAP system constraint guidelines may be selected based primarily upon AIDAPS experience, knowledge of data acquisition and processing, engineering logic and the application of the Qualitative Material Requirements (QMR).

The material as presented in this report section concerns the establishment of these generic constraints and their subsequent application to derive practical conceptual configurations. The established configurations are subsequently assessed with respect to the A/C dependent constraints, herein under report Section 2.3, to derive practical AIDAPS conceptual approaches for the Phase C tradeoff analysis.

2.2.1 Elements of Consideration

As previously discussed in the study Phase A interim report, the most obvious consideration is whether the AIDAPS is airborne or ground base or a combination of the two, referred to as a hybrid, and designated as A/B, G/B and H/B, respectively. In association with these configurations are the basic functions of a data system; i.e., data sensing/instrumentation (I), collection/acquisition (C'), analysis (A), and display/record (D).

Inherent within the functions are elements of sophistication relevant to complexity; i.e., simple (S), medium (M), or complex (C), which are also considered.

The foregoing discussion identifies complexity and magnitude within the independent considerations. It is therefore appropriate to assess these elements on an individual basis and project each result into subsequent individual assessments.

The independent considerations as treated herein are described as follows:

a) A/B, H/B and G/B Functional Configuration.

b) Overall Level of Functional Sophistication.

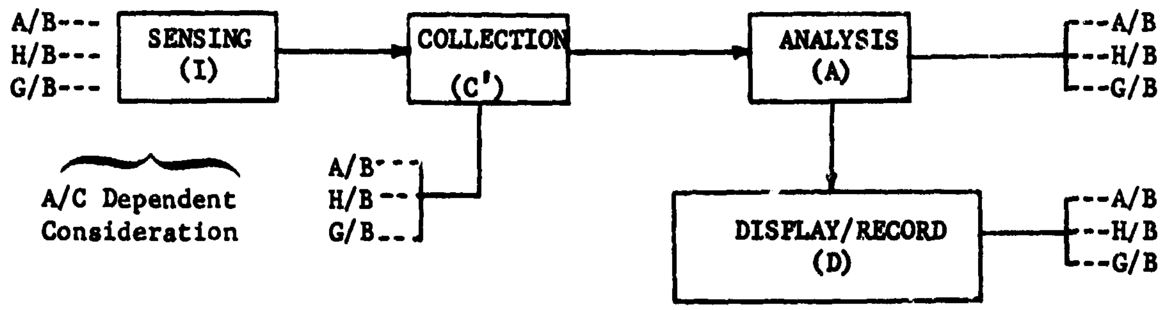
c) Level of Sophistication Relevant to A/B, H/B and G/B Configurations and Resultant Combinations.

2.2.1.1 A/B, H/B and G/B Configuration Constraints and Application

Functional; i.e., (I), (C'), (A) and (D), definitions and constraints were established for all combinations of A/B, H/B, and G/B.

The following figure depicts all combinations of functional configurations:

Figure 2.2-1 FUNCTIONAL CONFIGURATIONS



2.2.1.1.1 Sensing A/B, H/B, G/B Constraint Application(s)

The following constraint was established for the sensing function configuration. All sensors will be installed on the aircraft (A/C) at all times. Sensor installation time, calibration problems and sensor sensitivity to handling do not permit daily or frequent handling of such items; in addition, A/C turnaround time at the organizational flightline will not permit such action. Therefore, the sensing function will be considered only as an A/B function, expressed as:

$$I = A/B, \; I \neq H/B \text{ and } I \neq G/B$$

2.2.1.1.2 Collection A/B, H/B, G/B Constraint Application(s)

The function of collection was defined as the acquisition process and consists of electrical load isolation, signal amplification, filtering, multiplexing, and analog-to-digital (A/D) conversion.

Constraints for the above function are discussed as follows:

a) Inflight monitoring of flight-critical parameters which are not currently instrumented is a desirable AIDAP objective which would enhance the pilot's judgment in a possibly unsafe condition using existing A/C displays. This sensing mode would require some inflight collection and processing.

b) An important consideration is the fact that a random symptom of a deteriorating LRU which can occur in flight may not repeat itself during ground runups. The random deterioration could well progress with a high rate of deterioration during a subsequent flight. Therefore, it would be desirable to collect data on flight-critical LRU's on a real-time basis during the flight mission.

c) Inasmuch as the most severe helicopter operating condition is the Hovering Out of Ground Effect (HOGE) flight mode, a hardwire umbilical could be utilized to couple the sensing function to the ground base collection function. This would minimize the aircraft associated AIDAP equipment.

d) The communication link could also be in the form of a magnetic tape link whereby the sensed parameters are multiplexed, converted to digital signals and continuously recorded directly onto the magnetic tape onboard the aircraft for a short controlled interval during Hover. The electronics unit, which normally contains the equipment that performs the collection tasks, could then be removed along with the recorded data which which are transferred to the ground data recovery equipment for subsequent editing of data, compression, analysis and display. The removal of the electronics unit appears to be an impractical and unnecessary complication because the current solid state electronics circuit design and packaging techniques result in relatively small and light weight equipment. As previously stated in paragraph 2.1.2.1.2, the function of collection would be considered airborne when the hardware is permanently installed in the aircraft and is therefore flown on the aircraft during all flight modes. Even though this configuration would require tape removal and "quick playback" before the flight mission, it would be a more effective and easier method than a hardwire umbilical and certainly would be less costly and less complex than a telemetry link.

The application of the above considerations, as applied to the function of collection, establishes the following collection constraints.

$$(C') \neq H/B .$$

therefore: $(C') = A/B$ or $(C') = G/B$

2.2.1.1.3 Analysis A/B, H/B, G/B Constraint Application(s)

The function of analysis was defined as the processing of data to detect parameter performance thresholds; perform parameter cross-correlations, summations, integrations, differentiations, scaling, editing or compression, and the control of data transmission to achieve the objectives of A/C subsystems fault detection, fault isolation, and fault prediction.

Constraints for the above function are discussed as follows:

a) Although AIDAPS is primarily a maintenance tool, one of its anticipated contributions to safety is through prognosis, the capability to detect and/or to predict imminent A/C subsystem critical failure or abnormal subsystem operation during the flight would allow possible adaptive/corrective action; e.g., throttle back, selection of a suitable place to land, return to friendly territory, etc. This capability will require some airborne analysis.

b) Pure A/B analysis is impractical for the less complex class of aircraft under study. The configuration of analysis, that is, whether it is a pure airborne function, a combination of airborne and ground configuration, or a pure ground function, is dependent upon the degree of applied aircraft system's complexity. The effectiveness of a particular configuration must be determined during the model tradeoff analysis performed during Phase C of this contract.

The application of the considerations to the function of analysis establishes the following constraints.

(A) = A/B, (A/C with a high degree of complexity)

therefore: (A) = H/B or (A) = G/B

2.2.1.1.4 Display/Record A/B, H/B, G/B Constraint Application(s)

The function of display/record was defined herein as the presentation of information in an audible, visual or memory format in various mechanized forms; e.g., voice, buzzer, light, flag, counter, print copy, wire recorder, magnetic tape, etc.

Constraints for the above function are discussed as follows:

a) As a minimum, the display for any safety or maintenance level must identify the abnormalcy. If the data collection and analysis allow the inflight function of alerting the crew to an unsafe condition, then these functions will require simple airborne display.

b) Inasmuch as the objective of AIDAPS is to serve all levels of aircraft maintenance, the complement of existing aircraft records will require some ground base analysis. Therefore, ground base display will be required to present associated information for observation and interpretation at higher levels in the logistic system than organizational support.

c) Airborne display only is impractical relevant to the above.

The application of the constraints to the function of display establishes the following configurations.

(D) $\neq$ A/B

therefore: (D) = H/B or (D) = G/B

2.2.1.1.5 Selection of Functional Configurations

Figure 2.2-1 describes 27 various combinations excluding the function of sensing. The combining of the constraints and the recognition of mutually exclusive combinations results in the following selected functional configurations.

S_1 = (I) A/B · (C') A/B · (A) H/B · (D) H/B (See Figure 2.2-2)

S_2 = (I) A/B · (C') A/B · (A) A/B · (D) H/B (See Figure 2.2-2)

S_3 = (I) A/B · (C') A/B · (A) G/B · (D) G/B (See Figure 2.2-2)

S_4 = (I) A/B · (C') G/B · (A) G/B ·· (D) G/B (See Figure 2.2-3)

Figure 2.2-2 S_1 THROUGH S_3 BLOCK DIAGRAM

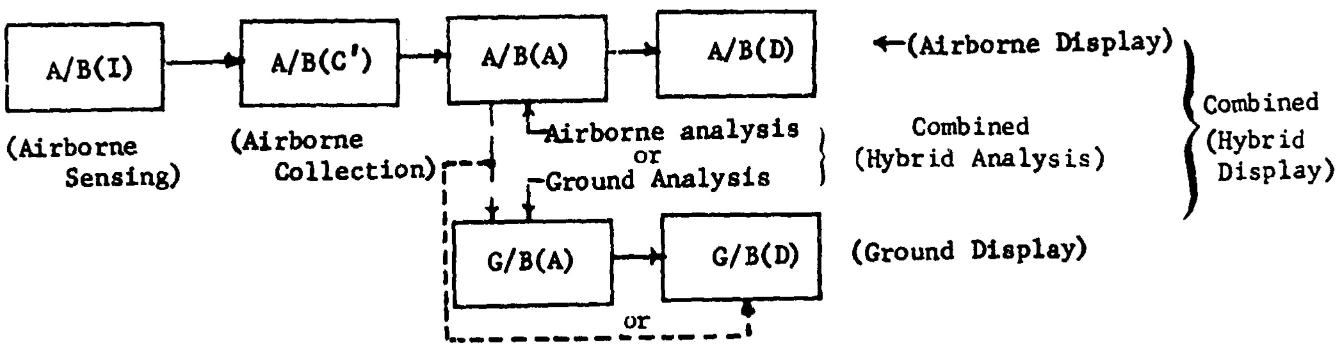
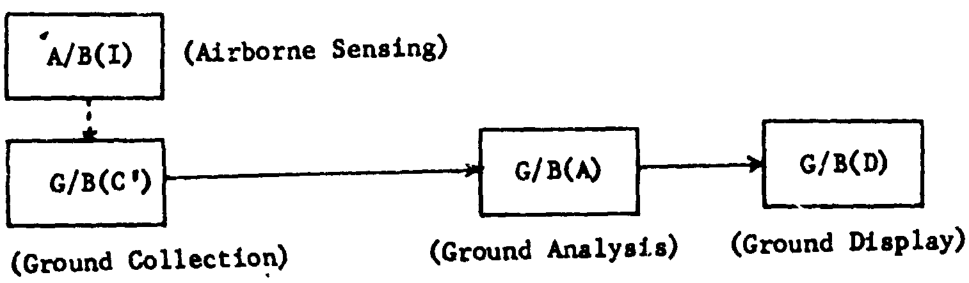


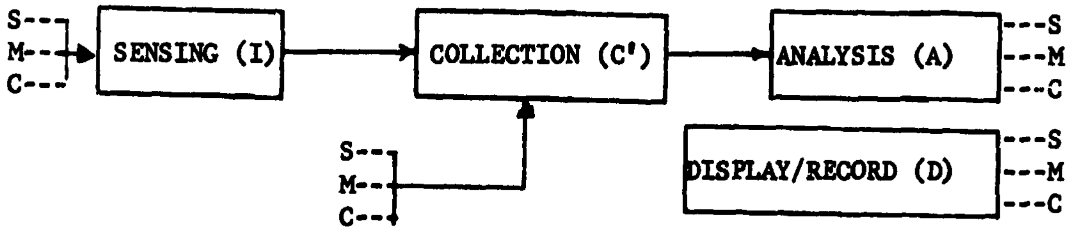
Figure 2.2-3 S_4 BLOCK DIAGRAM



2.2.1.2 Overall Level of Sophistication Configuration Constraint Applications

Sophistication definitions and constraints were established for all combinations of simple (S), medium (M), and complex (C) sophistications, as associated with each of the basic functions (I), (C'), (A) and (D). The following figure depicts all combinations of sophistication configurations.

Figure 2.2-4 SOPHISTICATION CONFIGURATIONS



2.2.1.2.1 Sensing Sophistication Constraint Application(s)

The sensing sophistication is primarily dependent upon specific A/C requirements and constraints. The establishment of these requirements and constraints was previously discussed in Section 2.1.3.1.

The material herein describes the applications of the subject constraint to reduce the number of possible sensing configurations to those which are practical. The constraint data defined as "Weighted Sensor Count" (WSC) are treated in detail within Section 2.3 of this report.

The sensing configuration illustrated in Section 2.1.3.1 is depicted as A/B(I) • (S + M + C).

2.2.1.2.2 Collection Sophistication Constraint Application(s)

The establishment of the subject constraints was based upon an assessment of the definitions for the degree of capabilities within the collection function. (Reference paragraph 2.1.3.2) The capability of DC to DC voltage signal conversion and that of synchro to DC conversion are considered as the extremes of basic signal conditioning. These capabilities, based on practical design engineering must exist in any collection function sophistication which is adapted to aircraft data systems.

This assessment as related to practical data systems engineering and the desired objectives of AIDAPS established the following constraints.

1) Simple or medium collection would contribute to excessive data bulk and complexity of analysis, data storage, and presentation techniques.

2) Complex collection must be applied to control and minimize the level of data bulk and reduce costs for data analysis, storage and presentation.

The foregoing constraints establish the collection sophistication as:

$$(C') \neq S \text{ and } (C') \neq M$$

therefore: $(C') = C$

2.2.1.2.3 Analysis Sophistication Constraint Application(s)

Three basic analysis definitions which depict the sophistication of analysis in terms of S, M or C were established.

An assessment of the definitions, reference paragraph 2.1.3.3, relevant to the desired objectives of AIDAPS, established the following constraints.

1) Simple analysis is inadequate for providing A/C subsystem LRU fault isolation for subsystems which require parameter correlation; i.e., diagnosis, which is a basic AIDAP system requirement.

2) Complex analysis is required to achieve the desired capability of A/C subsystem prognosis.

The foregoing considerations establish the analysis sophistication as:

$$(A) \neq S \text{ and } (A) \neq M$$

therefore: $(A) = C.$

2.2.1.2.4 Display/Record Sophistication Constraint Application(s)

1) Simple display is inadequate for providing permanent data records and data storage to support observation and interpretation of LRU inspection, diagnostic, and prognostic information.

2) Complex display would contribute to excessive and impractical implementation and operational costs for the aircraft under consideration. Visual, audible, and hardcopy printer records in numeric or English language are considered adequate.

The foregoing constraints establish the display/record sophistication as:

$$(D) \neq S \text{ and } (D) \neq C$$

therefore: $(D) = M.$

2.2.1.2.5 Selection of System Sophistication Configurations

Figure 2.2-4 describes 81 various combinations of S, M and C as applicable to each of the four functions. The combining of the aforementioned constraints results in the following selected sophistication configuration(s):

$$S_{1,2,3} = (I)\ |S+M+C| \cdot (C')\ (C) \cdot (A)\ (C) \cdot (D)\ (M)$$

implies

$$S_1 = (I)\ S \cdot (C')\ C \cdot (A)\ C \cdot (D)\ M$$

$$S_2 = (I)\ M \cdot (C')\ C \cdot (A)\ C \cdot (D)\ M$$

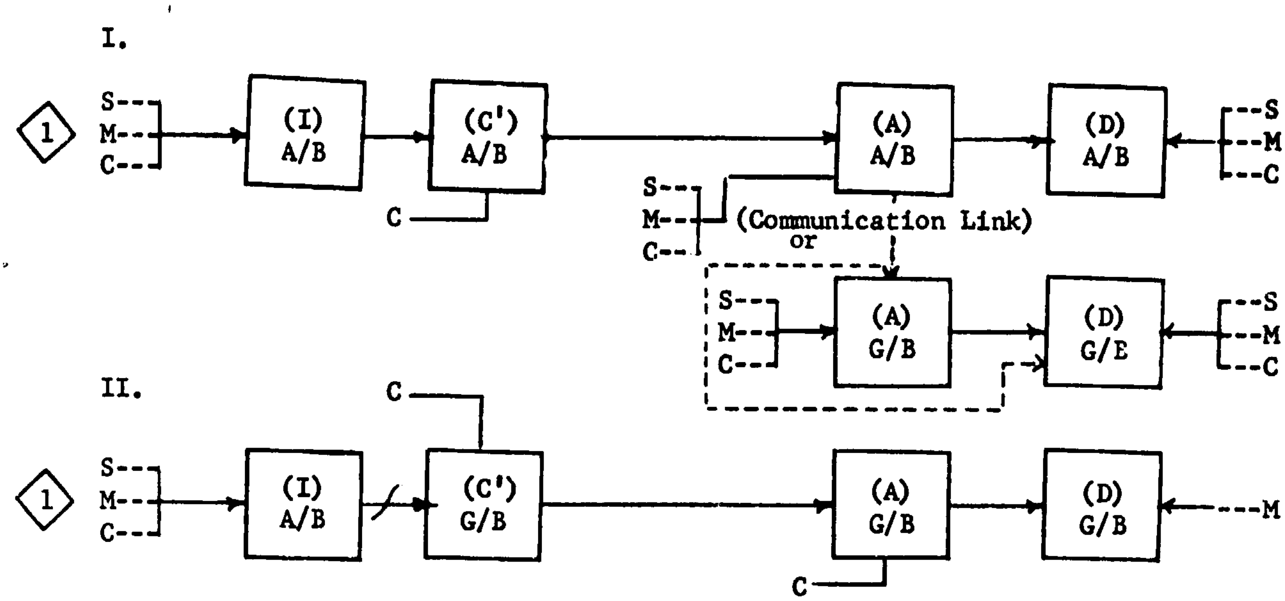
$$S_3 = (I)\ C \cdot (C')\ C \cdot (A)\ C \cdot (D)\ M$$

2.2.1.3 Combined Functional and Sophistication Configurations

The hardware mechanization and the inherent capability characteristics of an AIDAP system are dependent upon the configured divisional combination of the functions and their associated sophistication. Therefore, considerations must be established for the division of sophistication within a function which is divided between two base areas.

The purpose of these considerations is readily understood upon examination of Figure 2.2-5 which describes the combination of sophistication which may be derived.

Figure 2.2-5 COMBINED CONFIGURATIONS



NOTES: ◇1 A/C Constraint
⌿ Umbilical Link

Configuration I. above describes the selected functional configuration defined herein as S_1 under paragraph 2.2.1.1.5, in conjunction with the division of sophistication.

Configuration II. above describes the selected functional configuration defined herein as S_2 under paragraph 2.2.1.1.5, and is illustrated for the purpose of comparison to Configuration I. sophistication complexity.

2.2.1.3.1 Sophistication Division Constraints and Application

The allocation/division of the analysis and display functions in configuration I above, must be assessed relevant to the desired objectives of AIDAPS and the mutually exclusive combinations of sophistication.

2.2.1.3.1.1 A/B and G/B Division of Analysis Sophistication

The following constraints were established for the analysis sophistications.

a) Inflight collection and display of critical parameter limits relevant to unsafe conditions will require airborne limit detection or threshold logic analysis (reference paragraphs 2.2.1.1.2 and 2.2.1.1.4).

b) Inflight data acquisitions of limit exceedance and random symptoms of parameter deterioration may be analyzed as an airborne or ground base function. Therefore, an airborne inflight short-term prognosis capability may be required to support the organizational level maintenance operation relevant to A/C turn-around time; e.g., knowledge of a pending fault and cause isolation immediately upon landing of A/C would greatly reduce time allocated for ground diagnostic functions.

c) Airborne analysis should be limited to that required in the above discussion to control airborne AIDAPS complexity and life cycle costs. Any additional in-depth analysis in support of higher levels of maintenance operations and A/C subsystems long-term performance predictions should be allocated within the ground base AIDAPS equipments to ensure that the highest effectiveness and lowest life cycle cost is achieved. Therefore, the ground base function will require parameter long-term trending and prediction logic analysis, referred to herein as complex analysis (reference paragraph 2.2.1.2.3).

The application of the above constraints establishes the division of analysis sophistication as:

$$(A)A/B \neq C \text{ and } (A)G/B \neq S \text{ and } (A)G/B \neq M.$$

Therefore: $(A)A/B = S$ or $(A)A/B = M$ and $(A)G/B = C$

2.2.1.3.1.2 A/B and G/B Division of Display Sophistication

The following constraints were established for the display/record sophistication, based upon an assessment of the association of constraint guidelines between the functions of analysis and display as discussed in paragraphs 2.2.1.1.3, 2.2.1.1.4 and 2.2.1.2.4.

a) Simple airborne display is adequate to support inflight safety data presentation requirements.

b) Medium ground base display is required to provide adequate presentation of AIDAPS inspection, diagnostic and prognostic data.

c) Complex ground base or airborne display is not required and would only contribute to excessive design complexity, lower AIDAPS reliability, lower maintainability, and a higher life cycle cost.

d) Simple A/B display will support the objectives for airborne display relevant to A/C turnaround.

The application of the above constraints establishes the division of display/record sophistication as:

(D)G/B $\neq$ S and (D)A/B $\neq$ C and (D)G/B $\neq$ C

therefore: (D)A/B = S and (D)A/B = M and (D)G/B = M

2.2.1.3.2 Selection of Conceptual Configurations

Figure 2.2-5 Configuration I describes 81 combinations, excluding the sensing function, for the hybrid AIDAP system approach. The application of the above constraints precludes the mutually exclusive and impractical configurations and results in the configurations described in the following set of system (S) expressions.

$$S_1 = A/B \left|(I)S \cdot (C')C \cdot (A)S \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

$$S_2 = A/B \left|(I)S \cdot (C')C \cdot (A)M \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

$$S_3 = A/B \left|(I)M \cdot (C')C \cdot (A)S \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

$$S_4 = A/B \left|(I)M \cdot (C')C \cdot (A)M \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

$$S_5 = A/B \left|(I)C \cdot (C')C \cdot (A)S \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

$$S_6 = A/B \left|(I)C \cdot (C')C \cdot (A)M \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

$$S_7 = A/B \left|(I)S + M + C \cdot (C')C \cdot (A)C \cdot (D)M\right|$$

Figure 2.2-5 Configuration II describes three combinations for a ground base AIDAP system approach. These selected configurations are described in the following set of system expressions.

$$S_8 = A/B(I)S \cdot G/B \left|(C')C \cdot (A)C \cdot (D)M\right|$$

$$S_9 = A/B(I)M \cdot G/B \left|(C')C \cdot (A)C \cdot (D)M\right|$$

$$S_{10} = A/B(I)C \cdot G/B \left|(C')C \cdot (A)C \cdot (D)M\right|$$

An additional element of consideration for the G/B concept as related to helicopter ground hover inspection tests, is that of substituting the hardwire umbilical with A/B data storage.

2.2.1.3.2.1 Selected System Approach Concept Definitions

The following definitions are provided for the foregoing systems sub-statements; e.g., A/B(I)S, A/B(C')C, G/B(A)C, etc.

Systems S_1 through S_7 are hybrid systems which have the following characteristics within their assigned combinations.

1) A/B(I)S - airborne sensing function which monitors an average of 40 parameters with a weighted sensor count (WSC) up to, but not including, 200.

2) A/B(I)M - airborne sensing function which monitors an average of 80 parameters with a WSC of 200 to 400.

3) A/B(I)C - airborne sensing function which monitors an average of 130 parameters with a WSC of 400 and greater.

4) A/B(C')C - airborne collection function which provides AIDAP equipment versus A/C electrical load isolation, signal amplification control of sampling intervals, analog-to-digital conversion, data compression, and process control logic.

5) A/B(A)S • G/B(A)C - hybrid analysis function which provides simple airborne analysis; i.e., limit detection logic analysis only in conjunction with a complex ground base analysis capability; i.e., threshold, fault isolation, prediction logic analysis, and maintenance directive reference logic.

6) A/B(A)M • G/B(A)C - hybrid analysis function which provides medium airborne analysis; i.e., limit detection, and fault isolation logic in conjunction with a complex ground base analysis capability; i.e., prediction logic, and maintenance directive reference logic.

7) A/B (A)C · A/B(D)S · G/B(D)M - airborne analysis function which provides limit detection, fault isolation and prediction, computational logic, in conjunction with a hybrid display function.

8) A/B(D)S · G/B(D)M - hybrid display/record function which provides simple airborne display with medium ground based multiple purpose data presentations, with semi-automatic/automatic select in conjunction with airborne data storage and ground-based data playback.

Systems S_8 through S_{10} are considered as ground base systems. The system substatements define the same capabilities as systems S_1 through S_7, as applicable.

As previously noted, the foregoing selected configurations are the results of the assessment of the independent considerations. Aircraft dependent considerations must now be assessed and associated constraints applied to the approach concepts to establish candidates for the study Phase C trade-off model analysis. The dependent considerations are discussed herein in Section 2.3 with subsequent application of constraints in Section 2.4.

2.3 AIRCRAFT COMPARISON FOR AIDAPS SELECTION

The AIDAP System approaches have been evaluated and reduced to a reasonable number of alternatives without regard to individual aircraft types. Impractical approaches were deleted from the list of possible system candidates independent of aircraft type. The constraints considered were of a generic nature which considered basic guidelines such as the Army logistics structure and environment and AIDAPS objectives. It is recognized that aircraft exhibit distinct individual characteristics within a type, model, or series, and will be accommodated by employment of adaptive data processing techniques.

A comprehensive review of all factors of AIDAPS relative to specific aircraft type establishes the following considerations.

a) The weight and size of the aircraft in conjunction with the QMR guidelines indicate the maximum weight and size of the airborne system hardware.

b) The cost of an aircraft restricts the cost and complexity of the AIDAPS recommended for that specific aircraft type.

c) The number and type of parameters selected to be monitored on each aircraft are significant in determining the complexity of AIDAPS. It is directly related to the sensing functional block.

d) The mission of the aircraft has an influence on the system configuration as related to increased mission effectiveness.

e) The number of aircraft of a particular type in the inventory will have an influence on the design of a dedicated system for that specific aircraft type.

f) The aircraft utilization will influence the AIDAPS sophistication for each aircraft type.

g) The potential reduction in the aircraft Maintenance Manhours per Flight Hour (MMH/FH) will be a consideration in the allowable AIDAPS costs.

h) The fixed wing and rotary wing aircraft will indicate the approaches applicable to both type vehicles.

i) The number of engines an aircraft has will influence the amount of airborne real-time engine analysis performed to effect flight safety.

j) The number of crew members in each aircraft will influence the type of airborne display.

k) The accident rate due to subsystem malfunction will indicate the airborne AIDAPS sophistication for flight safety.

The main concern at this point is to attempt to group aircraft into categories based on the commonality of aircraft type. These groupings will reduce the number of alternate AIDAP systems for Phase C tradeoffs. Rather than having 10 different systems (i.e., 1 per aircraft type) the systems may be so configured that they will serve 2 or 3 aircraft types. Therefore, fewer AIDAP system configurations will, of course, result in improved interchangeability of hardware and reduced costs.

The guidelines presented in the following paragraphs and the rationale described for the derivation of these guidelines are based upon variations of aircraft type. The groups as presented are not necessarily final and may change after the model has been exercised in Phase C.

2.3.1 Aircraft Weight Comparison

The size, weight, and power requirements of the airborne hardware are determined, in part, by the size of the aircraft. An increase in aircraft size and weight generally accompanies an increase in payload. By increasing aircraft availability due to AIDAPS implementation, the effective payload is increased. This increase in effective payload can justify a reduction in actual payload resulting from the added weight of the airborne AIDAPS equipment. Approximate design gross weights are given in Table 2.3-1 for 8 of the 10 Army air aircraft under study to illustrate the weight comparisons. Approximations are used because different gross weights are associated with the various series within a type and model.

TABLE 2.3-1 AIRCRAFT WEIGHT COMPARISON

Aircraft	Average Gross Weight (pounds)
OH-6	2,400
OH-58	2,645
U-21	9,650
OV-1	11,715
UH-1	6,600
AH-1	6,600
CH-47	38,550
CH-54	42,000

2.3.2 Aircraft Cost Comparison

The cost of the aircraft has an influence on the selection of AIDAPS hardware sophistication and cost. The economic benefits derived from AIDAPS must be in excess of the cost of implementing AIDAPS into the Army logistic system. The AIDAPS cost of monitoring a particular component must be less than the decrease in maintenance cost of that particular component.

A summary of the procurement cost of each of the existing eight aircraft is given in Table 2.3-2.

TABLE 2.3-2 AIRCRAFT COST COMPARISON

Aircraft	Average Procurement Cost (dollars)
OH-6	74,578
OH-58	81,204
OV-1	976,437
U-21	246,337
UH-1	255,365
AH-1	365,254
CH-47	1,100,000
CH-54	2,000,000

2.3.3 Comparison of the Number and Types of Parameters

The number and type of parameter monitored are significant in the grouping of aircraft to reduce the number of systems from 1 for each individual aircraft; i.e., 10 systems to 1 for each aircraft group. This is a major factor which lends itself to quantitative grouping. The methodology of weighting each aircraft is as follows.

The size, complexity, and costs of measurement/information systems are often expressed in terms of the "number of sensors" either installed or contemplated. This convenient measure, however, can be very misleading since it contains no information about the type or characteristics of the various data sources or the size and complexity of the associated signal conditioning.

To derive a more meaningful "figure of complexity," the following table of weighting factors for the various types of signal conditioning was compiled.

The assumed unit weight of one was assigned to the discrete or ON-OFF signal. Larger numbers for increasingly more complex, larger, and more costly signal conditioners were assigned based upon current signal conditioning application experience.

WEIGHTING FACTORS FOR VARIOUS SIGNAL CONDITIONERS

Item	Name	Weighting Factor
a	Discrete (Switch Closure)	1
b	Simple Voltage (Current) Analog	4
c	Charge Amplifier	5
d	Bridge Amplifier	6
e	Linear Differential Transformer	8
f	Tachometer	10
g	Synchro	12

The Weighted Sensor Count (WSC) is the summation of the weighting factors for each sensor on a particular aircraft type.

The totals represent the magnitude of the complexity of the data acquisition section of the airborne equipment.

In Phase A the lists of the existing sensors for the aircraft which are of concern to this study were compiled, excluding the projected UTTAS, HLH (Single Rotary) and HLH (Twin Rotor) in Table 2.3-3, "Aircraft Sensor Comparison" from the Phase A report. The weighting factors for each parameter are noted as the encircled numerals. For each aircraft type, two numbers are accumulated: E_e which is the WSC for the existing sensors which are concerned with the engines, and E_s which is the WSC for existing sensors which are concerned with the balance of subsystems of the aircraft. In the case of UTTAS and the two versions of the HLH, Tables 2.3-4, 2.3-5, and 2.3-6 developed in Phase A, were used since the necessary information on these future types is not in Table 2.3-3.

The tabulated totals are for existing sensors. The detailed consideration of each subsystem and its associated additional sensors is part of Phase C. In this phase it is necessary to produce estimates of system size, complexity, and costs as a preliminary guide for the tradeoff of various practical hardware configurations. In order to do this, some estimate must be made of the number

TABLE .3-3 AIRCRAFT · SENSOR COMPARISON

ACTIVITY MONITORED	SENSOR DEVICE							
	OH-6	OH-58	OV-1	CH-47	CH-54	UH-1	U-21	AH-
FUNCTIONAL GROUP 01 AIRFRAME	None	None	None	None	None	None	None	None
FUNCTIONAL GROUP 02 ALIGHTING GEAR								

Main and Nose Gear Position	NA	NA	Switch (6) ⑥ Rheostat (1)	Limit Switch ①	None	NA	Switch (3) ③	NA
Parking Brake	NA	NA	None	Switch ①	Switch ①	NA	None	NA
Tail Skid	NA	NA	NA	NA	Switch ①	NA	NA	NA
FUNCTIONAL GROUP 03 ENGINE								
Gas Producer Turbine Speed	Tachometer Generator ⑩	Tachometer Generator ⑩	Tachometer Generator (2) ⑳	Tachometer Generator (2) ⑳	Tachometer Generator (2) ⑳	Tachometer Generator ⑩	Tachometer Generator (2) ⑳	Tachometer Generator ⑩
Power Turbine Speed	Tachometer Generator ⑩	Tachometer Generator ⑩	None	Tachometer Generator (2) ⑳	Tachometer Generator (2) ⑳	Tachometer Generator ⑩	None	Tachometer Generator ⑩
Exhaust Gas Temperature	Thermocouple Harness ⑤	Thermocouple Harness ⑤	Thermocouple (2) Harness - ⑩	Thermocouple (2) Harness ⑩	None	Thermocouple Harness ⑤	None	Thermocouple Harness ④
Engine Torque Pressure	Torquemeter ④	Torquemeter ④	Torquemeter (2) ⑧	Torquemeter (2) ⑧	Torquemeter (2) ⑧	Torquemeter ④	Torquemeter (2) ⑧	Torquemeter ④
Oil Temperature	Temperature Bulb ④	Temperature Bulb ④	Temperature Bulb (2) ⑧	Temperature Bulb (2) ⑧	Temperature Bulb (2) ⑧	Temperature Bulb ④	Temperature Bulb (2) ⑧	Temperature Bulb ④
Oil Pressure	Pressure Transmitter ④	Pressure Transmitter ④	Pressure Transmitter (2) ⑧	Pressure Transmitter (2) ⑧	Pressure Transmitter (2) ⑧	Pressure Transmitter ④	Pressure Transmitter (2) ⑧	Pressure Transmitter ④
Chip Detection	Magnetic Plug ①	Magnetic Plug (2) ②	Magnetic Plug (2) ②	Magnetic Plug (2) ②	None	Magnetic Plug (2) ②	None	Magnetic Plug ①
Oil Level	Float Switch ①	Float Switch ①	None	Float Switch ①	None	None	None	None
Engine Pressure Ratio	None	None	None	None	Pressure Transmitter (2) ⑧	None	None	None
Oil Pressure Low	None	None	None	None	None	Pressure Switch ①	None	Pressure Switch ①
Oil Temperature High	None	None	None	None	Thermo-Switch (2) ②	None	None	None
Engine Barrier Filter	Differential Pressure Switch ①	None	None	None	Differential Pressure Switch (2) ②	Differential Pressure Switch ①	None	Differential Pressure Switch ①
Turbine Inlet Temperature	None	None	None	Thermocouple (2) ⑧	Thermocouple (2) ⑧	None	None	None
Interstate Turbine Temperature	None	None	None	None	None	None	Thermocouple (2) ⑧	None
RPM Low	Switch ①	None	None	None	None	Switch ①	None	Switch ①
	41	40	54	85	84	42	52	36

FUNCTIONAL GROUP 04 TRANSMISSION								
Rotor Speed	Tachometer Generator ⑩	Tachometer Generator ⑩	NA	Tachometer Generator ⑩	Tachometer Generator ⑩	Tachometer Generator ⑩	NA	Tachometer Generator ⑩
Oil Temperature	Temperature Bulb ④	Temperature Bulb ④	NA	Temperature ⑧ Bulb (2)	Temperature ④ Bulb	Temperature ④ Bulb	NA	Temperature ④ Bulb
Oil Pressure	Pressure ④ Transmitter	Pressure ④ Transmitter	NA	Pressure ⑳ Transmitter (5)	Pressure ④ Transmitter	Pressure ④ Transmitter	NA	Pressure ④ Transmitter
Oil Temperature High	Thermo-Switch ①	Thermo-Switch ①	NA	None	Thermo-Switch ①	Thermo-Switch ①	NA	Thermo-Switch ①
Oil Pressure Low	Pressure Switch ①	Pressure Switch ①	NA	None	Pressure Switch ①	Pressure Switch ①	NA	Pressure Switch ①
Chip Detector	Magnetic Plug ①	Magnetic Plug ①	NA	Magnetic ③ Plug (3)	Magnetic Plug ①	Magnetic Plug ①	NA	Magnetic Plug ②
Tail Rotor 90° Gear Box Chip Detector	Magnetic Plug ①	Magnetic Plug ①	NA	NA	Magnetic Plug ①	Magnetic Plug ①	NA	Magnetic Plug ②
Tail Rotor 42° Gear Box Chip Detector	NA	NA	NA	NA	Magnetic Plug ①	Magnetic Plug ①	NA	Magnetic Plug ②
Tail Rotor 42° Gear Box Oil Pressure	NA	NA	NA	NA	Pressure Switch ①	None	NA	None
		22		41	24	23		26
FUNCTIONAL GROUP 05 PROPELLER AND PROPELLER ACCESSORIES								
Propeller Speed	NA	NA	Tachometer ⑳ Generator (2)	NA	NA	NA	Tachometer ⑳ Generator (2)	NA
Auto Feather Armed	NA	NA	Switch ①	NA	NA	NA	None	NA
FUNCTIONAL GROUP 06 HYDRAULIC SYSTEM								
Hydraulic Pressure	NA	None	Pressure ④ Transmitter	Pressure ⑧ Transmitter (2)	Pressure ⑧ Transmitter (2)	None	None	None

Hydraulic Pressure Low	NA	Pressure Switch (1)	None	Pressure Switch (1)	Pressure Switch (3) (3) 11	Pressure Switch (1)	None	Pressure Switch (2) (-)
FUNCTIONAL GROUP 07 PNEUMATIC SYSTEM	NA	NA	None	NA	NA	NA	NA	NA
FUNCTIONAL GROUP 08 INSTRUMENTS								
Heading	Compass System NA	Compass System	Compass System	Compass System	Compass System	None	Compass System	None
Ground Speed/ Drift Angle	None	None	Doppler Radar	None	None	None	None	None
Pitch/Roll	None	None	None	None	None	None	None	None
Vertical Acceleration	None	None	Accelerometer (5)	None	None	None	None	None
Terrain Height	None	None	Radar Altimeter	None	None	None	None	None
Outside Air Temperature	Resistance Bulb (4)	None	Resistance Bulb (4)	None	None	None	None	None
Max Safe Steady State Condition	None	None	None	None	Servo Transducer (8) 8	None	None	None
FUNCTIONAL GROUP 09 ELECTRICAL SYSTEM								
DC Generator Failure	Relay (1)	Relay (1)	Relay (2) (2)	NA	NA	Relay (1)	None	Relay (1)
DC Load	Ammeter (4)	Ammeter (4)	Ammeter (2) (8)	NA	NA	Ammeter (8) (2)	None	Ammeter (2)

[illegible] Inverter "ON"	Manual Switch ①	None	None	NA	NA	None	None	None
Inverter Failure	None	Relay ①	Relay ①	NA	NA	Relay ①	Relay ①	Relay ①
DC Generator Voltage	None	None	Voltmeter ④	NA	NA	Voltmeter ④	None	Voltmeter ④
Excessive Inverter Load	None	None	Relay ①	NA	NA	None	None	None
External Power On	None	None	None	Relay ①	Relay ①	Relay ①	None	Relay ①
Transformer-Rectifier Output Load	NA	NA	NA	Ammeter ④	None	NA	NA	NA
Rectifier Failure	NA	NA	NA	Relay ①	Relay (2) ②	NA	NA	NA
Alternator Output Load	NA	NA	NA	Ammeter ④	None	NA	NA	NA
Alternator Failure	NA	NA	NA	Relay ①	Relay ①	NA	NA	NA
Inverter Voltage	None	None	None	NA	NA	AC Voltmeter ⑫ (3)	None	AC Voltmeter ⑫ (3)
			16		4	27	1	27
FUNCTIONAL GROUP 10 FUEL SYSTEM								
Filter Condition	Differential Pressure Switch ①	Differential Pressure Switch ①	Differential Pressure Switch ①	None	Differential Pressure Switch (2) ②	Differential Pressure Switch ①	Differential Pressure Switch ①	Differential Pressure Switch ①
Fuel Quantity	Fuel Probe (2) ⑩	Fuel Probe ⑤	Fuel Probe (2) ⑩	Fuel Probe (6) ㉚	Fuel Probe (8) ㊵	Fuel Probe (2) ⑩	Fuel Probe (10) ㊿	Fuel Probe (2) ⑩
Fuel Low	Float Switch ①	Float Switch ①	Float Switch ①	Float Switch ①	Probe Switch (4) ④	Probe Switch ①	Float Switch ①	Float Switch ①
Fuel Boost Pump Out	None	Pressure Switch ①	Pressure Switch ①	Pressure Switch ④ (4)	Pressure Switch ④ (4)	Float Switch ② (2)	Pressure Switch ①	Float Switch ② (2)
Fuel Flow	None	None	Flowmeter Transmitter (2) ⑳	None	Flowmeter Transmitter (2) ⑳	None	Flowmeter Transmitter ⑩	None
Engine Fuel Pump Out	None	None	Differential Pressure Switch (2) ②	None	None	Differential Pressure Switch ①	None	Differential Pressure Switch ①
Fuel Temperature	None	None	None	None	Plug stat ② (2)	None	None	None
Fuel Pressure	None	None	Pressure Switch ④ (4)	None	Pressure Switch ③ (3)	Pressure Transmitter ④	Pressure Transmitter ④	Pressure Transmitter ④
Emergency Fuel	None	None	Switch (2) ②	None	None	Switch ①	None	Switch ①
Drop Tanks Fuel Pressure	NA	NA	Switch (2) ②	NA	NA	NA	NA	NA

Fuel Pressure	NA	NA	Switch (2) (2)	NA	NA	NA	NA	NA
	12	8	43	35	75	20	67	20
FUNCTIONAL GROUP 11 **FLIGHT CONTROL SYSTEM**								
Rudder Position	NA	NA	Synchro (12)	NA	NA	NA	None	NA
Elevator Position	NA	NA	Synchro (12)	NA	NA	NA	None	NA
Aileron Position	NA	NA	Synchro (12)	NA	NA	NA	None	NA
Flap Position	NA	NA		NA	NA	NA	None	NA
Cyclic Trim Indicator	None	None	NA	Rheostat (4)	None	None	NA	None
			36					
FUNCTIONAL GROUP 12 **UTILITY SYSTEMS**								
Deicer Generator Load	None	None	Ammeter (4)	None	None	None	None	None
Camera Compartment Temperature	NA	NA	Resistance (4) Bulb	NA	NA	NA	NA	NA
Engine Fire Detection	None	None	Ceramic Temp-(4) erature Sensor	Ceramic Temp-(4) erature Sensor	Ceramic Temp-(4) erature Sensor	Ceramic Temp-(5) erature Sensor	Ceramic Temp-(5) erature Sensor	Ceramic Temp-(5) erature Sensor
Oxygen Pressure	NA	NA	Pressure (4) Transmitter	NA	NA	NA	NA	NA
Oxygen Flow	NA	NA	Flow Switch (1)	NA	NA	NA	NA	NA
Icing Condition	NA	NA	None	None	Differential (2) Pressure Switch (2)	Differential (1) Pressure Switch	None	Differential (1) Pressure Switch
Deicing Electrical Failure or Probe Clogged	None	None	None	None	None	Switch (1)	None	Switch (1)
			17		6	7	5	
FUNCTIONAL GROUP 17 **CARGO AND PERSONNEL HANDLING**								
Cargo Hook Position	NA	NA	NA	Switch (1)	Switch (1)	NA	NA	NA
Cable Length	NA	NA	NA	None	Variable (4) Resistor	NA	NA	NA
Auto Hook Release	NA	NA	NA	None	Switch (1)	NA	NA	NA

					6			
FUNCTIONAL GROUP 18 AUXILIARY POWER UNIT								
Shaft RPM	NA	NA	NA	Tachometer Generator (10)	Tachometer Generator (10)	NA	NA	NA
Exhaust Gas Temperature	NA	NA	NA	Thermocouple (4)	Thermocouple (4)	NA	NA	NA
Oil Pressure Low	NA	NA	NA	Pressure Switch (1)	None	NA	NA	NA
EGT High	NA	NA	NA	None	Thermo-Switch (1)	NA	NA	NA
					15			
FUNCTIONAL GROUP 19 AVIONICS EQUIPMENT								
IFF Failure	None	Switch (1)	None	None	None	Switch (1)	None	Switch (1)
FUNCTIONAL GROUP 30 ARMAMENT SYSTEMS								
XM27 E1 Gun Not Cleared	Switch (1)	NA	NA	NA	NA	NA	NA	NA
XM27E1-Armed	NA	NA	NA	NA	NA	NA	NA	Switch (5)
XM27E1--Ammo Low	NA	NA	NA	NA	NA	NA	NA	Switch ( )
	$E_e = 53$ $E_s = 33$	$E_e = 48$ $E_s = 30$	$E_e = 118$ $E_s = 88$	$E_e = 120$ $E_s = 87$	$E_e = 159$ $E_s = 76$	$E_e = 53$ $E_s = 59$	$E_e = 119$ $E_s = 23$	$E_e = 56$ E_s 65

TABLE 2.3-4 UTTAS AIRCRAFT CONFIGURATION (Sheet 1 of 7)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 01							
AIRFRAME							
Forward Fuselage		1					
Tail Boom		1					
Crew Door		2					
Cargo Door		2					
FUNCTIONAL GROUP 02							
ALIGHTING GEAR							
Nose Gear		1					
• Steering Mechanism		1	Position		Indicator		
• Wheel/Tire		1					
		1					
Main Gear		2					
• Brakes		2					
• Wheel/Tire		2					
Tail Skid		1	Position	Switch (1)	Caution Light		
• Actuator		1					
• Motor		1					
Parking Brake		1	Position	Switch (1)	Caution Light		
FUNCTIONAL GROUP 03							
ENGINE							
Basic Engine		2	Power Turbine Rotor Speed	Tachometer Generator (20)	Indicator		
1. Compressor & Air Induction Assembly		2					
2. Combustion Assembly		2	Gas Producer Rotor Speed	Tachometer Generator (20)	Indicator		
3. Turbine & Exhaust Assembly		2					

TABLE 2.3-4 UTTAS AIRCRAFT CONFIGURATION (Sheet 2 of 7)

SYSTEM/LRU/COMPONENT	FSN or PART NO	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
Basic Engine (Continued)							
4. Gas Generator Shaft		2					
5. Power Shaft & Output Shaft/Gear Reduction Assembly		2					
Engine Electrical System		2					
1. EGT Harness Assembly		2	Exhaust GAS Temperature	Thermocouple (8)	Indicator		
2. Ignition Assembly		2					
3. Starter-Generator		2					
4. Tach. Generator		2		(8)			
Engine Oil System		2	Oil Pressure	Pressure Transmitter	Indicator		
1. Oil Cooler Assembly		2	Oil Temperature	Resistance Bulb (8)	Indicator		
2. Main Pressure Pump Assembly		2	Oil Filter about to be bypassed	Differential Pressure Switch (2)	Caution Light		
3. Oil Filter & Bypass Valve Assembly		2	Chips Detection	Magnetic Plug (2)	Caution Light		
Fuel System		2	Fuel Quantity (Lbs)	Fuel Probe (20)	Indicator		
1. Eng. Fuel Control		2	Fuel Flow Rate	Flowmeter (20)	Indicator		
2. Eng. Driven Fuel Pump		2					
3. Boost Pump		2					
4. Fuel Quantity Probe		2	Fuel Filter about to be bypassed	Differential Pressure Switch (2)	Caution Light		
5. Fuel Flow Transmitter		2					
6. Fuel Tank		2					
7. Fuel Filter		2					
Anti-Ice System							
Engine Torquemeter System							
Auxiliary Power Unit (APU) System							

TABLE 2.3-4 UTTAS AIRCRAFT CONFIGURATION (Sheet 3 of 7)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
Tail Rotor 90° Gear Box		1	Oil Level Chip Detection	Sight Gage Magnetic Plug (1)	Caution Light		
<u>FUNCTIONAL GROUP 06</u> <u>HYDRAULIC SYSTEM</u>							
Reservoir		2	Hydraulic Pressure	Pressure Transmitter (8)	Indicator		
Pump		2	System Stage Pressure Low	Pressure Switch (2)	Caution Light		
Cyclic Power Cylinder		2					
Collective Power Cylinder		2					
Directional Power Cylinder		2					
Hoist Pump		1					
Cable Release System		1					
Hoist Control		1					
<u>FUNCTIONAL GROUP 08</u> <u>INSTRUMENTS</u>							
<u>Indicators</u>							
• Airspeed		2	Indicated Airspeed	Pilot-Static System	Indicator		
• Turn and Slip		2	Turn and Slip	Self Contained	Indicator		
• Rate of Climb		2	Vertical Velocity	Pilot-Static System	Indicator		
• Altimeter		2	Pressure Altitude	Pilot-Static System	Indicator		
• Attitude		2	Attitude	Vertical Gyro	Indicator		
• Head's Up Display		1	Aircraft Position	AFCS	Indicator		
• Terrian Height		2	Terrain Height	Radar Altimeter	Indicator		
• Moving Map Display		1					

TABLE 2.3-4 UTTAS AIRCRAFT CONFIGURATION (Sheet 4 of 7)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C OR ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 09							
ELECTRICAL SYSTEM							
Main AC Generator		1	DC Voltage	Shunt (4)	Voltmeter Ammeter		
			DC Load	Shunt (4)			
			Generator Failure	Relay (1)	Caution Light		
Standby Generator		1					
Inverter		2	Voltage	Shunt (4)	Voltmeter (AL)		
			Inverter Failure	Relay (2)	Caution Light		
FUNCTIONAL GROUP 10							
FUEL SYSTEM							
Fuel Control & Overspeed Governor		1					
Fuel Housing		2					
Boost Pump		2	Pressure Low	Pressure Switch (2)	Caution Light		
Engine Driven Fuel Pump		2					
Fuel Filter		2					
Tank		2	Fuel Quantity	Fuel Probe (20)	Indicator		
			Fuel Low	Float Switch (1)	Caution Light		
FUNCTIONAL GROUP 11							
FLIGHT CONTROL SYSTEM							
Collective Pitch Control		2	Position for AFCS	Not Applicable	Indicator		
Cyclic Control		2	Position for AFCS		Indicator		
Directional Control		2	Position for AFCS		Indicator		
Synchronized Elevator		1	Position for AFCS		Indicator		

TABLE 2.3-4 UTTAS AIRCRAFT CONFIGURATION (Sheet 5 of 7)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C OR ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 09							
ELECTRICAL SYSTEM							
Main AC Generator		2	DC Voltage DC Load Generator Failure	Shunt (4) Shunt (4) Relay (1)	Voltmeter Ammeter Caution Light		
Standby Generator		1					
Inverter		2	Voltage Inverter Failure	Shunt (4) Relay (2)	Voltmeter (AL) Caution Light		
FUNCTIONAL GROUP 10							
FUEL SYSTEM							
Fuel Control & Overspeed Governor		1					
Fuel Hose		[illegible]					
Boost Pump		2	Pressure Low	Pressure Switch (2)	Caution Light		
Engine Driven Fuel Pump		2					
Fuel Filter		2					
Tank		2	Fuel Quantity Fuel Low	Fuel Probe (20) Float Switch (1)	Indicator Caution Light		
FUNCTIONAL GROUP 11							
FLIGHT CONTROL SYSTEM							
Collective Pitch Control		2	Position for AFCS	Not Applicable	Indicator		
Cyclic Control		2	Position for AFLS		Indicator		
Directional Control		2	Position for AFCS		Indicator		
Synchronized Elevator		1	Position for AFCS		Indicator		

TABLE 2.3-4 UTTAS AIRCRAFT CONFIGURATION (Sheet 6 of 7)

SYSTEM/LRU/COMPONENT	FSN or PART NO	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 12							
UTILITY SYSTEMS							
Heating System		1					
Defogging System		1					
Ventilation System		1					
Anti-Icing System		2	Icing Condition	Differential Pressure Switch (2)	Caution Light		
Static Electricity Dissapater System		1					
Cargo Hook System		1	Hook Position Cable Length	Switch (1) Rheostat (4)	Caution Light Indicator		
FUNCTIONAL GROUP 16							
AUXILIARY POWER UNIT							
Gas Turbine		1	RPM of Turbine	Tachometer Generator (10)	Indicator		
• Fuel Control		1	EGT High	Thermoswitch (1)	Caution Light		
• Boost Pump		1	Oil Pressure Low	Pressure Switch (1)	Caution Light		
• Hydraulic Pump Motor		1					
FUNCTIONAL GROUP 19							
AVIONICS EQUIPMENT							
Avionics							
Low Level TAC NAV System		1					
ADF-Low Frequency		1					
VHF-FM Homing		1					
TAC. Approach Sys/DM Capability		1					
Dead Reckoning Capability		1					
VOR/LOC,GS, and MB Capability		1					
VHF-AM		1					

TABLE 2.3-4 UTTAS AIRCRAFT CONFIGURATION (Sheet 7 of 7)

SYSTEM/LRU/COMPONENT	FSN OR PART NO	QTY PER A/C OR ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
Avionics (Continued)							
UHF-AM		1					
VHF-FM		2					
MF-HF/SSB		1					
Interphone System		1					
Fixed Format Message Entry Device/TACFIRE System		1					
IFF/SIF System		1					
Voice Warning/Recorder System		1					
FUNCTIONAL GROUP 30							
ARMAMENT							
7.62 MM Machine Gun System		2	Power on Armed Ammo Low	Switch (2) Switch (1) Switch (1)	Caution Light Caution Light Caution Light		

$E_e = 131$ $E_s = 73$

TABLE 2.3-5 HLH AIRCRAFT CONFIGURATION (SINGLE MAIN ROTOR SYSTEM) (Sheet 1 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 01							
AIRFRAME							
F 'elage/Equipment Assembly		1					
Cc.kpit Assembly		1					
Aircraft Structure Assembly		1					
FUNCTIONAL GROUP 02							
LANDING GEAR AND RELATED SYSTEMS							
Nose Gear Assembly		1					
Main Gear Assembly		1					
Parking Brake Assembly		1	Position-ON	Switch (1)	Caution Light		
Power Steering Unit		1	Turning Limits	Switch (1)	Caution Light		
FUNCTIONAL GROUP 03							
ENGINE GROUP							
Basic Engine		3					
Compressor/Air Induction Assembly		3					
Combustion Assembly		3	Gas Producer Turbine Speed	Tachometer (30)	Indicator		
Turbine/Exhaust Assembly		3					
Gas Generator Shaft		3	Power Turbine Speed	Tachometer (30)	Indicator		
Power Shaft/Output Shaft-Gear Reduction Assembly		3	Engine Torque	Torquemeter (15)	Indicator		
'gine Electrical System							
E'haust gas Temperature Harness		3	Exhaust gas Temperature	Thermocouple (12)	Indicator		
Ignition Assembly		3					
Starter-Generator		3					
Tachometer Generator		3					
Engine Oil System							
Oil Cooler Assembly/Bypass		3	Oil Pressure	Pressure Transmitter (12)	Indicator		

TABLE 2.3-5 HLH AIRCRAFT CONFIGURATION (SINGLE MAIN ROTOR SYSTEM) (Sheet 2 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
<u>Engine Oil System</u> (Contd.)							
Main Pressure Pump Assembly		3	Oil Temperature	Temp. Switch (3)	Caution Light		
Oil Filter & Bypass Valve Assembly		3	Chip Detection Filter blockage	Magnetic Plug (3) Pressure Switch (3)	Caution Light Caution Light		
<u>Engine Fuel System</u>							
Fuel Control		3					
Engine Driven Fuel Pump		3					
Anti Ice System		3	Icing Condition	Switch (3)	Caution Light		
Engine Air Particle Separator		3	Particle Contamination Inlet Pressure	Switch (3)	Caution Light		
<u>FUNCTIONAL GROUP 04</u>							
<u>MAIN ROTOR & TAIL ROTOR</u>		1	Rotor RPM	Tachometer Generator (10)	Indicator		
Main Rotor Head Assembly		1					
Main Rotor Blade Assembly		6					
Blade Deicing Assembly		6					
Hub Assembly		1					
Swashplate Assembly		1					
Control Rod		6					
Tail Rotor Head Assembly		1					
Tail Blade Assembly		4					
<u>FUNCTIONAL GROUP 06</u>							
<u>HYDRAULIC SYSTEM</u>		2					
AFCS Servo Assembly		2					
Main Rotor Servo Assembly		2					
Tail Rotor Servo Assembly		2					
Utility Hydraulic System		2					
Load Leveller Hydraulic		2					
Cable Release System		2					
Lock/Sequence Valve		2					
Hoist System							
Pump		2	Hydraulic Pressure	Pressure Transmitter (8)	Indicator		
Reservoir		2	Pressure Low	Pressure Switch (2)	Caution Light		

TABLE 2.3-5 HLH AIRCRAFT CONFIGURATION (SINGLE MAIN ROTOR SYSTEM) (Sheet 3 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 07							
TRANSMISSION AND RELATED SYSTEMS							
Main Engine Transmission Assembly		3	Chip Detector	Magnetic Plug (3)	Caution Light		
Main Transmission Lubrication		3					
Oil Pump Assembly		3	Oil Temperature	Temperature Bulb (12)	Indicator		
Oil Filter		3					
Oil Cooler Bypass Assembly		3	Oil Cooler Bypass	Pressure Switch (3)	Caution Light		
Rotor Brake Assembly		3					
Tail Rotor Drive Shaft		3	Chip Detector	Magnetic Plug (3)	Caution Light		
Combining Transmission Assembly		1	Oil Pressure	Pressure Switch (1)	Caution Light		
Oil Pump		1					
Tail Rotor Gear Box		1	Chip Detector	Magnetic Plug (1)	Caution Light		
Pylon Drive Shaft Assembly		1					
FUNCTIONAL GROUP 06							
INSTRUMENTS							
Airspeed		2	Indicated Airspeed	Pilot-static System	Indicator		
Gyro-Horizon		2	Attitude	Vertical Gyro	Indicator		
Rate of Climb		2	Vertical Velocity	Pilot-Static System	Indicator		
Altimeter		2	Pressure Altitude	Pilot-Static System	Indicator		
Hoist Cable Length		1	Cable Length	Rheostat (4)	Indicator		
Radio Magnetic Ind.		2	ADF and VOR	Receivers	Indicator		
Twin Bank Indicator		1					
Hoist Hyd. Temperature		1	Hydraulic Temperature	Resistance Bulb (8)	Indicator		
Clock		2	Time	Mechanical Clock			
Radio Altimeter		2	Terrain Height	Radar Antenna	Indicator		

TABLE 2.3-5 HLH AIRCRAFT CONFIGURATION (SINGLE MAIN ROTOR SYSTEM) (Sheet 4 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 09							
ELECTRICAL SYSTEM							
Battery		1					
Flood Light Assembly		1					
Anti-Collision Light		2					
Navigational Light		3					
Electrical System			Generator Failure	Relay (1)	Caution Light		
Main DC Generator		[illegible]	DC Load	Shunt (4)	Ammeter		
Standby Generator		1	DC Voltage	Shunt (4)	Voltmeter		
AC Inverter		2	Inverter Failure	Relay (2)	Caution Light		
			Inverter Load	Shunt (8)	Ammeter		
FUNCTIONAL GROUP 11							
FLIGHT CONTROL SYSTEM							
Control Stick Assembly		3	Stick Position	Mechanical Linkage	Indicator		
Collective Stick Assembly		3					
Syncho Assembly		2					
Directional Control Actuators		4					
Pylon Control Assembly		1					
FUNCTIONAL GROUP 12							
UTILITY SYSTEMS							
Heating Duct Defroster System Blower Assembly		2					
Cockpit Heater/Fuelline Heater Assembly		2					
Ignition Unit Assembly		2					
Fire Detector System		4	Fire Hazard	Sensing Element (4)	Light		

TABLE 2.3-5 HLH AIRCRAFT CONFIGURATION (SINGLE MAIN ROTOR SYSTEM) (Sheet 5 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 17							
CARGO AND PERSONNEL HANDLING							
Cargo Hoist Assembly		1	Cable Length	Variable Resistor	Indicator		
Decoupler, Spring Device		1	Cable Tension	Strain Gage (4)	Indicator		
Hook, Cargo Assembly		1					
Motor, Hydraulic		1					
Gear Box Assembly, Cargo		1					
Tow Installation Assembly		1	Cable Length	Resistor	Indicator		
Cargo Pod Lifting Assembly		1	Cable Tension	Strain Gage	Indicator		
FUNCTIONAL GROUP 18							
APP							
Gas Turbine		1	EGT	Thermocouple (4)	Indicator		
FUNCTIONAL GROUP 19							
AVIONICS							
Interphone System		1					
UHF Radio		1					
VHF Radio		1					
Emergency VHF Radio		1					
Liaison Radio		1					
Direction Finder		1					
Automatic Flight Control		1					
Direction Finder		1					

$E_e = 114$ $E_s = 108$

TABLE 2.3-6 HLH AIRCRAFT CONFIGURATION (TANDEM ROTOR SYSTEM) (Sheet 1 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 01							
AIRFRAME							
Fuselage/Equipment Assembly		1					
Cockpit Assembly		1					
Aircraft Structure Assembly		1					
FUNCTIONAL GROUP 02							
LANDING GEAR AND RELATED SYSTEMS							
Nose Gear Assembly		1					
Main Gear Assembly		1					
Parking Brake Assembly		1	Position-ON	Switch (1)	Caution Light		
Power Steering Unit		1	Turning Limits	Switch (1)	Caution Light		
FUNCTIONAL GROUP 03							
ENGINE GROUP							
Basic Engine		3					
Compressor/Air Induction Assembly		3					
Combustion Assembly		3	Gas Producer Turbine Speed	Tachometer (30)	Indicator		
Turbine/Exhaust Assembly		3					
Gas Generator Shaft		3	Power Turbine Speed	Tachometer (30)	Indicator		
Power Shaft/Output Shaft-Gear Reduction Assembly		3	Engine Torque	Torquemeter (15)	Indicator		
Engine Electrical System							
Exhaust gas Temperature Harness		3	Exhaust gas Temperature	Thermocouple (15)	Indicator		
Ignition Assembly		3					
Starter-Generator		3					
Tachometer Generator		3					
Engine Oil System							
Oil Cooler Assembly/Bypass		3	Oil Pressure	Pressure Transmitter (12)	Indicator		

TABLE 2.3-6 HLH AIRCRAFT CONFIGURATION (TANDEM ROTOR SYSTEM) (Sheet 2 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C OR ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
Engine Oil System (Contd.)							
Main Pressure Pump Assembly		3	Oil Temperature	Temp. Switch (3)	Caution Light		
Oil Filter & Bypass Valve Assembly		3	Chip Detection Filter blockage	Magnetic Plug (3) Pressure Switch (3)	Caution Light Caution Light		
Engine Fuel System							
Fuel Control		3					
Engine Driven Fuel Pump		3					
Anti Ice System		3	Icing Condition	Switch (3)	Caution Light		
Engine Air Particle Separator		3	Particle Contamination Inlet Pressure	Switch (3)	Caution Light		
FUNCTIONAL GROUP 04							
ROTOR AND TRANSMISSION SYSTEMS							
Forward Main Rotor		1	Rotor Speed	Tachometer Generator (10)	Indicator		
Aft Main Rotor		1					
Engine Transmission		3					
Oil Pump		3					
Filter		3	Chip Detection	Magnetic Plug (3)	Caution Light		
Shaft		3	Oil Pressure	Pressure Transmitter (12)	Indicator		
Combining Transmission		1	Oil Level	Sight Gage			
Pump		1	Oil Temperature	Resistance Bulb (4)	Indicator		
Filter		1	Chip Detection	Magnetic Plug (1)	Caution Light		
Brake		1	Oil Pressure	Pressure Transmitter (4)	Indicator		
Forward Transmission		1	Oil Level	Sight Gage			
Lube Oil Pump		1	Oil Temperature	Resistance Bulb (4)	Indicator		
Filter		1	Chip Detection	Magnetic Plug (1)	Caution Light		
			Oil Pressure	Pressure Transmitter (4)	Indicator		
Aft Transmission		1	Oil Level	Sight Gage			
Lube Oil Pump		1	Oil Temperature	Resistance Bulb (4)	Indicator		
Filter		1	Chip Detection	Magnetic Plug (1)	Caution Light		
		3	Oil Pressure	Pressure Transmitter (12)	Indicator		

TABLE 2.3-6 HLH AIRCRAFT CONFIGURATION (TANDEM ROTOR SYSTEM) (Sheet 3 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
<u>FUNCTIONAL GROUP 06</u>							
<u>HYDRAULIC SYSTEM</u>		2					
AFCS Servo Assembly		2					
Main Rotor Servo Assembly		2					
Tail Rotor Servo Assembly		2					
Utility Hydraulic System		2					
Load Leveller Hydraulic		2					
Cable Release System		2					
Lock/Sequence Valve		2					
Hoist System		2	Hydraulic Pressure	Pressure Transmitter (8)	Indicator		
Pump		2	Pressure Low	Pressure Switch (2)	Caution Light		
Reservoir		.					
<u>FUNCTIONAL GROUP 08</u>							
<u>INSTRUMENTS</u>							
Airspeed		2	Indicated Airspeed	Pilot-static System	Indicator		
Gyro-Horizon		2	Attitude	Vertical Gyro (24)	Indicator		
Rate of Climb		2	Vertical Velocity	Pilot-Static System	Indicator		
Altimeter		2	Pressure Altitude	Pilot-Static System	Indicator		
Hoist Cable Length		1	Cable Length	Rheostat	Indicator		
Radio Magnetic Ind.		2	ADF and VOR	Receivers	Indicator		
Twin Bank Indicator		1					
Hoist Hyd. Temperature		1	Hydraulic Temperature	Resistance Bulb (8)	Indicator		
Clock		2	Time	Mechanical Clock			
Radio Altimeter		2	Terrain Height	Radar Antenna	Indicator		
<u>FUNCTIONAL GROUP 09</u>							
<u>ELECTRICAL SYSTEM</u>							
Battery		1					
Flood Light Assembly		1					
Anti-Collision Light		2					
Navigational Light		3					
Electrical System			Generator Failure	Relay (1)	Caution Light		
Main DC Generator		1	DC Load	Shunt (4)	Ammeter		
Standby Generator		1	DC Voltage	Shunt (4)	Voltmeter		

TABLE 2.3-6 HLH AIRCRAFT CONFIGURATION (TANDEM ROTOR SYSTEM) (Sheet 4 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO	QTY PER A/C OR ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
ELECTRICAL SYSTEM (Continued)							
AC Inverter		2	Inverter Failure Inverter Load	Relay (1) Shunt (8)	Caution Light Ammeter		
<u>FUNCTIONAL GROUP 11</u>							
<u>FLIGHT CONTROL SYSTEM</u>							
Control Stick Assembly		3	Stick Position	Mechanical Linkage	Indicator		
Collective Stick Assembly		[illegible]					
Syncho Assembly		2					
Directional Control Actuators		4					
Pylon Control Assembly		1					
<u>FUNCTIONAL GROUP 12</u>							
<u>UTILITY SYSTEMS</u>							
Heating Duct Defroster System Blower Assembly		2					
Cockpit Heater/Fuel Line Heater Assembly		2					
Ignition Unit Assembly		2					
Fire Detector System		4	Fire Hazard	Sensing Element (4)	Light		
<u>FUNCTIONAL GROUP 13</u>							
<u>CARGO AND PERSONNEL HANDLING</u>							
Cargo Hoist Assembly		1	Cable Length Cable Tension	Variable Resistor (4) Strain Gage (6)	Indicator Indicator		
Decoupler, Sprin, Device		1					
Hook, Cargo Assembly		1					
Motor, Hydraulic		1					
Gear Box Assembly, Cargo		1					
Tow Installation Assembly		1	Cable Length Cable Tension	Resistor (4) Strain Gage (6)	Indicator Indicator		
Cargo Pod Lifting Assembly		1					

TABLE 2.3-6 HLH AIRCRAFT CONFIGURATION (TANDEM ROTOR SYSTEM) (Sheet 5 of 5)

SYSTEM/LRU/COMPONENT	FSN or PART NO.	QTY PER A/C or ASSY	ACTIVITY MONITORED	SENSOR SIGNAL DEVICE	OUTPUT DISPLAY	AIDAPS SUITABILITY	COMMENT
FUNCTIONAL GROUP 18							
APP							
Gas Turbine		1	EGT	Thermocouple (4)	Indicator		
FUNCTIONAL GROUP 19							
AVIONICS							
Interphone System		1					
UHF Radio		1					
VHF Radio		1					
Emergency VHF Radio		1					
Liaison Radio		1					
Direction Finder		1					
Automatic Flight Control		1					
Direction Finder		1					

E_c = 117 E_s = 130

and type of sensors which must be added to each aircraft. The UH-1 was used to develop a hypothetical list of additional sensors as a guide to providing "multiplying factors," whereby the listing of the existing sensors in each type of aircraft can be extrapolated to an assumed AIDAPS complement. The assumption is that the sensors which are added and conditioned for AIDAPS purposes will be approximately the same type and the same ratio as those added to the UH-1.

The use of the WSC aids in this extrapolation since it allows a generalized approach without loss of the sense of magnitude. Because there are different ratios for the engines and the balance of the aircraft subsystems, the ratios were determined separately in the following manner.

a) The WSC was compiled for the existing instrumentation on the engine of the UH-1; i.e., E_e equals 53 (WSC). The WSC was compiled for the existing instrumentation on the balance of the subsystems of the UH-1; i.e., E_s equals 59 (WSC).

b) The WSC was compiled for the engine instrumentation which was assumed to be added. (Given in Table 2.3-7; i.e., 61 (WSC).

c) The WSC was compiled for the instrumentation of the other subsystems assumed to be added; i.e., 57 (WSC).

The aircraft multiplying factor for the engines is 61/53 and for the other subsystems, 57/59. The computational expression becomes:

$$\text{WSC (for AIDAPS} = E_e \times 61/53 + E_e + E_s \times 57/59 + E_s$$

where E_e = WSC of existing engine sensors

and E_s = WSC of existing subsystem sensors.

$E_e = 53$ and $E_s = 59$ for the UH-1.

To illustrate:

Substituting $53 \times 61/53 + 53 + 59 \times 57/59 + 59 = 230$ (WSC)

Computations for all the aircraft are given in Table 2.3-8.

TABLE 2.3-7 SENSORS ASSUMED TO BE ADDED TO UH-1 FOR AIDAPS

Parameter	Type of Signal: Discrete	Type of Signal: Analog	Engine Parameter	WSC
Bleed Air	X		X	1
Vibration (3 Accelerometers)		X	X	3x5
Compressor Pressure Ratio		X	X	4
Outside Air Temperature		X	X	4
Ambient Pressure		X	X	4
Fuel Pressure		X	X	4
Collective Pitch		X	X	4
Differential Pressure Across Oil Filter	X		X	1
Thermal Bypass		X	X	4
Oil Temperature (in Cooler)		X	X	4
Oil Temperature (out Cooler)		X	X	4
#2 Bearing Scavenge Temperature		X	X	4
#3 and #4 Bearing Scavenge Temperature		X	X	4
Torquemeter Boost Pump		X	X	4
				61 E_e Total
Differential Pressure Across Transmission Oil Filter	X			1
Transmission Thermal Bypass				4
Transmission Vibration (Lateral)		X		5
Transmission Vibration (Verticle)		X		5
Transmission Oil Temperature (in Cooler)		X		5
90° Gearbox Vibration		X		5
90° Gearbox Outside Temperature		X		4
42° Gearbox Outside Temperature		X		4
Hydraulic Pressure Relief Valve	X			1
Hydraulic Temperature		X		4
Aircraft Acceleration (Lateral)		X		5
Aircraft Acceleration (Longitudinal)		X		5
Aircraft Acceleration (Verticle)		X		5
Pitot Heater Current		X		4
				57 E_s Total

TABLE 2.3-8 COMPUTING FOR EACH AIRCRAFT TYPE

OH-6, E_e = 53; E_s = 33; WSC = 53 x 61/53 + 53 + 33 x 57/59 + 33 = 179

OH-58, E_e = 48; E_s = 30; WSC = 48 x 61/53 + 48 + 30 x 57/59 + 30 = 163

OV-1, E_e = 118, E_s = 88; WSC = 118 x 61/53 + 118 + 88 x 57/59 + 88 = 427

CH-47, E_e = 120; E_s = 87; WSC = 120 x 61/53 + 120 + 87 x 57/59 + 87 = 429

CH-54, E_e = 159; E_s = 76; WSC = 159 x 61/53 + 159 + 76 x 57/59 + 76 = 490

UH-1, E_e = 53; E_s = 59; WSC = 112 + 118 = 230

U-21, E_e = 119; E_s = 29; WSC = 119 x 61/53 + 119 + 29 x 57/59 + 29 = 313

AH-1, E_e = 56; E_s = 65; WSC = 56 x 61/53 + 56 + 65 x 57/59 + 65 = 240

UTTAS, E_e = 121; E_s = 73; WSC = 131 x 61/53 + 131 + 73 x 57/59 + 73 = 424

HLH (Twin), E_e = 117, E_s = 130; WSC = 117 x 61/53 + 117 + 130 x 57/59 + 130 = 509

In Table 2.3-9 the aircraft are arranged in terms of increasing WSC. The possibility of meaningful groupings becomes evident. The simple, medium, and complex "levels of technology" of section 2.1 are illustrated. These levels of sophistication will be used exclusively to determine the "sensing" function complexity and as guidelines for the aircraft group selection in addition to other factors.

TABLE 2.3-9 ARRANGING IN ORDER OF INCREASING WSC

Aircraft Designation	WSC	
		0 ↓
OH-58	163	Simple
OH-6	179	↓ 200
UH-1	230	Medium
AH-1	240	
U-21	313	400
UTTAS	424	Complex
OV-1	427	
CH-47	429	
CH-54	490	
HLH - Twin	509	↓

2.3.4 Aircraft Mission Comparison

A consideration in determining aircraft commonality as related to AIDAPS is the mission of the aircraft. This will influence how much ground equipment as opposed to airborne equipment will be used. For example, if some onboard and some ground processing is employed, the required recorder storage capacity is related to the maximum amount of time an aircraft remains away from its base of operation without a change of the tape cartridge. A summary of the primary missions of each of the 10 study aircraft follows.

a) OH-6 - The primary missions of the Cayuse are command and control (C&C), observation, reconnaissance, and target acquisition.

b) OH-58 - The Kiowa is employed primarily for visual observation, reconnaissance, and target acquisition. The OH-58 and OH-6 are both members of the LOH family.

c) OV-1 - The Mohawk is principally concerned with Combat (C) and Combat Support (CS) missions in support of G-2 functions including observation surveillance, artillery spotting, emergency resupply, and radiological and IR monitoring.

d) CH-47 - The primary mission of the Chinook is combat support (CS) and combat service support (CSS), consisting of the transport of cargo, troops, and equipment within the combat area.

e) CH-54 - The mission of the Tarhe is similar to that of the Chinook. Its primary purpose is combat support and combat service support examples of which are transport of personnel and cargo, carrying externally slung loads, and in some cases towing ground vehicles.

f) UH-1 - The Huey has served in a variety of combat, command and control, and conduct service support missions including transportation of personnel, special teams, equipment and supplies, medical evacuation and emergency ambulance service within the combat zone.

g) U-21 - The primary mission of the Ute is combat service support within a Theater of Operations and the ConUS. Its principal use is as a utility vehicle for transportation of commanders and their staffs, administration, liaison, and aero-medical evacuation.

h) AH-1 - The Huey Cobra is used primarily as a gun ship for a variety of combat missions, including aerial escort, armed reconnaissance, and security of landing sites.

i) UTTAS - The Utility Tactical Transport Aircraft System is planned as a replacement for the Huey and will assume all the responsibilities and missions previously accomplished by the Huey fleet.

j) HLH - The Heavy Lift Helicopter will be used for combat support and combat service support in a Theater of Operations including transportation of personnel and cargo, and carrying large externally slung loads short distances within the combat zone.

2.3.5 Aircraft Fleet Size Comparison

The total number of aircraft, by type, in the Army inventory is another consideration of commonality. The number of a particular type of aircraft will influence whether or not tailoring a specific AIDAP system for that one aircraft is economically justifiable. It may be advantageous to utilize the same AIDAP system designed for another aircraft even though it has greater capability than required. For example, the UH-1 monitors approximately the same number of parameters and has basically the same mission as the AH-1. Since there are so few of the AH-1, and it is so similar to the UH-1, the AIDAPS will probably be identical. Table 2.3-10 identifies the percentage of each aircraft to the total inventory as projected for FY 71.

TABLE 2.3-10 AIRCRAFT INVENTORY

Aircraft	Percent of Fleet
OH-6	20.1
OH-58	9.3
OV-1	2.3
U-21	1.4
UH-1	53.4
CH-47	5.7
AH-1	6.9
CH-54	0.9

2.3.6 Aircraft Utilization Comparison

The historical utilization rate of a type of aircraft is a good indication of the potential value of AIDAPS to that specific type. A relatively low utilization rate is due to many factors including maintenance. A summary of the target flight hours in 1 month is given for the 8 existing aircraft under study in Table 2.3-11.

2.3.7 Aircraft Maintenance Manhours per Flight Hour (MMH/FH)

Another factor in determining the justifiable cost of an AIDAP system is the MMH/FH for each aircraft type. The higher the MMH/FH, the greater allowable

TABLE 2.3-11 AIRCRAFT UTILIZATION

Aircraft	Monthly Target Flight Hours
OH-6	60
OH-58	60
U-21	75
OV-1	75
UH-1	70
AH-1	70
CH-47	55
CH-54	50

complexity of the AIDAP system. A summary of the maintenance manhours per flight hour for each level of maintenance is given in Table 2.3-12.

TABLE 2.3-12 AIRCRAFT MAINTENANCE MANHOURS/FLIGHT HOURS

Aircraft	Organizational	Direct Support	Ground Support	Depot	Total
OH-6	2.50	1.19	1.04	**	4.73
OH-58	2.50*	1.19*	1.04*	**	4.73*
OV-1	7.14	3.22	1.96	**	12.32
U-21	2.60	2.60	1.99	**	4.59
UH-1	5.80	2.10	1.54	**	9.44
AH-1	5.80*	2.10*	1.54*	**	9.44*
CH-47	13.30	8.12	5.18	**	26.60
CH-54	16.21	13.60	2.98	**	32.79

*Estimated
**To be determined. } Information not available at this time.

To demonstrate the possible impact of some of the data which was accumulated in the previous sections, the following computations were performed for the UH-1C aircraft.

- From Table 2.3-12 the MMH/FH ratio is 9.44.
- From Table 2.3-9 the average number of hours the UH-1C is flown is 70. Therefore the average monthly MMH/UH-1 = 70 x 9.44 = 661.

- If the assumption is made that 1 MMH has a total cost of $10.00, the monthly cost of maintenance = $6,610.00/UH-1.
- A further reasonable assumption is made that the total cost of AIDAPS is $15,000.00/UH-1 (including cost of airborne hardware and retrofit and prorated costs of ground equipment, training, manuals, spares, etc.).
- If the cost of AIDAPS/UH-1 is amortized over a 10-year period, the cost per month is $15,000/120 = $125.00.
- In conclusion, if the AIDAPS is to "pay for itself," it must reduce the MMH by 125/6,610 x 100 = 2%, as an absolute minimum.

2.3.8 Fixed Wing Versus Rotary Wing

The selection of the parameters to be monitored will be different for rotary wing and fixed wing aircraft. There are subsystems in each group that do not exist in the other, such as transmissions and gear boxes in the rotary wing and propellers for the fixed wing. It is anticipated that the differences will affect the AIDAP System.

The major impact on system selection is airborne versus ground based. As an example, using a ground-based system with an umbilical cable, significant data can be obtained from a helicopter in a hover mode (or light-on-the-skids) since these modes require high power settings. With a fixed-wing aircraft in a ground engine run-up mode (brakes locked, wheels chocked), less significant data would be acquired. Therefore, the rotary-wing aircraft may lend themselves more practically to a ground-based system than the fixed-wing aircraft.

For example, small, low-cost helicopters such as the OH-6 and OH-58 may be possible candidates for a complete ground-based system, whereas the two fixed-wing aircraft under study, OV-1 and U-21 possibly would not.

2.3.9 Number of Engines per Aircraft

A two-engine aircraft which is capable of operating at a reduced performance in the event of an engine failure has a built-in safety featyre. Therefore, any onboard analysis to predict engine failure necessary for flight safety may be more sophisticated on single-engine aircraft than twin-engine vehicles. The number of engines in each of the 10 aircraft is shown in Table 2.3-13.

TABLE 2.3-13 NUMBER OF ENGINES PER AIRCRAFT

Aircraft	Number of Engines
OH-6	1
OH-58	1
OV-1	2
U-21	2
UH-1	1
AH-1	1
CH-47	2
CH-54	2
UTTAS	2
HLH	Multiple

2.3.10 Number of Flight Crew Members

The number of members of the flight crew will have an affect on the amount and type of onboard display. In an aircraft such as the OH-6, the pilot is concerned primarily in flying the aircraft and will not be able to use a visual display. An aircraft with two pilots may use limited visual display. The addition of a third crew member may warrant a more sophisticated onboard visual display to enhance flight safety. An audible warning system is more desirable for a single-pilot aircraft than for a multicrew aircraft. Table 2.3-14 shows the typical number of flight crew members for each aircraft.

TABLE 2.3-14 NUMBER OF FLIGHT CREW PER AIRCRAFT

Aircraft	Number of Crew Members
OH-6	1
OH-58	1
OV-1	2
U-21	2
UH-1	2
AH-1	2
CH-47	3
CH-54	3
UTTAS	3
HLH	4

2.3.11 Attrition Rate Comparison

The attrition rate which AIDAPS can influence is a consideration for the amount of airborne equipment installed to effect in-flight safety. The higher the attrition rate, the greater the allowable AIDAPS airborne analysis sophistication. An aircraft with a very low attrition rate need have little or no airborne analysis for flight safety purposes. Table 2.3-15 outlines the attrition factors for each of the eight existing aircraft.

TABLE 2.3-15 ATTRITION FACTOR

Aircraft	Peace Time	War Time
OH-6	0.0041	0.0280
OH-58	0.0041*	0.0280*
OV-1	0.0032	0.0219
U-21	0.0009	0.0026
UH-1	0.0030	0.01870
AH-1	0.0030	0.0083
CH-47	0.0005	0.0083
CH-54	0.0005	0.0213

*Estimated

2.3.12 Summary

The material presented in the preceding paragraphs of section 2.3 has two purposes. First, it is presented to aid in the grouping of aircraft based on their similarities, and secondly, to aid in the selection of the most practical systems related to each aircraft group for Phase C tradeoff analysis. The information related to each of the 10 Army aircraft under study has been summarized in Table 2.3-16.

2.3.12.1 Aircraft Group Selection

By comparing the significant features, outlined in Table 2.3-16, consisting of weight, cost parameters, missions, number of aircraft, utilization, MMH/FH, fixed wing versus rotary wing, number of engines, number of crew members, and accident rate, aircraft groups have been defined. The aircraft have been listed left to right in order of increasing AIDAPS complexity. The 11 factors considered in arriving at this rank ordering of aircraft types are

TABLE 2.3-16 AIRCRAFT COMPARISON

AIDAPS Considerations	OH-6	OH-58	OV-1	U-21	UH-1	AH-1	CH-47	CH-54	UTTAS	HLH
Weight (pounds)	2,400	2,645	11,715	9,650	6,600	6,600	38,000	42,000	-	-
Cost (dollars)	74,578	81,204	976,457	246,357	255,365	365,254	1,100,000	2,200,000	-	-
Parameters (WSC)	179	163	427	313	230	240	429	490	424	509
Primary Mission	C CC	C CC	CC CS	CSS	C CC	C	CS CSS	CS CSS	C CC	CS CSS
Percent of Aircraft in Inventory	20.1	9.3	2.3	1.4	53.4	5.7	6.9	0.9	-	-
Utilization (hours per month)	60	60	75	75	70	70	55	50	-	-
MMH/FH	4.73	4.73	12.32	4.59	9.44	9.44	26.60	32.79	-	-
Fixed Wing (FW) VS Rotary Wing (RW)	RW	RW	FW	FW	RW	RW	RW	RW	RW	RW
Number of Engines	1	1	2	2	1	1	2	2	2	2+
Number of Flight Crew	1	1	2	2	2	2	3	3	3	4
Attrition Factor*	0.0041	0.0041	0.0032	0.0009	0.0030	0.0030	0.0005	0.0005	-	-

*Peace Time

listed in an assumed decreasing level of importance as related to AIDAPS design from top tc bottom. The major factor in arriving at this breakdown is the parameters to be monitored which are numerically represented by the weighted sensor count (WSC).

The WSC is considered the most significant factor since the parameters monitored have a direct affect on the size and complexity of the AIDAPS. The maintenance manhours per flight hour is the second most significant factor since it is a guide to the amount of maintenance costs AIDAPS potentially can effect. The weight of the aircraft is also of relatively high importance because it is used as an indication of the allowable AIDAPS airborne weight. The cost of the aircraft can be used to limit the cost of AIDAPS based on a possible increase in aircraft availability. The remaining factors do influence the AIDAPS design, but to a lesser extent. From a careful review of Table 2.3-16, distinct groups become evident.

The rationale for selecting the aircraft groups is as follows:

The OH-6 and OH-58 are both members of the LOH family with identical missions. The weight, size, cost and maintenance manhour/flight hours cost are very similar. Although manufactured by different concerns, they have the same basic engine with only a dash number difference. The crew size is the same and WSC is almost identical, therefore the OH-6 and OH-58 will be considered as one aircraft group.

The UH-1 and AH-1 are very similar in most aspects. The weight, cost, maintenance manhours per flight hours, engine type, crew size, attrition factor, and WSC, are so similar that they naturally form a second group.

The U-21 and OV-1 are both fixed wing aircraft which puts them in a class by themselves. However, they may be put in separate groups due to the many differences between them, such as; a medium WSC for the U-21 and complex WSC for the OV-1; the cost of the OV-1 is four times that of the U-21; the maintenance manhours per flight hour is almost three times as high for the OV-1 as it is for the U-21; the U-21 is primarily used as a utility aircraft for transport of staff personnel and/or high priority cargo whereas the OV-1 is a special mission aircraft utilized to gather intelligence information about enemy operations; and the attrition factors are significantly different. Therefore, both the U-21 and OV-1 will form two separate single aircraft groups.

The UTTAS, CH-47, CH-57, and HLH are the largest most complex of the study aircraft. The estimated WSC's for each of these four aircraft is in the complex sensing category; they all have two or more engines, and the crew size is three or more. The CH-47 and CH-54, presently in the army inventory, are very much the same when comparing the maintenance manhours per flight hour; the same approximate design gross weight; both have their primary missions as combat support and combat service support; and have the same peacetime attrition factors. The UTTAS and HLH, both future aircraft, do not have data associated with most of the factors being considered, but are assumed to be similar to the CH-47 and 54. Therefore, they will all be placed in the same group.

Table 2.3-17 presents the five groups of aircraft derived by considering all factors outlined in Table 2.3-16. They are not, by any means, fixed, and may change as a result of the Phase C findings after exercising the detailed tradeoff analysis model.

TABLE 2.3-17 AIRCRAFT GROUPS

Groups	Aircraft Types
1	OH-6 OH-58
2	UH-1 AH-1
3	U-21
4	OV-1
5	UTTAS CH-47 CH-54 HLH

2.3.12.2 AIDAPS/Aircraft Considerations

After a careful review of the results of the individual aircraft analysis as outlined in Table 2.3-16, additional constraints elated directly to aircraft type were developed. These constraints were developed to further distill the number of practical system approaches which must be analyzed in Phase C. The constraints limit the types of systems which are practical for each group of aircraft. The consideration for arriving at these configurations is that a ground-based system is less costly per aircraft than a hybrid, but is less effective. The ground-based version will not monitor the aircraft throughout its complete flight and, therefore, cannot detect intermittent problems that may not be duplicated in hover, and does not allow for improvement in real-time flight safety. Therefore, the ground-based system may be more suited to the smaller vehicles with low procurement and maintenance costs. The hybrid system may be more expensive per aircraft, but has the advantage of increased AIDAPS efficiency which may be justified on a larger aircraft where the payload is less significant, and the maintenance costs are high. The following constraints were developed based on the above criteria.

2.3.12.2.1 Constraints Common to All Groups

A ground based AIDAP system can be expected to have lower hardware cost than a hybrid system. However, potential benefits may be reduced. Therefore a low cost simple aircraft with an associated low MMH/FH figure would be more suited to a ground based or a very simple hybrid system.

Certain systems apply only to specific aircraft groups based on the WSC. For example a system incorporating simple sensing, i.e. (I)s, only applies to aircraft group with a WSC of less than 200.

The systems selected for each aircraft group may be redistributed for subsequent analysis after initial application of these systems to the model. For example, if the most sophisticated hybrid system proved cost effective for Group 2 aircraft, then it would also be applied to the less complex aircraft of Group 1, even though the sophisticated hybrid system may not originally be a candidate. Therefore, the feedback generated as a result of exercising the model in phase C may significantly change the current phase B configurations.

2.3.12.2.2 Group 1 Constraints

Group 1 aircraft have a WSC of less than 200, therefore the only system which will apply are systems utilizing simple sensing.

2.3.12.2.3 Group 2 Constraints

Group 2 aircraft have WSC of greater than 200, but less than 400. Therefore the only systems which will apply are those incorporating medium sensing.

2.3.12.2.4 Group 3 Constraints

The Group 3 aircraft is a fixed wing airplane and has a WSC of greater than 200 and less than 400. Therefore the same systems applied to Group 2 also apply to Group 3.

2.3.12.2.5 Group 4 Constraints

The Group 4 aircraft is a fixed wing airplane with a WSC of greater than 400. Therefore, only systems utilizing complex sensing apply.

2.3.12.2.6 Group 5 Constraints

Group 5 aircraft are the most complex, sophisticated helicopters of the 10 study aircraft with a WSC of greater than 400. Therefore the same systems applied to Group 4 also apply to Group 5.

In addition, the complexity of the Group 5 aircraft may warrant a pure airborne complex analysis application. Therefore AIDAP systems employing pure airborne analysis will be applied in the Phase C tradeoff model analysis.

2.4 CANDIDATE AIDAP APPROACH CONCEPTS FOR TRADEOFF ANALYSIS

The assessment of the aircraft dependent considerations, as discussed in the foregoing report, Section 2.3, projected the concerned aircraft into five groups. The aircraft grouping was based on certain commonalities of the aircraft, similarities of AIDAP requirements and the practicality of application. A review of the aforementioned grouping discussions established the following constraints and associated applications.

2.4.1 Aircraft Commonality Grouping and Application of Practical Constraints

The established aircraft grouping and associated practical constraints are presented as follows:

a) Aircraft Group I (reference paragraph 2.3.12.2.2)

OH-6
OH-58 $S \neq S_3 + S_4 + S_5 + S_6 + S_9 + S_{10}$

where + represents the 'OR' operator.

Therefore, the selected Group I tradeoff concepts are as follows:

OH-6
OH-58 $S = S_1 + S_2 + S_7 + S_8$

b) Aircraft Group II (reference paragraph 2.3.12.2.3)

UH-1
AH-1 $S \neq S_1 + S_2 + S_5 + S_6 + S_8 + S_{10}$

therefore the selected Group II tradeoff concepts are as follows:

UH-1
AH-1 $S = S_3 + S_4 + S_7 + S_9$

c) Aircraft Group III (reference paragraph 2.3.12.2.4)

U-21 $S \neq S_1 + S_2 + S_5 + S_6 + S_{10}$

therefore the selected Group III tradeoff concepts are as follows:

U-21 $S = S_3 + S_4 + S_7 + S_9$

d) Aircraft Group IV (reference paragraph 2.3.12.2.5)

OV-1 $S \neq S_1 + S_2 + S_3 + S_4 + S_8 + S_9$

therefore the selected Group IV and Group V tradeoff concepts are as follows:

<u>OV-1</u> $S = S_5 + S_6 + S_7 + S_{10}$

e) Aircraft Group V (reference paragraph 2.3.12.2.6)

UTTAS
CH-47 $S \neq S_1 + S_2 + S_3 + S_4 + S_8 + S_9$
CH-54
HLH

Therefore the selected Group V tradeoff concepts are as follows:

UTTAS
CH-47 $S = S_5 + S_6 + S_7 + S_{10}$
CH-54
HLH

The following system expressions describe the selected candidate AIDAP approach concepts resulting from the above constraint applications.

$$S_1 = A/B \left|(I)S \cdot (C')C \cdot (A)S \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

which is a hybrid system configuration employing simple airborne sensing and analysis functions, subsequently referred to as a "Level I Hybrid System."

$$S_2 = A/B \left|(I)S \cdot (C')C \cdot (A)M \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

which is a hybrid system configuration employing a simple sensing function in conjunction with a medium airborne analysis function, subsequently referred to as a "Level II Hybrid System."

$$S_3 = A/B \left|(I)M \cdot (C')C \cdot (A)S \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

which is a hybrid system configuration employing medium sensing and simple airborne analysis, subsequently referred to as a "Level III Hybrid System."

$$S_4 = A/B \left|(I)M \cdot (C')C \cdot (A)M \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

which is a hybrid system configuration employing medium airborne sensing and analysis, subsequently referred to herein as a "Level IV Hybrid System."

$$S_5 = A/B \ \left|(I)C \cdot (C')C \cdot (A)S \cdot (D)S\right| \cdot G/B \left|(A)C \cdot (D)M\right|$$

which is a hybrid system configuration employing complex sensing in conjunction with simple airborne analysis, subsequently referred to herein as a "Level V Hybrid System."

$$S_6 = A/B \ \left|(I)C \cdot (C')C \cdot (A)M \cdot (D)S\right| \cdot G/B \ \left|(A)C \cdot (D)M\right|$$

which is a hybrid system configuration employing complex sensing in conjunction with medium airborne analysis, subsequently referred to herein as a "Level VI Hybrid System."

$$S_7 = A/B \ \left|(I)S + M + C \cdot (C')C \cdot (A)C \cdot (D)M\right|$$

which is a pure airborne system configuration employing complex analysis in conjection with medium display.

$$S_8 = A/B(I)S \cdot G/B \ \left|(C')C \cdot (A)C \cdot (D)M\right|$$

$$S_9 = A/B(I)M \cdot G/B \ \left|(C')C \cdot (A)C \cdot (D)M\right|$$

$$S_{10} = A/B(I)C \cdot G/B \ \left|(C')C \cdot (A)C \cdot (D)M\right|$$

The above system expressions, S_8 through S_{10} describe a ground-based system configuration with varying degrees of sensing complexity; i.e., (I)S, (I)M, and (I)C, respectively, coupled with complex data collection and analysis and medium display.

2.5 SYSTEM SELECTION SUMMARY

Constraints were established and applied for the 10 study aircraft initially on a collective basis independent of aircraft type, and then on an individual basis considering the peculiarities and similarities of the aircraft by type. The systems resulting from the constraints as applied are outlined in Table 2.5.1. These are the systems that will be analyzed in Phase C.

A total of 81 system configurations were considered based on airborne, ground based or hybrid as related to each of the four functional blocks, sensing collection, analysis and display. The system alternatives also considered 81 combinations of sophistication as related to each functional block. Therefore, the total number of possibilities is 81 x 81 or 6,561. Considering 10 different aircraft for each system configuration, the number of possibilities is increased to 65,610. As a result of the application of the constraints, the number of systems that must be compared to the aircraft was reduced to 10 discrete configurations. These system configurations were assessed relevant to constraints based on the aircraft group characteristics and resulted in 20 tradeoffs as applied to the 5 aircraft groups that must be subjected to a full cost/effectiveness analysis in Phase C. These 10 configuration concepts and their associated aircraft are shown in Table 2.5-1.

The systems selected for each aircraft group may be redistributed for subsequent analysis after initial application of these systems to the model. For example, if the ground based systems did not prove economically justifiable for the Group 1 and 2 aircraft, they would not be subsequently considered. If they did show a favorable result for Group 2 aircraft, they would be applied to other groups containing more complex aircraft for the model analysis. The converse is true. If the most sophisticated hybrid system proved cost effective for Group 2 aircraft, then it would also be applied to the less complex aircraft of Group 1, even though the sophisticated hybrid system is not a candidate at this time. Therefore, the feedback generated as a result of exercising the model in Phase C may significantly change the current Phase B configurations.

SELECTED SYSTEM APPROACH SUMMARY

TABLE 2.5-1

AIRCRAFT GROUPS	SELECTED SYSTEM STATEMENTS
Group 1	$S_1 = A/B\left[(I)S \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
OH-6	$S_2 = A/B\left[(I)S \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
OH-58	$S_7 = A/B\left[(I)S \quad (C')C \quad (A)C \quad (D)M\right]$
	$S_8 = A/B(I)S \cdot G/B\left[(C')C \cdot (A)C \quad (D)M\right]$
Group 2	$S_3 = A/B\left[(I)M \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
UH-1	$S_4 = A/B\left[(I)M \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
AH-1	$S_7 = A/B\left[(I)M \cdot (C')C \cdot (A)C \cdot (D)M\right]$
	$S_9 = A/B(I)M \cdot G/B\left[(C')C \cdot (A)C \cdot (D)M\right]$
Group 3	$S_3 = A/B\left[(I)M \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
	$S_4 = A/B\left[(I)M \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
U-21	$S_7 = A/B\left[(I)M \cdot (C')C \cdot (A)C \cdot (D)M\right]$
	$S_9 = A/B(I)M \cdot G/B\left[(C')C \cdot (A)C \cdot (D)M\right]$
Group 4	$S_5 = A/B\left[(I)C \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
OV-1	$S_6 = A/B\left[(I)C \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
	$S_7 = A/B\left[(I)C \cdot (C')C \cdot (A)C \cdot (D)M\right]$
	$S_{10} = A/B(I)C \cdot G/B\left[(C')C \cdot (A)C \cdot (D)M\right]$
Group 5	$S_5 = A/B\left[(I)C \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
UTTAS	$S_6 = A/B\left[(I)C \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$
CH-47	$S_7 = A/B\left[(I)C \cdot (C')C \cdot (A)C \cdot (D)M\right]$
CH-54	$S_{10} = A/B(I)C \cdot G/B\left[(C')C \cdot (A)C \cdot (D)M\right]$
HLH	

An example read-through of the above system expressions is described as follows: S_1 equates to an AIDAP System consisting of airborne (A/B) simple sensing (I)S, and complex data collection (C')C, and simple analysis (A)S, and simple display (D)S in conjunction with ground based (G/B) complex analysis (A)C and medium display (D)M.

SECTION 3

3.0 HARDWARE APPROACHES

This section outlines and discusses the various hardware approaches and alternatives. Recommendations for selection of the optimum hardware approach(s) will be made in Phase C. Some obvious conclusions relevant to the hardware configurations are arrived at in this phase, such that impractical approaches will not be carried forward to Phase C. The hardware is considered collectively, as a system and also as individual physical units.

3.1 BASIC HARDWARE CONSIDERATIONS

The considerations applicable to the overall system hardware are discussed in this section. There are many aspects which must be considered if practical systems are to be described and costs determined in Phase C. The actual hardware techniques will be selected as a function of several factors. The primary consideration is a detailed examination of the parameters and their characteristcs. In this regard, evaluation will have to be made of the interrelated factors of the sophistication of the sensors, the number of sensors applied to any one aircraft subsystem, and the degree of logic analysis which is necessary to perform the AIDAP functions for that subsystem. The non-quantitive statements are that, in general, fewer sensors will be needed on a given subsystem if those that are used are more sophisticated. Fewer sensors may be required if these few are supported by an increase in logical analysis. Conversely, if more sensors are used, perhaps the logical analysis can be reduced. The quantitive decisions will have to be made for each specific subsystem based upon detailed knowledge of its purpose and functional characteristics. However, the judgments can be expected to favor the increased use of logical analysis since, in all systems, it can be presumed logic will already be included for other AIDAPS purposes.

3.1.1 Physical Factors

The usual hardware considerations of minimum size and weight, ease of accessibility and maintenance, and high reliability apply. The method of retrofit and the weight of cabling are also considerations. Recent technology relevant to AIDAPS-like equipment has shown that the cables and connectors weigh as much as the electronics. Consideration must be given, therefore, to methods such as distributed multiplexing, remote signal conditioning and voltage-balancing schemes to reduce the weight of cabling.

3.1.2 Digital Vs Analog Systems

The data from most of the sensors will be in an analog form such as the magnitude of a voltage, current or a phase difference between two ac voltages. Simple systems could continue the processing of the data, beyond acquisition, in an analog form. The situation, however, would rapidly become unwieldy if more than a few sensors were to be accommodated and the processing were to be more than the simplest of arithmetic operations. For example, the least complex method of processing is to compare each parameter to a series of limits such as "normal," "caution," and "failure." To establish each limit a device similar to a voltage divider must be used. The analog approach obviously becomes impractical as well as unreliable for systems with more than just a few parameters. If an automatic record is to be made, analog techniques have been found to present difficulties in matters such as the large volume of tapes that are required, the accuracy with which the data can be extracted, and the complexity of the data recovery equipment. Therefore, it is recommended that all practical system considered for AIDAPS be digital in their operation.

The advantages over analog operation are: the equipment will be smaller, more reliable, and less expensive; it will have greater flexibility, with "adjustments" easily accomplished without hardware changes; the data processing can be carried to any economically justified length without increase in errors; the "limits" are stored in a digital memory which is non-volatile and highly reliable; the data are in optimum form for magnetic recording or other permanent record.

3.1.3 Data Compression

3.1.3.1 Necessity for Data Compression

Many otherwise useful systems have been [illegible] in the past by the great magnitude of the data which was collected. The "mass of data" must be reduced to reasonable proportions. At the same time the overall efficiency of the AIDAPS must be retained. In the following sections, the basic, well-known methods of data compression are listed and comments are made therein.

3.1.3.2 Methods of Data Compression

There are two basic methods of data compression: one is to reduce the mass of data by merely not taking data where there is reason to believe nothing of interest is occurring; and two is to use arithmetic methods to eliminate redundancies and so output "useful information," rather than just raw data. The following paragraphs describe techniques used in applying these methods.

3.1.3.2.1 Recording Durations and Number of Parameter Exceedances

When a parameter is found to exceed a fixed limit, the name of the parameter, exceedance duration, and the number of exceedances is recorded. Examples are EGT and vertical 'g's. It has been affirmed that the useful life of a jet engine (including turbojets) is inversely proportional to the integral of the EGT-time history of the engine. In a somewhat similar manner, there is strong evidence that airframe failures can be directly related, for a particular type of aircraft, to the number of "hard landings" or the number of times the vertical acceleration has exceeded a predetermined limit.

3.1.3.2.2 Short Duration Recording of Raw Data

Raw data is recorded, but the total amount of data is reduced by logically determining that certain short periods of acquisition are sufficiently indicative of the continued "health" of the aircraft. In this classification are the following techniques:

a) Acquisition of data for only a few seconds or minutes during a ground run-up. It is obvious that time-function intervals cannot be accumulated in this mode. In addition, any events which may occur during the subsequent flight can be known only if they leave some trace which is discernible in the next runup. This is representative of the method used by aviation to date.

b) Acquisition of a "full frame" of data whenever critical parameters exceed predetermined limits. This concept is based upon the fact that it [illegible] difficult to anticipate the actual parameters which are involved in any specific incidence. It is, therefore, best to record everything and make specific determinations later.

c) Acquisition of data during periods in the flight when it is presumed the aircraft is in the maximum stress condition. This is more applicable to non-combat or transport type aircraft where the low-stress periods can be predicted. Since with combat aircraft, "full military power" and excessive maneuvers may occur at any time, this method must be combined with a) or b).

d) Acquisition of selected parameters or a "full frame" at the command of a member of the flight crew. This serves as a handy "scratch-pad" to augment the memory of the crew by recording adverse conditions which may occur during a flight.

e) Acquisition of data by combinations of the methods above. Methods b), c), and d) are usually employed in various combinations. An additional voice channel may be added such that the air crew can record verbal comments.

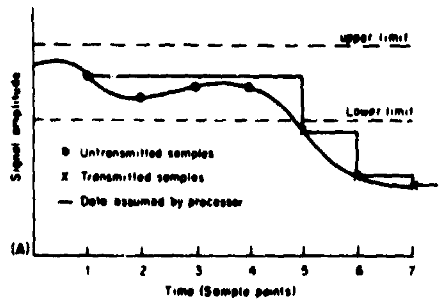
3.1.3.2.3 Short Term Recording of All Parameters

Recording of all "raw data" in a short term memory with a "data dump" in the event of a detected exceedance of one or more selected parameters is the basis for this technique. It is primarily a research tool to provide a "look ahead" in the event of a failure or serious degradation. The purpose is to see if an adverse condition could have been predicted by the deviation of a parameter.

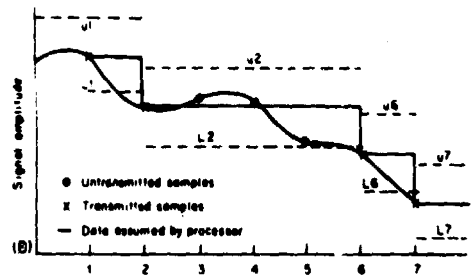
3.1.3.2.4 Data Compression by Computation

Compression of data by computational means is the the most powerful and flexible of compression methods. The previously described methods of compression can be "programmed," either singularly or in any combination. In addition, the application of a purely arithmetic compression algorithm will allow the output of information, in contrast to data which must be further reduced. The availability of a computational means will allow the data to be "refined" such that detected exceedances are actual deviations from a historic norm, not merely transients. A short discussion of arithmetic data compression follows.

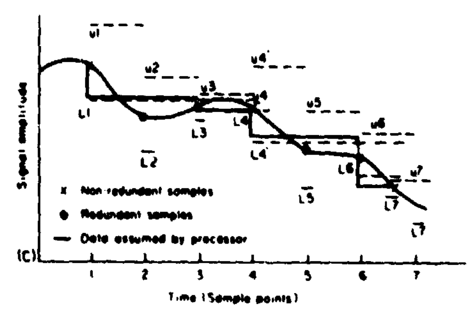
Data compression



Fixed limits



Floating aperture



Extended step

The overwhelming flow of data generated by modern sensors is strangling transmission media and choking up the processing electronics of data acquisition systems. If you're willing to live with tolerances on data accuracy—the pressure can be reduced.

Eliminate redundant data, and the information transfer rate of your system (not to be confused with bit transfer rate) can be increased, simplifying the data processing. A data compressor (general purpose or special digital computer) built into your system between the encoding electronics (A/D converters) and transmission electronics can do this. The computer lets you utilize the bandwidth better, and lowers acquisition and processing costs.

A simple computer algorithm that prevents the transmission of unnecessary data uses a fixed upper and lower limit (A). If the data is within this band at the sample time, no information flows; if the sample point is outside this band, its value is sent on to the processor. When the processor does not receive data, it simply takes the middle value between upper and lower limit. It's simple, but it works.

A more sophisticated algorithm uses a fixed-height (in magnitude) aperture, but the aperture floats (B). In essence, it predicts future samples. The sampler sends the first sample (1) to the processor, and at the same time it establishes the location of the tolerance band (U1 to L1). Since the second sample falls outside this band, it is also sent, and the tolerance band drops to U2—L2. The next three samples (3, 4 and 5) fall between U2 and L2, so the sampler sends no new data; it assumed the value to be the same as the last sample sent. The aperture moves again at both sample times 6 and 7. A refined version of this algorithm varies the aperture height with the magnitude of the sample to keep the data uncertainty at a fixed percentage of the data.

Extended-step redundancy reduction (C) is also predictive and uses a floating aperture, but differs in several ways from the preceding technique. First, the tolerance range varies. Second, a sample is considered redundant if its tolerance range overlaps that of the preceding sample. And third, when a non-redundant sample occurs, the mid-point of the tolerance corridor is transmitted as the preceding sample. Besides eliminating redundant data, this procedure provides a noise averaging effect that eliminates small amplitude noise on the signal.

Applying the Extended Step method to the signal of example B, the first sample establishes the same tolerance range. This tolerance stays for sample 2, which is redundant because the upper limit U2 falls between U1 and L1. U2 is more restrictive than U1, however, so the new tolerance range is L1 to U2. Using this new range about sample 3, we find that sample 3 is redundant and again we pick the most restrictive tolerance range (U3 to L1). With this latest aperture height, U4 and L4 fall outside the range of L1 to U3, so the midpoint between U3 and L1 is sent as the value of sample 3. The processor also uses this value for all preceding redundant samples. The process starts again with the original tolerance limits on sample 4. The colored line indicates the data acquired by the processor at the receiver, which is more accurate than in B.

FIGURE 3.1-1

This page in its entirety is reprinted from "Time-Division Demultiplexing and Decoding," in the March 1969 issue of the Electronic Engineer.

3.1.4 Airborne Data Processing

Conceptually, airborne data processing can vary in complexity and function from a relatively simple, hardwired sequencer to a full scale, general purpose, digital computer. The degree of complexity of the processor will be determined in the studies of Phase C. The tasks that are briefly discussed herein are listed in the order of complexity.

3.1.4.1 Storage and Application of Limits

As previously noted, a digital system allows the storage of several limits for each parameter. By proper selection of the scaling factors for the parameters, it is possible to monitor a large number of parameters with a very small library of limit values.

3.1.4.2 Adjustment of Limits as a Function of Related Parameters

There are relatively few limits that can be set with precision on an absolute basis. If limits are set wide enough to accommodate variations due to other factors, they become less effective as definative criteria. The most effective method, therefore, is to arrange circuits or logic such that the absolute level of a limit is varied as a function of all the parameters which can affect that limit. Basic factors such as Indicated Air Speed, Free Air Temperature, Altitude, and Power Settings very often affect other parameter limits. Certain discrete conditions may also affect limit levels. For example, one could expect a different "normal" torque level when bleed air is being taken than when it is not being taken.

3.1.4.3 Control of an Airborne Display

As defined previously, an airborne display may be lights, flags, messages from a Voice Warning Unit, etc. The primary function of AIDAPS is the enhancement of the maintenance function. However, the airborne equipment may be able to discover malfunctions or incorrect adjustments which, if continued, could endanger the aircraft. The airborne processor can contribute to flight safety and efficient operation if it can control appropriate displays.

3.1.4.4 Logical Control of Data Acquisition

If the processor is allowed to control the sequence and frequency of data sampling, it is possible to have different sampling programs for different situations or phases of a flight. For example, one sampling routine may be suitable when full military power is being drawn, while a quite different sequence and rate may be most satisfactory when power settings are within the "green-band."

Control of acquisition by the processor will also allow, in the more sophisticated versions, conditional sampling as a function of primary data. As an example, the sampling rate of a particular parameter or a related series of parameters can be varied as a function of the rate of change of a key parameter.

3.1.4.5 Process Control

Similar to the functions which were discussed previously, this is the ability to control data processing as a function of a key parameter or an interrelated series of parameters. A good example is in the possible application of vibration analysis. By this particular technique, the analysis is only performed when the overall vibration levels exceed a predetermined level. When the vibration exceeds a critical level, other tasks of the processor would be temporarily abandoned to control digital filters to determine the energy levels at each component frequency. Thus the source of a failing component can be identified.

3.1.4.6 Data Smoothing by Digital Filtering

Aircraft exhibit large amounts of electrical, acoustic and mechanical noise. The signals from sensors can also exhibit large non-informative perturbations which are normally damped out of indicators. These noise and perturbation elements must be filtered out to secure "good data" for subsequent analysis. Short term transients or "spikes" can and should be removed by analog filtering. Digital methods, however, allow very long time constant filters to be simulated to filter out long term transients and provide for flexible and adaptive operation. Since there are no savings in operating electronic equipment slowly, the technique will be to operate at the maximum sampling rates which the processor can accommodate consistent with transient rejection techniques.

The objective is to secure the maximum number of samples per unit time for each parameter. This will permit the most effective averaging, smoothing, and correlation of data.

3.1.4.7 Performance of Airborne Real-Time Diagnostics

The processor can perform real-time diagnostics on all subsystems in which failing or degrading components are revealed during aircraft operations. Diagnostic procedures which call for special settings, adjustments, or usage would interfere with flight operations and cannot be allowed. For example, the flight controls cannot be cycled in flight to their extreme positions to find any possible binding or excessive looseness. A processor which has the arithmetic, logic, and memory facilities to perform the tasks, which have been previously described, will require only a small additional capacity to perform diagnostics.

3.1.4.8 Performance of Airborne Real-Time Prognostics

Because of the large dynamic memory which would be required, it is unlikely that long-term trend analysis can be performed in an airborne processor. However, very useful short term prognosis can be done with a relatively few additional words of memory. The basic technique is illustrated in Figure 3.1-2. The smoothed data is examined at regular time intervals. If an incremental increase is detected, the "slope" of the function can be determined. A simple computation then yields the value N which is the predicted time to failure. Actually, the slope would be determined over several unit times to avoid possible action or noise which could have penetrated the smoothing function.

One of the major contributions that prognosis can make to flight safety is to warn of situations which, if continued, will lead to failure or loss of airworthiness. Corrective action is also illustrated in Figure 3.1-2.

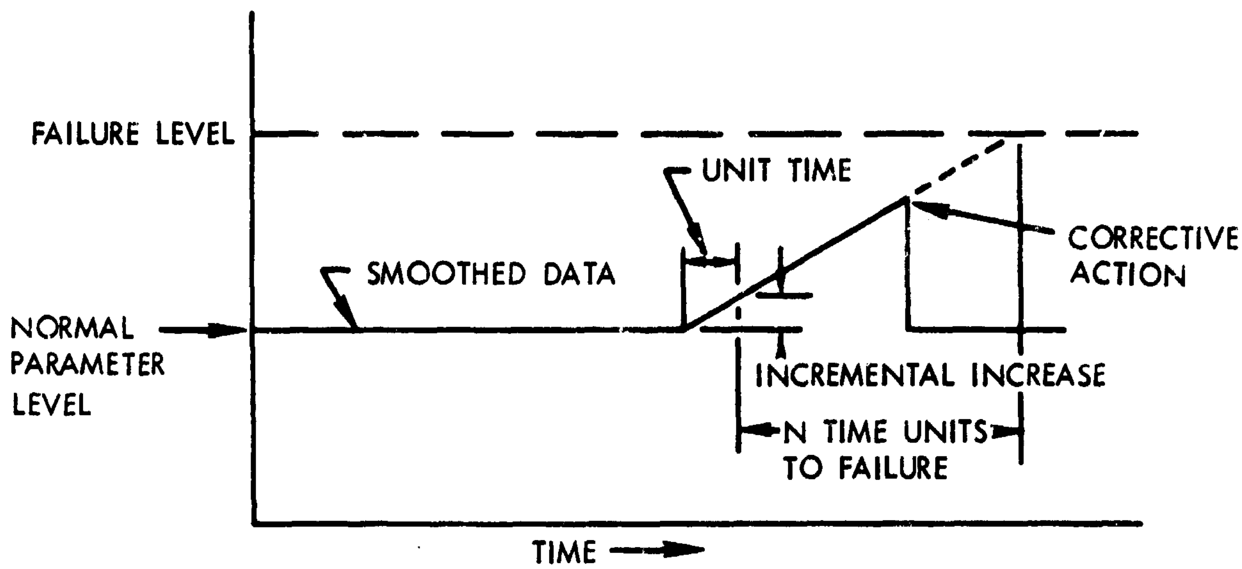


FIGURE 3.1-2 BASIC PROGNOSIS PROCESS

3.1.5 System Built-In-Test-Equipment (BITE)

It will be necessary for AIDAPS to have the most comprehensive built-in testing that is technically feasible and economically practical. In addition to specific BITE, several techniques for continual testing can be applied to the actual data. For example, momentarily excessive values can be rejected if the maximum possible rate of change of a parameter is known. Similarly, a knowledge of the normal values of related parameters can be used to detect calibration shifts of a particular parameter. Another technique for automatic testing is to require that sensors have zero offsets or static bias so that known values are acquired and processed when the aircraft is "cold-parked" (except for the AIDAPS).

3.1.6 Aircraft-Ground Communications

It is anticipated that the sensors which are added for AIDAPS will be permanently installed in the aircraft. Also, as a principle of AIDAPS operation, maximum usage will be made of existing aircraft sensors. Therefore, some means of communication between the aircraft and the ground must be established, irrespective of whether the overall system is hybrid or completely ground based.

There are three basic methods of communication: one, a hard wire umbilical cable; two, a telemetry link; and three, a magnetic tape cartridge. The umbilical cable would probably be used in the ground based systems. An umbilical system may consist of a unit, temporarily attached to the aircraft under test, which would derive power from the aircraft and contain signal conditioners, multiplexing and analog-to-digital conversion. The umbilical would therefore carry only serial digital data, thus reducing its noise susceptibility. It would also be light and small, but relatively long.

The digital cable, postulated above, could be replaced by a low power telemetry link, but the added cost and complexity may be prohibitive. Perhaps more important is the fact that continued transmission would be unwise in combat zones.

In all systems which are classified as hybrid, it is assumed that a magnetic tape cartridge will be the communication medium. Although it will function primarily as a device for the transmission of information from the aircraft to the ground processor, in the more sophisticated systems it may be used as an input medium to program the airborne processor.

3.1.7 Ground Processing Equipment (GPE)

According to current thinking, without the confirmation of the phase C studies, the ground processing equipment will consist of five subsystems: a data input device, a computer, a medium capacity non-volatile memory, a printer, and a manual data entry keyboard. The functional diagram of this suggested equipment is shown in Figure 3.1-3.

3.1.7.1 Data Input Device

As discussed in section 3.1.7, the data may be presented to the GPE as either a digital data stream on a hard wire or from a magnetic tape cartridge. If both ground based and hybrid systems are found to be technically and economically effective for any type(s) of aircraft, it could well be that commonality could be achieved by constructing equipment which could accept either type of input with only a change of an input module.

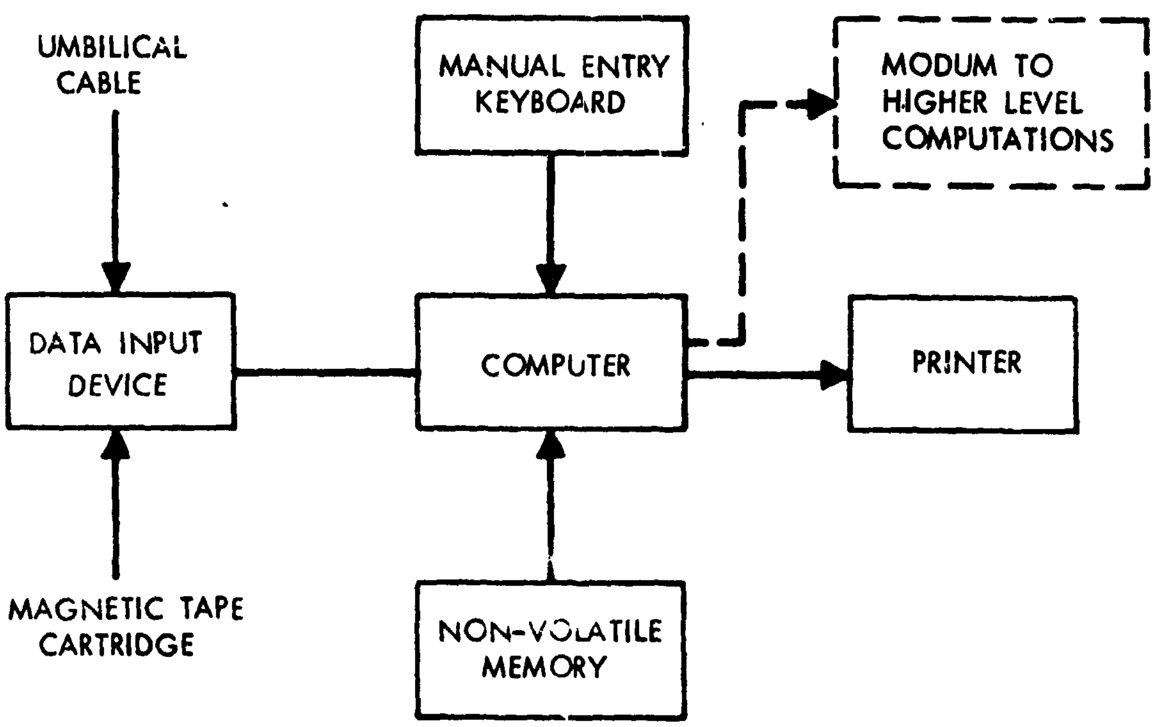


FIGURE 3.1-3 AIDAPS GROUND PROCESSING EQUIPMENT

3.1.7.2 Computer

Continued study will be necessary to "size" the computer. A device of the class currently known as the "mini-computer" is contemplated. It is felt that the same machine can be used irrespective of whether the system is ground based, hybrid with no airborne analysis, or hybrid with airborne analysis. Upon first examination it appears that less ground analysis is required if some analysis is performed in the aircraft. The situation tends to balance since, presumably more complex airborne analysis will be used on the more complex aircraft which, in turn, will have a proportionally larger amount of data to process. Similarly, with a ground-based system all data will be processed by the ground facility but data will be taken for only a few minutes for each aircraft.

The actual computational and logical tasks and the computer language will be a function of the basic system operation and the parametric-diagnostic-prognostic processes which will be determined in Phase C. In very general terms, the memory subunit will contain programs for the type of aircraft being serviced, subroutines for diagnostics, and a dossier on each aircraft. The "new" data from an aircraft is then processed, according to the stored program, with the maintenance directions and prognostications outputted from the printer and the applicable portions of the memory updated or augmented.

3.1.7.3 Medium Capacity Non-Volatile Memory

As noted in the preceding paragraph, the memory will contain programs, subroutines, and a dossier on each aircraft or group of aircraft. It is important that this memory be non-volatile and protected such that the contents can not be unintentionally altered or lost upon the removal of power. At the present state of the memory art, this requirement can be satisfied with a magnetic-mechanical unit such as tape or disc. It is likely, however, that current technology can provide solid-state, non-volatile, read-mostly memories. These are projected to be competitive in size and cost to tape or disc memories with the important features of higher reliability and much lower power consumption.

3.1.7.4 Printer

In Section 4.2.2.6 of this report the possible printout formats are discussed. The Printers to produce these formats are currently available. Since the unit will be operated under combat field conditions, it is desirable that the unit be of a non-impact type which is not position sensitive and which does not use toners or free fluids. Printing speed is of primary importance since higher speed units will require less memory for buffering.

3.1.7.5 Manual Entry Keyboard

It is desirable to make manual data entries, primarily of a documentary nature, via a keyboard. A keyboard is also necessary for the entry of special commands and test procedures. This is not to state that other manual energy methods are necessarily precluded. Decisions will be made during Phase C when the actual manual data requirements have been identified. It may be that an entry device should not be furnished with the organizational level equipment to preclude inadvertent false operation. Rather, a portable entry unit, supplied at Direct Support level, could be taken, by a properly skilled individual, to the Organizational level units for documentary entry.

3.1.8 MODUM to Higher Maintenance Levels and MIDAS

Present plans indicate a printout at only Organizational Level with higher level AIDAPS functions achieved via the TAMMS on existing or projected Army computers (Section 4.2.2.4 of this report). It is possible, however, at some future date, that it would be desirable to automatically enter some or all of the AIDAPS information into large scale, Division or Corps level, computers and/or Automatic Technical Manual display systems such as the MIDAS. To provide for the contingency, it is contemplated that the AIDAPS ground equipment will be designed such that a MODUM to accomplish this possible coupling can be added at any time. This is indicated by the dashed lines in Figure 3.1-3. The implementation and mode of operation of [illegible] cannot be specified without information about the receiving device. The availability of Integrated and Hybrid circuits for these purposes, however, allows great variation in codes, logic levels, data rates, modulation modes, etc. without extensive changes in size, weight, power and costs.

3.1.9 Application And/Or Integration of Special Techniques Into an AIDAPS

There are many techniques and special equipments which have been developed or suggested for the monitoring of aircraft subsystems. Several of these were discussed in Section 5.0 of the Phase A Interim Report. Examples are Leak Detectors, Metal Fatigue Sensors, Radioactive Wear Traces, In Line Oil Analysis, Sonic Analysis, and dedicated equipments such as Engine Hot Section or Compressor Analyzers.

In the case of the dedicated analyzers the AIDAPS performs these functions as part of its routine engine analyses; i.e., the Engine Hot Section and Compressor analysis are incorporated in the AIDAPS and there is no need for separate "black boxes."

As was also cited in the Phase A report, some of the techniques which have been developed for other usages would require further development for AIDAPS. Specifically, In-Line Oil Analysis by spectrographic methods, would require considerably more effort before a cost effective flyable unit could be produced.

In regard to Sonic Analysis, Northrop experience has demonstrated that an equally powerful inspection and diagnostic technique for the same purposes is vibration analysis. An important advantage of vibration methods is the reduced complexity and cost of real-time equipment.

In general, Northrop has found that effective AIDAPS can be produced using existing types of standard aircraft sensors. In the hardware design, in Phase C, equipment will be so configured that special sensors can be accommodated whenever possible, if increased AIDAPS performance can be achieved.

3.2 DETAILED HARDWARE CONSIDERATIONS

An AIDAPS must accommodate the maintenance function authorized by the aircraft MAC chart. The basic system hardware division and hardware functions are developed with consideration given to the objectives of aiding maintenance personnel in their respective functions outlined in the MAC chart as highlighted in Section 4.1.1.2. In addition to the existing functions, diagnosis and prognosis are being considered for possible inclusion in the future MAC chart.

For purposes of the hardware discussion, the most complex version of the hybrid AIDAP System was used as the basis for the hardware discussion and considerations. The same discussions apply to the ground-based system excluding the airborne data processing, display and recorder, and the ground playback transport. The system will be divided into the physical units as illustrated in Figure 3.2-1 and briefly discussed as follows:

a) System inputs consisting of existing sensors, added sensors, and documentary data such as aircraft identity, time, etc.

b) Central Electronics Unit which includes data acquisition and data processing.

c) Flight safety outputs (hybrid system only) for Voice Warning System and existing warning lights.

d) Flight Display Unit for maintenance purposes only.

e) Flight Data Recorder for recording voice and digital information for subsequent ground processing.

f) Playback Transport which provides for tape reading and data reconstruction within the ground processing equipment.

g) Central Processing Unit to process the AIDAPS data into meaningful information the maintenance crew can use in the inspection, diagnosis and prognosis of aircraft maintenance items.

h) Ground Display to translate the information gathered by AIDAPS to a recognizable form such that the maintenance personnel can take the appropriate action.

The considerations and altern[illegible] within each section of the AIDAPS hardware are discussed and recommendat[illegible] cited w[illegible]re a detailed study is not [illegible] the best approach. The [illegible] applicable to a ground based versus hybr[illegible] identified. [illegible] systems will be recommended in Phase [illegible].

3.2.1 System Inputs Considerations

The system inputs include all [illegible] information the AIDAPS must receive in order to adequately perform the desired functions. The actual list of recommended parameters and their physical characteristics will be developed

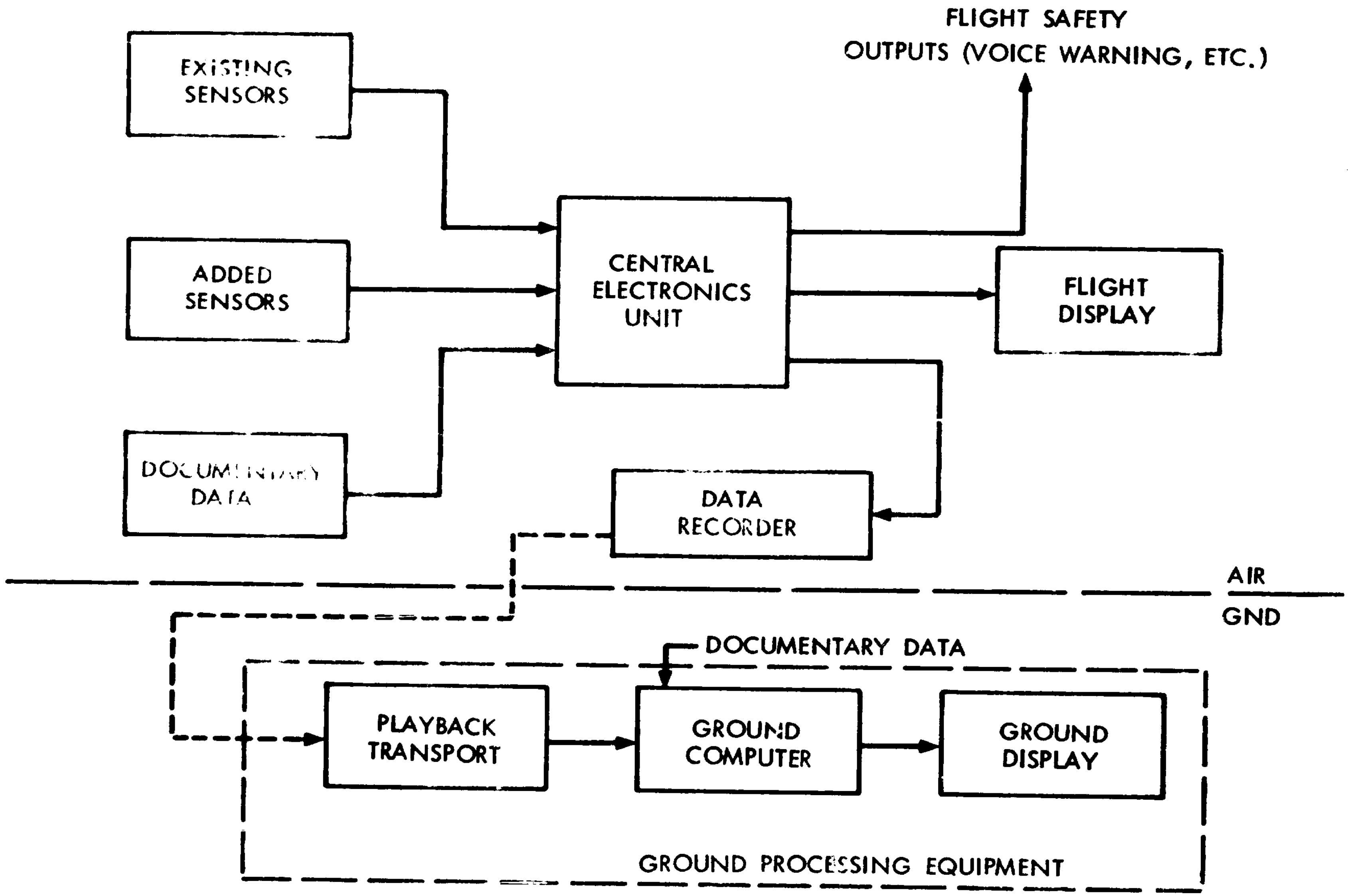


FIGURE 3.2-1 AIDAPS HARDWARE BLOCK DIAGRAM

in Phase C for each study aircraft or group of aircraft. This information will then be assessed to define the existing sensors that can be used and the sensors which must be added to accommodate the selected parameter list. Certain information such as aircraft type, model, series, tail number, and date may be printed out in conjunction with the inspection, diagnostic and prognostic data. This information can be inserted either on the ground or in the air. This data will be referred to as documentary data.

3.2.1.1 Existing Sensors

Existing sensors which can be used by AIDAPS must be selected based on many aspects. The primary concern is parameter selection. A list of parameters which are currently instrumented in each aircraft will be developed from the overall parameter list. These parameters will be possible candidates for AIDAPS. In almost all cases signal conditioning can be designed to utilize the electrical output of the existing sensor without significant degradation in aircraft instrument readings due to AIDAPS loading. The following elements must be considered when an existing sensor is to be utilized.

a) Electrical output signal characteristics
b) Sensor range (engineering units)
c) Actual parameter range
d) Sensor output range
e) Output impedance
f) Indicator impedance
g) Indicator resolution
h) Static error band
i) Repeatability
j) Frequency response.

3.2.1.2 Added Sensors

After the parameter list is developed and the existing sensors which can be utilized by AIDAPS identified, sensors for the remaining parameters must be evaluated. Sensors required to monitor certain parameters may be standard off-the-shelf type whereas others may be special types. A prime consideration is the type of sensor to be utilized. Aside from meeting the basic monitoring requirements as dictated by maintenance data needs, several other factors must also be considered.

The method of installation in the aircraft must be considered when selecting sensors. The simplest method which minimizes installation involvement and has negligible effect on reliability is preferred. This includes selecting sensors that are lightweight and do not require special wiring. However, the ability of sensors to properly function in the local installation environment must not be sacrificed. If possible, sensors should not require in-place calibration and should be maintenance free.

Choice of sensors must include consideration of compatibility with signal conditioning capability. Minimizing the need for zeroing, scaling, ranging, etc. of sensor outputs minimizes the circuit involvement in adapting sensor outputs to signal processing.

When selecting sensors, consideration will be given to commonality with sensors presently installed to monitor similar parameters, and secondly to sensors already in the Army inventory for other aircraft, when practical. Since many of the aircraft types have similar subsystems, selecting sensors which are employed in more than one aircraft type would simplify logistics and reduce system cost. Multiple use of the same or similar type of sensor on the same type of aircraft would also simplify circuit design and would provide an opportunity for circuit saving techniques such as time sharing. Many detailed considerations must be given to the selection of additional sensors such as:

1) Sensitivity
2) Parameter range (engineering units)
3) Sensor range (engineering units)
4) Over range
5) Sensor electrical output range
6) Output impedance
7) Static error band

8) Repeatability
9) Time constant
10) Stability
11) Weight
12) Size
13) Power dissipation
14) Excitation requirements
15) Environmental qualifications (MIL Std.)
16) EMI qualifications (MIL Std.)
17) Linearity
18) MTBF (reliability)
19) Shelf life
20) Maximum temperature
21) Frequency response
22) Availability
23) Price
24) Guarantee
25) Used previously on MIL equipment
26) Cycling life
27) Type
28) A/C drawings

3.2.1.3 Documentary Data

Some documentary data must be printed out with the maintenance information for identification. The documentary data will be used to associate the source of the data, time of occurrence, applicable maintenance level, etc. with the failure information extracted from the parameter data. This documentary data can be inserted on the ground or in the air, manually or automatically. Some information will best be inserted in the air, whereas other information will best be inserted on the ground. For example, items such as aircraft identification may lend themselves to automatic airborne insertion whereas the date may be manually inserted into the ground processing equipment via a keyboard entry.

A list of documentary information that may be printed out with the normal data is presented. These alternatives are presented for evaluation only. The documentary information to be presented and hardware design approach for accomplishing this will be recommended based on the optimum approach to meet the Army's need and interface with the present MAC chart and TM's.

1) Aircraft type, model and series
2) Aircraft tail number
3) Engine serial number
4) Time of each occurrence (recording)
5) Time of liftoff
6) Time of touchdown
7) Time of coast down
8) Total running hours
9) Total flying hours
10) Date
11) TM number and chapter
12) Time to engine overhaul
13) Time to next periodic

3.2.2 Central Electronics Unit

The Central Electronic Unit (CEU) will contain the functional blocks defined in Section 2.0 as collection and analysis. Selection of the pertinent design criteria is dependent upon desired acquisition and processing capabilities. The basic data acquisition portion consists of the following:

1) Sensor isolation
2) First level multiplexing
3) Signal conditioning
4) Second level multiplexing
5) Analog to Digital Conversion (ADC)

The processing section of the CEU contains all circuitry relevant to data compression for subsequent ground analysis, and circuitry for onboard analysis to decrease turnaround time and increase in-flight safety. A block diagram of the CEU is shown in Figure 3.2-2.

Circuits employed should minimize requirements for calibration. Offset adjustments, gain timing, zeroing, etc. should be avoided. When required, calibration should be simple and straightforward, with a minimum of support effort and equipment.

Circuit mechanization techniques must consider the logic and interface of processing circuits which use conditioning outputs. Certain relationships between sensors may be more conveniently accommodated by conditioning circuits than by processing circuits. In conjunction with processing requirements, time sharing of conditioning circuits must be evaluated; this should include exceedance detection as well as basic signal conditioning.

There are considerations applicable to each block of the CEU individually and those which apply to the CEU in general. The considerations which must be given to each block are discussed on an individual basis in the following paragraphs. Considerations basic to the CEU are:

1) Component cost
2) Environmental performance (MIL Std.)
3) EMI (MIL Std.)
4) Reliability
5) MIL Std. components
6) Size, weight, and power requirements
7) Mounting configuration
8) Aircraft retrofit for installation
9) Accessibility, existing space
10) Maintainability (no special tools)
11) Modularization
12) Flexibility in design
13) Connector interface design
14) Expansion capability
15) Sampling rate

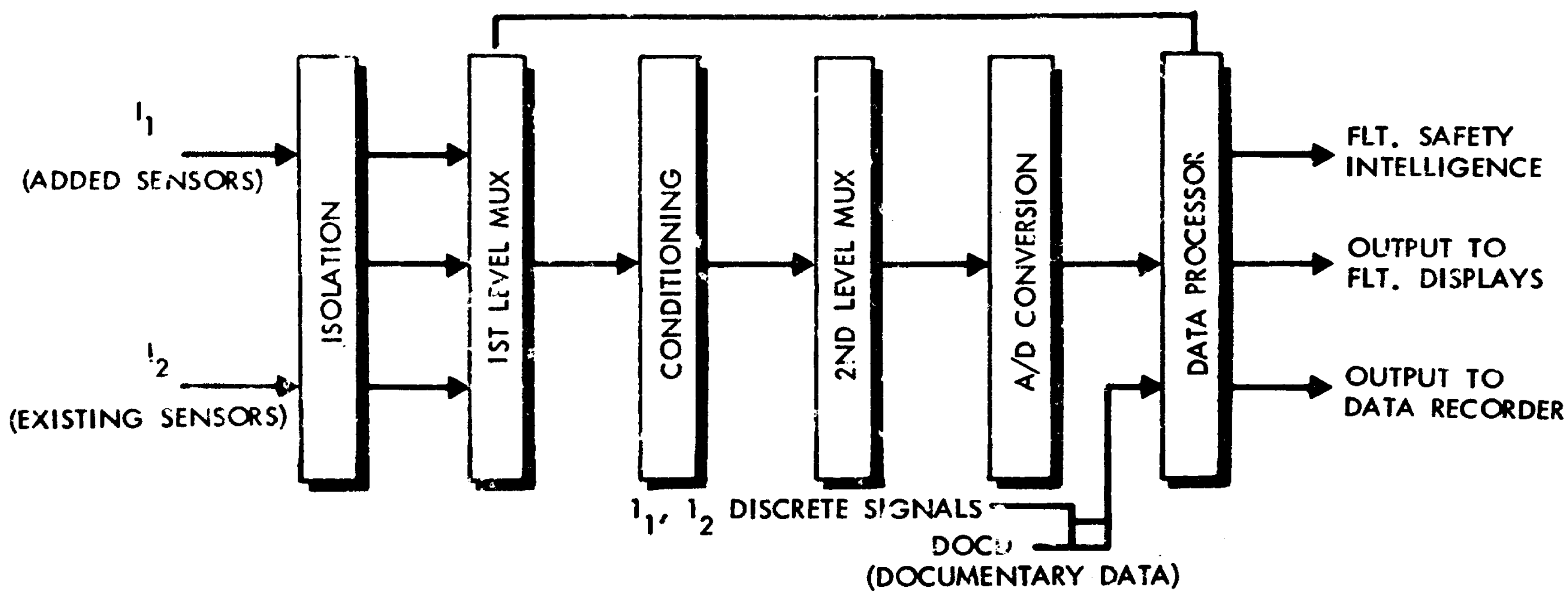


FIGURE 3.2-2 CEU BLOCK DIAGRAM

16) Sampling period
17) Recorder start - automatic/manual start signal characteristics
18) Record logic
19) Tape format (record)
20) Data format
21) BITE
22) Display control logic

There are many alternatives when developing a hardware mechanization for the CEU. Some of the alternatives which must be considered are:

Continuous inflight monitoring and recording	vs	Selective sampling of parameters only at specific flight modes (e.g., hovering)
Automatic data acquisition at multiple preprogrammed modes upon fault detection	vs	Automatic at takeoff and/or hover mode only. Pilot option to record inflight
Multiplexing of two or more similar but independent parameters	vs	Discrete individual parameter processing
Multiple "exceedance of limits" triggering levels of selected performance values	vs	Exceedance of one fixed parameter limit
Operation on unregulated ac power	vs	Operation on stabilized regulated power
Complete inflight data processing for real-time warning and/or display, plus simplified post-flight data presentation	vs	Partial inflight data processing for selective warning and/or display with completion of prognostic data analyses using ground-based computation

Inflight data editing and data compression techniques	vs	Postflight data editing during processing
Automatic mode blocking and control logic	vs	Manual turn-on and operation control
Capacity expansion by internal growth provisions	vs	Capacity expansion by building-block concept using separate modules
Single airborne electronic module, including specific signal conditioning	vs	Separate signal conditioning custom designed for each aircraft mating with universal electronic unit

These alternatives will be addressed in detail in Phase C.

3.2.2.1 Sensor/AIDAPS Isolation

Sensor/AIDAPS isolation reduces loading effects on the aircraft's instruments to a non-detectable level. The isolation is accomplished with precision resistors which also are used for scaling to the signal conditioners. The values of these isolation resistors are typically 200 kΩ. They are located as close to the CEU input connector as practical to insure proper aircraft instrument readings in the event of a failure within the AIDAP System. Values must be developed to limit the percent loading in normal operation and worst case AIDAPS failed condition.

3.2.2.2 First-Level Multiplexing

The first-level multiplexing is provided to route the input parameters to their appropriate signal conditioners. This allows the signal conditioners to be time shared thus contributing to a decrease in the number of signal conditioners required. For example, N_1 and N_2 may time-share the same frequency-to-dc converter by means of an MOS multiplexing switch. Historically, reed relays have been used to accomplish this. The present state of the art has antiquated the reed relays due to the development of highly reliable, low cost MOS LSI multiplexing switches. The following elements must be considered when selecting multiplexing techniques.

1) Multiplexed or dedicated conditioners
2) Number of signals multiplexed together
3) Type of multiplexing switches (solid state, MSI, LSI, reed relays)
4) Addressable or fixed address
5) Type of signals multiplexed
6) Signal degradation caused by the multiplexing switch

3.2.2.3 Signal Conditioning

Signal conditioning is used to convert the various types of electrical signals from the aircraft sensors to a common signal type. This conversion facilitates the handling and digitizing of the data for processing. For example, sensor outputs such as synchros, tachometer generator outputs, ac, low level dc, vibration, and high level dc signals may all be conditioned to 0 to 5 vdc signals such that a common analog to digital converter could handle all signals.

Conditioning must be compatible with sensors. In the case where existing aircraft sensors are utilized, conditioning circuits must have a negligible effect on aircraft instruments.

A list of considerations for selecting signal conditioning are as follows:

1) Type of conditioners
2) Accuracy
3) Scale factor
4) Linearity
5) Number of each type conditioner
6) Multiplexed gain components
7) LSI, MSI, discrete components
8) Techniques for conditioning signals such as sync/dc or frequency/dc
9) Signal conditioning input impedance

3.2.2.4 Second-Level Multiplexing

The second-level multiplexing is incorporated to channel the outputs of all the signal conditioners in one common data line to the analog-to-digital converter. The discussion of first-level multiplexing in paragraph 3.2.2.2 related to solid state versus reed relays applies equally to the second level multiplexing. The basic considerations for the second-level multiplexing follow.

1) Number of conditioners
2) Type of multiplexing switch
3) Levels required for isolation
4) Addressable or fixed address
5) Signal degradation

The following article discusses the various advantages and disadvantages of multiplexing. The text is an extract of an article authored by Hermann Schmid, published in Electronic Design, January 4, 1969 entitled "TIME-SHARING SAVES HARDWARE." * (Reference 1)

Often, not one, but several analog signals must be converted into digital form. The question then arises whether one a/d converter should be used for each analog signal, or whether one a/d converter should be time shared - or multiplexed - between several analog input signals.

If, for example, there is a control system in which 16 dc voltages must be converted into digital signals, several possibilities exist. These include using 16 converters, one for each input, and using 8 converters, each time-shared between two inputs, etc.

With the complexity, size, weight and cost of most presently available a/d converters, the most economical approach is to use one converter and time-share it between all 16 inputs. But this holds true only for most presently available hardware. With small and inexpensive monolithic converters, the economics are quite different.

*(Reference 1)

Economics, however, is not the only consideration in deciding whether or not to time-share. Overall performance must also be considered.

Every time an analog signal is processed by some circuit, no matter how simple, an error is introduced. Such is the case with time-sharing, where analog signals are connected sequentially in time to the a/d converter. Time-sharing deteriorates the overall conversion accuracy: errors due to time-sharing generally increase with the number of signals being multiplexed.

There is another penalty paid for time-sharing; namely, conversion rate. When "n" analog signals are sequentially converted in time, each signal is converted only at a conversion rate of 1/n. Using the example of 16 inputs again, and assuming that the maximum conversion rate is 16,000 per second, then each of the 16 inputs can be converted only a rate of 1000 per second. Obviously, any economy in hardware through time-sharing can be achieved only by sacrificing conversion speed.

Time-sharing of a/d converters can, therefore, be employed only if the overall system will permit reductions in accuracy and speed.

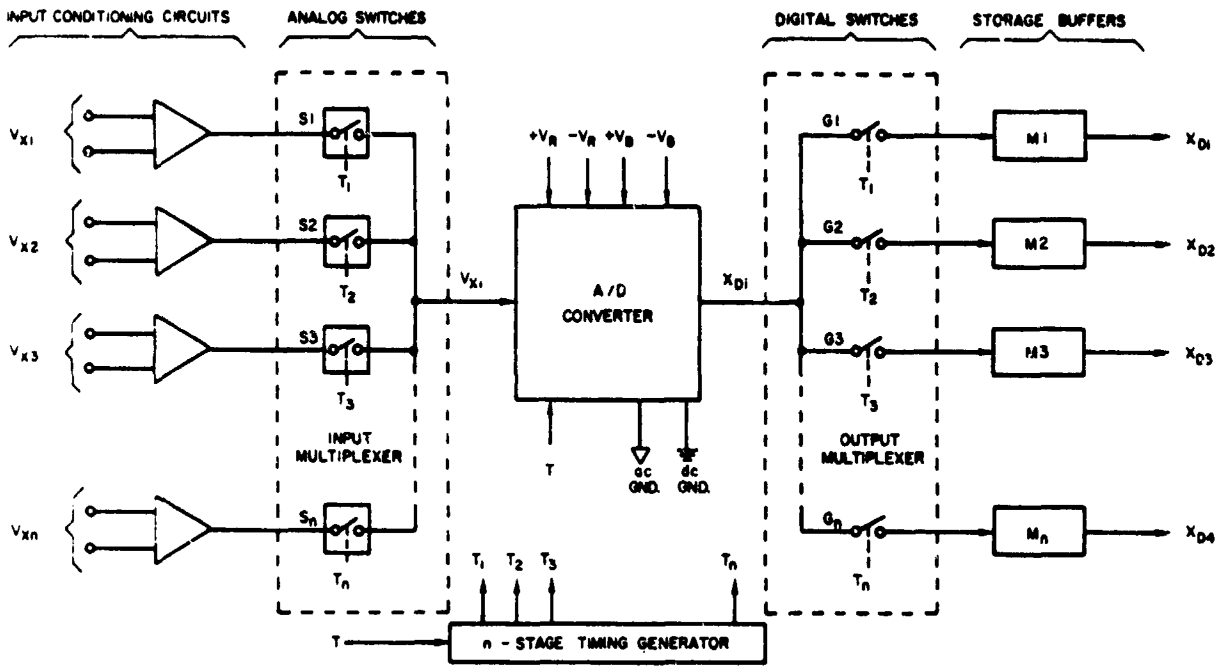
Only when the a/d converter is much more complex than the circuitry needed to multiplex one channel will time-sharing offer a reduction in hardware. But only when the error and reduction in conversion rate introduced by the multiplexing circuitry can be tolerated is time-sharing desirable.

General Organization*

The general organization of a time-shared a/d converter, including all peripheral circuits, is shown in Figure 13. To time-share any a/d converter, no matter what type, requires a set of analog switches, S1 to Sn, at the input and a set of logic gates, G1 to Gn, at the output. Only one switch and one gate are closed at any one time, so that only one input signal is connected to the input of the converter and only one buffer circuit connected to its output.

The switches and gates are controlled by the outputs, T_1 to T_n, of an n-stage timing generator. These timing pulses have an ON-time equal to one conversion period of the particular a/d converter used. Often the timing generator is an n-bit ring counter.

*(Reference 1)



13. **Time-shared a/d converter** has one analog input, V_x, connected to its input and one storage buffer, M_n, connected to its output during each conversion period, T_n. Switching is controlled by a timing generator.

*(Reference 1)

Frequently there is a need in time-shared a/d converters to provide a special conditioning circuit for each input signal. Such an input signal-conditioning circuit is also needed for an a/d converter that is not time-shared; in this case, it is usually part of the converter itself. The input signal conditioning compensates for ground potential differentials, scales the input signals, eliminates the effect of noise on the signal lines, and provides the input signals with a low-impedance source.

Because the operation of time-shared a/d converters generally can not be synchronized with the operation of the digital control or the computation circuits that use the outputs of the converter, a buffer circuit must be provided for each output signal. Shift registers or simple flip-flop latches generally are employed to perform these functions.

The output multiplexer and buffer circuits are straightforward and pose no problems, although the buffers require a considerable amount of hardware. In contrast, the multiplexing and conditioning of the analog input signals is quite difficult.

In any a/d converter the signal connected to the converter must be an exact representation of the signal generated by the analog signal source. Often, however, the signal at the converter is quite different from that at the source. Noise induced into the signal lines and the differences in ground potentials may completely distort the analog signal. Besides, the full scale output of the transducer may be greatly different from that required by the converter. And in another case, the impedance of the analog source may be too high.

To eliminate the effects of noise on the signal and the effect of ground-potential differences, to provide a capability of scaling, and to provide a low-impedance signal, the differential amplifier circuit in Figure 14 is frequently employed. Assuming zero offset and infinite gain, the output voltage of the amplifier is

$$V_o = \frac{R_2}{R_1} (E_1 - E_2).$$

Any difference in scale factor between the sensor output and the converter input can be corrected by proper choice of resistors R_1 and R_2, where for the sake of simplicity, R_1, R_2, R_1', and R_2' are assumed to be the same. Any difference in ground potential, ΔV_o, between the sensor and the a/d converter has no effect on the output of the differential amplifier, since V_o is proportional only to the difference voltage $(E_1 - E_2)$. In addition, any induced noise, V_n, has equal amplitudes on both the signal line and the signal-return line and therefore will cancel, if the common-mode rejection of the amplifier is sufficiently high.

The output impedance, Z_o, of the differential amplifier is very low (less than 1 ohm) and is usually much lower than that required by the input multiplexer. In the circuit of Figure 14, R_s may have any value, provided that the sum of R_s and R_1 is smaller than R_2/K, and that R_s remains constant. (K = the desired closed-loop gain of the differential amplifier circuit.) If R_s varies, then its magnitude must be much smaller than that of R_1. The exact limit depends on how much R_s changes.

If the amplifier of Figure 14 had no offset and infinite gain, all would be well. However, amplifiers approaching this ideal goal are very expensive and large in size. And if low-cost monolithic amplifiers are used, offset and gain problems arise, which must be kept within reasonable bounds. Either way, input signal conditioning is expensive.

Input Signal-Multiplexing*

The input multiplexer of Figure 13 connects each of the input signals sequentially in time to the a/d converter. Since the input signals are dc voltages, the input multiplexer is an array of a number of analog voltage switches. Only one switch is closed at any one time, and the outputs of all the switches are common.

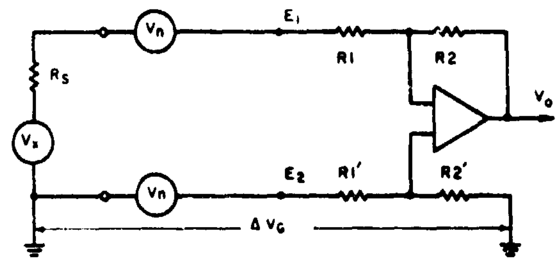
Each of the following types of series voltage switches is suitable for use in the input multiplexer. However, each has particular advantages and disadvantages which must be evaluated.

- Direct-coupled bipolar junction transistor switches,
- Transformer-coupled bipolar junction transistor switches,
- J-FET switches, and
- MOSFET switches.

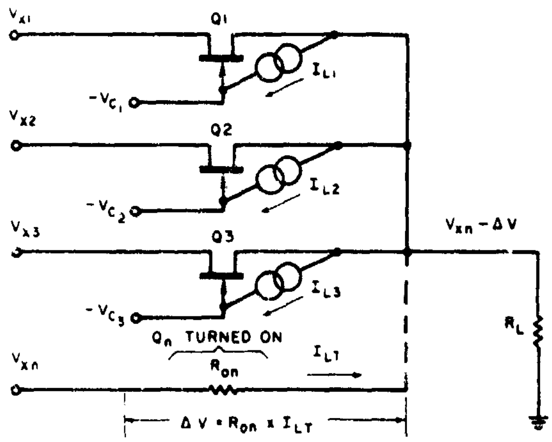
Errors in the input multiplexer can be caused by leakage current through the OFF switches and capacitance feedthrough transients. The error produced by leakage current is very small. This may be surprising, as there are always (n - 1) switches turned OFF. Since, however, one switch is always closed, the total leakage current, I_{LT}, flows into the ON-resistance of the closed switch. The resulting error voltage is therefore the product of R_{ON} times I_{LT}, which is usually very small. This is shown in Figure 15 for a multiplexer made of J-FET switches.

Whenever an analog switch operates, the change in control voltage is fed through the parasitic capacitances to the signal current. The resulting feedthrough transients can often cause problems. These problems are very much reduced in an analog multiplexer, where only the control signal to one switch changes while all others remain constant.

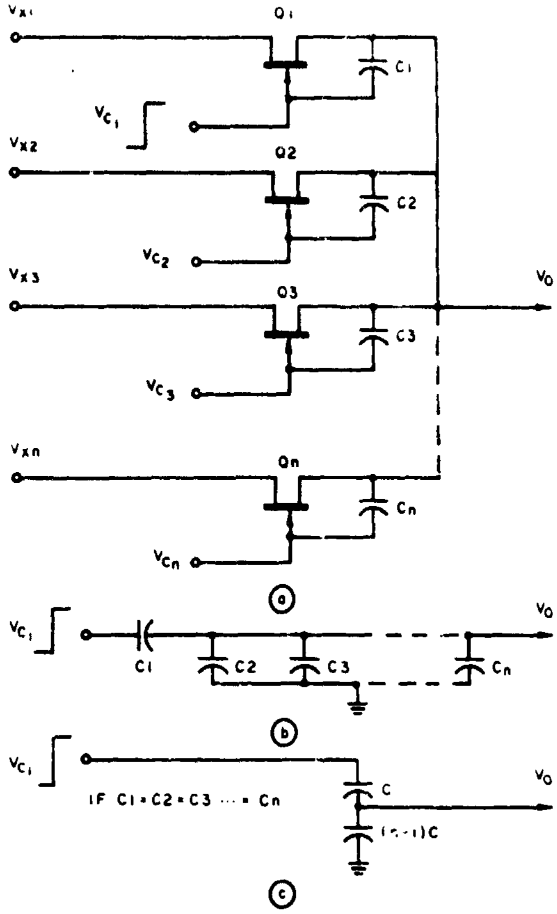
*(Reference 1)



14. **Differential amplifier circuit** provides input signal conditioning **for each channel of a time-shared a/d converter.** One amplifier is used **for each channel.**



15. **Leakage current causes only small error** in input multiplexer, because total leakage current of all OFF switches flows into ON-resistance of closed switch.



16. **Capacitive feedthrough transients** in the input multiplexer are generally small. This is because the actual parasitic capacitances (a) reduce to the equivalent of (c).*

*(Reference 1)

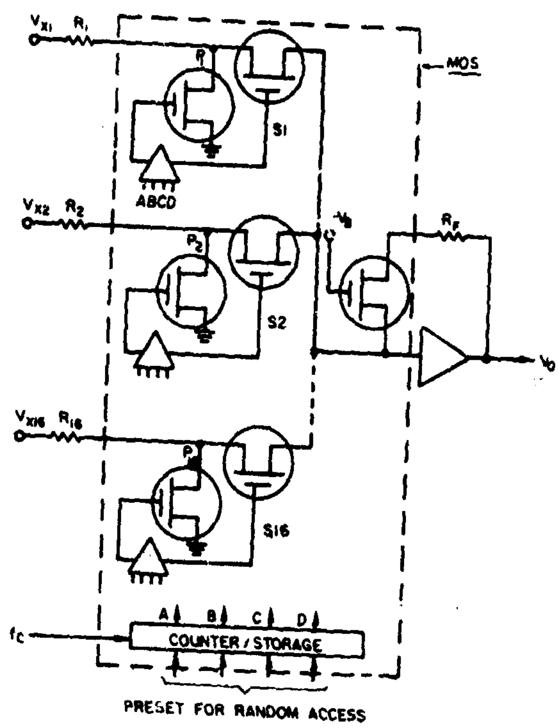
However, this statement is valid only when the control voltages come from drivers that have a low impedance when they generate the turn-OFF signal. The situation is illustrated in Figure 16a for a J-FET multiplexer, where a changing control signal is connected to Q1 and where constant and low-impedance turn-OFF signals are connected to Q2 through Q9. The transient equivalent for this multiplexer is shown in Figure 16b. If $C_1 = C_2 = C_3 \ldots = C_n$, the circuit can further be simplified to that shown in Figure 16c. From these equivalent circuits it is evident that any transient introduced through one capacitor is reduced by a factor of 1/(n - 1).

Switching speed is generally no problem in multiplexers used with a/d converters. This is because the multiplexer switches generally operate an order of magnitude slower than the switches inside the converter.

The impact of integrated circuits, and especially of MOS circuits, can nowhere be seen better than with analog multiplexers. It is more than ironic to see how present-day multiplexers are offered both as 19-inch rack modules and in IC flat-packs. Granted that the 19-inch rack model outperforms the present monolithic versions by far -- that it still, to this day, represents a masterpiece of engineering -- but for how much longer will this hold true? The MOS technique has come a long way; so has the engineer's ability to design around any deficiencies inherent in MOS circuits. The MOS current multiplexer shown in Figure 17 is a good example of this.

In the 16-channel multiplexer of Figure 17, MOSFET's are employed as current switches. The 16 input voltages, V_{X1} to V_{X16}, are connected to one side of a set of resistors, R_1 to R_{16}. The other sides of these resistors are connected either to the summing point of an operational amplifier, or to the ground by the 16 switches, S1 to S16. Each of these switches is a series-shunt type. When the series switch is closed, the shunt switch is open, and vice versa. The points, P1 to O16, which are the junctions of the input resistors and the series and shunt switches, are always therefore at ground potential. This offers the following advantages:

- The ON-resistances of both the series and shunt switches do not change with the input signal amplitude.
- There is essentially no leakage current, since source, drain, and substrate electrodes are at ground potential.
- The amplitude of the voltage to be switched is limited only by the size of available input resistors. The multiplexer can operate just as well with ±10-volt levels as it can with ±100-volt levels.
- The multiplexer can perform scaling operations on its input signals.
- The accuracy of the multiplexer can be made independent of the value of the ON-resistance of the switches by connecting a permanently closed MOSFET -- identical to those used in the series switches -- in series with the feedback resistor of the amplifier. The accuracy and the maximum value of the ON-resistance of the switches is, therefore only a function of how well R_{ON} can be matched.



17. **Series-shunt current switches** are used in this all-MOSFET input multiplexer. *

*(Reference 1)

The disadvantages of MOSFET current switches in the arrangement are:

- Additional precision resistors are needed. But since they also perform the function of scaling, this is a small price to pay.
- Capacitive feedthrough transients have considerable more effect when the transistors are connected directly to the summing point. However, because of the capacitive divider action, as previously discussed, this effect is reduced by a factor of $1/(n - 1)$. In any event, capacitive feedthrough transients become troublesome only at high frequencies, at which input multiplexers for a/d converters seldom have to operate.
- Twice as many switches are needed. But since the ON-resistance may be quite high, this disadvantage is well compensated for.

With the current switching technique of Figure 17, it is now possible to build an analog multiplexer on a single chip that matches the dc performance of even the most sophisticated multiplexers now on the market.

Output Multiplexer *

The output multiplexer of Figure 13 is a simple and straightforward array of logic gates. Output multiplexers are now available in all-monolithic form as binary-to-decimal, or binary to "1 in 4", "1 in 8", or to "1 in 16" decoders.

Output Buffers *

The time-shared a/d converter of Figure 13 generates the "n" digital output signals, X_{D1} to X_{Dn}, sequentially in time. The rate at which they are generated is a function of how much time the converter requires for one conversion and of how many signals there are to be converted.

Output buffer or storage circuits are normally required to accept the output signals from the a/d converter when they are generated, and to hold them until they are needed by the digital control or computation circuits. The buffer circuits should also be able to handle any required serial-parallel or parallel-serial conversion.

The most convenient and widely used of these is the serial-in, serial-out type. This buffer must not only have the capability of being loaded and read

*(Reference 1)

at any time, but must also have the capability of operating its input register with one clock frequency and its output register with another. Output buffers are also often required to provide galvanic isolation between the control or computation circuits and the converter circuit. In addition, the specific application can impose many other requirements on the output buffer.

Although the output buffer is a rather complex circuit that requires a considerable amount of hardware, it is possible today to build one on a single monolithic chip.

☆ ☆ ☆

3.2.2.5 Analog to Digital Conversion (ADC)

Analog to digital conversion is the process of converting an analog voltage level to a digital word. The count value of the digital word is directly proportional to the analog voltage level. The following discusses the analog-to-digital converter. The text and illustrations are an extraction of an article titled "Modern Analog-to-Digital Converters for Instrumentation Systems," authored by John O. Bowers, published in the Electronics Instrument Digest, September 1970. *(Reference 2)

The basic techniques used to convert analog data into digital form have remained essentially the same for the past 10 years. However, the methods of implementing these conversion techniques are even now undergoing rapid change -- due, primarily, to recent advances in monolithic integrated-circuit technology.

Among analog-to-digital converters, probably the most widely used are the feedback encoders that employ a digital-to-analog converter as the feedback element in the encoding circuitry. One of the principal reasons for the extensive application of this family of devices is its capability to provide high resolution and high accuracy at modest to high encoding rates. Moreover, feedback encoders are relatively simple (as encoders go), and can be made to operate accurately and reliably over a wide range of temperatures.

In addition to D-to-A converter, the implementation of a feedback-type A-to-D converter requires only a modest amount of digital logic and an analog voltage comparator. The most completely integrated monolithic building blocks that are available at the present time for use in A-to-D conversion employ

*(Reference 2)

MOSFET technology, which facilitates diffusion of both the analog and the digital circuitry into a common substrate. Bipolar integrated-circuit technology, on the other hand, requires separate substrates for analog and digital circuitry. Despite this limitation, it is capable of much faster encoding rates, and provides a wider temperature range and superior accuracy, as well. Another argument in favor of bipolar technology is the fact the MOSFET encoders also require precision resistance ladder networks of much greater resistance, that are more difficult to fabricate using thick- or thin-film resistance techniques.

The availability of a wide variety of low-cost, medium-scale-integration digital functions, together with the recent availability of moderately priced, high-performance, monolithic bipolar D-to-A converters makes possible a new generation of small, fast, reliable, accurate, and inexpensive A-to-D converters. A description of the three principal techniques that are commonly employed to accomplish A-to-D conversion follows.

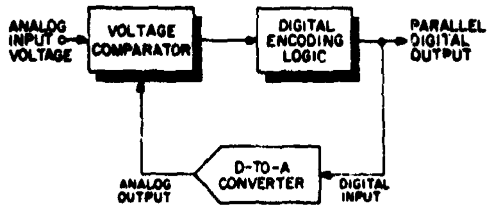
Feedback Encoding *

Figure 1 illustrates the basic principle of feedback encoding, as employed in A-to-D converters. The function of the digital encoding logic is to develop a digital output that will cause the D-to-A converter, which it drives, to produce a corresponding analog output voltage that exactly equals the analog input voltage to the encoder. The voltage comparator is used to compare the D-to-A converter output with the analog input, and to drive the digital encoding logic in such a manner as to minimize the difference between the two analog voltages. When this difference has been minimized, the parallel digital output signal from the encoding logic will correspond to the digital equivalent of the analog input voltage, within the basic resolution afforded by the comparator and the D-to-A converter.

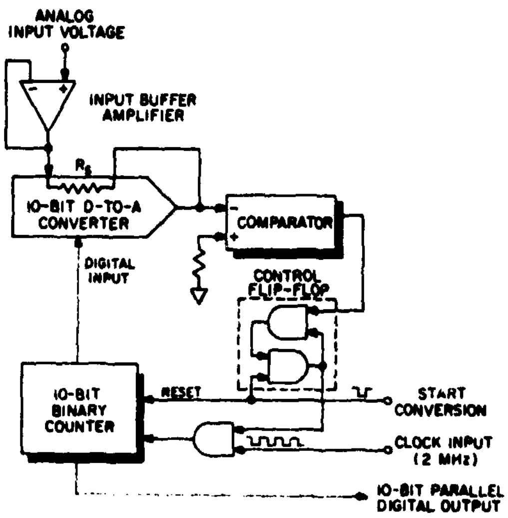
An n-bit A-to-D converter can be realized by means of an n-bit D-to-A converter as the feedback element. Three basic types of feedback converters are commonly encountered: the ramp encoder, the tracking or error-tracking A-to-D converter, and the successive-approximation converter. In each of these techniques, the analog-to-digital conversion is accomplished by means of an iterative process in which a digital input to the D-to-A converter is determined that causes the corresponding analog output to equal, as nearly as possible, the analog input voltage to the system.

*(Reference 2)

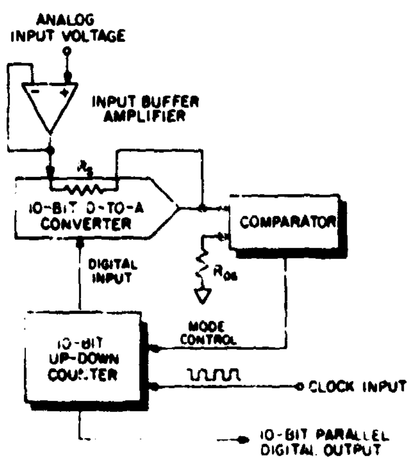
Fig. 1. Simplified block diagram of the basic feedback analog-to-digital converter. Fig. 2. Block diagram of a ramp-type analog-to-digital converter. Fig. 3. Block diagram of a tracking-type analog-to-digital converter.*



1



2



3

*(Reference 2)

Ramp-Type A-to-D Converter*

Although the ramp-type A-to-D converter is a relatively slow device, it has the advantage of simplicity. As shown in Figure 2, the encoding cycle is initiated by a START pulse that sets the binary counter to zero, while simultaneously setting the control flip-flop to the state that enables the logic gate controlling the clock-pulse input to the counter. In turn, the digital output from the counter drives the D-to-A converter, which produces a corresponding staircase output. At the point where the staircase output becomes equal to the analog input, the comparator output changes state, thereby resetting the control flip-flop, which gates off the clock pulses to the counter. The counter's digital output then corresponds to the digitized value of the analog input, and is held until a new encoding cycle is initiated.

Tracking Type A-to-D Converter*

The tracking A-to-D converter is unique in that it tracks an analog input signal continuously, so that its digital output code changes automatically in accordance with variations of the input signal. This feature, in conjunction with the relative simplicity of the design, suits the tracking A-to-D converter well to applications as a single-channel (i.e., not multiplexed) device that converts an analog input into a digital output on a continuous basis.

The block diagram of a tracking-type A-to-D converter is presented in Figure 3. Here, a 10-bit up-down counter is driven continuously by a clock signal. The parallel digital output from the counter drives a D-to-A converter, the output of which is then compared with the analog input signal to be digitized. The comparator senses the direction of the error between its two inputs, and controls the up-down mode of the counter so as to decrease the error. Once the correct digital output, corresponding to the analog input, has been achieved by the counter, the converter proceeds to "track" the analog input voltage by "hunting" between adjacent quantizing levels. The track-type A-to-D converter is thus essentially a regulator, in which the output of its D-to-A converter is made to equal a reference level -- which, in this case, is the analog input voltage.

*(Reference 2)

Successive-Approximation A-to-D Converter*

The successive-approximation technique is the most commonly used of all the A-to-D conversion techniques. It is the fastest of all the feedback encoding techniques, and its speed advantage is achieved with only a modest increase in digital-logic complexity.

Conversion at speeds higher than that provided by the highest speed successive-approximation A-to-D converters can be achieved only by means of parallel or feed-forward encoding techniques, which trade off resolution for speed, and which involve rather complicated circuitry.

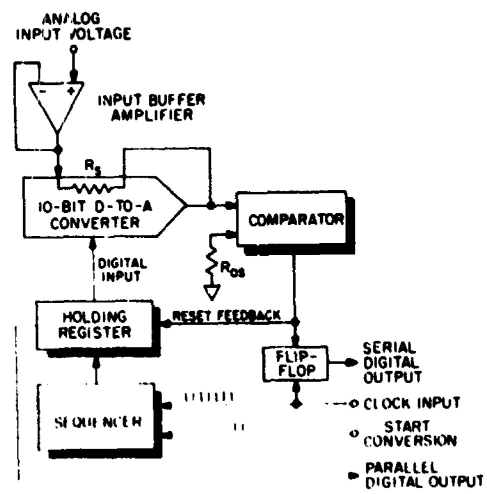
Figure 4 shows the block diagram of a successive-approximation-type A-to-D converter. Since the successive-approximation procedure is well known, we shall describe it only briefly. Successive approximation is a trial-and-error process in which the correct digital value is determined by a sequence of trials. It begins with the most-significant bit set to ONE, which produces an analog output of one-half of full scale. This value is compared with the analog input. At the end of the bit trial period, the ONE is retained if the analog input is equal to or greater than one-half of full-scale, and the most-significant bit is reset to zero if the analog input is equal to less than one-half of full-scale. Each bit is then tried in a sequence of descending significance, ending with the least-significant bit. Thus, only n clock (or bit) periods are required to accomplish an n-bit conversion.

The logic required to implement the successive-approximation encoding process is shown in Figure 4. A holding register is needed to generate and hold the digital code. During the encoding process, the holding register is programmed by means of a set of sequential pulses that are entered on a set of parallel lines, one of which connects to each bit position in the register. At the conclusion of each bit period, the appropriate flip-flop is either retained in the ONE state, or reset to ZERO - as controlled by the reset feedback signal at the comparator output. Although the reset-feedback function has long been performed with logic gates, IC flip-flops are now available that are capable of performing both the holding-register and the reset-feedback functions directly.

An additional advantage of the successive-approximation A-to-D converter is that a serial digital output can be provided readily by means of a single flip-flop which is steered by the comparator output and clocked by the clock input, as shown in Figure 4.

*(Reference 2)

Fig. 4. Block diagram of a successive-approximation analog-to-digital converter.*



- End of Reference 2 material -

*(Reference 2)

In addition to the previous discussion on Analog to Digital Conversion methods, various other factors must be considered. A list of these considerations follows:

1) Number of bits
2) LSI, MSI
3) Discretes
4) Parallel or Serial
5) Conversion rates (clock)
6) Number system, binary, octal, decimal

3.2.2.6 Data Processing

The main functions of the airborne data processing hardware are to edit the data collected, to reduce the bulk of data recorded to that which is meaningful for performing ground analysis, to effect a decrease in aircraft turnaround time, and to increase flight safety. To achieve these objectives, the following significant factors must be considered:

1) Compression
2) Editing
3) Threshold Levels
4) Parameter Cross-Correlation
5) Signature Comparisons
6) Inspection (limit detection)
7) Diagnosis (fault isolation)
8) Prognosis (fault prediction)
9) Data Output
    a) Recorder
    b) Safety outputs
    c) On-board display
10) Maximum data rates
11) Buffer
12) Memory size, type

3.2.2.7 CEU Outputs

The outputs from the CEU go to the Recorder, airborne maintenance display, and the existing flight safety displays when the data is collected in the air. If the AIDAPS is a ground based system, the only output of the CEU will be to the ground data processing unit. The AIDAPS may provide outputs to the existing aircraft Voice Warning System and subsystem caution warning lights. These outputs will be compatible with the input requirements of the existing systems. The data format to the recorder and the on-board maintenance display are open for consideration. There are many types of output data format which can be used, and the relative merits of each will be considered in Phase C. The following are some of the items to be considered:

1) Data channel capacity
2) Error rates and error detection
3) Maximum data acceptance rates
4) Recording mode
    a) NRZ-clocked
    b) Bi-phase-self clocked
5) Recording format

3.2.3 Recorder

The recorder is assumed to be digital rather than analog, as discussed in section 3.1.2, except for a possible voice channel. The voice channel is used by the flight crew to note anything of significance observed during the flight. This eliminates the need to write it down during flight when it may be inconvenient to do so. A tradeoff is a single inflight recorder for both AIDAPS and voice versus separate recorders for each.

A major consideration is the method of transferring the data from the recorder to the ground playback transport. One approach is to use a miniature sealed data cartridge for playback on a special data recovery unit. Another is to use standard IBM reels for post-flight data transfer and processing on a universal recovery machine. The following additional items must be considered:

1) Recording media
2) Tape cartridge
3) Tape reels

4) Removable recorder
5) Size, weight and power regulation
6) Tape speed
7) Retention time
8) Indicators - tape motion, self test, end of tape, tape low
9) Self test methods
10) Voice channel
11) Number of tracks
12) Parity
13) Skew
14) Speed stability
15) Tape guide mechanism
16) Continuous loop recorder
17) Program header information

3.?.4 Airborne Display

The data presentation may take the form of various displays. Since the airborne system will only display information necessary to affect turnaround time, the display may only be a GO/NO-GO indication. Such an indication can be used when the aircraft lands. It is desirable for the pilot to know immediately if he can proceed on the next flight without having to remove the tape and analyze it on the ground processing equipment. If the "GO" is activated, he can continue with the next flight after refueling and a quick visual inspection. If the "NO-GO" indication is present, the tape must be removed for ground analysis to identify the problem.

The considerations when selecting displays are:

1) Indication of parameter
2) Method of display (light or flag)
3) Location
4) Dependability
5) Positive GO indication
6) Existing displays
7) Recording only for subsequent ground playback versus inflight processing with real time display (recording optional)

8) Visual dynamics display (CRT or equivalent) versus "flags" on maintenance fault indication panel

9) On-board, high-speed printer (in lieu of recorder) versus post-flight printout of recorded outputs.

3.2.5 Playback Transport

The playback transport is used to extract the data from the magnetic tape recorded in the aircraft and to reconstruct the data for ground analysis. The playback transport, data processing unit, and ground display may be mounted in the same mobile structure and interconnected by rear mounted cables.

When selecting the playback transport, many factors must be considered to ensure that the proper interface is provided from the recorder to the data processing unit. These factors are summarized as follows:

1) Speed
2) Data reconstruction
3) Stop-Start
4) Indication - tape motion
   - end of tape
5) Automatic/manual operation
6) Skew
7) Speed stability
8) Synchronization

3.2.6 Ground Computer

The ground computer is used for processing the data recorded previously during normal flight for the hybrid system and for processing the real-time data when used with the ground system. It must have sufficient memory to perform, as a minimum, short-term prognosis. The processor should provide a means of manually entering documentary data such that it may be printed with the normal data gathered during flight.

Significant tradeoffs which must be considered are:

Integral logic for preselected exceedance of limit condition	vs	Total range of analog scale for data processing
Fixed custom logic and computation memory tailored to specific characteristics	vs	General purpose programmable computer
First order linear approximation of engine gas dynamics cycle analysis in region of specific interest	vs	Precise engine gas dynamic cycle analysis encompassing entire engine operating envelope
Accountability of variation of engine-to-engine on a statistical basis	vs	Accountability of performance variation on a self-adaptive mathematical basis.
Signature deviation recognition technique for diagnosis and analysis	vs	Signature deviation recognition technique supplemented with pattern recognition technique
Signature recognition technique circuitry incorporated integral with hardware	vs	Historical tapes for trend or prognostic analyses

The basic factors which must be evaluated before the computer can be selected are:

1) Memory size
2) Speed
3) Program Requirements
4) Documentary data input
5) Control logic
6) Buffer
7) Optional outputs
8) Maintenance Logic
9) Data format to display

3.2.7 Ground Display

The ground display will be the link between AIDAPS and Maintenance Personnel. The data must be in a form which is usable by the maintenance crew. From a practical view, a hard copy must be generated. A display such as CRT cannot be used because the data must be either remembered or recopied by the mechanic and is impractical. Significant variations involved in the selection are:

Alphanumeric printout in coded format	vs	Printout in plain language
Quantitative readout in arbitrary digital units for Tech manual correlation	vs	Quantitative readout in engineering units
Data presentation limited to organizational, direct support (DS), and general support (GS) maintenance (e.g., engine bearing has failed)	vs	Data acquisition and presentation for organizational direct support (DS), general support (GS), plus depot level (e.g., what specific engine bearing has failed)
Digital data transmission by cable from flight line to remote EDP	vs	Overland transport of recorded data to Electronic Data Processing (EDP) Center
Equipment designed for data recovery in flight line environment using mobile jeep as option	vs	Data recovery at Air Mobile Shop (AMS) using extensive specialized data analyzer equipment
Complete data (inspection, diagnosis and prognosis) available directly at organizational level upon landing	vs	Inspection and diagnostic data only at flight line, and prognostic data at DS or GS only when convenient to process
Daily data acquisition records retained with aircraft flight log for referral	vs	Long-term data storage and referral at central point using computer memory and printout facilities
Digital go/no-go coded printout data with Tech Manual cross-referenced instructions	vs	Normalized digital counts and/or multiple channel analog presentations for interpretation at GS level

There are many basic factors which must be considered when selecting the proper printer to accomplish the intended objectives including:

1) Format
2) Speed
3) Number characters per line
4) Types
5) Available symbols
6) Control
7) Media
8) Paper low indication

3.3 HARDWARE APPROACH SUMMARY

The basic hardware guidelines and considerations have been outlined within this section. Conclusions have not been drawn except where the optimum solution is obvious and not applicable to a tradeoff analysis conducted in Phase C. The hardware considerations were identified for the basic system and for each separate physical unit which includes existing sensors, added sensors, documentary data, central electronics unit, flight safety outputs, flight display, data recorder, playback transport, central processing unit, and ground display.

The conclusions which were reached are summarized as follows:

- Digital system
- Use of existing sensors where possible
- Commonality of added sensors with those existing
- Need for documentary data
- Solid state multiplexing
- Existing aircraft indicators for flight safety
- Digital recorder
- Printer for ground display
- Need for data compression
- No telemetry
- Cartridge loading magnetic tape recorder

Recommendations will be made for the remaining hardware considerations in Phase C.

3.4 AIDAP SYSTEM HARDWARE CONFIGURATION AND DESCRIPTION

3.4.1 Scope

This section establishes the AIDAP system conceptual hardware applied configurations and the basic descriptive elements for the subject hardware. The equipment is configured around a constant AIDAP system functional capability, subsequently referred to as the functional base. This functional base supports aircraft subsystems fault detection and diagnosis, and performance prognosis. The complexity of hardware application is essentially controlled by this functional base.

3.4.1.1 Considerations

The hardware configurations and basic design were based upon the following considerations and criteria. The aircraft monitoring activities, defined in Table 2.3-3 of this report, were assessed with respect to the degree of impact on inspection and maintenance activities at the Army aviation organizational support level. The monitored parameters adaptability to instrumentation mechanization was also considered. This assessment established a generic set of parameter types for a basic AIDAP system.

Weighted indexes were assigned to the selected parameter types to relate them to signal conditioning and processing circuit complexities. Parameter counts were then established for each of the aircraft groups defined in Table 2.3-17. The assigned counts were based upon an evaluation of parametric quantities required to permit satisfactory inspection of the aircraft subsystems and upon previous monitoring application experience on similar aircraft The parameter indexes were then summed to establish "Weighted Sensor Count" (WSC) values for each of the subject aircraft groups. These values were utilized to establish the circuit sizing within the conditioning and processing hardware. This application is discussed herein under section 3.4.2.1.

3.4.1.2 Hardware Configurations

A modular hardware concept was selected and applied in the following three basic AIDAP system configurations:

- Hybrid
- Airborne
- Ground

The modular approach permits the adaptability of the basic data acquisition and processing units to a variety of AIDAP system application requirements. Reasonable expansion of conditioning and processing capabilities may be introduced without any change to a modular envelope and without significant change in weight. Solid state MOS integrated digital circuit devices are applied to the greatest degree possible to minimize power requirements, modular weight and cost. As previously noted, the hardware configuration is based on a constant AIDAP functional base. Likewise the modular units internal configurations are essentially controlled by this same base. A reduction of this base can be readily adapted to by eliminating a specific modular element and as necessary, incorporating a desired functional replacement within a remaining unit without affecting the aircraft/AIDAPS peripheral interface design.

3.4.1.2.1 Hybrid Configuration

Figure 3.4-1 Configuration I, depicts a hybrid allocation of AIDAP system hardware. The hardware elements utilized within the configurations and their functional purpose(s) are briefly discussed in the following text.

3.4.1.2.1.1 "Flight Data Entry Panel" (FDEP)

The FDEP is utilized to provide the following functions:

- Manual/Automatic insertion of aircraft "Documentary Data" (DOCD)
- Power and operational mode control of a voice warning unit.
- Primary power control of an airborne digital processor, when applied to the AIDAP system.

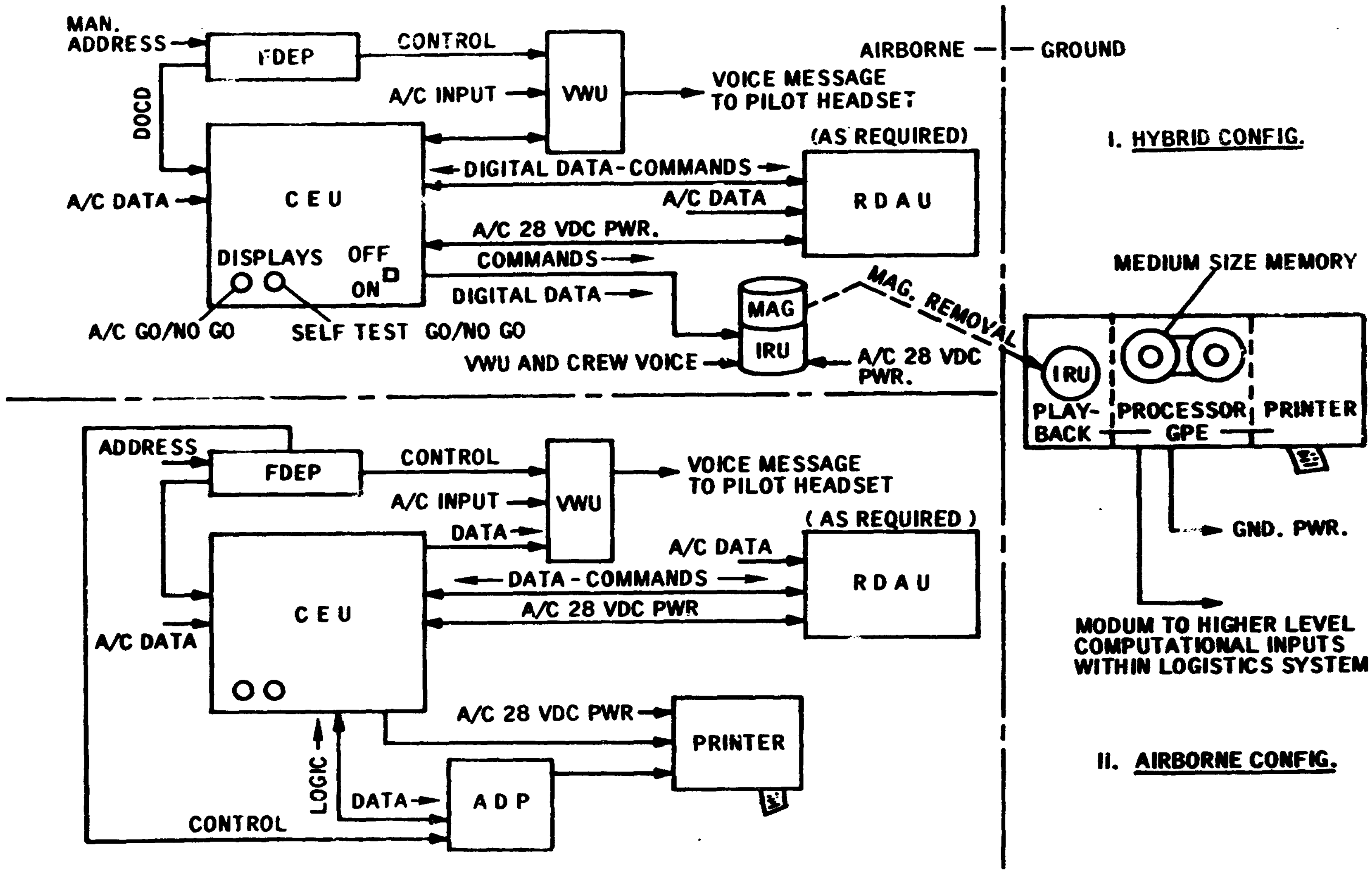
3.4.1.2.1.2 "Voice Warning Unit" (VWU)

The VWU is utilized to enhance aircraft and crew inflight safety.

The unit performs the following:

- Accepts, conditions and processes sensor analog data from selected flight critical aircraft parameters in a direct mode and via digital data from a central electronics unit.

FIGURE 3.4-1 AIDAPS EQUIPMENT CONFIGURATION



- Provides control logic for selection of pre-recorded voice warning messages and outputs voice messages to the pilot headset and to an inflight magnetic tape recorder for data storage.

3.4.1.2.1.3 "Central Electronics Unit" (CEU)

The CEU is the basic data acquisition and processing module for the system. It serves the following purpose(s):

- Accepts sensor analog data from selected aircraft parameters in a direct mode and via digital data from a remote data acquisition unit.
- Provides aircraft interface circuit isolation.
- Performs signal noise filtering, operational process control, multiplexing, conditioning, analog-to-digital signal conversion, data compression, computational analysis and record process control.
- Provides appropriate displays for visual monitoring of selected aircraft subsystems and AIDAP system operational status, i.e., go/no-go.
- Outputs timing and operational logic data to the VWU, remote data acquisition unit and to an inflight recorder unit.
- Outputs inspection and diagnostic digital data to the inflight recorder unit for data storage, and to an airborne digital processor when applied in the AIDAPS pure airborne configuration.

3.4.1.2.1.4 "Remote Data Acquisition Unit" (RDAU)

The RDAU is primarily used to permit the adaptability of the basic CEU to aircraft types of significantly different complexities. This configuration approach also reduces the harness wire weight normally required between remote sensing areas and a centrally located data conditioning and processing unit.

The functional purpose(s) are as follows:

- Accepts sensor analog data from selected aircraft parameters; provides aircraft interface circuit isolation; performs signal noise filtering, operational process control, signal multiplexing and analog-to-digital signal conversion.

- Outputs digital data to the CEU for subsequent processing functions as previously described.

Primary power to the RDAU and the CEU is locally provided by aircraft 28 vdc power. Power regulation is integral with each of the units.

3.4.1.2.1.5 "Inflight Recorder Unit" (IRU)

The IRU is utilized for inflight data storage. It is an incremental speed, four track cartridge type magnetic tape recorder. The tape motion is automatically controlled by the CEU output data logic. The data tracks consists of

- One audio channel
- Two digital data channels
- One time data channel

The unit is a split case design which permits quick removal of the tape cartridge for conveyance to the ground processing equipment for data reconstruction and readout. The IRU accepts the following data inputs:

- Digital data from the CEU
- Voice data from the VWU and/or the crew.

3.4.1.2.1.6 "Ground Processing Equipment" (GPE)

The GPE is utilized for flight line data reconstruction and data printout. It is a ground portable or airmobile unit. It consists of modular segments identified as

- Magnetic tape reproducer
- Data processor with a medium size magnetic tape memory
- Non-impact hardcopy data printer

The GPE accepts data in the following configurations:

- Magnetic tape cartridge from A/C recorder
- Aircraft data via a remote data acquisition unit and hardware umbilical
- System checkout and test data from gr[illegible]st support equipment.

The unit also has the following capabilities:

- Long term data storage
- Performs long term data trending
- Outputs data to higher maintenance levels when logistic interface capability permits such.

3.4.1.2.2 Airborne Configuration

Figure 3.4-1 Configuration II depicts a pure airborne allocation of AIDAP system hardware. The FDEP, CEU, VWU and RDAU are the same basic physical units and perform the same functions as described for the hybrid configuration. An "Airborne Digital Processor" ADP is applied to perform real-time on-condition performance prognosis.

3.4.1.2.3 Ground Configuration

Figure 3.4-2 depicts a pure ground based allocation of AIDAP system hardware. The RDAU is the same basic package described for the hybrid configuration. It is sized such that it can be used as a ground based data acquisition unit. Multiple units are employed as required. The RDAU is temporarily installed in the aircraft and interfaces with the ground umbilical cable. It accepts sensor analog data from selected aircraft parameters and performs operations as previously described. Digital data is transmitted via the hardwire umbilical cable to the GPE for data compression; computational processing for inspection, diagnostic and prognostic data; record process control and hardcopy data printout. The GPE processor provides timing and control logic for system operation.

3.4.2 Hardware Description

Figures 3.4-3 through 3.4-10 describes each of the AIDAP system hardware units in terms of signal interfaces, weight, size, input power, and cost. In addition, basic electronic "Printed Circuit Board" (PCB) configurations are described where applicable.

FIGURE 3.4-2 AIDAPS EQUIPMENT CONFIGURATION

III. GROUND CONFIG.

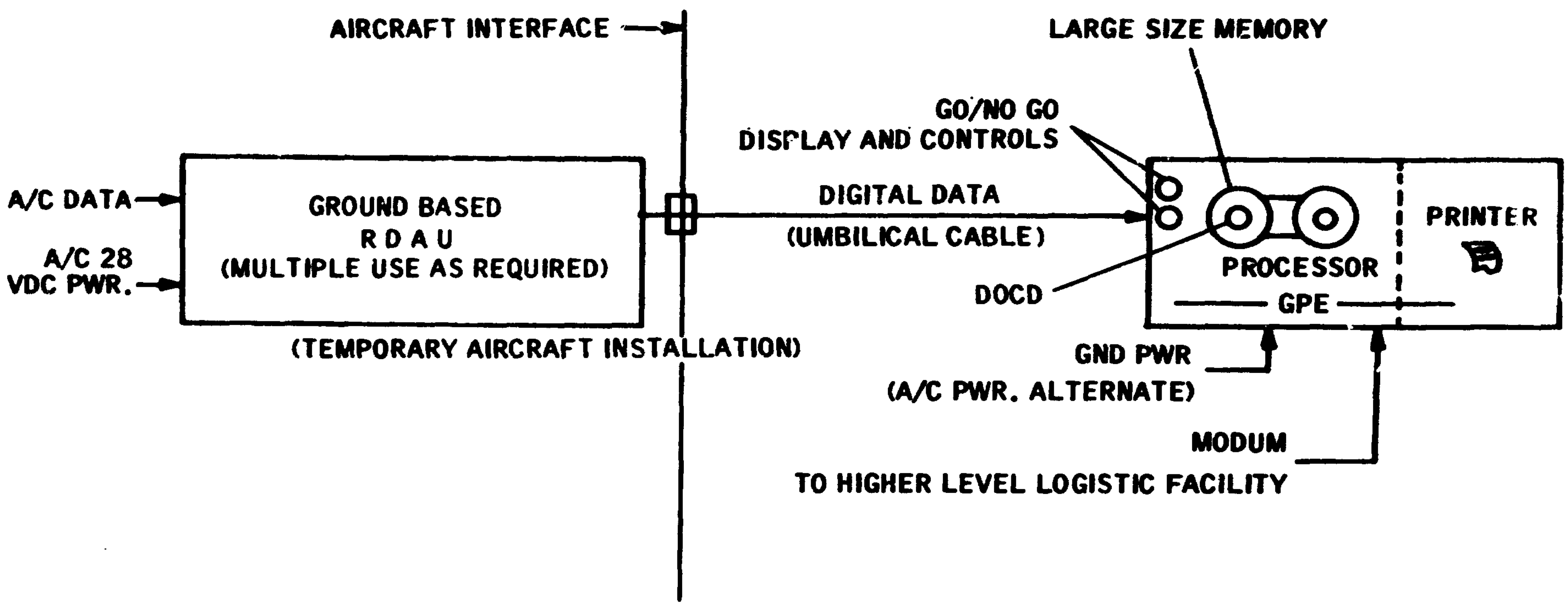
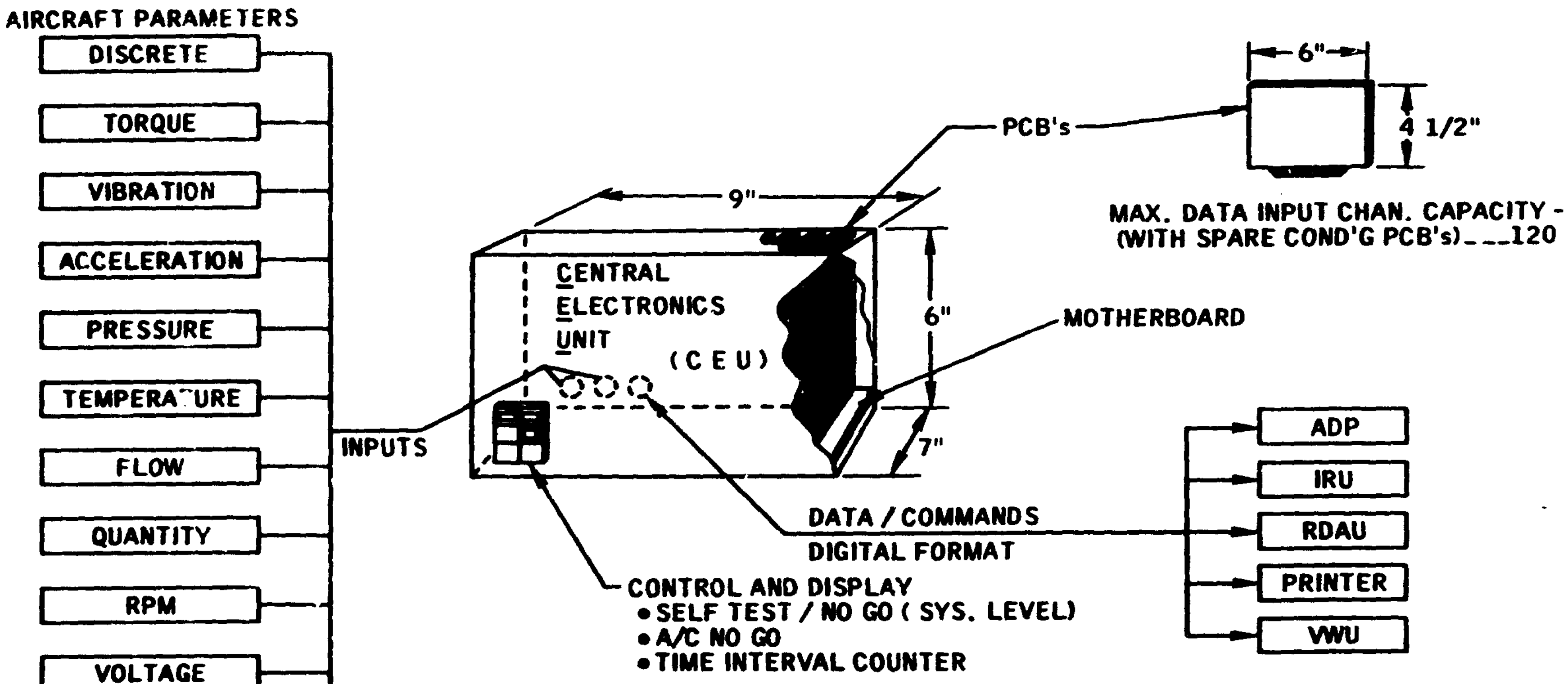


FIGURE 3.4-3 AIDAPS CEU HARDWARE DESCRIPTION (BASIC)



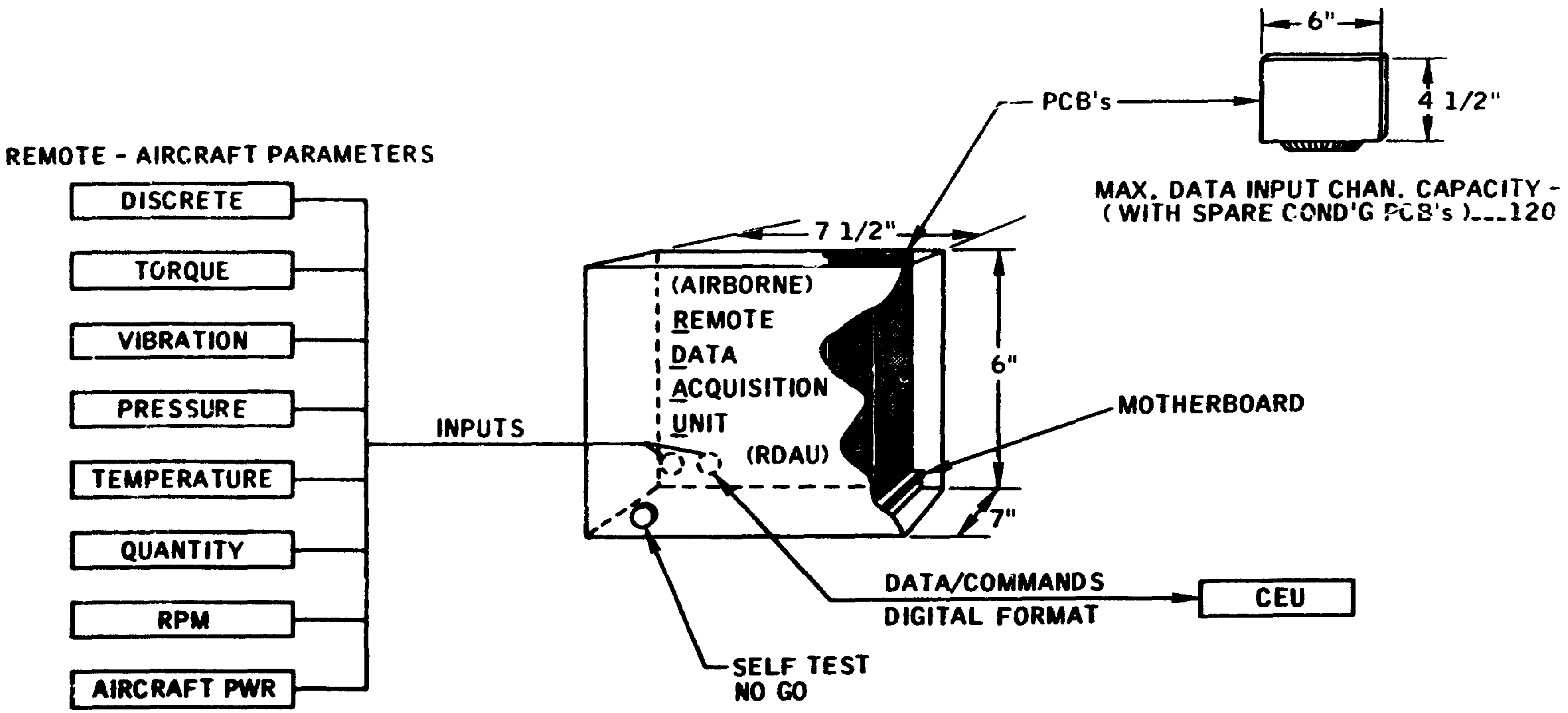
PHYSICAL DATA:	(BASIC)*
PCB CONFIG. - LEVEL 1 MUX ---- 2 CONDITIONING ---- 5 LEVEL 2 MUX ---- 1 A/D CONV. / PROCESSOR ---- 2 COMPUTATION LOGIC ---- 2 MEMORY ---- 1 PWR. REG. AND RECORD CONT. ---- 1 MOTHERBOARD ---- 1 • ISOLATION • BUSING LOGIC	WT. ---- 9.0 LBS PWR. ---- 30 WATTS AT 28 VDC VOL. ---- 0.22 FT^3 COST DATA: ≈ $ 8.4 K WITH CHASSIS AND CONNECTORS

NOTES:
ALL DATA IS TENTATIVE

* APPLICABLE TO AIDAPS A/B AND HYBRID CONFIG'S WITH A/B MEDIUM ANALYSIS.

VALUES VARY WHEN APPLIED TO AIDAPS HYBRID CONFIG. WITH A/B SIMPLE ANALYSIS.

FIGURE 3.4-4 AIDAPS RDAU HARDWARE DESCRIPTION (BASIC)



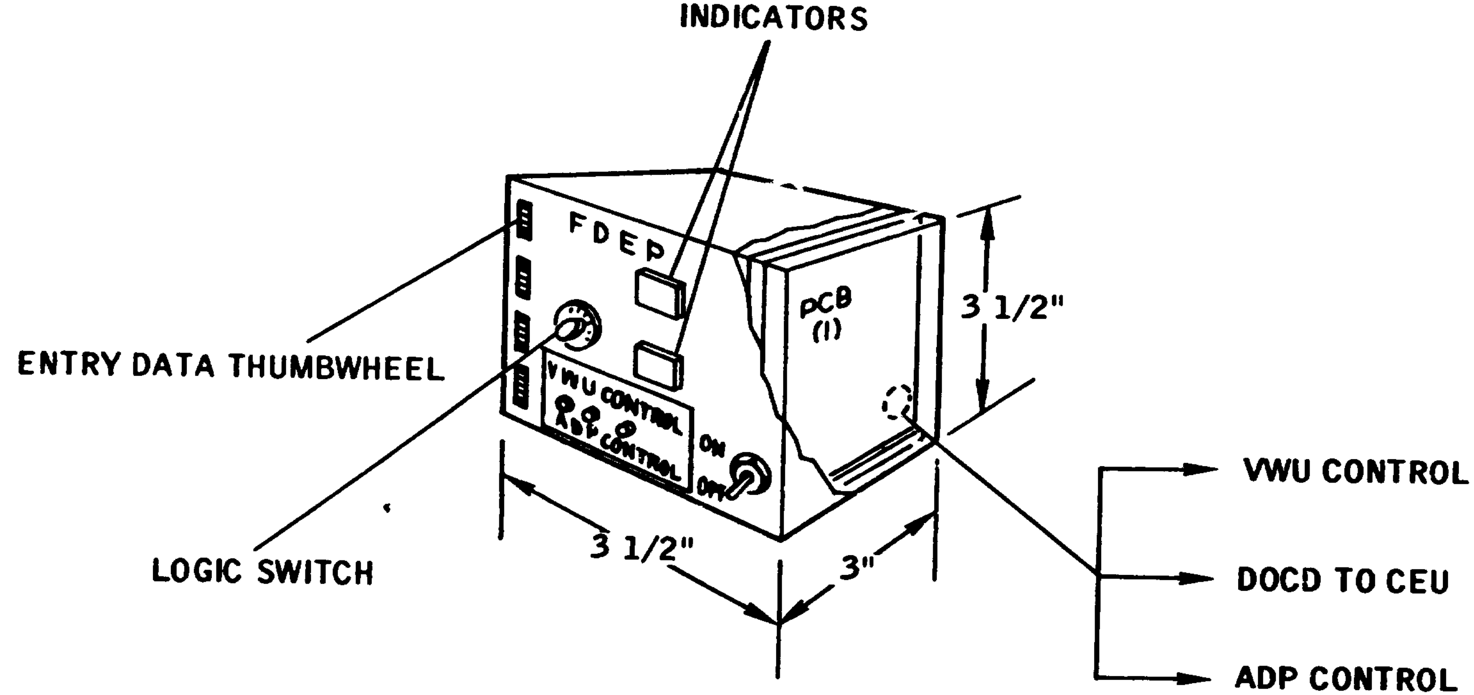
PHYSICAL DATA:	(BASIC)*
PCB CONFIG. - LEVEL 1 MUX ---------- 2 CONDITIONING ---------- 5 LEVEL 2 MUX ---------- 1 A/D CONV./ PROCESSOR ----- 1 PWR. REG. ---------- 1/2 MOTHERBOARD ---------- 1 ● ISOLATION ● BUSING LOGIC	WT.------8 LBS PWR.----25 WATTS AT 28 VDC VOL.----0.12 FT^3 COST DATA: ≈ $6.5K WITH CHASSIS AND CONNECTORS

NOTE:

ALL DATA IS TENTATIVE

* VARIES WHEN APPLIED AS A G/B UNIT.

FIGURE 3.4-5 AIDAPS FDEP HARDWARE DESCRIPTION



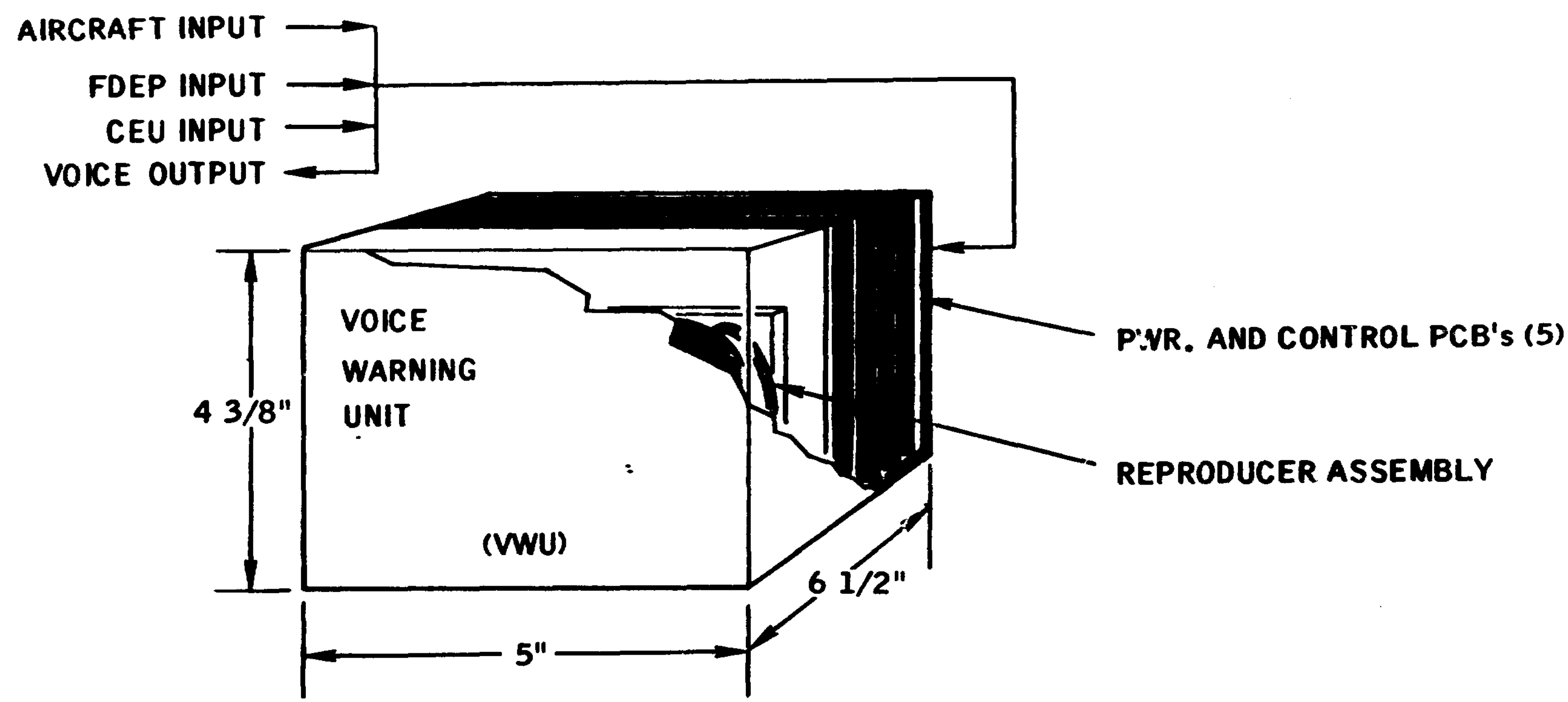
FLIGHT DATA ENTRY PANEL (FDEP) DATA:

WT. _ _ _ ≈ 12 OZ.

COST _ _ _ ≈ $ 0.2K

NOTE:
ALL DATA IS TENTATIVE

FIGURE 3.4-6 AIDAPS VWU HARDWARE DESCRIPTION

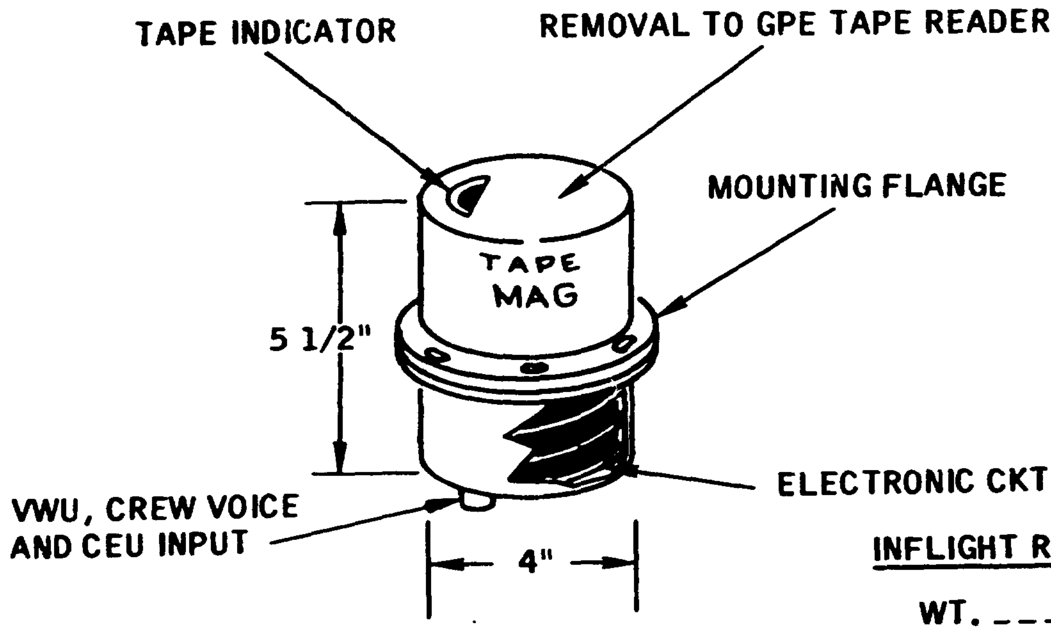


VWU DATA:

WT. ________ ≈ 4.5 LBS.
COST _______ ≈ $5.0 K
INPUT PWR. REQ'MTS ___15 WATTS AT 28 VDC

NOTE:
ALL DATA IS TENTATIVE

FIGURE 3.4-7 AIDAPS IRU HARDWARE DESCRIPTION



INFLIGHT RECORDER UNIT (IRU) DATA:

WT. ------ ≈ 3.5 LBS.

COST ---- ≈ $3.0 K

INPUT PWR. REQ'MTS ----15 WATT AT 28 VDC

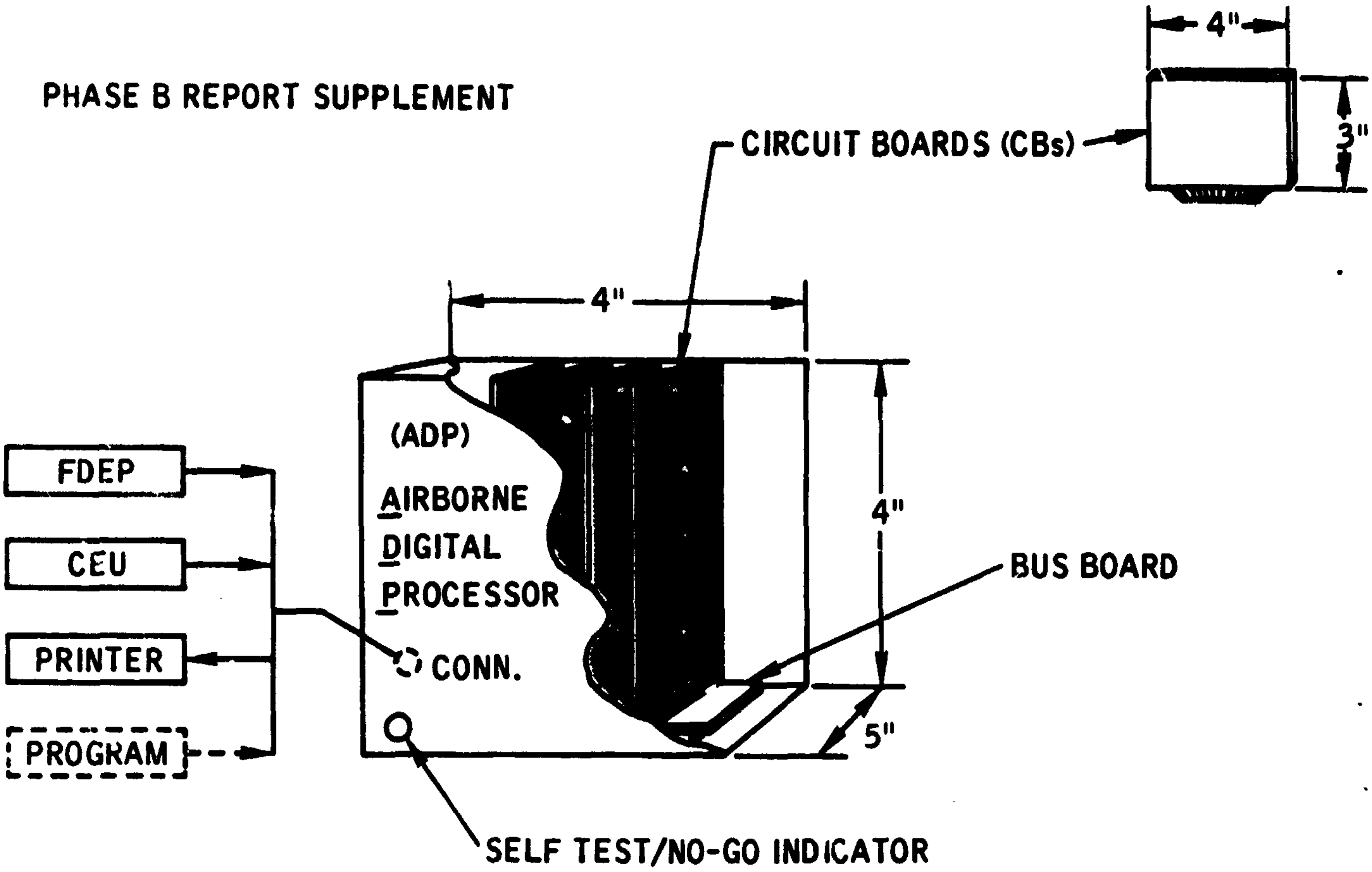
4 TRACK ----

- 1 AUDIO
- 1 TIME
- 2 DIGITAL

NOTE:
ALL DATA IS TENTATIVE

FIGURE 3.4-8 AIDAPS ADP HARDWARE DESCRIPTION

PHASE B REPORT SUPPLEMENT

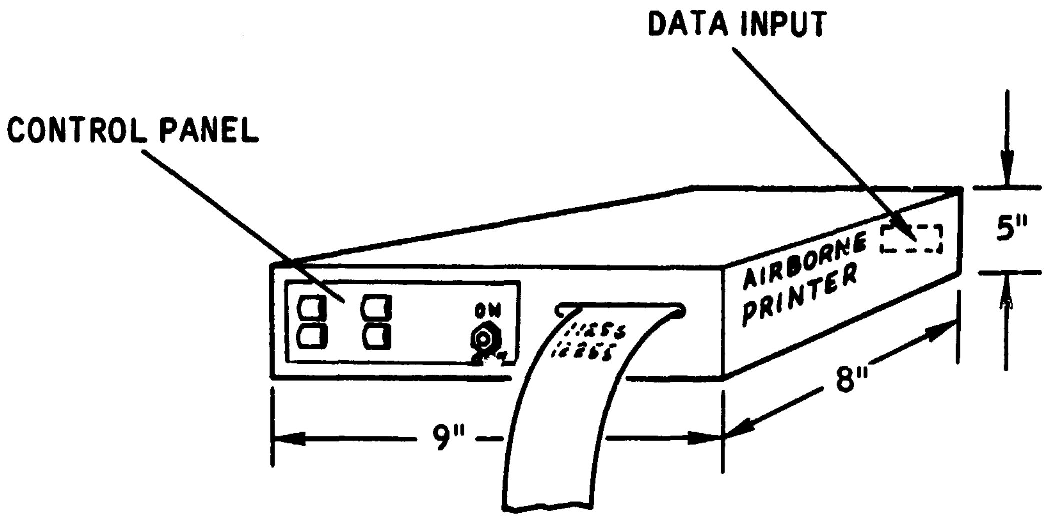


PHYSICAL DATA:	(BASIC)
CB CONFIG.-	WT.______2.5 LBS
INPUT/OUTPUT (I/O)______1	PWR.___20 WATTS AT 28 VDC
PROCESSOR___________1	VOL.___0.046 FT^3
MAGNETIC MEMORY______1	**COST DATA:**
ROM AND RAM__________1	≈ $2.0K
SPARES______________2	WITH CHASSIS AND
BUS BOARD____________1	CONNECTOR

NOTE:

ALL DATA IS TENTATIVE

FIGURE 3.4-9 AIDAPS A/B PRINTER HARDWARE DESCRIPTION

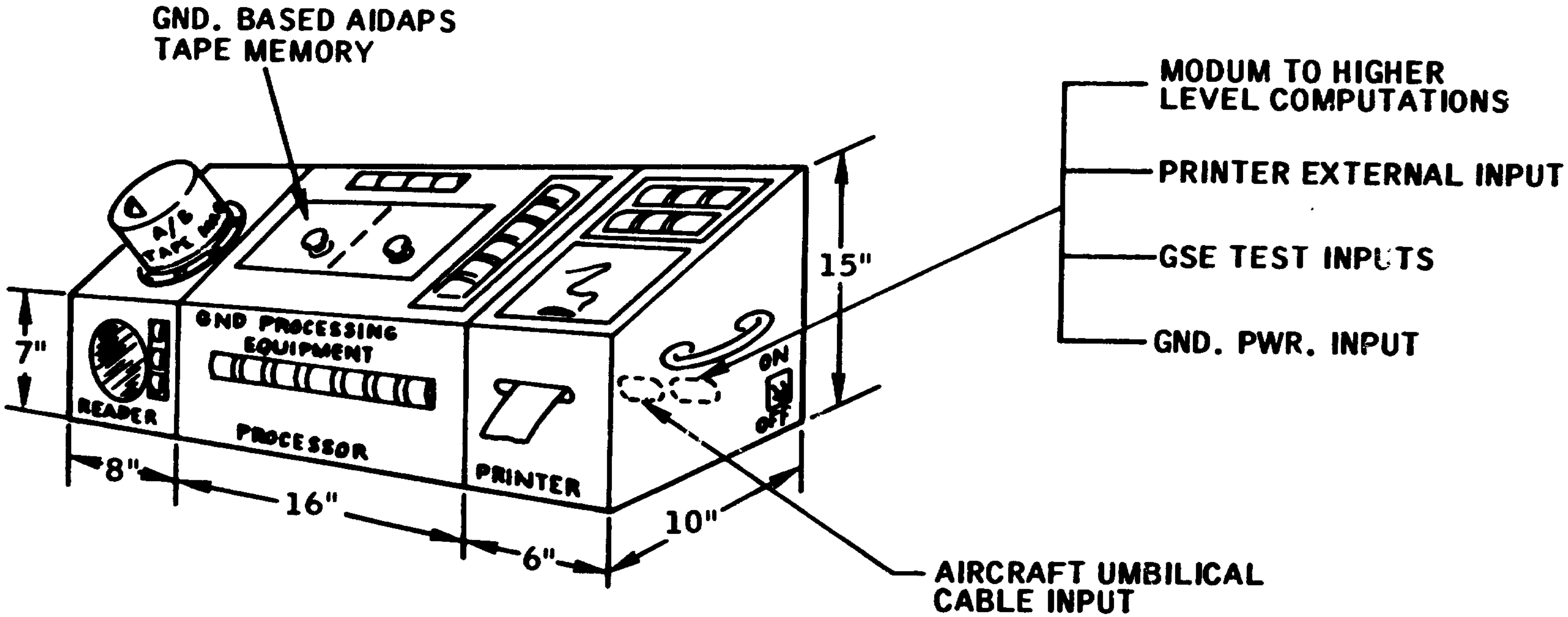


PRINTER DATA:

NON-IMPACT TYPE -
WT. _ _ _ _ _ _ _ _ ≈ 5 LBS.
COST _ _ _ _ _ _ ≈ $6 K
PRINT RATE _ _ _ _
30 CPS, 300 WORDS/MIN.
PAPER WIDTH _ _ _ _ _ ≈ 3 5/8"
PRINT MEDIUM _ _ _ _ _ THERMAL
INPUT PWR. REQ'MTS _ _ 10 WATTS AT 28 VDC

NOTE:
ALL DATA IS TENTATIVE

FIGURE 3.4-10 AIDAPS GPE HARDWARE DESCRIPTION



GPE DATA: (DEPENDENT ON AIDAP CONFIG. APPLICATION)

AIDAP CONFIG.	WT.	COST	DELTA BETWEEN AIDAPS CONFIGURATION
HYBRID - A/B (A)S	33	$17.2K	ADDT'L DIGITAL PROCESSING AND MEDIUM SIZE MEMORY
HYBRID - A/B (A)M	30	$14.7K	BASIC
GROUND BASED	40	$25.0K	ADDED DIGITAL PROCESSING, SPECIAL COMPUTATIONAL ANALYSIS AND LARGE SIZE MEMORY. DELETED DATA REPRODUCER/ READER

NOTE:
ALL DATA SUBJECT TO CHANGE
BASED ON MODEL ANALYSIS

3.4.2.1 Printed Circuit Board Sizing

As previously discussed in section 3.4.1.1, the aircraft weighted sensor count (WSC) values were used to establish the circuit sizing for the signal conditioning boards within the CEU and RDAU. An effective PCB unit circuit area of 1/2 square inch was established for an average complexity of signal conditioning. The aircraft grouping WSC values were summed, an average value computed and then multiplied by the effective unit circuit area to establish the total circuit area required for conditioning for an AIDAP system basic hardware configuration. Utilizing a PCB size of 4.5" x 6" with an effective circuit area of 21 square inches, the number of conditioning PCB's was established by dividing the required circuit area by the board's effective circuit area. PCB's for multiplexing, analog-to-digital signal conversion, computational processing, power regulation and record process control were also sized based upon current circuit design technology.

Spare PCB slots are provided for design adaptability to varied aircraft parameter types and counts. Operational bus boards referred to as mother boards are utilized within the CEU and RDAU to permit interchangable PCB positioning. The operational bus approach also contributes to the simplification of hardware configuration control.

3.4.2.2 Parameter Input Capacity

The parameter input capacity, for any given configuration of the AIDAP system hardware modules illustrated, is dependent upon the application of the RDAU. The subject capacity for the individual CEU and RDAU units will be dictated by connector sizing and permissible wire interfaces on the operational bus boards, dedicated conditioning and first level multiplexing PCB's. The tentative assigned input capability for the units are 80 to 120 for the CEU and 60 to 90 for the RDAU. The input capability for the VWU is tentatively defined as 40 to 60.

3.4.2.3 Data Processing Capacity

The data processing capacity of the AIDAP system hardware modules illustrated, is dependent upon design factors related to conditioning and processing circuit time sharing, data compression logic, and time variables throughout the diagnostic and prognostic processing routines. The major factors which will prescribe the processing design are the final selection of aircraft parameter types, quantities and data contribution. The final parameter selection and the inherent processing capability of the AIDAP system configuration(s) selected during the Phase C tradeoff studies, will be defined in the proposed system specification.

3.4.2.4 Hardware Sizing and Cost Data

The subject data as described in Figures 3.4-3 through 3.4-10 are based upon an assessment of the current solid state circuit fabrication and packaging technologies, material availability, volume purchasing of production units, and aircraft data system hardware applications currently being programmed.

3.4.3 Aircraft Groups and Applied Hardware

Tables 3.4-1 through 3.4-20 describe the specific application(s) of the previously discussed hardware units for each of the concerned aircraft groups. Parameter information as related to type, count, sensor availability, added sensor cost and weight (includes harness wire weight) is provided in columns one through five. AIDAP system hardware information as related to identity, basic and added PCB configuration, weight, volume and cost is provided in columns 6 through 11. comments are provided to reference applied data and to describe the specific hardware configuration functional capabilities.

The model analysis notation C_{a_1} (AIDAPS Unit Cost), added Airborne Total Weight (ATW) and AIDAPS airborne input power requirements are computed for each configuration as shown in Table 3.4-1. The unit cost of the GPE hardware is distributed over a tentative utilization of 15 aircraft for the hybrid configurations. This allocation was based upon a maximum data recovery run time of 10 minutes per data run. Therefore 30 data runs could be performed in an established daily GPE utilization of 5 hours per day. Assuming an average of two aircraft flights per day, the aircraft utilization per GPE would be 15.

The AIDAP system cost for the ground based configuration is distributed over a tentative utilization of five aircraft. This distribution was based upon a minimum setup and run time of 30 minutes per aircraft. Therefore assuming 2 flights per day per aircraft, 5 aircraft could be tested in a 5-hour period by 1 ground based system.

All data provided is tentative and will be finalized during the Phase C study effort. Only minor changes are foreseen. The changes will be affected by the possible differences between the parameter type and count currently identified and the selection resulting from the Phase C analysis of the actual aircraft maintenance histories.

AIRCRAFT: OH-6 & OH-58 GROUP: 1 AIDAP SYSTEM BASE: AIRBORNE - (REF. CONFIG. II)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{7a} = A/B |(I)S · (C)C · (A)C · (D)M|

WEIGHTED SENSOR COUNT (WSC): 189

TABLE 3.4-1

SENSOR/PARAMETER DATA						AIDAPS HARDWARE IDENTITY	PCB CONFIG.		WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
TYPE	COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)			BASIC	DELTA				
DISCRETE	13	2				CEU	X		9.0	0.22	8.4	All Data is Tentative
TORQUE	1											
VIBRATION		4				VWU	X		4.5	0.08	1.0*	Functional Capability:
ACCELERATION		3										• Fault Inspection
PRESSURE		7				FDEP	X		0.5	0.02	0.2	• Fault Diagnosis
TEMPERATURE	2	6										• Broad Band Performance
FLOW		1				PRINTER	X		5.0	0.20	6.0	Prognosis
QUANTITY	1											• Flt. Safety Monitor
RPM	3					ADP	X		2.5	0.046	2.0	
VOLTAGE	2											*1/5 of Cost Applied to
CURRENT	1											AIDAPS for Flt. Safety
DOCD	X											over and above that which
VOICE	X											is currently provided.
DISPLAYS	X											
TOTALS	23	23	4.8	13.8					21.5	1.564	17.6	

Added A/B wt. = $A_{TW} = A_{SW} + E_W$

Where: A_{SW} = added sensor & wire wt.

E_W = AIDAPS Equip. wt.

AT_W = 13.8 + 21.5

= 35.3 lbs.

A/B PWR. Req'mt. = A_P = 75 watts at 28 VDC

AIDAPS UNIT COST = $C_{a1} = A_{cc} + E_{ac} + \frac{E_{gc}}{n}$

where: C_{a1} = Model Cost Notation

n = number of aircraft serviced

A_{SC} = cost of added sensors and wiring harness

E_{ac} = cost of AIDAPS airborne equipment

E_{gc} = cost of AIDAPS ground equipment

C_{a1} = 4.8 + 17.6 + 0

= $ 22.4 K

PHASE B REPORT

AIRCRAFT: OH-6 & OH-58 GROUP: 1 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: $S_{1_a} = A/B\ |(I)S \cdot (C')C \cdot (A)S \cdot (D)S| \cdot G/B\ |(A)C \cdot (D)M|$

WEIGHTED SENSOR COUNT (WSC): 189

TABLE 3.4-2

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	13	2			CEU	X	Δ	5.0	0.12	5.6	All Data is Tentative
TORQUE	1										ΔNo Flt. Comput. Logic
VIBRATION		4			VWU	X		4.5	0.08	1.0*	Functional Capability:
ACCELERATION		3									A/B-[illegible].Mode Control Sn
PRESSURE		7			FDEP	X		0.5	0.02	0.2	Shot Recording
TEMPERATURE	2	6									• Flight Safety Monitor
FLOW		1			IRU	X		3.5	0.04	3.0	G/B -Fault Detection an
QUANTITY	1										Diagnosis and Performan
RPM	3				A/B Totals			13.5	0.26	9.8	Prognosis
VOLTAGE											
CURRENT											
DOCD		X			GPE	X		33.0		17.2	GPE Cost is Distributed
VOICE		X									over 15 aircraft at the
DISPLAYS	X										organizational level.
TOTALS	23	23	4.8	13.8							*1/5 of Cost Applied to AIDAPS for Additional Flight Safety.

$A_{TW} = 13.8 + 13.5$
$= 27.3$ lbs.

$A_P = 60$ watts at 28 VDC

$C_{a1} = 4.8 + 9.8 + \frac{17.2}{15}$
$= \$15.7K$

PHASE B REPORT

AIRCRAFT: OH-6 & OH-58 GROUP: 1 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{2a} = A/B |(I)S · (C')C · (A)M · (D)S| · G/B |(A)C · (D)M|

WEIGHTED SENSOR COUNT (WSC): 189

TABLE 3.4-3

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	13	2			CEU	X		9.0	0.22	8.4	All Data is Tentative
TORQUE	1										
VIBRATION		4			VWU	X		4.5	0.08	1.0*	
ACCELERATION		3									
PRESSURE		7			FDEP	X		0.5	0.02	0.2	Functional Capability:
TEMPLRATURE	2	6									A/B- • Fault Inspection
FLOW		1			IRU	X		3.5	0.04	3.0	• Fault Diagnosis
QUANTITY	1										• Flt. Safety Monitor
RPM	3				A/B Totals			17.5	0.36	12.6	
VOLTAGE	2										G/B- • Broad Band Per-
CURRENT	1										formance Prognosis
DOCD		X			GPE			30.0	14.7		
VOICE		X									
DISPLAYS	X										*1/5 of cost applied to
TOTALS	23	23	4.8	13.8							AIDAPS for additional Flight Safety

A_{TW} = 13.8 + 17.5

= 31.3 lbs.

A_P = 60 watts at 28 VDC

$C_{ai} = 4.8 + 12.6 + \frac{14.7}{15}$

= $18.4K

PHASE B REPORT

AIRCRAFT: OH-6 & OH-58 GROUP: 1 AIDAP SYSTEM BASE: GROUND-(REF.CONFIG. III)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{8_a} = A/B (I)S · G/B |(C')C · (A)C · (D)M|

WEIGHTED SENSOR COUNT (WSC): 189

TABLE 3.4-4

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	13	2			RDAU(G/B)	X		8.0	0.12	6.5	All data is tentative
TORQUE	1										
VIBRATION		4			GPE	X		40.0	–	25.0	(C) Cond'g. PCB's Added
ACCELERATION		3									
PRESSURE		7									Functional Capability:
TEMPERATURE	2	6									• Fault Inspection
FLOW		1									• Fault Diagnosis
QUANTITY	1										• Limited/Narrow Band
RPM	3										Performance Prognosis
VOLTAGE	2										
CURRENT	1										
DOCD	X										
VOICE	X										
DISPLAYS	X										
TOTALS	23	23	4.8	13.8				48.0	0.12	31.5	

$A_{TW} = 13.8 + 8$

$= \underline{21.8}$ lbs.

$C_{a1} = 4.8 + 0 + \frac{31.5}{5}$

$= \underline{\$11.1K}$

NOTE: RDAU is temporarily installed within aircraft during data acquisition period.

PHASE B REPORT

AIRCRAFT: UH-1 & AH-1 GROUP: 2 AIDAP SYSTEM BASE: AIRBORNE - (REF. CONFIG. II)

EQUIVALENT AIDAP SYS. EXPRESSION: $S_{7_b} = A/B\ [(I)M \cdot (C)C \cdot (A)C \cdot (D)M]$

WEIGHTED SENSOR COUNT (WSC): 233

TABLE 3.4-5

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	17	2			CEU	X	1(C)	9.3	0.22	8.8	All data is tentative
TORQUE	1										(C) Cond'g. PCB Added
VIBRATION		5			VWU	X		4.5	0.08	1.0*	Functional Capability:
ACCELERATION		3									• Fault Inspection
PRESSURE	4	5			FDEP	X		0.5	0.02	0.2	• Fault Diagnosis
TEMPERATURE	3	10									• Broad Band Performance
FLOW		1			PRINTER	X		5.0	0.20	6.0	Prognosis
QUANTITY	1										• Flt. Safety Monitor
RPM	3				ADP	X		2.5	0.046	2.0	
VOLTAGE	3										
CURRENT	1										*Refer to note for GRP
DOCD		X									I A/C
VOICE		X									
DISPLAYS	X										
TOTALS	33	26	5.2	15.6				21.8	0.566	18.0	

$A_{TW} = 15.6 + 21.8$
$= 37.4$ lbs.

$C_{a1} = 5.2 + 18.0 + 0$
$= \$23.2K$

$A_P = 75$ watts at 28 VDC

PHASE B REPORT

AIRCRAFT: UH-1 & AH-1 GROUP: 2 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{3_a} = A/B [(I)M · (C)C · (A)S · (D)S] · G/B [(A)C · (D)M]

WEIGHTED SENSOR COUNT (WSC): 233

TABLE 3.4-6

SENSOR/PARAMETER DATA					AIDAPS HARDWARE IDENTITY	PCB CONFIG.		WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
TYPE	COUNT		*COST ($K)	*WT (lb)		BASIC	DELTA				
	EXIST	ADD*									
DISCRETE	17	2			CEU	X	Δ	5.3	0.12	6.0	All Data is tentative
TORQUE	1						1(c)				Δ No Flt. Computational
VIBRATION		5			VWU	X		4.5	0.08	1.0*	Logic.
ACCELERATION		3									(C) cond'g. PCB added
PRESSURE	4	5			FDEP	X		0.5	0.02	0.2	FUNCTIONAL CAPABILITY:
TEMPERATURE	3	10									A/B- • Flt. Mode Control
FLOW		1			IRU	X		3.5	0.04	3.0	Snap Shot Recording
QUANTITY	1										• Flt. Safety Monitor
RPM	3				A/B Totals			13.8	0.26	10.2	G/B- •Fault Detection &
VOLTAGE	3										Diagnosis and Performance
CURRENT	1										Prognosis
DOCD		X			GPE	*		33.0	-	17.2	Refer to GRP I A/C GPE Co
VOICE		X									Note
DISPLAYS	X										*Refer to GRP I A/C Note
TOTALS	33	26	5.2	15.6							

A_{TW} = 15.6 + 13.8

= 29.4 lbs.

A_p = 60 Watts at 28 VDC

$C_{a1} = 5.2 + 10.2 + \frac{17.2}{15}$

= \$16.6 K

PHASE B REPORT

AIRCRAFT: UH-1 & AH-1 GROUP: 2 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{4_a} = A/B · |(I)M (C)C · (A)M · (D)S| · G/B (A)C · (D)M|

WEIGHTED SENSOR COUNT (WSC): 233

TABLE 3.4-7

SENSOR/PARAMETER DATA					AIDAPS HARDWARE IDENTITY	PCB CONFIG.		WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
TYPE	COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)		BASIC	DELTA				
DISCRETE	17	2			CEU	X	(C)	9.3	0.22	8.8	All data is tentative
TORQUE	1										
VIBRATION		5			VWU	X		4.5	0.08	1.0*	(C) Cond'g. PCB Added
ACCELERATION		3									
PRESSURE		5			FDEP	X		0.5	0.02	0.2	FUNCTIONAL CAPABILITY:
TEMPERATURE		10									A/B- • FAULT INSPECTION
FLOW		1			IRU	X		3.5	0.04	3.0	• Fault Diagnosis
QUANTITY											• Flt. Safety Monitor
RPM					A/B Total			17.8	0.36	13.0	G/B- • Broad Band Per-
VOLTAGE											formance Prognosis
CURRENT											
DOCD		X			GPE			30.0	-	14.7	
VOICE		X									*Refer to GRP I A/C Note
DISPLAYS	X										
TOTALS	33	26	5.2	15.6							

A_{TW} = 15.6 + 17.8

= 33.4 lbs.

A_P = 60 watts at 28 VDC

$C_{a1} = 5.2 + 13.0 + \frac{14.7}{15}$

= $19.2 K

PHASE B REPORT

AIRCRAFT: UH-1 & AH-1 GROUP: 2 AIDAP SYSTEM BASE: GROUND - (REF. CONFIG. III)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{9_a} = A/B (I)M · G/B (C)C · (A)C · (D)M

WEIGHTED SENSOR COUNT (WSC): 233

TABLE 3.4-8

TYPE	SENSOR/PARAMETER DATA: COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	17	2			RDAU	X	1(c)	8.3	0.12	6.9	All data is tentative
TORQUE	1										
VIBRATION		5			GPE	X		40.0	-	25.0	(C)-Cond'g PCB Added
ACCELERATION		3									
PRESSURE	4	5									FUNCTIONAL CAPABILITY:
TEMPERATURE	3	10									• Fault Inspection
FLOW		1									• Fault Diagnosis
QUANTITY	1										• Limited/Narrow Band
RPM	3										Performance Prognosis
VOLTAGE	3										
CURRENT	1										
DOCD		X									
VOICE		X									
DISPLAYS	X										
TOTALS	33	26	5.2	15.6				48.3	0.12	31.9	

A_{TW} = 15.6 + 8.3

= 23.9 lbs.

Refer to Note for GRP I A/C

$C_{a1} = 5.2 + 0 + \frac{31.9}{5}$

= \$11.5K

Refer to Note for GRP I A/C

PHASE B REPORT

AIRCRAFT: U-21 GROUP: 3 AIDAP SYSTEM BASE: AIRBORNE - (REF. CONFIG. II)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{7_c} = A/B | (I)M · (C)C · (A)C · (D)M |

WEIGHTED SENSOR COUNT (WSC): 316

TABLE 3.4-9

SENSOR/PARAMETER DATA				
TYPE	COUNT		*COST ($K)	*WT (lb)
	EXIST	ADD*		
DISCRETE	8			
TORQUE	2			
VIBRATION		5		
ACCELERATION		3		
PRESSURE	5	6		
TEMPERATURE	6	10		
FLOW	2	2		
QUANTITY	1			
RPM	3	3		
VOLTAGE	3			
CURRENT	1			
DOCD		X		
VOICE		X		
DISPLAYS	X			
TOTALS	31	29	5.8	17.4

AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
CEU	X	2(c)	10.8	0.26	9.7	All data is tentative
						(C) Cond'g. PCB's Added.
VWU	X		4.5	0.08	1.0*	
FDEP	X		0.5	0.02	0.2	FUNCTIONAL CAPABILITY:
						• Fault Inspection
PRINTER	X		5.0	0.20	6.0	• Fault Diagnosis
						• Broad Band Performance
						Prognosis
						• Flt. Safety Monitor
ADP	X		2.5	0.046	2.0	
						*Refer to GRP. I A/C Not
			23.3	0.606	18.9	

A_{TW} = 17.4 + 23.3

= 40.7 lbs.

A_P = 75 watts at 28 VDC

C_{a1} = 5.8 + 18.9 + 0

= \$24.7 K

PHASE B REPORT

AIRCRAFT: U-21 GROUP: 3 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{3_b} = A/B |(I)M · (C')C · (A)S · (D)S| · G/B |(A)C · (D)M|

WEIGHTED SENSOR COUNT (WSC): 316

TABLE 3.4-10

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	B				CEU	X	Δ	5.5	0.12	6.4	All Data is Tentative
TORQUE	2						2(c)				ΔNo Flt. Comput. Logic
VIBRATION		5			VWU	X		4.5	0.08	1.0*	(C)-Cond'g. PCB's Added
ACCELERATION		3									
PRESSURE	5	6			FDEP	X		0.5	0.02	0.2	FUNCTIONAL CAPABILITY:
TEMPERATURE	6	10									A/B-● Flt.Mode Cntrl Snap
FLOW	2	2			IRU	X		3.5	0.04	3.0	Shot Recording
QUANTITY	1										● Flt. Safety Monitor
RPM	3	3			A/B Totals			14.0	0.26	10.6	G/B- ● Fault Detection &
VOLTAGE	3										Diagnosis and Performance
CURRENT	1										Prognosis
DOCD		X			GPE			30.0	-	17.2	Refer to GRP. I A/C GPE
VOICE		X									Cost Note
DISPLAYS	X										
TOTALS	31	29	5.8	17.4							

$A_{TW} = 17.4 + 14.0$

$= 31.4$ lbs.

A_P = 60 watts at 28 VDC

$C_{a1} = 5.8 + 10.6 + \frac{17.2}{15}$

$= \$17.5K$

PHASE B REPORT

AIRCRAFT: U-21 GROUP: 3 AIDAP SYSTEM BASE: JUBROD = (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{4_b} = A/B |(I)M · (C')C · (A)M · (D)S| · G/B |(A)C · (D)M|

WEIGHTED SENSOR COUNT (WSC): 316

TABLE 3.4-11

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)
DISCRETE	8			
TORQUE	2			
VIBRATION		5		
ACCELERATION		3		
PRESSURE	5	6		
TEMPERATURE	6	10		
FLOW	2	2		
QUANTITY	1			
RPM	3	3		
VOLTAGE	3			
CURRENT	1			
DOCD		X		
VOICE				
DISPLAYS	X			
TOTALS	31	29	5.8	17.4

AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
CEU	X	2(c)	10.8	0.26	9.2	All data is tentative
VWU	X		4.5	0.08	1.0*	(C)- Cond'g. PCB's Added
FDEP	X		0.5	0.02	0.2	
						FUNCTIONAL CAPABILITY:
IRU	X		3.5	0.04	3.0	A/B- • Fault Inspection
						• Fault Diagnosis
A/B Totals			19.3	0.40	13.4	• Flt. Safety Monitor
						G/B- o Broadband Perform-
						ance Prognosis
GPE			30.0	-	14.7	Refer to GRP I A/C GPE
						cost note
						*Refer to GRP I A/C Note

A_{TW} = 17.4 + 19.3

= 36.7 Lbs.

A_P = 60 watts at 28 VDC

$C_{a1} = 5.8 + 13.4 + \frac{14.7}{15}$

= \$20.2 K

PHASE B REPORT

AIRCRAFT: U-21 GROUP: 3 AIDAP SYSTEM BASE: GROUND - (REF. CONFIG. III)

EQUIVALENT AIDAP SYS. EXPRESSION: X_{9_b} = A/B (I)M · G/B [(C')C · (A)C · (D)M]

WEIGHTED SENSOR COUNT (WSC): 316

TABLE 3.4-12

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	8				RDAU	X	2(c)	8.5	0.12	7.3	All Data is Tentative
TORQUE	2										
VIBRATION		5			GPE	X		40.0	-	25.0	(C)-Cond'g. PCB's Added
ACCELERATION		3									
PRESSURE	5	6									FUNCTIONAL CAPABILITY:
TEMPERATURE	6	10									• Fault Inspection
FLOW	2	2									• Fault Diagnosis
QUANTITY	1										• Limited/Narrow Band
RPM	3	3									Performance Prognosis
VOLTAGE	3										
CURRENT	1										
DOCD		X									
VOICE		X									
DISPLAYS	X										
TOTALS	31	29	5.8	17.4				48.5	0.12	32.3	

$A_{TW} = 17.4 + 8.5$

$= 25.9$ lbs.

Refer to Note for GRP. I A/C

$C_{a1} = 5.8 + 0 + \frac{32.3}{5}$

$= \$12.3K$

Refer to Note for GRP. I A/C

PHASE B REPORT

AIRCRAFT: OV-1 GROUP: 4 AIDAP SYSTEM BASE: AIRBORNE - (REF. CONFIG. II)

EQUIVALENT AIDAP SYS. EXPRESSION: $S_{7_d} = A/B\left[(I)C \cdot (C')C \cdot (A)C \cdot (D)M\right]$

WEIGHTED SENSOR COUNT (WSC): 333

TABLE 3.4-13

SENSOR/PARAMETER DATA					AIDAPS HARDWARE IDENTITY	PCB CONFIG.		WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
TYPE	COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)		BASIC	DELTA				
DISCRETE	13				CEU	X	2(c)	10.8	0.26	9.2	All Data is Tentative
TORQUE	2										(C) Cond'g. PCB's Added
VIBRATION		5									
ACCELERATION		3									
PRESSURE	4	8			VWU	X		▽	▽	▽	FUNCTIONAL CAPABILITY:
TEMPERATURE	6	10									• Fault Inspection
FLOW	2	2			FDEP	X		0.5	0.02	0.2	• Fault Diagnosis
QUANTITY	2										• Broadband Performance
RPM	3	3			PRINTER	X		5.0	0.20	6.0	Prognosis
VOLTAGE	3										• Flt. Safety Monitor
CURRENT	1				ADP	X		2.5	0.046	2.0	
DOCD		X									
VOICE		X									▽ Flt. Safety Unit Current-
DISPLAYS	X										ly exists on A/C
TOTALS	36	31	6.2	18.6				18.8	0.526	17.4	

$A_{TW} = 18.6 + 18.8$

$= 37.4$ Lbs.

$C_{a1} = 6.2 + 17.4 + 0$

$= \$23.3K$

$A_P = 75$ watts at 28 VDC

PHASE B REPORT

AIRCRAFT: OV-1 GROUP: 4 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: $X_{5_a} = A/B \left[(I)C \cdot (C')C \cdot (A)S \cdot (D)S \right] \cdot G/B \left[(A)C \cdot (D)M \right]$

WEIGHTED SENSOR COUNT (WSC): 333

TABLE 3.4-14

SENSOR/PARAMETER DATA					AIDAPS						
TYPE	COUNT		*COST	*WT	HARDWARE	PCB CONFIG.		WT	VOL	COST	COMMENTS
	EXIST	ADD*	($K)	(1b)	IDENTITY	BASIC	DELTA	(1b)	(cu. ft)	($K)	
DISCRETE	13				CEU	X	Δ	5.5	0.12	6.4	All Data is Tentative
TORQUE	2						2(C)				ΔNo Flt. Comp. Logic
VIBRATION		5									(C) Cond'g. PCB's Added
ACCELERATION	.	3									
PRESSURE	4	8			VWU	X					FUNCTIONAL CAPABILITY:
TEMPERATURE	6	10									A/B- • Flt. Mode Cntrl
FLOW	2	2			FDEP	X		0.5	0.02	0.2	Snap Shot Recording
QUANTITY	2										• Flt. Safety Monitor
RPM	3	3			IRU	X		3.5	0.04	3.0	G/B- • Fault Detection &
VOLTAGE	3										Diagnosis and Performance
CURRENT	1				A/B Totals			9.5	0.18	9.6	Prognosis
DOCD		X									
VOICE		X			GPE			33.0	-	17.2	Refer to GRP. I A/C GPE
DISPLAYS	X										cost note.
TOTALS	36	31	6.2	18.6							Flt. Safety Unit Currently exists on A/C

$A_{TW} = 18.6 + 9.5$

$= 28.1$ Lbs.

$A_P = 60$ Watts at 28 VDC

$C_{a1} = 6.2 + 9.6 + \frac{17.2}{15}$

$= \$16.9K$

PHASE B REPORT

AIRCRAFT: OV-1 GROUP: 4 AIDAP SYSTEM BASE: HYBRID -(REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: $S_{b_a} = A/B \left[(I)C \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$

WEIGHTED SENSOR COUNT (WSC): 333

TABLE 3.4-15

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	13				CEU	X	2(c)	10.8	0.26	9.2	All Data is tentative
TORQUE	2										(C) Cond'g. PCB's Added
VIBRATION		5									
ACCELERATION		3									
PRESSURE	4	8			VWU	X		▽	▽	▽	
TEMPERATURE	6	10									FUNCTIONAL CAPABILITY:
FLOW	2	2			FDEP	X		0.5	0.02	0.2	A/B- • Fault Inspection
QUANTITY	2										• Fault Diagnosis
RPM	3	3			IRU	X		3.5	0.04	3.0	• Flt. Safety Monitor
VOLTAGE	3										
CURRENT	1				A/B Totals			14.8	0.32	12.4	G/B-Broadband Performance
DCCD		X									Prognosis
VOICE		X			GPE			30.0	-	14.7	Refer to GRP. I A/C GPE
DISPLAYS	X										Cost Note
TOTALS	36	31	6.2	18.6							Flt. Safety Unit Currently exists on A/C

$A_{TW} = 18.6 + 14.6$

$= 33.4$ Lbs.

$A_P = 60$ watts at 28 VDC

$C_{a1} = 6.2 + 12.4 + \frac{14.7}{15}$

$= \$19.6$ K

PHASE B REPORT

AIRCRAFT: OV-1 GROUP: 4 AIDAP SYSTEM BASE: GROUND - (REF. CONFIG. III)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{9_c} = A/B (I)M G/B (C')C (A)C (D)M

WEIGHTED SENSOR COUNT (WSC): 333

TABLE 4.3-16

SENSOR/PARAMETER DATA					AIDAPS HARDWARE IDENTITY	PCB CONFIG.		WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
TYPE	COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)		BASIC	DELTA				
DISCRETE	13				RDAU-1	X	2(c)	8.5	0.12	7.3	All Data is Tentative
TORQUE	2										(C)-Cond'g PCB's Added
VIBRATION		5									FUNCTIONAL CAPABILITY:
ACCELERATION		3									• Fault Inspection
PRESSURE	4	8			GPE			40.0	-	25.0	• Fault Diagnosis
TEMPERATURE	6	10									• Limited/Narrow Band
FLOW	2	2									Performance Prognosis
QUANTITY	2										
RPM	3	3									
VOLTAGE	3										
CURRENT	1										
DOCD		X									
VOICE		X									
DISPLAYS	X										
TOTALS	36	31	6.2	18.6				48.5	0.12	32.3	

$A_{TW} = 18.6 + 8.5$

$= 27.1$ Lbs.

Refer to Note for GRP. I A/C

$C_{a1} = 6.2 + 0 + \frac{32.3}{5}$

$= \$12.7$ K

Refer to Note for GRP. I A/C

PHASE B REPORT

AIRCRAFT: CH-47, CH-54 UTTAS & HLH GROUP: 5 AIDAP SYSTEM BASE: AIRBORNE - (REF. CONFIG. II)

EQUIVALENT AIDAP SYS. EXPRESSION: $S_{7_e} = A/B \left[(I)C \cdot (C')C \cdot (A)C \cdot (D)M \right]$

WEIGHTED SENSOR COUNT (WSC): 426

TABLE 3.4-17

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	23	2			CEU	X		9.0	0.22	8.4	All Data is Tentative
TORQUE	2										
VIBRATION		10			RDAU	X		8.0	0.12	6.5	
ACCELERATION		3									
PRESSURE	10	6			VWU	X		▽	▽	▽	
TEMPERATURE	7	17									FUNCTIONAL CAPABILITY:
FLOW	2	2			FDEP	X		0.5	0.02	0.2	• Fault Inspection
QUANTITY	2										• Fault Diagnosis
RPM	3	3			PRINTER	X		5.0	0.20	6.0	• Broad Band Performance
VOLTAGE	3										Prognosis
CURRENT	1				ADP	X		2.5	0.046	2.0	• Flt. Safety Monitor
DOCD		X									
VOICE		X									▽ Flt. Safety Unit Cur-
DISPLAYS	X										rently exists on CH-54
TOTALS	53	43	8.6	25.8				25.0	0.606	23.1	

$A_{TW} = 25.8 + 25.0$
$= 50.8$ Lbs.

Note: Add 4.5 Lbs. for VWU Wt. on CH-47, UTTAS and HLH

$A_D = 100$ watts at 28 VDC

$C_{a1} = 8.6 + 23.1 + 0$
$= \$31.7$ K

Note: Add $1.0K for VWU Cost on CH-47, UTTAS and HLH

PHASE B REPORT

AIRCRAFT: CH-47, CH-54 UTTAS & HLH GROUP: 5 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: $S_{5_b} = A/B\left[(I)C \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B\left[(A)C \cdot (D)M\right]$

WEIGHTED SENSOR COUNT (WSC): 426

TABLE 3.4-18

SENSOR/PARAMETER DATA					AIDAPS HARDWARE IDENTITY	PCB CONFIG.		WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
TYPE	COUNT EXIST	COUNT ADD*	*COST ($K)	*WT (lb)		BASIC	DELTA				
DISCRETE	23	2			CEU	X	Δ	5.0	0.12	6.7	All Data is Tentative
TORQUE	2										
VIBRATION		10			RDAU	X		5.0	0.12	6.5	ΔNo Flt. Comp. Logic
ACCELERATION		3									∇Flt. Safety Unit Cur-
PRESSURE	10	6			VWU	X		∇	∇	∇	rently exists on CH-54
TEMPERATURE	7	17									FUNCTIONAL CAPABILITY:
FLOW	2	2			FDEP	X		0.5	0.02	0.2	A/B-• Flt. Mode Control
QUANTITY	2										Snap Shot Recording
RPM	3	3			IRU	X		3.5	0.04	3.0	• Flt. Safety Monitor
VOLTAGE	3										G/B-• Fault Detection &
CURRENT	1				A/B Totals			14.0	0.30	16.4	Diagnosis and Performance
DOCD		X									Prognosis
VOICE		X									
DISPLAYS	X				GPE			33.0	-	17.2	Refer to GRP. I A/C GPE
TOTALS	53	43	8.6	25.8							Cost Note

$A_{TW} = 25.8 + 14.0$

$= 39.8$ Lbs.

Note: Add 4.5 lbs. for VWU Wt. on CH-47, UTTAS and HLH

$A_P = 85$ watts at 28 VDC

$C_{a1} = 8.6 + 16.4 + \frac{17.2}{15}$

$= \$26.1$ K

Note: Add $1.0 K for VWU Cost on CH-47, UTTAS and HLH

PHASE B REPORT

AIRCRAFT: CH-47, CH-54 UTTAS & HLH GROUP: 5 AIDAP SYSTEM BASE: HYBRID - (REF. CONFIG. I)

EQUIVALENT AIDAP SYS. EXPRESSION: $S_{6_b} = A/B \left[(I)C \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$

WEIGHTED SENSOR COUNT (WSC): 426

TABLE 3.4-19

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)
DISCRETE	23	2		
TORQUE	2			
VIBRATION		10		
ACCELERATION		3		
PRESSURE	10	6		
TEMPERATURE	7	17		
FLOW	2	2		
QUANTITY	2			
RPM	3	3		
VOLTAGE	3			
CURRENT	1			
DOCD		X		
VOICE		X		
DISPLAYS	X			
TOTALS	53	43	8.6	25.8

AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
CEU	X		9.0	0.22	8.4	All Data is Tentative
RDAU	X		8.0	0.12	6.5	
VWU	X		∇	∇	∇	∇Flt. Safety Unit Currently exists on CH-54.
FDEP	X		0.5	0.02	0.2	FUNCTIONAL CAPABILITY:
						A/B- • Fault Inspection
IRU	X		3.5	0.04	3.0	• Fault Diagnosis
						• Flt. Safety Monitor
A/B Totals			21.0	0.40	18.1	G/B- • Broad Band Performance Prognosis
GPE			30.0	-	14.7	Refer to GRP. I A/C GPE Cost Note

$A_{TW} = 25.8 + 21.0$
$= 46.8$ Lbs.

Note: Add 4.5 Lbs. for VWU Wt. on CH-47, UTTAS and HLH

$A_P = 85$ watts at 28 VDC

$C_{a1} = 8.6 + 18.1 + \frac{14.7}{15}$
$= \$27.7$ K

Note: Add $1.0 K for VWU Cost on CH-47, UTTAS and HLH

PHASE B REPORT

AIRCRAFT: CH-47, CH-54, UTTAS & HLH GROUP: 5 AIDAP SYSTEM BASE: GROUND - (REF. CONFIG. III)

EQUIVALENT AIDAP SYS. EXPRESSION: S_{10_a} = A/B (I)C · G/B [(C')C · (A)C · (D)M]

WEIGHTED SENSOR COUNT (WSC): 426

TABLE 3.4-20

TYPE	SENSOR/PARAMETER DATA COUNT EXIST	ADD*	*COST ($K)	*WT (lb)	AIDAPS HARDWARE IDENTITY	PCB CONFIG. BASIC	PCB CONFIG. DELTA	WT (lb)	VOL (cu. ft)	COST ($K)	COMMENTS
DISCRETE	23	2			RDAU-1	X		8.0	0.19	6.5	All Data is Tentative
TORQUE	2										
VIBRATION		10			RDAU-2	X		8.0	0.19	6.5	
ACCELERATION		3									
PRESSURE	10	6			GPE			40.0	-	25.0	
TEMPERATURE	7	17									FUNCTIONAL CAPABILITY:
FLOW	2	2									• Fault Inspection
QUANTITY	2										• Fault Diagnosis
RPM	3	3									• Limited/Narrow Band
VOLTAGE	3										Performance Prognosis
CURRENT	1										
DCCD		X									
VOICE		X									
DISPLAYS	X										
TOTALS	53	43	8.6	25.8				56.0	0.38	38.0	

A_{TW} = 25.8 + 16.0

= 41.8 Lbs.

Refer to Note for GRP. I A/C

$C_{a1} = 8.6 + 0 + \frac{38.0}{5}$

= \$16.2 K

Refer to Note for GRP. I A/C

SECTION 4

4.0 ARMY LOGISTICAL ENVIRONMENT

4.1 DIFFERENCES BETWEEN EXISTING AND FUTURE LOGISTICS SYSTEMS

4.1.1 Introduction

This section deals with the Army aviation logistical environment, with emphasis on identifying those areas where the introduction of an AIDAP system may effect significant improvement. Sections 4.2 through 4.6 summarize broad Army maintenance doctrine and principles, followed by a discussion of the existing and future Army logistical systems, and concluding with identification of the differences between the two systems.

4.1.2 Army Maintenance Definition

Maintenance of materiel consists of any action taken to retain materiel in a serviceable condition or to restore it to serviceability. It includes inspection, testing, servicing, classification for serviceability, reclamation, repair, overhaul, rebuild, modification, retrofit, calibration, and renovation. Thus, the scope of maintenance tasks ranges from simple preventive maintenance services performed by the operator of equipment to complex depot maintenance operations performed in fixed shop facilities.

4.1.3 Principles of Maintenance

The following are the basic principles of maintenance as announced by the Department of the Army:

a) Each commander is responsible for the maintenance of equipment issued to his unit.

b) Maintenance will be performed in accordance with published maintenance doctrine at the lowest category consistent with the tactical situation and available facilities, skills, manhours, repair parts, tools, and test equipment.

c) Repairs will be accomplished on site whenever feasible.

d) Maintenance will be accomplished in accordance with the applicable Maintenance Allocation Chart (MAC) which assigns maintenance functions to specific categories (part of each aircraft TM -20 series).

e) Unserviceable materiel which is beyond the maintenance authority or capability of an organization will be reported or evacuated promptly to the organization responsible for the next higher category of maintenance.

f) Unless precluded by the operational situation, all authorized maintenance within the capability of an organization will be accomplished before equipment is evacuated to the next higher category of maintenance. Higher categories will perform the maintenance functions of lower categories when directed by appropriate commander.

g) Ordinarily, Table of Organization and Equipment (TO&E) units will not be designated to perform as a primary mission, a combination of categories such as direct support and general support maintenance. Specific exceptions may be authorized by HQ, DA, for combining direct support and general support maintenance in special cases involving unit assignment, low density equipment, complex weapons systems, and similar instances when justified. The Maintenance Support positive concept currently being staffed in Army channels may impact on this principle.

h) Each unit will possess an organizational maintenance capability to the greatest extent practicable, considering the size of the unit, its mission, the economy of resources, and the operational environment.

i) Table Distribution and Allowance (TDA) maintenance facilities at installations may be assigned combined direct and general support maintenance missions to provide maintenance support to units* on a repair and return-to-user basis. These combined DS and GS maintenance facilities may also repair or overhaul unserviceable equipment for return to the local supply system.

j) Maintenance will be accomplished with due consideration to the economy of resources. Where practicable, the Inspect and Repair Only as Necessary (IROAN) principle will be applied at all categories of maintenance.

k) Continuous command emphasis on the prompt evacuation of repairable unserviceable components and end items to direct support, general support and depot maintenance facilities is mandatory for timely maintenance contributions to materiel readiness.

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*locally and remotely

4.1.4 Maintenance Objectives

The overall objective of materiel maintenance is to assure that Army materiel is sustained in a ready condition, consistent with economy, to fulfill its designed purpose. The attainment of this objective is contingent on the timely accomplishment of the following actions:

a) The identification and establishment of essential maintenance requirements for materiel in feasibility studies, Qualitative Materiel Requirements (QMR), and Small Development Requirements (SDR).

b) The development of materiel in a manner that permits operation and maintenance requirements to be consistent with attainable skill levels, with maximum emphasis on human factors and safety engineering during design and development.

c) The conducting of in-process reviews during development to assure that the maintenance concept in the QMR or SDR is being followed.

d) The achievement of maximum repair parts standardization.

e) The development and implementation of a definitive maintenance support plan for equipment items and weapons systems.

f) The identification, during development, of qualitative and quantitative personnel and training requirements.

g) The achievement of optimum materiel reliability and maintainability.

h) The timely provision of support to fielded equipment.

4.1.5 Categories of Maintenance Within the Army

Categories of maintenance are used as a means of designating the scope of maintenance to be performed by units and activities at various command levels within the Department of the Army. The responsibility for the performance of maintenance within a given category is assigned to a unit or activity in accordance with its primary mission; its degree of mobility; and the intended availability of personnel, skills, and materiel resources. These categories, briefly defined are as follows:

a) Organizational maintenance. This category of maintenance is the responsibility of the unit commander in maintaining the operational readiness of equipment assigned or under his control. It includes preventive maintenance services and those organizational level functions authorized in the -20 technical manuals.

b) Direct support maintenance. Direct Support Maintenance is assigned to and performed by designated TOE and TDA maintenance activities in direct support of using organizations. The repair of end items or unserviceable assemblies is performed in support of using units on a return-to-user basis.

c) General support maintenance. This category of maintenance normally is assigned to and performed by designated TOE and TDA maintenance units or activities in support of individual Army area supply requirements. General support maintenance represents the principal maintenance capability available to the Field Army Commander for overhauling his materiel assets. When required, general support maintenance may provide support on a return-to-user basis for equipment whose repair is beyond the capability of direct support units.

d) Depot maintenance. This category of maintenance is the responsibility of, and is performed by, designated maintenance activities, that is, organic Army facilities including the Floating Aircraft Maintenance Facilities (both Operations, Maintenance Army (OMA) financed and Army Industrial Fund (AIF) activities), facilities of other DOD elements, and commercial contractor facilities. Depot maintenance augments depot stocks of serviceable materiel and supports organizational and direct and general support maintenance activities by use of more extensive shop facilities, equipment, and personnel of higher technical skill than are available at lower categories of maintenance. Actions in this category normally consist of the following: inspection and test; repair; modification; alteration; modernization; conversion; calibration; overhaul; renovation (for ammo only); reclamation; and rebuild of parts, assemblies, subassemblies, components, basic or end items, and the emergency manufacture of nonavailable parts for immediate consumption.

4.1.6 Maintenance Operations

Maintenance operations are performed by various maintenance activities in accordance with mission requirements. The scope of the operations are dictated by the category of maintenance designated to be performed. Among the maintenance operations and functions performed by maintenance activities, the following are considered to be most important.

a) Spares and Repair Parts Supply. Spares and repair parts allowances and initial guide quantities are identified and allocated in appropriate technical manuals for organizational, DS, GS and depot maintenance organizations. Direct support TOE maintenance activities supply repair parts to units they support. TOE general support maintenance units normally are not assigned a repair parts distribution mission. Controlled cannibalization is used as a source of supply for repair parts and components when authorized.

b) Equipment Records. Commanders at all levels are responsible for the accurate recording of data required and generated by TAMMS.

c) Technical Assistance. Technical assistance is provided at each level of command. This activity includes advising, assisting, and training personnel to install, to operate, and to maintain equipment. Upon request, skilled personnel are provided to field commanders by elements of the CONUS logistics base to assist in the solution of maintenance problems.

d) Contract Maintenance. Contract maintenance is used to supplement the inhouse maintenance capability of the Army. This method is not used, however, when it precludes or jeopardizes attaining and sustaining the military organic capability necessary to support mission-essential equipment. Contract maintenance has its principal application in the support of nontactical activities.

e) Maintenance Float. A maintenance float consisting of end items or major components of mission-essential, maintenance significant equipment is authorized for stockage, normally by DS/GS maintenance units or activities. It replaces unserviceable equipment to meet operational commitments.

f) Command Maintenance Management Inspections (CMMI). CMMI are conducted by qualified personnel as often as necessary, but at least once each year. These inspections are geared to providing major commanders with an appraisal of maintenance management of each subordinate unit and activity, an indication of the condition and serviceability of selected equipment, and a measure of the effectiveness of organization, DS, and GS support maintenance. The CMMI is the principal means for insuring discipline in the maintenance system.

g) Equipment Serviceability Criteria. The equipment serviceability criteria, initially prepared and included in the maintenance test package for each mission-essential maintenance-significant item, provides for the rapid categorization of equipment into one of three conditions of combat serviceability: Green (operational), Amber (operational with limited reliability), and Red (nonoperational or unacceptable reliability). Commanders at all levels use these criteria in evaluating serviceability of equipment authorized and issued to units under their command.

h) Maintenance Standards. Maintenance standards, initially prepared and included in the maintenance test package, are used at the several categories of maintenance. These standards recognize the principles of maintenance economy which recommend complete replacement of parts supplied as repair kits, gasket sets, and similar groupings. The application of IROAN to standards for organizational and DS maintenance is given primary consideration in the repair operations and servicing of equipment.

i) Repair Limits. Repair limits, tially established and included in the maintenance support plan, are based upon maximum one-time repair costs and are predicated upon an established life expectancy of the item.

j) Modifications. All aircraft or component modifications are authorized by DA modification work orders (MWO). The agency (AVSCOM for aviation items) assigned responsibility for maintenance support of an item initiates MWO in accordance with established modification criteria as depicted in AR 750-1 and AR 750-5. The MWO includes a designation of the maintenance category responsible for its application and cites the degree of urgency of the modification.

k) Reporting. All maintenance accomplished on equipment is reported by all levels of command in accordance with TAMMS and other established policies a... criteria.

l) Maintenance Management. Maintenance management is the responsibility of commanders at all levels and includes

1) Determining and establishing appropriate resources essential in accomplishing the maintenance mission.

2) Organizing, planning, programming, and budgeting for the proper use of maintenance resources.

3) Providing technical supervision and management control over maintenance programs and activities.

4) Conducting reviews and analysis of maintenance programs.

5) Evaluating maintenance concepts, doctrine, policies, plans and procedures to insure that they contribute to the accomplishment of the overall military mission.

6) Recommending new maintenance concepts, doctrine, policies, plans and procedures.

4.1.7 Existing Logistical System

4.1.7.1 General

The existing Army aviation logistical system will be evaluated by concurrently addressing the two major divisions of Army logistics which are the Continental United states (CONUS) and the Army-in-the-Field. These major divisions are defined as follows:

a) CONUS Logistics - CONUS logistics from an AIDAPS viewpoint, encompasses the organization, systems, and procedures together with the equipment, materials and facilities needed.

1) To train and to equip Army aviation forces

2) To support trained aviation forces while in CONUS, prior to deployment to a theater of operations

3) To support CONUS Army aviation activities organic to the CONUS armies and the military District of Washington.

b) Army-in-the-Field Logistics - Includes all the combat service support organizations, systems, and procedures together with the manpower, equipment, materials and facilities needed in an overseas theater of operations to support military forces deployed there.

4.1.7.2 Personnel Training

Army aviation logistical personnel both military and civilian (Civil Service) receive their logistical training by attendance at Army service schools, on the job training (OJT), mobile training teams, or by attendance at selected prime manufacturer factory courses. These courses of training historically have emphasized theory in lieu of practical exercises, primarily due to the short retention periods for nonvolunteer military personnel. The concentration on theory combined with shortened class duration has permitted the Army to accommodate quantitative requirements for logistical personnel, but, has not produced an experienced individual who could adequately diagnose maintenance problems in Army aircraft systems. The result of a lack of diagnostic talent in the Army has been highlighted by the thousands of components returned to Army depots, which when tested, were found to be serviceable. The Army recognized this problem many years ago, and initiated study effort leading to Department of the Army approval of the AIDAPS Qualitative Materiel Requirement (QMR). Introduction of an AIDAP System into Army assets will eliminate much of the present technique of "troubleshooting with parts" by positive AIDAPS diagnosis of malfunctioning components. In addition, service school training can be restructured with emphasis on more "practical" training in removal/replacement/repair of LRU's as opposed to courses in theory. Two new areas of training generated by an AIDAPS are training on the AIDAPS itself, and selected personnel training in trend analysis to facilitate implementation of the AIDAPS diagnostic/prognostic capability. As indicated later in this section, the Army Life Cycle Management Model for new systems is geared to address this requirement at an appropriate point in the developmental cycle. In summary, the major difference in future Army aviation personnel training induced by an AIDAP System, will be a change in Programs of Instruction (POI) emphasizing practical experience in lieu of theory, AIDAP System training, and trend analysis training. The end result will be higher skill level mechanics in terms of being able to remove/repair/replace LRU's identified as bad by an AIDAPS. The higher skill levels may dictate revamping of the Maintenance Allocation Charts (MAC), although skills are only one factor in determining MAC maintenance functions and must be traded off against unit mobility, special tool and repair parts requirements and time. This area will receive treatment in greater detail during Phase C of the study.

4.1.7.3 The Maintenance Allocation Chart (MAC)

The MAC is the source document that guides and controls all levels of maintenance. It assigns maintenance functions to the lowest level of maintenance based on past experience and the following consideration:

a) Skills available.

b) Time required.

c) Tools and test equipment required and/or available.

1) Only the lowest level of maintenance authorized to perform a maintenance function is indicated.

2) A maintenance function assigned to a maintenance level will automatically be authorized to be performed at any higher maintenance level.

3) A maintenance function that cannot be performed at the assigned level of maintenance for any reason may be evacuated to the next higher maintenance organization. Higher maintenance levels will perform the maintenance functions of lower maintenance levels when required or directed by the appropriate commander.

4) The assignment of a maintenance function will not be construed as authority to carry the associated repair parts in stock. Authority to requisition stock, or otherwise secure necessary repair parts will be as specified in the repair parts appendix.

5) Normally there will be no deviation from the assigned level of maintenance. In cases of operational necessity, maintenance functions assigned to a maintenance level may, on a one-time basis and at the request of the lower maintenance level, be specifically authorized by the maintenance officer of the level of maintenance to which the function is assigned. The special tools, equipment, etc., required by the lower level of maintenance to perform this function will be furnished by the maintenance level to which the function is assigned. This transfer of a maintenance function to a lower maintenance level does not relieve the higher maintenance level of the responsibility of the function. The higher level of maintenance will provide technical supervision and inspection of the function being performed at the lower level.

6) Organizational through depot maintenance of the U. S. Army Electronics Command Equipment will be performed by designated U. S. Army Electronics Command personnel.

7) Changes to the Maintenance Allocation Chart will be based on continuing evaluation and analysis by responsible technical personnel and on reports received from field activities.

4.1.7.3.1 Definitions

The following definitions are used in a maintenance allocation chart.

a) Inspect. To determine serviceability of an item by comparing its physical, mechanical and electrical characteristics with established standards.

b) Test. To verify serviceability and to detect electrical or mechanical failure by the use of test equipment.

c) Service. To clean, to preserve, to charge, and to add fuel, lubricants, cooling agents and air.

d) Adjust. To rectify to the extent necessary to bring into proper operating range.

e) Align. To adjust specified variable elements of an item to bring to optimum performance.

f) Calibrate. To determine the corrections to be made in the readings of instruments or test equipment used in precise measurement. Consists of the comparison of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument or test equipment being compared with the certified standard.

g) Install. To set up for use in an operational environment such as an emplacement, site or vehicle.

h) Replace. To replace unserviceable items with serviceable assemblies, sub-assemblies or parts.

i) Repair. To restore an item to serviceable condition through correction of a specific failure or unserviceable condition. This includes, but is not limited to, inspection, cleaning, preserving, adjusting, replacing, welding, riveting, and strengthening.

j) Overhaul. To restore an item to a completely serviceable condition as prescribed by maintenance serviceability standards prepared and published for the specific item to be overhauled.

k) Rebuild. To restore an item to a standard as nearly as possible to the original or new condition in appearance, performance, and life expectancy. This is accomplished through the maintenance technique of complete dis-assembly of the item; inspection of all parts or components, repair or re-placement of worn or unserviceable elements (items) using original manu-facturing tolerances and specifications; and subsequent reassembly of the item.

4.1.7.3.2 Symbols

a) The letters "O, F, H, and D" represent Organization (O), Direct Support (F), General Support (H) and Depot (D) and when placed on the Maintenance Allocation Chart indicate the lowest level of maintenance responsible for performing the particular maintenance function. Maintenance levels higher than the level of maintenance marked by the symbol are authorized to per-form the indicated function.

b) The symbol "%%" applies to organization maintenance and indicates that the particular maintenance function may be performed provided it is specifically authorized by the Direct Support Maintenance Officer. In no case will the Direct Support Maintenance Officer require the accomplishment of a "%%" maintenance function by an organization or unit, and in no case will a "%%" function authorize stockage of parts at the organizational level.

A MAC for the AH-1 (Cobra) is presented in Figure 4-1.

4.1.8 Organizational Levels of Maintenance (Existing)

4.1.8.1 Functions

Organizational levels of maintenance are authorized by the MAC to accomplish the maintenance functions listed below.

a) Inspection

b) Service

c) Adjustment

d) Alignment

e) Calibration

f) Replacement

g) Repair

The depth of accomplishment of these functions is limited by skills, repair parts, special tools, time, and the tactical situation.

4.1.8.2 Inspection

The bulk of organizational maintenance is concerned with inspection. These inspections are mainly preventive in nature and are described below.

a) Preventive Maintenance Daily (PMD). Accomplished after the last flight of the day or preceding the next day flight. Consists of visual examination and operational check to determine that the aircraft can safely and efficiently perform its assigned mission. Inspection requirements are

FIGURE 4-1

MAINTENANCE ALLOCATION CHART FOR AH-1G

(AR 310-3)

(1) GROUP NO	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTION: INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
00	AIRCRAFT													
	Clean													O
	Moor													O
	Tow													O
	Jack													O
	Hoist													O
	Spot Paint													O
	Preservation													O
	Weight and Balance													F
01	AIRFRAME													
	Sheet metal, structural members and sandwich panels not requiring jigs and fixtures								F	F				
	Sheet metal, structural members and sandwich panels involving jigs and fixtures										D			
	Fire Detector Unit	O							O	F				
	(Aft) Engine Mount Adapters	O							F				(Replacement of rod ends)	
	Engine Mount Support Arms (Brace Rods & Tripod)	O							F	F				
	Engine Mount Trunnion and Bearing Assembly	O							F	F				
	Engine Floor Mount Attaching Brackets	O							F					
	Tail Boom	O							F	F	D			
	Wings	O							O	F				
	Protective Armor	O							O					
	Cockpit Doors	O			O				O	F				
	Windows All	O		O					F					
	Pilots & Gunner's Seats	O							O	F				
	Seat Belts, Shoulder Harness, Inertia Reel and Webbing	O							O					
	Sound-Proofing	O							O	O				
	Cowling and Fairings	O			O				O	F				

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART
FOR
AH-1G

(AR 310-3)

(1) GROUP NO	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTION: INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
02	**ALIGHTING GEAR**													
	Tail Skid	O							O					
	Skid Tubes, Cross Tubes and Skid Shoes	O							O	F				
	Ground Handling Wheel Actuating Mechanism	O		O					O	F				
	Wheels, Tires and Tubes	O		O					O	O				
03	**ENGINE AND RELATED SYSTEMS**													
	Engine as a Complete Assembly	O	H			O			F	%%	D			
	Fuel and Oil Hoses	O							O					
	Electrical Harness and Ignition Leads	O							O					
	Ignition Exciter	O							O					
	Igniter Plugs	O							O					
	Fuel Control Assembly	O		O	O				O		D			
	Electrical Solenoid Valve	O							O					
	Overspeed Governor Assembly	O			O				O		D			
	Fuel System Filter and Strainers	O							O					
	Starting Fuel Solenoid Valve	O							O					
	Main Fuel Manifolds	O							O	F				
	Starting Fuel Manifold	O							O					
	Starting Fuel Nozzles	O							O	H				
	Oil Pump	O			O				O		H			
	Bearing Housing Oil Strainers	O		O					O					
	Main Oil Filter	O		O					O	O				
	Engine Oil Coolers	O		O					O	F				
	Engine Oil Cooler Blower	O		O					O	F				
	Engine Oil Tank	O		O					O	F				
	Interstage Airbleed Actuator	O							O	F	D			
	Interstage Airbleed Band	O			O				O	O				
	Interstage Airbleed Hoses	O							O					
	Inline Valve	O							O	F	H			

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART
FOR
AH-1G
(AR 310-3)

(1) GROUP NO	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTION: INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
03	ENGINE AND RELATED SYSTEMS (Cont)													
	Airbleed Connecting Manifold and Adapter	O							O					
	Exhaust Thermocouple Harness	O	F						O					
	Combustion Chamber Drain Valve	O							O					
	Accessory Drive Gearbox	O							O	O*	D			*Limited to replacement of seals
	Overspeed Governor and Tachometer Drive Assembly	O			O*				F	F				*Pressure regulation valve
	Torquemeter Booster Pump	O							O	F	H			
	Oil Transfer Tubes (For reduction gears)	F*							F	F				*During special inspection
	Output Shaft Seal	O*							F					*For leakage
	Reduction Carrier and Gear Assembly	F*							F	F** H	D			*During special inspection **Limited to replacement of parts
	Overspeed Governor and Tachometer Drive Support and Gear	F							F	F				
	Accessory Gear Carrier	F							F					
	Combustion Chamber Housing	F							F	F				
	Combustion Chamber Liner	F							F	F*				*Stop-drill cracks
	Fuel Vaporizers	F							F	F				

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART FOR AH-1G (AR 310-3)														
(1)	(2)	(3) MAINTENANCE FUNCTION											(4)	(5)
GROUP NO	FUNCTIONAL GROUP	INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	TOOLS AND EQUIPMENT	REMARKS
03	ENGINE AND RELATED SYSTEMS (Cont)													
	Power Turbine Nozzle and Cylinder	F							F	F				
	Fireshield	F							F					
	Exhaust Diffuser	O							F	H				
	Second Stage Turbine Rotor Assembly	O							F	F				
	First Stage Turbine Rotor Assembly	F							F	F				
	First Stage Turbine Nozzle and Flange	F							F	F				
	Combustion Chamber Deflector	F							F					
	Diffuser Housing	O							D	F				
	Rear Bearing Seal and Seal Housing	F							F					
	Rear Bearing Seal Liner and Forward Rear Cones	F							F					
	Impeller Housing	O							F	F				
	Compressor Housing	O							F	F				
	Compressor Stator Vanes	F							F	F				
	Compressor Rotor Blades	O							F	F				
	Power Shaft	F*							D					*During special inspection
	Inlet Housing	O							D	F				
	Inlet Guide Vanes	O							D	F				
	Engine Oil Cooler Fan Assembly	O		O					O	F	H			
	Engine Control Linkage	O			O				O	O				
	Droop Compensator	O			O				O	O				
	Actuator	O			O				O	O	H			
	Particle Separator (Sand & Dust)	O		O				O	O	F				

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART FOR AH-1G (AR 310-3)														
(1)	(2)	(3) MAINTENANCE FUNCTION											(4)	(5)
GROUP NO	FUNCTIONAL GROUP	INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	TOOLS AND EQUIPMENT	REMARKS
04	ROTOR AND TRANSMISSION SYSTEMS													
	Main Rotor Hub and Blade Assembly	O			O*	F**			O					*Track **Balance
	Main Rotor Blades	O							O	%% D				
	Main Rotor Hub	O				F*			O	F	H			*Balance
	Scissors & Sleeve Assembly	O		O					O	F	H			
	Swashplate & Support Assembly	O		O					O	F	H			
	Tail Rotor Hub & Blade Assembly	O		O	O	F*			O					*Balance
	Tail Rotor Blades	O							F	%% D				
	Tail Rotor Hub	O		O					F	F	H			
	Tail Rotor 42° and 90° Gear Boxes	O		O					O	O	D			
	Tail Rotor Gear Box Quills (42° and 90°)	O							F	F	D			
	Tail Rotor Drive Shafting	O							O	O				
	Tail Rotor Drive Shaft Hanger Assemblies	O		O					O		H			
	Main Transmission	O		O					F	F	D			
	Transmission Mount Assemblies	O							F	F				
	Auxiliary Transmission Dampers	O		O					O	F*			*Repair Kit SGT-1270-1-RK	
	Drive Quill Assemblies	O							%%	F	D			
	Main Drive Shaft (Engine to Transmission)	O		O		O			O		H			
	Transmission Lubrication System	O		O										
	Lines, Manifolds, Fittings, Oil Jets and Sight Gages	O							O					
	Filters, Filter Housings and Screens	O		O					O					

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART
FOR
AH-1G

(AR 310-3)

(1) GROUP NO	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTION: INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
04	ROTOR AND TRANSMISSION SYSTEMS (Cont)													
	Transmission Oil Cooler Assembly, Housing, Tubing, Fittings and Valves	O		O					O	F				
	Oil Pump								%%		D			
	Relief Valve	O			O				O	O				
	Mast Assembly	O							%%	F	H			
	Friction Collet	O			O				O					
06	HYDRAULIC SYSTEM													
	Pumps	O							O		H			
	Reservoirs	O		O					O	O				
	Valves	O		O					O					
	Hoses, Tubing & Fittings	O							O					
	Hydraulic System Filters and Filter Housings	O		O					O					
	Hydraulic Module	O		O					O	O				
	Hydraulic Power Cylinders	O							O	F	H			Except ASE
	Hydraulic Accumulator	O		O					O	F	H			
08	INSTRUMENTS													
	Instrument Panels	O							F	F				
	Miscellaneous Instruments													
	Clock	O							O	H				
	Free Air Temperature Gage	O							O					
	Fuel Quantity Indicator and Amplifier	O					F		F		H			
	Fuel Flow Meter	O	F						O					
	Accumulator Air Pressure Gage	O							O					
	Flight Instruments													
	Vertical Velocity Indicator	O							O		H			
	Stand-by Compass	O					O		O					
	Airspeed Indicator	O	F						O					
	Height Indicator	O					O		O		H			
	Attitude Indicator	O	F						O		D			

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART FOR AH-1G

(AR 310-3)

(1) GROUP NO	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTION: INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
08	INSTRUMENTS (Cont)													
	Turn and Slip Indicator	O							O		H			
	Pitot System	O	F	O					F					
	Engine Instruments													
	Engine & Rotor Tachometer	O	F						O		H			
	Exhaust Temperature Indicator	O					F		F		H			
	Engine Oil Temperature Gage	O	F						O		H			
	Engine Oil Pressure Transmitter and Indicator	O	F						O		H			
	Fuel Pressure Indicator and Transmitter	O							O		H			
	Torquemeter & Transmitter	O							O		H			
	Gas Producer Tachometer	O	F						O		H			
	Transmission Instruments													
	Oil Temperature Gage	O	F						O		H			
	Oil Pressure Gage and Transmitter	O	F						O		H			
	Thermocouples and Temperature Bulbs	O	F						O					
09	ELECTRICAL SYSTEMS													
	AC Power System													
	Inverters	O							O					
	Circuit Breakers, Conduits, Leads, Switches and Wiring	O							%%	F				
	DC Power System													
	Relays, Rheostats, Switches, Circuit Breakers, Plugs, Leads, Connectors, Wiring, Conduits, Receptacles, Shunts and Shock Mounts	O							%%	F				
	Regulator	O			%%				O		H			
	Battery	O		O*					O					*Cleaning
	Starter Generator	O							O	F	H			

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART FOR AH-1G (AR 310-3)															
(1)	(2)	(3) MAINTENANCE FUNCTION												(4)	(5)
GROUP NO	FUNCTIONAL GROUP	INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD		TOOLS AND EQUIPMENT	REMARKS
09	ELECTRICAL SYSTEMS (Cont)														
	Lights														
	Landing, Navigation, Intrument, Search, Interior Cabin, Anti-Collision and Flasher Units	O							O	%%					
	Electrical Mechanical Actuators	O			O				O	F	H				
	Caution Panels	O							O	F					
	RPM Warning System	O			O				O	H					
	Chip Detector System	O								%%					
10	FUEL SYSTEM AND LINES														
	Main Fuel Tanks	O	F	O					O	F					
	Auxiliary Fuel Tank Assembly	O							O	F					
	Boost Pumps	O							O		H				
	Valves and Fittings	O							O						
	Filters and Filter Housing	O		O					O						
	Hoses, Tubing & Filler Caps	O													
11	FLIGHT CONTROL SYSTEMS					O									Rigging
	Main Rotor Control Tubes and Rod Ends	O		O					O	F					Rotating Controls
	Force Gradient Assembly	O			O				O	F					
	Control Stick (Collective and Cyclic)	O							O	F					
	Synchronized Elevator	O			O				O	F					
	Magnetic Brake	O							O			H			
	Collective & Cyclic Linkage	O							O	F					
	Tail Rotor Pedal Assembly	O							O	F					
	Pedal Adjusting Assembly	O			O				O	F					
	Tail Rotor Pitch Control Linkage	O							O	F					
	Tail Rotor Pitch Control Mechanism	O			O				O	F					
	Tail Rotor Pitch Change Rods and Links	O			O				O	O					

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART
FOR
AH-1G

(AR 310-3)

(1) GROUP NO	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTION INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
11	FLIGHT CONTROL SYSTEMS (Cont)													
	Stabilization Equipment													
	Control Panel	O	F						O	O				Replacement of bulbs Replacement of Modules and Fuses
	Control Box	O	F						O	F				
	Electro Hydraulic Actuators	O	H F*						O	H	D			*Trouble-Shooting
	Solenoid Valves, Hoses, Connectors	O							O					
	Transducers	O			O				O					
	Wiring and Connectors	O							%%					
12	UTILITY SYSTEMS													
	Anti-Icing System													
	Engine Anti-Icing Detector and Interpreter	O							O	F				
	Hot Air Valve	O							O		H			
	Heating & Ventilating System													
	Bleed Air Heater System	O							F	F				
	Control Valves	O							O	F				
	Mixing Valve & Sensor	O	O						O	F				
	Vent Blower	O							F	F				
	Ventilating Ducts, Inlet Door and Control	O			O				O					
16	COOLING SYSTEM													
	Engine Cooling System													
	Fan Assembly	O							O					
	Ejector Assembly	O			F				F	F				

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART FOR AH-1G (AR 310-3)

(1) GROUP NO	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTION: INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
19	AVIONICS													
	Note													
	TM 11-1520-221-20 contains maintenance instructions for avionics													
	Communications Equipment													
	Inter-Communications Equipment													
	Navigation Equipment													
	Antennas and Antenna Couplers													
30	ARMAMENT													
	Pilot's and Gunner's Control Panels	O	F						F	F				
	Relays, Circuit Breakers, Switches, Plugs, Leads, Connectors and Wires	O							%%	F				
	Hydraulic Solenoid Valves, Lines and Connectors	O							O	F				
	External Stores													
	Emergency Manual Jettison System, Cables, Levers, Pulleys and Brackets	O			O				O	O				
	Ejector Rack	O	O	O					O	O* F				*Replace O-rings and packings
	Note													
	Organizational maintenance of the armament subsystem will be performed by Aircraft Armament Repairmen.													
70	MAINTENANCE SUPPLIES													
	Dye Penetrant Inspection													O
	Magnaflux and/or Fluorescent Penetrant Inspection													F
	Annealing & Hardness Testing													H
	Heat Treat													H
	Cadmium Plating													H

FIGURE 4-1 (Continued)

MAINTENANCE ALLOCATION CHART FOR AH-1G (AR 310-3)														
(1)	(2)	(3) MAINTENANCE FUNCTION											(4)	(5)
GROUP NO	FUNCTIONAL GROUP	INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	TOOLS AND EQUIPMENT	REMARKS
	Chrome Plating													D
	Welding and Brazing													F

specified in TM 55-1520-2XX -20 PMD for each type, model and series of Army aircraft.

b) Preventive Maintenance Intermediate (PMI). Accomplished every 25 flying hours in accordance with TM 55-1520-2XX -20 PMI, for each type model and series of Army aircraft (not applicable to OH-6 and OH-58).

c) Preventive Maintenance Periodic. Accomplished every 100 flying hours in accordance with TM 55-1520-2XX -20 PMP for each type, model and series of Army aircraft.

d) Special Inspections. Accomplished when contingencies arise such as hard landings, overspeed, sudden stoppage, etc. Requirements are outlined in the -20 technical manuals for Army aircraft.

4.1.8.3 Spares, Repair Parts and Special Tools

Quantities of these items are initially authorized in the -20P tech manuals for unit aircraft. Subsequently, stockage of spares and repair parts is based on recurring demands for a particular item and appears on the unit Prescribed Load list (PLL). A copy of the PLL is furnished the organizational unit's Direct Support activity who will stock backup quantities of the demand supported repair parts.

4.1.8.4 Ground Support Equipment (GSE)

GSE is authorized in Tables of Organization and Equipment (TOE) for units of the Army-in-the-Field, and in Tables of Distribution and Allowance (TDA) for CONUS logistics activities. Quantities of GSE are determined by tradeoffs based on the MAC chart, unit mobility category, and the geographical area in which the unit is assigned, i.e., hot, cold or temperate weather conditions may require special items or additional quantities.

4.1.8.5 Technical Manuals (TM)

TM's authorized organizational levels of maintenance, both CONUS and the Army-in-the-Field, consist of the -10, -20 and -20P manuals. These manuals provide data covering the type, model and series of aircraft with which the unit is equipped.

4.1.8.6 Forms and Records

Forms and records are specified in TM 38-750, The Army Maintenance Management System (TAMMS). An index of TAMMS record and report forms is presented in Figure 4-2.

FIGURE 4-2

INDEX OF ALL TAMMS

RECORD AND REPORT FORMS

Form No.	Title
	OPERATIONAL
DA Form 2400	Equipment Utilization Record
DA Form 2401	Organizational Control Record for Equipment
	MAINTENANCE
DA Form 2402	Exchange Tag
DD Form 314	Preventive Maintenance Schedule and Record
DA Form 2404	Equipment Inspection and Maintenance Worksheet
DA Form 2405	Maintenance Request Register
DA Form 2406	Materiel Readiness Report
DA Form 2407	Maintenance Request
DA Form 2407-1	Maintenance Request Continuation Sheet
DA Form 2410	Component Removal and Repair/Overhaul Record
DA Form 2410-1	Component Removal, Installation, Movement and Condition Record (Trans Report)
DA Form 2418	Backlog Status and Workload Accounting Card
	HISTORICAL (Log)
DA Form 2408	Equipment Log Assembly (Records)
DA Form 2408-1	Equipment Daily or Monthly Log
DA Form 2408-4	Weapon Record Data
DA Form 2408-5	Equipment Modification Record
DA Form 2408-7	Equipment Transfer Report
DA Form 2408-8	Equipment Acceptance and Registration Record
DA Form 2408-10	Equipment Component Register
DA Form 2408-12	Army Aviator's Flight Record
DA Form 2408-13	Aircraft Inspection and Maintenance Record

INDEX OF ALL TAMMS

RECORD AND REPORT FORMS

HISTORICAL (Log) (Continued)

DA Form 2408-14	Uncorrected Fault Record
DA Form 2408-15	Historical Record for Aircraft
DA Form 2408-16	Aircraft Component Historical Record
DA Form 2408-17	Aircraft Inventory Record
DA Form 2408-18	Equipment Inspection List
DA Form 2408-19	Aircraft Engine Turbine Wheel Historical Record
DA Form 2409	Equipment Maintenance Log (Consolidated)

AMMUNITION

DA Form 2415	Ammunition Condition Report

CALIBRATION

DA Form 2416	Calibration Data Card
DA Form 2417	Unserviceable or Limited Use Tag
DA Label 80	US Army Calibration System

4.1.8.7 AIDAPS Impact

The envisioned impact of AIDAPS on organizational levels of maintenance includes possible MAC changes, reduction/elimination of inspections, quantity changes in allowances of spares/repair parts/special tools/GSE, and a reduction in TAMMS record keeping.

The positive identification, by an AIDAPS, of a malfunctioning aircraft component will permit downgrading of MAC removal/replacement functions to the organizational level of maintenance consistent with skills, special tool requirements, time and the tactical situation. This area will be addressed in Phase C tradeoffs.

Current inspections including the PMD, PMI and PMP are designed to insure daily and hourly checks of aircraft and components. They are required mainly because of the "unknown" condition of aircraft subsystems. An AIDAPS will reduce these unknowns so that it may be possible to eliminate the PMI's (every 25 hours) and extend the 100 hour PMP.

Determination of component condition by an AIDAPS may permit reduction in quantities of spares, repair parts and special tools since the main reason they are currently stocked is to have a component in case of failure or to use in troubleshooting which, as previously stated, has resulted in the unnecessary return of thousands of serviceable components to depots for overhaul. An AIDAPS will permit selective stockage within the theater of operations, without burdening the organizational levels of maintenance in carrying excess quantities of spares/repair parts/special tools. This technique could provide quant... ...creases in unit mobility.

Quantities of ground support equipment may likewise be reduced for the reasons outlined above.

In the field of record keeping, AIDAPS has a tremendous potential impact. Many of the TAMMS procedures deal with maintaining a record of operating hours, inspection accomplished, overhaul actions, etc.; an AIDAPS will permit many components to be replaced on a "condition" basis in lieu of calendar or flying hour replacement criteria, thus eliminating many record keeping requirements. It may eventually prove more cost effective to apply the "throw away" concept to components replaced after accumulation of thousands of flying hours, rather than engender the packaging, transportation and overhaul costs associated with return of components to depot facilities. This procedure would also eliminate additional record keeping requirements.

4.1.9 Direct Support Levels of Maintenance (DS) (Existing)

4.1.9.1 Functions

Direct support levels of maintenance are authorized by the MAC to perform all the functions listed for organizational levels but in greater depth due to the availability of higher skill levels, more sophisticated test sets, and greater quantities of spares, repair parts and special tools.

4.1.9.2 Army-in-the-Field

DS maintenance units provide direct support maintenance for Army aircraft and associated equipment in using units assigned to them for support, in their area of responsibility. The DS unit performs maintenance on the aircraft engines, components, and assemblies; performs maintenance on armament equipment, and avionics equipment; provides supply support, and when required, provides recovery and evacuation of aircraft.

The DS unit provides direct support maintenance services to units it supports, to include application of Modification Work Orders (MWO) that are the responsibility of the DS unit. The DS unit also performs its own organizational maintenance and assists supported units in the performance of their organizational aircraft maintenance when supported units require such assistance. As an essential element of its maintenance mission, the DS unit provides technical assistance to supported units.

When the direct support workload of the DS unit exceeds its capacity, augmentation may be provided or the overflow evacuated to a General Support (GS) unit. Jobs requiring general support maintenance are also evacuated to the GS unit. Disposition instructions should be in accordance with policies and procedures established by higher headquarters.

When a DS unit is operating in the forward area of the combat zone, it is assigned responsibility for providing support maintenance within a designated portion of that area. In the field Army service area, the DS unit is normally assigned responsibility for providing support maintenance in a specific area, this area being determined on the basis of aircraft densities and distribution, and the capabilities of the support unit.

The DS unit may operate as a complete unit or may, upon call of supported units, dispatch DS platoons or portions of DS platoons, maintenance sections, contact or maintenance teams, to perform on-site maintenance on a mission basis. When operating away from the company, the DS platoons, sections, or teams perform as much on-site direct support aircraft maintenance as practicable within the limitations imposed by available time or by the tactical situation. In addition to their maintenance mission, these platoons, sections, or teams furnish limited maintenance supply support on an emergency basis, and render technical assistance to the supported unit. Assigned technicians should include those necessary to perform direct support maintenance on the aircraft and its systems, and components. When required, these teams should be augmented by technicians from the shop platoon.

The DS unit's shop platoon operates at the maintenance site and accomplishes the bulk of the support mission, performing direct support maintenance which is not appropriate for on-site completion, or which is beyond the capability of the DS platoons, sections, or teams.

4.1.9.3 ConUS

DS units in the CONUS consist of fixed field maintenance shops at selected parts camps and stations. There activities are staffed by civil servants, and provide area support. Training base TOE military units are used to augment these fixed shops to ensure a high state of unit readiness in the event of deployment to a theater of operations.

4.1.9.4 Spares, Repair Parts and Special Tools

Quantities of these items are initially authorized in the -35P technical manuals. Subsequent stockage of spares and repair parts is based on recurring demands from supported organizational levels of maintenance and in-house repair activities. Spares and repair parts are listed on Authorized Stockage Level (ASL) lists. These lists will include at least one backup item of all the items on supported organizational Prescribed Load Lists (PLL).

4.1.9.5 Ground Support Equipment (GSE)

GSE for DS units (as for organizational levels) is authorized by TOE for units of the Army-in-the-Field, and in TDA's for CONUS units.

4.1.9.6 Technical Manuals (TM)

TM's authorized DS units consist of the -30, -35, and -35P manuals for all types of aircraft included in the support mission.

4.1.9.7 Forms and Records

DS activities utilize the forms and records outlined in TM 38-750 and displayed in Figure 4-2.

4.1.9.8 AIDAPS Impact

The impact of an AIDAPS on DS levels of maintenance parallels the organizational effects, with reductions in inspections, MAC changes, quantity changes in allowances of spares/repair parts/special tools/GSE, and a reduction in TAMMS record keeping.

Fault diagnosis of bad components will permit selective downgrading of General Support functions to DS thus providing for maximum self-sufficiency at CONUS locations and in a theater of operations. Retrograde of faulty diagnosed serviceable components will be drastically reduced.

The placing of aircraft components on a "conditional" replacement basis should reduce the quantity of spares and repair parts at the DS level and provide increased unit mobility, while concurrently reducing component record keeping functions associated with flying hours or calendar replacement criteria.

4.1.10 General Support (GS) Levels of Maintenance

4.1.10.1 Functions

In CONUS, GS levels of maintenance are accomplished in fixed field maintenance shops, many of which are co-located at Army depots, and staffed with DA civilians. In a theater of operations, GS is accomplished by TOE military units. The TOE units are 50% mobile using organic transportation, hence must move in two lifts (shuttle) or obtain additional vehicles to move all the equipment in one movement.

GS maintenance companies complement the efforts of DS units, providing overflow and backup maintenance support. Although GS maintenance companies will accomplish that portion of the direct support maintenance work load that exceeds the capacity of supported units, general support maintenance is primarily established for, and functions more efficiently and productively in the performance of maintenance that exceeds the capability of supported units.

The distinction between direct and general support maintenance is largely one of more time and facility availability at the general support level because of less frequent movement requirements. These factors permit GS maintenance companies to remain in one location for longer periods; to expend more time in the performance of maintenance tasks; to stock greater varieties and quantities of spares and repair parts; to augment productive capacity by utilizing civilian labor; to utilize more elaborate structures, test equipment, and fixtures for the performance of shop operations; and utilize production techniques (e.g., assembly line production) which are not normally practical at the direct support maintenance level. Conversely, at the direct support maintenance level, direct support maintenance units must retain the mobility and responsiveness essential to efficient and timely support of using units. They must concentrate on the repair of those items that can be returned to service most expeditiously, with emphasis on the repair of end items and the correction of faults or malfunctions occurring with the greatest frequency.

At the direct support maintenance level, repair time is at a premium. Maintenance normally cannot afford to accumulate a large backlog of work because of frequent movement requirements. Repair of end items and their return to using units must be expedited. Therefore, the maintenance effort concentrates on the repair of end items by testing, adjustment, maintenance calibration, straightening, tightening, replacement of minor repair parts, and replacement of unserviceable components. Normally, unserviceable but economically repairable components removed from end item are evacuated to general support maintenance for repair.

The maintenance capability of a GS maintenance company is tailored to provide for the rapid return of repaired items to supply outlets or direct support units. Aircraft GS units do not have a direct supply mission. Both DS and GS units requisition directly from depot stores. GS maintenance companies are organized and equipped to perform both general support and direct support maintenance. When the tactical situation requires a direct support maintenance unit to move, the supporting general support maintenance company may be required to accept the direct support unit's incomplete repair jobs.

4.1.10.2 Maintenance Allocation Charts (MAC)

The maintenance allocation chart specifies the function that GS units may accomplish. These functions include all the functions performed at organization and direct support levels, but in greater depth. In addition, GS units accomplish overhaul and limited rebuild of selected aircraft subsystems. Normally GS units possess mobile engine test cells so testing of complete engines can be accomplished.

4.1.10.3 Repair Parts and Special Tools

Repair parts and special tools for GS units are authorized in the -34P, -35P, -40P and -45P technical manuals.

4.1.10.4 Forms and Records

Forms and records used at GS levels of maintenance are specified in TM 38-750, The Army Maintenance Management System (see Figure 4-2).

4.1.10.5 AIDAPS Impact on General Support Levels of Maintenance

Repairable components evacuated to GS levels of maintenance normally have little factual documentation as to the malfunction which dictated removal of the component. The GS unit must either run the component on a test stand, i.e., engines, starters, generators, or disassemble the component to troubleshoot the problem. Either technique is time consuming, expensive and delays repair and return to stock of the components. An AIDAPS will fault isolate to the component level and should permit rapid turnaround of repairables.

Timely diagnosis of and correction of malfunctions in components, made possible by an AIDAPS, may permit the assignment of a supply mission to GS units thus shortening the supply line between DS units and depots.

The usage of "Kits" for component repair in both DS and GS units has been tried for a number of years. A Kit may contain simple seals or bearings for high mortality components. This approach has only achieved limited success due to the problems encountered in diagnosing component malfunctions. An AIDAPS will permit greater implementation of the Kit concept and should result in major dollar savings. Army field experience has repeatedly demonstrated that low cost "bits and pieces" are frequently the key to returning high dollar cost components to a serviceable condition.

4.1.11 Depot Level of Maintenance

4.1.11.1 Functions

A typical U.S. Army depot in CONUS is concerned with the receipt, the storage, and the issue of general supplies, equipment, and materiel for distribution to CONUS installations and to designated oversea areas. In addition, when required, a depot stocks mobilization reserve supplies. The depot will also receive, segregate, identify, and classify excess and returned material for salvage, repair, renovation, storage, or other disposition. Included, normally, will be the requirement to assemble units and components of equipment and materiel into sets such as modification work order kits, and to issue both major and minor items.

Designated depots are concerned with the receipt, the storage, and the issue of commodities and items for other military services and government agencies. In addition, they repair, overhaul, modify, fabricate, and rebuild Army items of equipment, weapons, and materiel as well as materiel and equipment of other Department of Defense agencies.

Normally, depot maintenance is performed in Table of Distribution and Allowance shops or under contract at commercial facilities. The primary purpose of depot maintenance is to augment stocks of serviceable materiel. Selected depots, however, are assigned the mission of performing depot maintenance on medical equipment and returning this equipment to the user on a nonreimbursable basis. Another exception to the general procedure is Army aircraft. Selected AMC depots are assigned the additional mission of performing general support (GS) maintenance on Army aircraft. Generally, the GS capability is provided to using units by special maintenance shops located in proximity to the using unit. These shops are administered by the Director of Maintenance of an assigned Army depot.

Another unique Army aircraft depot facility is the Floating Aircraft Maintenance Facility I (FAMF I). This activity consists of a converted Navy seaplane tender which was renamed the USNS Corpus Christi Bay. The vessel was converted to accept machine shops, engine test cells and other depot level shops. Personnel performing the aircraft maintenance functions are military personnel from the 1st Transportation Corps Battalion (Aircraft Maintenance Depot) (Seaborne). This facility has provided a floating depot facility off the coast of Vietnam to fill the logistical gap between that country and depots located in CONUS.

The terms "branch depots" and "general depots" are no longer used to classify depots as to mission responsibilities. Neither is any distinction made for large depots handling many types of commodities, smaller depots handling a limited range of commodities, or depots which handle a single type of commodity such as ammunition. All depots presently are designated simply as Army depots. Civilian employees provide the bulk of the work force employed in CONUS depots, although there a few TOE depot maintenance units of company and battalion size attached to some depots in CONUS. Oversea depots may consist almost entirely of TOE depot maintenance units, but they also employ large numbers of indigenous personnel. Located on some depots are depot maintenance shops. The primary mission of these maintenance shops is to support supply on a return-to-stock basis. To accomplish this mission, depot maintenance shops employ production line, bay shop, or bench type methods of operation, as appropriate. These shops contain extensive facilities, specialized production equipment, and the most diverse technical skills in the Army maintenance system. Other depot operating personnel maintain close liaison with maintenance activities to insure that proper and adequate support is rendered and to provide for an orderly flow of work from lower categories of maintenance.

4.1.11.2 Depot Locations in CONUS

The following is a list of the CONUS aircraft and related equipment depot maintenance facilities and their general mission assignments:

	Type Activity	Mission
(1)	Army Aeronautical Depot Maintenance Center	Performs depot level maintenance on aircraft, aeronautical equipment, and avionics. Also perform calibration services.
(2)	Atlanta Army Depot	Performs depot maintenance on engineer, medical, and aircraft materiel; conducts general support maintenance on Army aircraft.
(3)	Fort Hood Aircraft Shop	Performs general support maintenance on Army aircraft.
(4)	Fort Riley Aircraft Shop	Performs general support maintenance on Army aircraft.
(5)	Granite City Army Depot	Performs maintenance, repair, and overhaul requirements on construction, topographic, electronic and cryogenic (refrigeration) equipment in depot and contract shops.
(6)	New Cumberland Army Depot	Performs depot maintenance on chemical and transportation type materiel and armament components. Performs overhaul and general support maintenance on Army aircraft.
(7)	Sharpe Army Depot	Performs depot maintenance on chemical, medical, engineer, and transportation-type materiel; performs overhaul and general support maintenance on Army aircraft.

Type Activity	Mission
(8) USNS Corpus Christi Bay (Floating Aircraft Maintenance Facility #1) (FAMF-1)	Performs depot level maintenance on aircraft, aeronautical equipment and avionics. Currently on station in Southeast Asia. Home station is Corpus Christi, Texas.

4.1.11.3 Personnel Skills

Unlike many industrial concerns which are able to achieve flexibility in their labor force by hiring workers in periods of peak production output and laying them off when the volume of work declines, most Army depot maintenance shops have labor forces that are relatively inflexible. This condition is true for several reasons. Many depot maintenance shops in CONUS, for example, are located in isolated, nonindustrial areas. Often, the military and civilian personnel who work in these shops form a large percentage of the skilled work force in the area. Under such circumstances, if labor requirements at the maintenance shop increase, it is often difficult or impossible to hire additional trained workers. If, on the other hand, the workload at the maintenance shop decreases, and workers are laid off, the workers may move away from the area entirely - especially if there is insufficient commercial industrial activity available to absorb them. It is imperative, therefore, that available manpower in the maintenance shops be retained. Another reason why the depot maintenance shop work force is relatively inflexible is that the size of the labor force required to execute the program for a budget year is usually determined during the budgetary process and, in most instances, is conditioned by the best available estimates of the shop's prospective workload. Estimates are based on historical records and, consequently, have a certain "built-in" inaccuracy. The labor ceiling prescribed in the budget is seldom exceeded in actual practice, not only because of restrictions imposed by directives but also because additional skilled personnel needed for an expanded overhaul operations are seldom available. Too, in all probability, additional skilled personnel who might be available would hardly be willing to work on a temporary basis.

Army depots in oversea theaters are faced with the same problem of inflexibility of the labor force as are the depots in CONUS. Moreover, other problems confront the commanders of an Army depot overseas. In relatively undeveloped countries, unskilled labor may be plentiful; but skilled labor is generally scarce; and most depot employees must be given extensive on-the-job training in production techniques. This training is usually hampered by a language barrier that is not easily overcome.

Civilians employed in depot maintenance activities usually are classified as either wage board or general schedule employees. As such, they have been trained, in many instances, in positions peculiar to a military specialty, and in some cases, the positions in which they work are infrequently found in private industry. The Army, therefore, has a valid interest in the retention of such trained personnel, and every effort is made to balance workloads so as to avoid personnel fluctuations.

4.1.11.4 Repair Parts, Special Tools and Test Equipment Allocation and Allowances

The National Maintenance Point (NMP) of the Aviation System Command is responsible for selecting and preparing a Repair Parts and Special Tools List (RPSTL) for Army aircraft. This list indicates the range and the quantity of repair parts, special tools, and test equipment required to maintain a specified number of end items for a definite period of time.

The range of repair parts, special tools, and test equipment are selected from the original provisioning list of all reparable parts and special tools of the major end item. This list is based on the Maintenance Allocation Chart (MAC). Repair parts, tools, and test equipment are allocated to the depot maintenance facility based on the maintenance function assigned in the detailed MAC. Generally, repair parts assigned to depot maintenance also include those assigned to all lower categories of maintenance, that is, organizational, direct support and general support.

Maintenance factors for repair parts are determined based on anticipated replacement rates under combat conditions. However, repair parts maintenance factors for new items, or items having new applications, are derived from available data from the manufacturer; results from engineering, service and troop tests; and reports of failure data on other repair parts having similar application. Maintenance factors are continually refined and updated by analyzing data collected from all available sources such as failure data reports, supply demand experience, Equipment Improvement Reports, TAMMS feedback data, and user experience. All data obtained in a non-combat environment is converted to a forecasted combat rate.

From repair parts allocated to depot maintenance, certain items are selected for inclusion in the Depot Maintenance Allowance Column of the RPSTL as the quantity of parts recommended for overhaul of 100 end items or components. Also, guide quantities are shown for those repair parts which, through recorded demand experience, show repetitive use. When the item is new to the Army supply system, guide quantities for maintenance significant repair parts are based upon experience with similar equipment or upon engineering estimates. Maintenance evaluation also determines those repair parts which may be required for performing maintenance. Items not authorized for the depot maintenance of components or end items are not listed in the depot maintenance repair part and special tool list.

4.1.11.5 Depot Repair Parts Forecasting

Parts management is a vital aspect of depot maintenance management. Its ultimate objective is to insure that adequate quantities of the right types of repair parts are available to meet production requirements at a particular maintenance activity. Proper parts management can mean the difference between efficient or inefficient repair or overhaul operations, economical or costly production, timely or delayed completion of scheduled work, and a high degree of equipment operability or an excessive amount of deadlined equipment. The maintenance function must be accomplished with a minimum investment in repair parts. If the maintenance shop overstocks repair parts, fewer funds will be available for other depot repair programs. Repair parts stocks must be kept at the minimum levels in order to reduce attendant "holding costs," that is, the costs to store, inventory, inspect, preserve, maintain records, and to dispose of excess and obsolete stocks. Most repair parts are now stock funded and must be paid for with appropriated funds; the return of any excess stock-funded parts for credit is discouraged because of the handling and transportation costs involved.

Parts forecasting is one of the most important elements of the depot parts management effort, for the accuracy of parts requirements forecasts often determines the effectiveness of production scheduling. The requirements for overhaul may be relatively predictable and therefore controllable, but forecasting repair parts requirements without a complete teardown and inspection of the item to be overhauled is difficult, and often impossible. The age of an item, the environment in which it was used, its operator, and a number of other variables combine to make the usage history of each item entering the depot maintenance shop unique. As a result of these variables, two items of the same make and model may have quite different parts requirements. In some cases, parts that are requisitioned for depot maintenance operations are not available in the Army supply system because they have no demand history; therefore, they are not procured until they are requisitioned (demanded). Often this procurement action requires a lead time of 6 months or more. As a result, depot shop requisitioning of unstocked parts must be initiated long before overhaul of equipment is begun. The long lead time required emphasizes the need for accurate forecasting of repair parts requirements; for otherwise, supplemental requisitions cannot be filled on a timely basis.

4.1.11.5.1 Parts Forecasting Process

The method of determining the number of parts required to repair an end item depends on the number of items to be repaired. If only a few end items require repair, management usually requires a teardown inspection for each end item. Lists of repair parts required are developed from these inspections, and the time frame as to the repair of the low density items is contingent upon the receipt of the repair parts. As the densities of the end items increase, it becomes less and less economical to hold the items in a disassembled state until parts are received; therefore, the determination of the number and kind of repair parts required must be based on forecasts.

The process of forecasting and the subsequent procurement of parts for the repair of moderate and high density end items begins with the initiation of a Work Authorization issued by the Depot Maintenance Coordinating Center. After initial preparation or review by the Production Control Element of the Depot Directorate for Maintenance, the order is sent to that maintenance element of the Maintenance Directorate which is responsible for determining parts requirements. This element computes the kinds and quantities of parts necessary to perform the work, whether it is a relatively small job likely to require only one or two days or a production line run scheduled to operate for a number of months. The information for these computations is generally taken from the mortality data file. This file contains historic data on parts usage and other repair operations of the past. Of most significance are the consumption or mortality rates which indicate the quantity of a part that was used in overhauling 100 end items. Thus, the quantity of repair parts required to support a scheduled maintenance program is established. When this quantity is costed and purified, utilizing NMP and National Inventory Control Point (NICP) feeder data, it is identified as the Depot Maintenance Level (DML) - a quantitative level established within the depot consolidated property account for that quantity of repair parts required to support the scheduled maintenance program.

The NMP of each commodity command develops and distributes for depot use consumption rates for nearly every major end item and many secondary items for which it is responsible. This rate is based on historical data and gives, as a percentage, the average number of times in the past that a certain part has been needed for the overhaul of 100 end items. The NICP uses these consumption rates to compute future worldwide repair parts requirements.

The consumption rate for repair parts is much like an historical performance standard. It is an average and is only useful if it represents an adequate number of items. Generally, the age, condition, and parts requirements of an unserviceable group of items from a particular geographic area will vary from the average age, condition, and repair parts requirements of a group of unserviceables from another geographic area. This variation requires the establishment of separate mortality data for unserviceables from different areas such as the Pacific, Europe, CONUS, Alaska, and other areas.

The parts manager does not rely on consumption data exclusively in computing repair parts needs. Consumption data are only a starting point for effective forecasting. In using consumption data, the parts manager should estimate the condition of particular unserviceables and how much they vary from the average. Equipment that is old and has had abnormally strenuous usage required more and different repair parts than newer equipment requires. Frequently, a pre-shop inspection of the equipment will indicate exceptional requirements, so the parts manager should consider such information in the parts requirement calculations. Because of peculiar conditions under which some equipment is operated, it is possible to predict that certain kinds of parts failures will occur. In such cases, an average consumption rate is not used because experience dictates otherwise. If specific parts fail unexpectedly in items of equipment and repeatedly deadline many end items, the consumption data for these and other parts belonging to the end items should be reviewed. When this condition exists, a representative sample of the lot of unserviceables may be completely torn down and inspected. This technique may be used also for new items on which no mortality data have been developed. In many instances, data concerning the continuous failure of the same parts are reflected in the reports generated by TAMMS. This information is disseminated to the depots. In all cases, the manager should apply experience, judgment, and all other available information in estimating parts requirements.

After the quantities of repair parts required have been forecasted, a determination is made as to the number of repair parts that can be obtained from reclamation. Reclamation is the process of restoring to usefulness any condemned, discarded, abandoned, or damaged materiel, or parts or components thereof, and returning these items to supply channels. Materiel Condition Codes as prescribed by AR 725-50 provide guidance for determining whether an item should be reclaimed. Repair standards, also, are considered when this decision is being made.

4.1.11.6 AIDAPS Impact on Depot Levels of Maintenance

4.1.11.6.1 Personnel Skills

The utilization of an AIDAP System will complement the skill level and personnel problems encountered in depot operation both in CONUS and overseas. Positive diagnosis of component problems will permit timely repair by depot personnel with a reduction in test cell running or teardown to determine component problems. Thus skilled personnel can be utilized to a greater degree in repair or overhaul functions which emphasize rapid turnaround of components for return to stock. This approach will reduce the maintenance work load "peaks and valleys" which require expansion/contraction of the total labor force.

4.1.11.6.2 Special Tools and Test Equipment

An AIDAPS will initially not significantly reduce the overall requirement for special tools and test equipment, but, by eliminating unnecessary testing (particularly initial testing of returned depot reparables) of components, will extend the life of the test equipment thus reducing the demand for replacement equipment.

4.1.11.6.3 Repair Parts Forecasting

Paragraph 4.1.11.15.1 outlined the problems in repair parts forecasting based on the variables of equipment density, age, environment in which used and teardown inspections required to isolate and identify component malfunctions. In addition, sudden trends of increased repair parts usage for a particular component present major problems in parts forecasting and supply systems responsiveness. An AIDAPS will provide a quantum improvement in repair parts forecasting by providing factual, timely information on the conditions of aircraft and components.

4.1.12 Future Army Logistical System

4.1.12.1 Principles of Maintenance

The principles of maintenance outlined in paragraph 4.3 for the existing logistical system are applicable to the future system. Increased emphasis will be placed on maximum self-sufficiency at the organizational level of maintenance. In the past history of Army aviation, there have been considerable friction and misunderstanding between levels of maintenance concerning accomplishment, in their entirety, of Maintenance Allocation Chart (MAC) functions. Thus, aircraft have been work-ordered from organizational to Direct Support (DS) levels of maintenance with outstanding organizational deficiencies that should have been corrected prior to evacuation to the DS level. Actions of this nature force the DS unit to adopt one of two "friction creating" courses of action: The DS unit can refuse to accept the work order until the organizational deficiencies are eliminated; or, accept the work order and keep the aircraft deadlined an additional period of time while accomplishing DS maintenance plus correcting the organizational deficiencies. The position of aviation unit commanders, at both levels of maintenance, concerning the problem area described above is easily understood. The organizational unit must periodically defer accomplishment of maintenance due to frequent moves, constraints imposed by the tactical situation, constant personnel rotation, and problems due to the limited maintenance experience (particularly diagnostic) of organizational personnel. On the other hand, the total aircraft maintenance mission is divided on a function basis by the MAC. Personnel and equipment are assigned each level of maintenance based on the MAC. Thus, each level of maintenance must assume its share of responsibility or a backlog situation develops, and the DS unit will dilute its mission capability on the accomplishment of organizational level functions.

As stated previously, the Army recognized these problems many years ago, when the AIDAPS QMR was approved. An AIDAP system with its diagnostic/prognostic capability will assist all levels of maintenance, but particularly organizational units, in developing a maximum self-sufficieny for accomplishment of its MAC mission in its entirety through positive identification of maintenance problems.

4.1.12.2 Maintenance Objectives

The objectives of the future Army logistical system are the same as for the present system, that is to assure that Army materiel is sustained in a ready condition, consistent with economy, to fulfill its designed purpose.

4.1.12.3 Categories of Maintenance

The present categories of maintenance consisting of organizational, direct support, general support and depot are combat proven under varying conflict situations and have application without major modification to the future Army logistical system.

4.1.12.4 Significant AIDAPS Impact on Future Logistical System

The most significant envisaged impact on the Army logistical system from AIDAPS will be the capability to diagnose subsystem/component maintenance problems, and by trend analysis, to predict impending component failure. This capability dictates consideration of the addition of two new maintenance functions to the Army adopted list used in Maintenance Allocation Charts. These are diagnosis and prognosis. A related consideration is a change in DS/GS/depot maintenance unit TOE/TDA to authorize a Military Occupational Specialty (MOS) skill that will provide an individual trained in diagnostic/prognostic maintenance methods. This area will be addressed in greater detail during Phase C of the study, with subsequent Army decision action as reflected in the Provisional Qualitative and Quantitative Personnel Requirements Information (PQQPRI) block of the Life Cycle Management Model, and changes to the Maintenance Allocation Charts.

4.1.12.5 Maintenance Operations (Future)

The goals and functions of future Army levels of maintenance, as influenced by introduction of an AIDAPS, are presented below.

4.1.12.6 Organizational Maintenance Levels

4.1.12.6.1 Goals

a) Reduction in number and frequency of inspections.

b) "On Condition" replacement of components as opposed to flying hours or expiration of calendar periods of time.

c) Minimum personnel skill level requirements.

d) Minimum quantity of common tools/test equipment/GSE.

e) Maximum usage of Air Mobile Shop (AMS) concept.

f) Increased aircraft availability.

g) Bulk of maintenance performed "on site" at the organizational maintenance unit location.

h) Reduction in quantity levels of spares and repair parts.

4.1.12.6.2 Functions

The following broad organizational maintenance functions are envisaged for the future Army logistical system.

a) Aircraft servicing.

b) Flight line inspection including aircraft go-no go AIDAPS data.

c) LRU removal and replacement.

d) Limited diagnosis to the degree required to identify and replace a bad LRU.

e) Large tolerance adjustments.

4.1.12.6.3 Aircraft Inspections

Introduction of an AIDAPS into Army assets will reduce the requirement for the 25 hour intermediate inspection (PMI) and permit extension of the periodic flying time interval. Future aircraft inspections are identified below.

a) Daily (PMI) accomplished after last flight of day or prior to next day's flight. Scope includes visual checks and use of AIDAPS to verify satisfactory functioning of aircraft subsystems.

b) Preflight - Visual walk around check by aviator to ensure servicing has been accomplished and to discover possible defects.

c) Periodic (PMP) - Accomplished at longer intervals and consists of a thorough check of all subsystems, and replacement of components prognosed by an AIDAPS as approaching failure.

4.1.12.7 Direct Support Maintenance Levels

Information concerning the Maintenance Support positive (MS+) Study indicates consideration is being given to consolidation of DS/GS activities. This study is currently being staffed within the Army. Consolidation of DS/GS activities would not impact significantly on the AIDAPS concept formulation study since the major change in Army logistics resulting from consolidation would be reflected in changes to Maintenance Allocation Charts.

4.1.12.7.1 Goals

a) Accomplishment of maintenance as far forward in the combat zone as practicable.

b) Reduction in quantity of special tools/test equipment.

c) Capability of fault isolation of components using AIDAPS (diagnosis).

d) Increased unit mobility by usage of the Air Mobile Shop (AMS) concept.

4.1.12.7.2 Broad Functions

a) Accomplish close tolerance adjustments.

b) Provide maximum technical assistance and backup support to organizational maintenance levels by on site contact team.

c) Usage of AIDAPS to diagnose faults in components thus permitting rapid repair and return to supported units.

d) Replacement of parts in LRU's.

e) Use of AIDAPS to prognose subsystem and component failure.

f) Functional test and calibration of applicable ground support equipment.

g) Fabrication and test of selected items such as hose assemblies, sheet metal components, etc., to reduce supply levels, NORM and NORS time.

h) Maintain maintenance float aircraft.

4.1.12.8 General Support Maintenance Levels

4.1.12.8.1 Goals

a) Reduction in faulty diagnosed serviceable components returned to CONUS depots.

b) Reduction in time required to repair/overhaul components for return to stock.

c) Reduction in quantities of repair parts.

d) Increased usage of the "Kit" concept for repair/overhaul of components.

4.1.12.8.2 Broad Functions

a) Provide backup support to DS units.

b) Accomplishes close tolerance adjustments.

c) Limited secondary standard calibration.

d) Limited manufacture of repair parts.

e) Repair, overhaul, modification and alteration of assemblies for return to stock.

f) Perform factory type testing of components.

g) Selection of aircraft for return to depot for cyclic overhaul or on site airworthiness repair.

h) Diagnosis and prognosis of maintenance problems using AIDAPS.

4.1.12.9 Depot Maintenance Levels

4.1.12.9.1 Goals

a) Reduction in faulty diagnosed serviceable components returned for overhaul.

b) Reduction in aircraft returned for cyclic overhaul that could have been returned to service by airworthiness repair at GS levels.

c) Reduction in backlog fluctuation.

d) Reduction in quantity levels of spares and repair parts.

4.1.12.9.2 Functions

a) Performs end and secondary item overhaul and rebuild for return to serviceable assets/stock.

b) Fabricates major items not available from stock.

4.1.13 Summary

Tables which follow provide detailed functional comparison of the maintenance levels (AIDAPS impact) for the present and future logistical systems; all functions are keyed to Army aircraft Maintenance Allocation Charts (MAC).

Table 4.3

Organizational Maintenance Level Detailed Functional Comparison*

Current System	Future System
1. **Inspect**	1. **Inspect**
a) Preventive Maintenance Daily (PMD)	a) Selected functions performed by AIDAPS
b) Preventive Maintenance Intermediate (PMI)	b) Deleted (major items performed by AIDAPS)
c) Preventive Maintenance Periodic (PMP)	c) Interval extended beyond 100 flying hours
d) Special Inspections	d) Selected functions performed by AIDAPS
e) Flight Tests (TBAVN 23-16)	e) Manual recordings by test pilot of A/C instrument values will be accomplished by AIDAPS
f) Standards of Serviceability (-20 Technical Manual)	f) No change except for drastic reduction in component replacement requirements since AIDAPS will permit "on condition" component replacement in lieu of flying hour or calendar criteria
g) Visual inspection of components for leaks, damage, missing items, etc. [Maintenance Allocation Chart (MAC)]	g) No change except as outlined above for PMD, PMI, PMP and Special Inspections
2. **Test**	2. **Test**
Maintenance Operational Checks (TBAVN 23-16 and MAC) for subsystems and component serviceability and/or failure.	AIDAPS will verify test flight results reported by aviator and ground checks by organizational level mechanic. AIDAPS will identify a failed LRU.
3. **Service (MAC)**	3. **Service (MAC)**
a) Engine and Related Systems	a) No change
b) Rotors and Transmission System	b) No change
c) Hydraulic System	c) No change
d) Electrical System	d) No change
e) Fuel System	e) No change
f) Armament System	f) No change

Organizational Maintenance Level Detailed Functional Comparison (Continued)

Current System	Future System
4. Adjust (MAC)	4. Adjust (MAC)
a) Airframe	a) No change
b) Engine and Related Systems	b) MAC may be changed to permit additional large tolerance adjustments using AIDAPS
c) Rotors and Transmission System	c) MAC may be changed to permit additional large tolerance adjustments using AIDAPS
d) Hydraulic System	d) MAC may be changed to permit additional large tolerance adjustments using AIDAPS
e) Aircraft Instruments	e) MAC may be changed to permit additional large tolerance adjustments using AIDAPS
f) Electrical System	f) MAC may be changed to permit additional large tolerance adjustments using AIDAPS
g) Fuel System	g) MAC may be changed to permit additional large tolerance adjustments using AIDAPS
h) Flight Controls	h) MAC may be changed to permit additional large tolerance adjustments using AIDAPS
i) Armament System	i) No change
5. Align (MAC)	5. Align (MAC)
None	No change
6. Calibrate (MAC)	6. Calibrate (MAC)
a) Aircraft Instruments	No change
(1) Compass Swing	
(2) Altimeter	
7. Install (MAC)	7. Install (MAC)
N/A	N/A

Organizational Maintenance Level Detailed Functional Comparison (Continued)

Current System	Future System
8. **Replace (MAC) (Selected Components)**	8. **Replace (MAC) (Selected Components)**
a) Airframe	a) No change with AIDAPS
b) Alighting Gear	b) Reduction in special inspections on AIDAPS monitored items, i.e., hard landing
c) Engine and Related Systems	c) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
d) Rotors and Transmission System	d) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
e) Hydraulic System	e) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
f) Aircraft Instruments	f) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
g) Electrical System	g) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
h) Fuel System	h) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
i) Flight Control System	i) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
j) Utility System	j) MAC can be changed to permit replacement of additional LRU's based on AIDAPS diagnosis
9. **Repair (MAC)**	9. **Repair (MAC)**
All aircraft functional groups	Selected MAC functions can be downgraded to the organizational maintenance level based on AIDAPS diagnosis of cause of component malfunction
10. **Overhaul (MAC)**	10. **Overhaul (MAC)**
N/A	N/A

Organizational Maintenance Level Detailed Functional Comparison (Continued)

Current System	Future System
11. Rebuild (MAC) N/A	11. Rebuild (MAC) N/A
12. Diagnosis N/A	12. Diagnosis (MAC)** Limited diagnosis not involving extensive analysis of printout data.
13. Prognosis N/A	13. Prognosis (MAC)*** Limited short term prognosis not involving extensive analysis of the data.

* Maintenance functions are those listed in the current study aircraft Maintenance Allocation Charts (MAC), and which may be influenced by an AIDAPS.

** Diagnosis is a proposed new functional addition to MAC based on AIDAPS capability.

*** Above comment on diagnosis applies to prognosis.

Direct Support Maintenance Level Detailed Functional Comparison*

Current System	Future System
1. **Inspect**	1. **Inspect**
a) Preventive Maintenance Periodic (PMP)	a) Selected DS functions performed by AIDAPS
b) Special Inspections	b) Selected DS functions performed by AIDAPS
c) Test Flights (TBAVN 23-16)	c) Manual recording of aircraft instrument values by test pilot will be accomplished by AIDAPS
d) Standards of Serviceability (-35 Technical Manual)	d) AIDAPS will permit "on condition" component replacement in lieu of flying hour or calendar period criteria
e) Visual Inspection of components for leaks, damage, missing items, etc.	e) No change except as outlined above for PMP and Special Inspections
2. **Test**	2. **Test**
a) Test equipment checkout of selected aircraft components except complete engines, gear boxes, main transmission(s), etc.	a) AIDAPS diagnostic capability will permit a reduction in initial test stand run requirements on reparable components
3. **Service**	3. **Service**
Function at DS level pertains to sophisticated aircraft components, i.e., filter assemblies on CH-47 aircraft	AIDAPS diagnostic/prognostic capability will permit elimina tion of selected servicing functions at the DS level
4. **Adjust**	4. **Adjust**
Close tolerance adjustments are authorized by Maintenance Allocation Chart on selected aircraft components (this function frequently requires special tools/test equipment)	No change except for a possible reduction in special equipment by use of AIDAPS diagnostic capability
5. **Align**	5. **Align**
Selected alignment functions not requiring a jig, primarily associated with rotor hub and blades assemblies	No change in basic functions. AIDAPS will assist in checking quality of work accomplished.

Direct Support Maintenance Level Detail Functional Comparison (Continued)

Current System	Future System
6. **Calibrate** MAC authorizes limited calibration, i.e., fuel quantity indicator, exhaust temperature indicator. In addition, DS calibrates selected items of GSE and special tools.	6. **Calibrate** No change
7. **Install** Function assigned infrequently by MAC, i.e., armor plate bracketry on CH-47. No AIDAPS impact.	7. **Install** No change
8. **Replace** Predominant maintenance function authorized by MAC applicable to majority of aircraft subsystems and components less major structural items at the DS level.	8. **Replace** AIDAPS will reduce the number of replacement actions by diagnosis/prognosis of faulty components, "on condition" replacement, and reduction of faulty diagnosed removals which are found serviceable when tested at higher levels of maintenance.
9. **Repair** This function applied extensively to DS level on a component repair and return to user basis.	9. **Repair** AIDAPS will reduce quantity of components returned for repair by positive diagnosis of component condition.
10. **Overhaul** Function rarely authorized at the DS level. Exception is the heater fuel solenoid valve for the CH-47.	10. **Overhaul** AIDAPS usage in a fault isolation mode will permit selected items to be downgraded for overhaul from the GS to the DS level.
11. **Rebuild** Not applicable to the DS maintenance level.	11. **Rebuild** No change

Direct Support Maintenance Level Detail Functional Comparison (Continued)

Current System	Future System
12. Diagnosis N/A	12. Diagnosis Diagnosis to include component fault isolation using a special MOS trained individual and AIDAPS.
13. Prognosis N/A	13. Prognosis Prognosis based on trend analysis by a special MOS trained individual and AIDAPS.

General Support Maintenance Level Detailed Functional Comparison

Current System	Future System
1. Inspect	1. Inspect
a) Special Inspections	a) Selected GS functions performed by AIDAPS.
b) Test Flights (TBAVN 23-16)	b) Manual recording of aircraft instrument values will be accomplished by AIDAPS.
c) Standards of Serviceability (-35 Technical Manual)	c) AIDAPS will permit "on condition" component replacement in lieu of flying hours or calendar period criteria.
2. Test	2. Test
Test equipment checkout of selected aircraft components including complete engine assemblies but excluding gear boxes, main transmissions, etc. Example - fuel control unit on CH-47.	AIDAPS diagnostic capability will permit a reduction in initial test stand run requirements on reparable components.
3. Service	3. Service
Function at GS level pertains to more sophisticated aircraft components than of DS level, i.e., main fuel manifold filters for CH-47.	AIDAPS diagnostic/prognostic capability will permit elimination of selected servicing functions at the GS level.
4. Adjust	4. Adjust
The adjustment function at the GS level is mainly applicable to adjustment of sophisticated aircraft components using special test equipment.	AIDAPS will reduce the quantity of components returned to GS levels of maintenance by positive diagnosis of the component status at lower levels of maintenance.
5. Align	5. Align
The alignment function is applicable to components and aircraft repair (requiring a jig) at the GS level of maintenance.	No change
6. Calibrate	6. Calibrate
The calibration function is applicable to aircraft components, organic and supported special equipment and GSE at the GS level of maintenance.	No change

General Support Maintenance Level Detailed Functional Comparison (Continued)

Current System	Future System
7. **Install** This function is rarely assigned to the GS maintenance level.	7. **Install** No change
8. **Replace** This function normally requires special tools/test equipment at the GS level, i.e., engine inlet housing replacement on the CH-47.	8. **Replace** No change
9. **Repair** This function normally requires high skill levels and special tools/test equipment/material at the GS level, i.e., repair of the engine turbine tail-pipe and inner cone on the CH-47.	9. **Repair** No change
10. **Overhaul** This function comprises the bulk of the GS workload and requires high skill levels, special tools and test equipment.	10. **Overhaul** AIDAPS usage in a fault isolation mode will permit selected items to be downgraded for overhaul from depot to the GS level.
11. **Rebuild** N/A to GS level	11. **Rebuild** No change
12. **Diagnosis** N/A	12. **Diagnosis**** Diagnosis to include wider range (vs. DS) of component fault isolation using a special MOS trained individual and AIDAPS
13. **Prognosis** N/A	13. **Prognosis** Prognosis of component failure by trend analysis of AIDAPS printout data by specially trained (MOS) personnel.

** Diagnosis and prognosis are recommended additions to future MAC's based on AIDAPS capability.

Depot Support Maintenance Level Detailed Functional Comparison

Current System	Future System
1. **Inspect**	1. **Inspect**
a) Overhaul and retirement schedule on major components is based on flying hour or calendar time criteria.	a) AIDAPS will permit "on condition" replacement of major components.
b) Standards of Serviceability	b) AIDAPS will permit determination of the actual condition of aircraft components thus eliminating arbitrary changeout of major components to meet standards of serviceability.
2. **Test**	2. **Test**
Test equipment checkout of all aircraft components returned for overhaul or rebuild plus test flights on overhauled/rebuilt aircraft.	AIDAPS identification of component failure will reduce test time of components received at the Depot.
3. **Service**	3. **Service**
This function is performed at the depot level subsequent to overhaul/rebuild actions.	No change
4. **Adjust**	4. **Adjust**
This function is performed at the depot level subsequent to overhaul/rebuild actions	No change
5. **Align**	5. **Align**
Major alignment functions are performed using jigs and special test equipment.	No change
6. **Calibrate**	6. **Calibrate**
A full range of calibration functions are accomplished to include references to secondary standards.	No change
7. **Install**	7. **Install**
This function is infrequently assigned by MAC.	No change

Depot Support Maintenance Level Detailed Functional Comparison (Continued)

Current System	Future System
8. **Replace** This function at the depot level includes replacement of major structural portions of aircraft.	8. **Replace** No change
9. **Repair** Comment 8 above applies.	9. **Repair** No change
10. **Overhaul** Primary mission of Army depots is to restore items to a completely serviceable condition as prescribed by maintenance serviceability standards using the IROAN principle.	10. **Overhaul** No change
11. **Rebuild** The rebuild function is the second major mission of Army depots. Rebuild actions are normally applicable to critical flight safety aircraft components, i.e., rotor blades.	11. **Rebuild** No change
12. **Diagnosis** N/A	12. **Diagnosis** Diagnosis to facilitate overhaul/rebuild functions using AIDAPS and a special MOS trained individual
13. **Prognosis** N/A	13. **Prognosis** Prognosis of component failure by trend analysis of AIDAPS printout data by specially trained MOS/job description personnel.

4.2 AIDAPS INFORMATION AT HIGHER LEVELS OF MAINTENANCE

4.2.1 Study Team Survey

In compliance with the AIDAPS study objectives, visits were made by study team personnel to selected Army operational and logistical activities. One of the objectives of these visits was to obtain aviation operational and logistical personnel opinions concerning AIDAPS data format and detail at the various levels of maintenance. These opinions or value judgments are considered extremely valuable in that they are in the main based on recent combat aviation maintenance experience. It also should be noted that many of the Army personnel contacted are the potential larger unit combat and logistical commanders of the future Army, who will be using an AIDAP system. The AIDAPS study team members were impressed with the overall knowledge and enthusiasm for AIDAPS concepts displayed by Army aviation personnel.

4.2.2 Data Format and Detail

4.2.2.1 Data Printout

In discussing the desired AIDAPS data format and detail with personnel from the Army Materiel Command, Combat Developments Command, and the Continental Army Command, three data format concepts were consistently advanced. These were an alphanumeric code, a printout in the English language, and a printout of numerical parameter values. These concepts will be addressed in some detail during Phase C.

4.2.2.2 Correlation with Maintenance Allocation Charts (MAC)

The majority of the Army personnel contacted indicated the selected AIDAPS printout should reflect the maintenance functions and levels of maintenance authorized by individual aircraft MAC charts. The MAC's are reviewed periodically and maintenance functions upgraded/downgraded within the levels of maintenance, based on analysis of inputs from field activities. Thus, future MAC changes induced by an AIDAPS could be handled by the Army as a routine change within the existing logistical system.

4.2.2.3 Correlation with Technical Manuals

Another major AIDAPS printout consideration that was emphasized by Army aviation personnel was correlation of the printout with aircraft Technical Manuals. The point was continually raised that the AIDAPS printout should reference the Technical Manual (TM) chapter containing maintenance instructions for a particular aircraft or component discrepancy reported by the AIDAPS system. Some of the Army personnel wanted the page and paragraph number of the maintenance instructions in the Technical Manual on the data printout; however, the frequency of TM changes tends to make impractical this level of detail.

4.2.2.4 Correlation with the Army Maintenance Management System (TAMMS) (Formerly TAERS)

The Army's Maintenance Management System is a program of interrelated actions, each basically simple in its concept and application yet capable of contributing to and benefitting from the master system. The system has three clearly identifiable areas of interest and activities; namely, operational units, field commands, and national agencies.

a) The operational-unit functions of TAMMS are accomplished by those individuals performing the actual maintenance tasks at using units and maintenance support activities. This level of TAMMS is the foundation of the entire system, because maintenance source data generates here. Personnel responsible for supplying this source data must recognize the importance of insuring that this initial input is accurate--for the reliability of subsequent feedback is dependent upon this accuracy. The first level of management activity occurs when the unit manager employs the data generated here to check the operational status, performance use, and deficiencies of equipment and other contributing elements.

b) At field commands, TAMMS is used primarily at either division or installation levels. At this level, information is received from two directions--from using units for analysis and forwarding to higher commands, and from national agencies as feedback data.

c) At national agency levels, data generated by TAMMS are compiled, analyzed, stored and used as needed. These data are used by commands to evaluate the readiness status of materiel, the failure data and service life of equipment, the demands on maintenance resources, and other pertinent major item information. In addition, they provide the basis for decisions as to corrective measures to be taken. The data are used by commodity managers for purposes such as identifying inventories, planning overhaul programs, and determining repair parts requirements. They are used by design agencies as a basis for developing some new items and modifying others. As with the other two areas of TAMMS, the national level provides feedback data--in this case to using units and the field commands. It is at the national level that the full impact of TAMMS potential is realized, for it is at this level that operating policies and concepts governing the entire Army maintenance management program receive final approval.

The Army personnel contacted urged that consideration be given to replacement of selected TAMMS forms with the automated AIDAPS printout, as a means of reducing the paper workload on the aviation mechanic. This appears to be a desirable objective and will be addressed in detail during Phase C of the study effort.

4.2.2.5 Data Elements Desired at the Various Levels of Maintenance

Section 4.1.12.4 presented a review and summary of the envisaged AIDAPS impact on the current and future Army logistical environment. As outlined therein, changes to be considered in the future logistical system include the addition of diagnosis and prognosis to the adopted list of Army maintenance functions in Maintenance Allocation Charts (MAC). A concurrent action also was recommended to authorize a new MOS diagnostic/prognostic skill at the DS/GS/depot levels of maintenance. It is anticipated that a single printout produced at the organizational level will serve higher levels of maintenance. The information can be transmitted using the current TAMMS procedures. To avoid confusion, information applicable to DS and GS activities should be so labeled (as per the MAC). The following paragraphs present the data printout elements deemed desirable at the various levels of maintenance.

4.2.2.6 Data Requirements at All Levels of Maintenance

The data elements outlined below are desirable on the AIDAPS data printout.

a) Date (Julian, Table 9, TM 38-750)

b) Unit Identification Code (AR 18-50 and AR 18-50-10)

c) Aircraft Type, Model and Series (TMS)

d) Aircraft tail number

e) Major component serial numbers

f) Identification of selected (MAC) faulty LRUs and/or malfunctioning subsystems (abbreviated English language or alphanumeric code printout plus parameters as appropriate coupled with failure codes used in TAMMS).

g) Technical Manual reference by chapter number applicable to item f) above.

h) Time correlation to events including: start, liftoff, hover (rotary winged aircraft), malfunction, landing and engine coastdown.

i) Record of accomplishment of AIDAPS feasible portion of scheduled inspections, servicing entries, time to next scheduled inspection (PMI and PMP).

j) Record of any pertinent prognosis including description of predicted failure, parameter values, and the computed time to the event.

The rationale for selection of these items is as follows. The date is needed for correlation with other TAMMS forms and records, missions that may have impacted on logistical problems and for trending (prognosis) purposes. The aircraft TMS and tail number will preclude, particularly at higher logistical levels, mistaken aircraft identity within a broad generic aircraft family; i.e., rotary wing and fixed wing.

The major component serial numbers will facilitate location identification of overall Army spares by higher logistical elements. For example, aircraft engines historically, have accounted for over 50% of the overall Army aircraft maintenance requirements, and in addition are high dollar value items. This information must come from the field (aircraft physical location) due to the sheer volume of logistical actions associated with aircraft components, and the worldwide dispersion of Army aircraft. This information when consolidated at the NICP level, with reports on non-installed major components, will permit a valid assessment of the overall logistical position on aircraft spares.

The addition of major component serial numbers on the data printout also is envisaged as another maintenance tool to facilitate accomplishment of the objectives of the Closed Loop Support System. The purpose of this system is to control the flow of critical serviceable and unserviceable end items, components and assemblies. Thus it provides an integrated effort to control the logistics functions of supply, retrograde, overhaul and resupply in a manner that permits commanders and other logistics managers to maintain the desired readiness posture of materiel assets. As previously stated, the AIDAPS report of installed components could be used with other reports of pipeline and backlog stocks in assessing the overall stock position for high dollar value components.

Data on faulty LRU identification and/or malfunctioning subsystems should be reflected in either an abbreviated English language or alphanumeric code format and coupled to the failure codes used in The Army Maintenance Management System (TAMMS). This approach facilitates understanding of the maintenance problem by the organizational mechanic, and uses the existing TAMMS system with which the Army mechanic is reasonably familiar. The abbreviated English language or alphanumeric code information, in lieu of part number of federal stock number identification, would minimize the impact of the thousands of annual number changes historically encountered in the Army logistical system. The key point is that the numbers change frequently, but the noun infrequently. There is also a CS_3 interface which will be addressed in a subsequent section.

In presenting Technical Manual (TM) information to the mechanic, analysis indicates one of the most simple methods is to provide numerical TM identification plus the chapter number containing the maintenance instructions for a particular function. This approach avoids the problems associated with myriad page and paragraph changes common to the TM system. Evaluation of the Army TM system indicates the basic numbering and chapter identification portions of the overall system are changed infrequently. In addition, consideration should be given to including TAMMS code data in the basic aircraft TM's, thus providing the mechanic a single reference document for interpretation and accomplishment of maintenance functions and preparation of logistical reports. Finally, presentation of the TM suffix will identify the level of maintenance authorized to perform a particular function (i.e., -20 for organization, etc.). This technique, when used in conjunction with the Maintenance Allocation Chart, will assist in the maintenance management activities of the organizational Maintenance Officer relative to requesting DS support.

To facilitate reconstruction of the events, particularly malfunctions, occurring during a flight, and to substantiate air crew findings, the following events should be selectively sampled and correlated to time by an AIDAPS. These events include, but are not limited to: start, liftoff, hover (rotary wing), malfunctions, landing and engine coastdown. The hours recorded on Army aircraft and components currently reflect actual flight time, and do not include ground run time which is, in many cases, an extensive block of time. This nonrecorded ground time obviously has an impact on aircraft maintenance problems. The reason this time has not been reported in the past is the difficulty in "remembering" and recording factual time subsequent to completion of maintenance action on the aircraft. In addition, the Army's position in the past has been that this ground time does not impose actual flight stresses on the aircraft, hence, the time should not be reported because it would result in premature changeout of major, high dollar value aircraft components that are based on an hourly replacement criterion. The AIDAPS potential of permitting "on condition" replacement of aircraft components in lieu of flying hours or calendar criteria will eliminate this consideration and makes it desirable to record the total operating hours on components.

A primary objective of the AIDAPS Qualitative Materiel Requirement (QMR) is automatic accomplishment of those portions of Army aircraft inspections amenable to electronic monitoring. In furtherance of this objective, automatic reporting of the accomplishment of these inspections (PMD, PMI, PMP and Special Inspections) is deemed mandatory.

To facilitate the accomplishment of trend analysis, whether it be in short term prognosis at the organizational level (perhaps for the next flight) or long term at the higher levels of maintenance, selected parameter values must be monitored and recorded. This consideration is discussed in some detail in section 3.1.4.8, and displayed in Figure 3.1-2. As indicated in that section, smoothed data is examined at regular time intervals. Incremental parameter increases can be detected, and by a relatively simple computation, the predicted time to failure determined for an aircraft component.

4.2.3 Summary

In summary, analysis of the recommendations of Army aviation personnel concerning desired AIDAPS data format and detail at the various levels of maintenance indicates three concepts should be addressed; alphanumeric code, abbreviated English language and selected parameter values. The data printed out should provide for multi-purpose usage; that is, inspection/diagnosis/prognosis of maintenance problems and to facilite stock control functions at the higher logistical levels of the Army. The basic TM system is good and should be retained with addition of a chapter on AIDAPS codes. The MAC system is working well and should be retained as a basic departure point in developing an AIDAP system.

4.3 ARMY COMPUTER INTERFACES FOR AIDAPS

4.3.1 General

The previous section presented details on visits to Army activities during Phase B of the study effort. The first objective of the visits was to obtain information on AIDAPS data format and detail. The second objective was to secure data from which to define Army computer interfaces with an AIDAPS. A key consideration in addressing the interface was the possibility of using Army field computers as opposed to dedicated AIDAPS computers for accomplishment of long-term trend analysis. Northrop appreciates the courtesy extended by the U.S. Army Computer Systems Command at Fort Belvoir, Virginia, during this phase of the study. Much of the Combat Service Support System (CS_3) information reflected herein was furnished by that command.

4.3.2 History of Automatic Data Processing Equipment (ADPE) in the Army

The Army first used ADPE in 1948 for mathematical applications. It was extended to selected administrative operations in 1954 and for artillery fire control in 1956. The nuclear age introduced increasing complexity in equipment and the need for rapid response on the battlefield. A study (1957) of these problems by a combined team from Department of the Army and the Continental Army Command resulted in the identification of 106 functions suitable for automation. These functions are identified in the documentation resulting from that study entitled, "Automatic Data Processing System for A Type Field Army" (February 1957). With the reorganization of the Army in 1962, the ADPE program was transferred to the U.S. Army Combat Developments Command and the Army Materiel Command. The Automatic Data Field Systems Command (ADFSC) was organized in 1965 to coordinate the total Army ADPE effort. ADFSC subsequently was renamed the Computer Systems Command (CSC) on 31 March 1969. The mission of CSC is to plan, direct and control all aspects of multicommand data systems development, test and installation, and to provide operational support to the commands using the developed systems. CS_3 is the major system currently envisaged for the Army-in-the-Field that may have a direct interface with an AIDAPS.

4.3.2.1 Current ADP Supply Systems

The other major logistics information systems, National ADP Program for AMC Logistics Management (NAPALM), System-Wide Project for Electronic Equipment at Depots Equipment Exchange (SPEEDEX), Centralization of Supply Management Operations System (COSMOS), and the USARPAC Standard Supply System (3-S), which input into the Army Master Data File (AMDF) system, were analyzed for potential AIDAPS interface.

All of these systems were eliminated from further consideration for the reasons listed below. The NAPALM project is planned to develop a standard ADP system for use by all Army commodity commands. Presently, the systems in use by the commodity commands are all quite different. Inasmuch as this project will be developed over a period of years, which precludes application to the current Army aircraft, and is not sufficiently defined for application to future aircraft, it was eliminated from further consideration in the AIDAPS study.

The SPEEDEX project is the follow-on program to the System-Wide Project for Electronic Equipment at Depots (SPEED) program which has been used for several years by major CONUS depots. These major depots are referred to as SPEED depots. This classification really means that the depot is utilizing the standard computer programs for processing supply transactions. The SPEED programs operate on IBM 1410 computers equipped with magnetic tapes and direct-access storage. The SPEEDEX system is an improvement and advancement of the SPEED programs and will be implemented on third-generation equipment. Since these programs are overwhelmingly supply oriented and do not have the capacity to handle additional maintenance functions, no direct interface is envisioned with AIDAPS.

COSMOS is the current title for the supply system for support of CONUS Class I installations. Installation of a COSMOS system is planned for each CONUS Army area and will provide a centralized supply management system for all logistics resources held by the individual posts, camps, stations, and resident units located within an Army area. The heart of the system is a computer controlled Asset Balance File containing all items in inventory with balance-on-hand data for each of the supply storage activities in the Army area. No AIDAPS interface with COSMOS is foreseen.

The 3-S system is a second-generation supply oriented project in the Pacific/Southeast Asia theater. It will replace the system presently in operation at Hawaii, Okinawa, Japan and Kerea. The present system has used a priority (handcarried) technique called "Redball Express" for forwarding supply requisitions from SEA to CONUS on critical deadlined equipment. Lower priority supply requisitions are transmitted by mail or through the Automatic Digital Network (AUTODIN). The 3-S system is also overwhelmingly supply-oriented with no excess capacity for maintenance functions or interface with AIDAPS.

All of the systems described above input into the Army Master Data File (AMDF) system. The AMDF is the primary source of current non-quantitative logistics information for all items in the supply system. This includes items managed by Army Commodity Commands, as well as items managed by DSA or GSA in which the Army has a registered interest.

4.3.3 Description of Combat Service Support System (CS_3)

4.3.3.1 Definition of Combat Service Support

In addressing the CS_3, it is first necessary to define Combat Service Support. Combat Service Support is provided only in theaters (areas) of operations, and consists of the logistic support functions provided to operating forces as exemplified by the acronym LMCHEST.

1) Labor
2) Maintenance
3) Construction
4) Hospitalization
5) Evacuation
6) Supply
7) Transportation

In view of the Army position that an AIDAPS is primarily a maintenance tool, the functional list has been reduced to those elements most significantly affected by an AIDAPS, which are: Maintenance and Supply. Transportation is a tertiary consideration with respect to return of reparables, but will not be considered in depth.

4.3.3.2 CS_3 Application and Concepts

The CS_3 concept has application to field army and theater levels; however, development has not progressed beyond the corps level. The discussion throughout this section will therefore address the division/corps aspects of CS_3. The logistical activities of the division are grouped in the Division Support Command (DISCOM) and the corps in the Corps Support Command (COSCOM). These terms will be used throughout this report.

4.3.3.3 Hardware Concept

1) The heart of CS_3 is a general purpose digital computer having a large, direct access data storage capability. This equipment provides a timely response to priority user transactions while processing a large volume of routine transactions concurrently.

2) The variety of peripheral equipment and its disperson throughout the area served by the computer provides users with ready access to the system. Input data from supported and supporting units is introduced into the system through the signal transceiver stations where the data is punched on cards and inserted into the transceiver which transmits the card image directly into the computer. Inputs from the headquarters elements are introduced into the system through inquiry devices at the headquarters locations where the input transaction is typed on a keyboard and transmitted directly into the computer. The computer operator introduces data reference tables and computer instructions which have been converted into decks of punched cards. Data is also introduced into the system through the computer console typewriter and, at COSCOM level, through the paper tape reader.

3) Computer prepared responses to interrogations are transmitted directly to the inquiry station typewriter that initiated the interrogation. Other reports prepared by the computer are printed in documentary form by the high speed printer at the computer site and distributed to users through message centers in accordance with the distribution instructions printed on the document. DISCOM computer output data required for input into the COSCOM computer may be transmitted directly by computer to computer electronic linkage or, if the communication link is not available, the data is

produced by the DISCOM computer on magnetic tape or punched card media and transported to the COSCOM computer site. Data required by Headquarters Department of the Army and other distant agencies is produced by the DISCOM and COSCOM computers on tape or punched card media and shipped to the receiving agency.

4.3.3.4 Software Concept

1) Software is the array of programs, routines, and subroutines comprising the procedural instructions that the computer follows to process the input data and produce the output requirements. In developing the software design for CS_3, consideration was given not only to the performance of all functions but to the ease with which the system could be understood, used, and modified. In view of these considerations, a concept of modular programming design was adopted. Whenever practicable, each logically distinct procedure is coded as a physically independent subroutine with minimal dependence upon other subroutines. A common process required by more than one program or executed several times within a single program is defined as a subroutine and coded only once. The commonly used subroutine is called in by the operating program to perform its process when it is required in the sequence of data processing operations.

2) Probably the most significant advantage of modular programming is in system modification and maintenance. A change in the performance of a certain function can normally be effected by changing one or more of the modules. This permits the change to be made with minimal effect on the remainder of the system. Without modularity, a very minor change frequently has such ramifications throughout the system that it is extremely difficult to make. The modular concept is especially valuable in incorporating system design change requirements identified during the operation of CS_3 under different environmental situations.

3) Common Business Oriented Language (COBOL) was selected for the applications programs of CS_3 because it saves coding and checkout time and because statements written in COBOL are readily understood by personnel who maintain and modify the CS_3 programs. Exceptions to the use of COBOL are found in those processes that are closely related to the hardware. In these instances, it was found more practicable to adopt software programmed by the manufacturer in machine oriented language. Examples of processes written in machine language are: transaction sorting, input/output queuing of transactions, and initial editing of transactions.

4.3.4 CS_3 Objective in Relation to AIDAPS

The basic objective of CS_3 is to increase the responsiveness of combat service support to the requirements of the army in the field through the judicious application of ADPE (Figure 4.3-1).

4.3.4.1 CS_3 Subsystem Structure

CS_3 is an integrated system of functional components called subsystems. Each subsystem is a separate entity; however, the subsystems are centrally controlled and use common processes and data files when practicable to use time and equipment most efficiently. The system lends itself to expansion. As additional logistical and administrative functions are developed, they will be integrated into the system. The four subsystems that comprise the current CS_3 configuration follow; Subsystems 1) and 2) may interface with an AIDAPS. Subsystems 3) and 4) are included to indicate possible sources of system loading.

1) Supply includes supply classes II, III (packaged) IV, VII, and IX; property book records keeping; Army Equipment Status Reporting System (AESRS); supply financial management; and demand analysis in the initial phases of system development.

2) Maintenance Reporting and Management (MRM) includes a materiel readiness reporting system which replaces TAMMS inputs from CS_3 equipped units.

3) Personnel and Administration (P&A) includes strength accounting and reporting; personnel requisitions, allocations, and assignments; and personnel records keeping. It also provides data for interface with the Joint Uniform Military Pay System-Army (JUMPS-ARMY) and the Army Personnel Reporting System.

4) Medical includes patient accounting and reporting and regulatory control over the movement of patients between various medical treatment facilities.

4.3.4.2 CS_3 Subsystem Objectives

While meeting the tactical needs of the commander it serves, CS_3 is designed to enhance the effectiveness of combat service support at all echelons. CS_3 utilizes standardized inputs and outputs that are compatible with DoD standards, Army Regulations, and other DA procedural guidelines. In addition, personnel

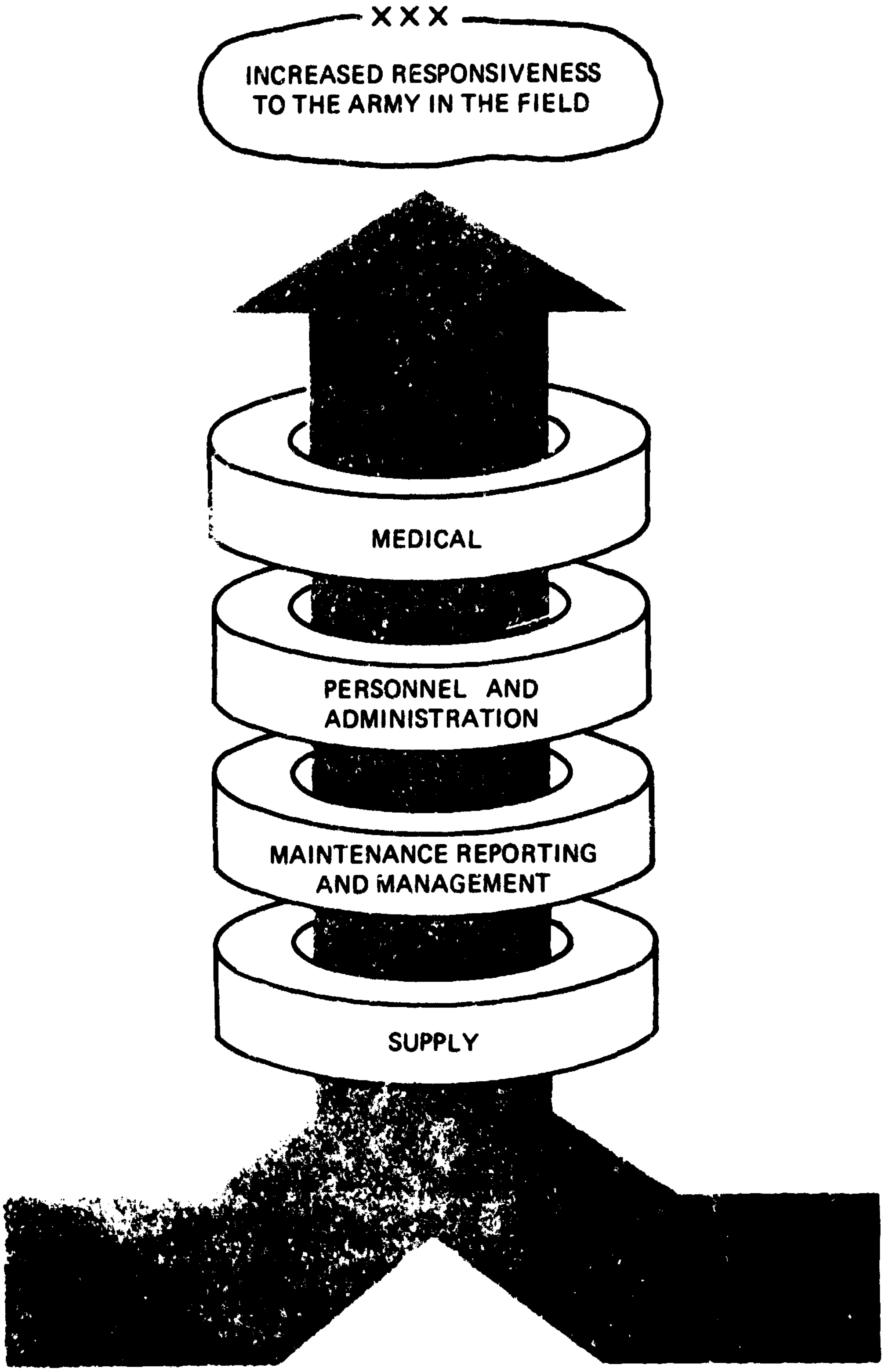


FIGURE 4.3-1 CS3 OBJECTIVE

trained in combat service support functions at one level can operate at any level with minimal additional training. Tactical commanders are provided with up-to-date information through scheduled, requested, or exception reports on status of supply, materiel readiness, unit personnel, and medical facilities. Operators and managers of CS_3 receive special reports designed to enable them to manage their assigned logistical, personnel, and administrative functions better. Tactical unit users are served by a centralized stock accounting system which materially reduces their record keeping task and will increase the probability that supply items will be available to satisfy unit demands. In addition, the personnel and administrative work load at the unit level is greatly curtailed by reduction of the unit record keeping and reporting requirements. Reports generated routinely by the computer relieve the clerical burden at all levels. The specific objectives (AIDAPS interface) for two of the CS_3 subsystems follow.

1) Supply
   a) Improve supply responsiveness to supported units
   b) Reduce errors in supply transactions
   c) Improve utilization of materiel
   d) Provide selected stockages in forward areas
   e) Improve mobility of direct support (DS) and general support (GS) units
   f) Improve the accumulation of supply costing documentation in order to provide sufficient, timely, and accurate information to facilitate decisions concerning supply funding requirements
   g) Reduce the manual effort required to maintain property books and prepare reports required for the AESRS.
2) Maintenance Reporting and Management
   a) Improve the responsiveness of maintenance reporting to meet the requirements of local commanders and managers
   b) Reduce the errors in maintenance reporting
   c) Reduce the administrative work load related to maintenance reporting
   d) Satisfy the requirement of the national level data bank.

4.3.4.3 Subsystem Functions

The major functions performed by the subsystems of CS_3 to accomplish the (AIDAPS related) system objectives listed above are outlined below and illustrated in Figure 4.3-2.

1) Supply

a) Forwards priority requisitions for stockage list items not available from the local storage activity and all requisitions for nonstockage items to the next higher supply source for action.

b) Maintains records of storage activity assets by processing transactions that change quantity, conditions, locations, or other identification of items.

c) Initiates automatic replenishment action.

d) Processes all requisitions from authorized requisitioners within the area serviced by the system.

e) Maintains records of requisitions and other transactions from which advice and status information is produced.

f) Schedules physical inventory for storage activities, produces inventory count cards, processes completed count cards, makes adjustments, and reports major inventory discrepancies.

g) Makes appropriate substitutions.

h) Maintains Master Inventory File Records which provide catalog data.

i) Produces supply study data and performance statistics.

j) Performs demand analyses that afford management the criteria for forecasting future requirements, variable, requisitioning objectives, parameters to provide flexibility of system control, and economic order policies.

k) Performs fund availability accounting for supply requisitions being passed above corps level and accumulates cost of supplies issued to using units.

l) Maintains an automated property book accounting system and furnishes AESRS reports which are by-products of the property book accounting at DISCOM level.

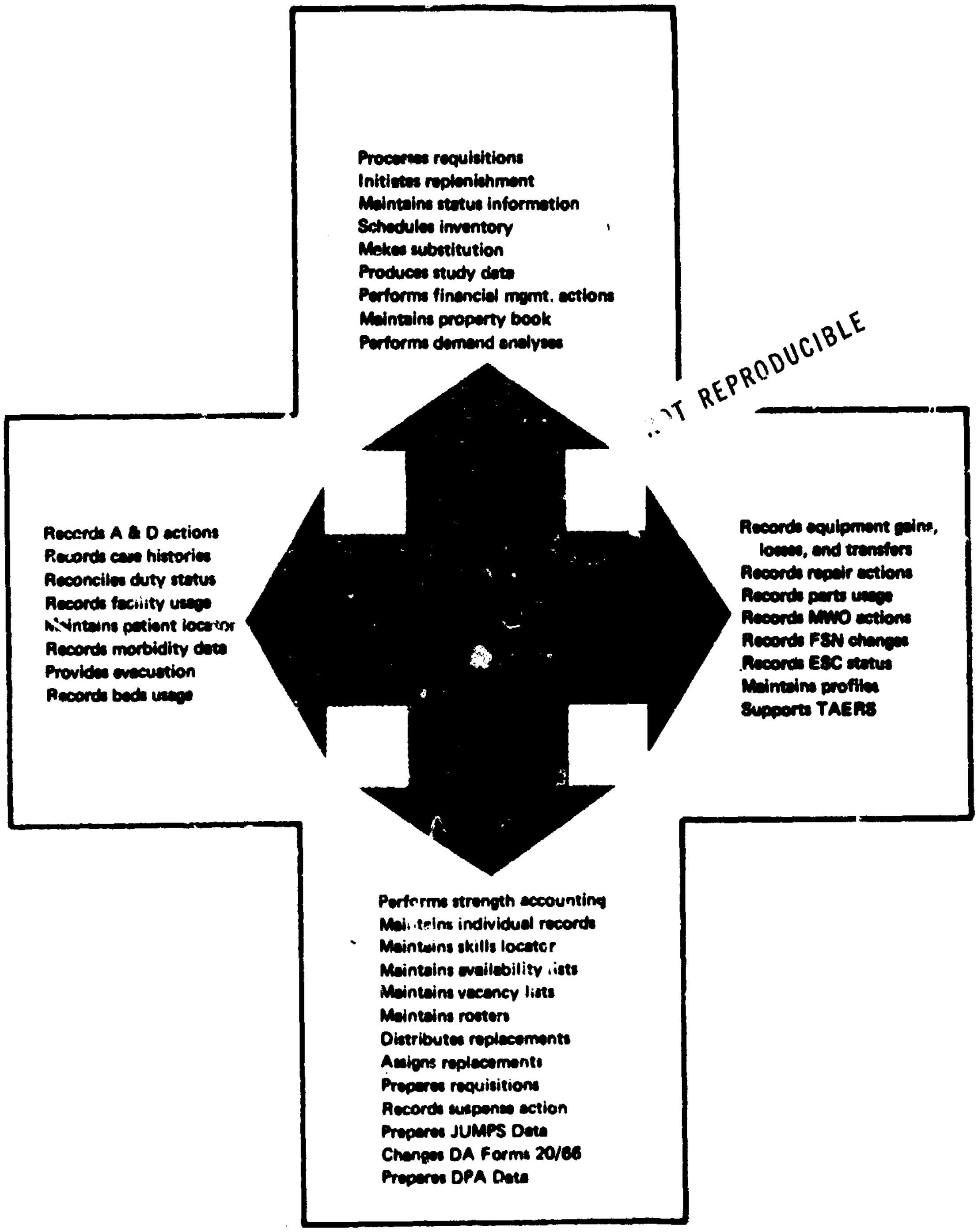


FIGURE 4.3-2 CS_3 SUBSYSTEM FUNCTIONS

m) Provides management the means for monitoring the performance of the Supply Subsystem.

n) Prepares reports covering supply activities including:
   (1) Stock status
   (2) Inventory control
   (3) Major stock level adjustments
   (4) Excess stock in storage activities and excess stockage positions
   (5) Fund availability summary data
   (6) Materiel costing documentation accumulation
   (7) AESRS reporting requirements.

2) Maintenance Reporting and Management

a) Maintains records of organizational and support maintenance activities including repair actions, parts usage, and modification work orders (MWO).

b) Maintains records of gains, losses, and transfers of equipment.

c) Updates data records upon receipt of notice of Federal stock number redesignation.

d) Updates records upon change of equipment serviceability criteria (ESC) status.

e) Maintains records of equipment readiness and calculates unit equipment profiles.

f) Prepares records to satisfy the requirements of the Logistics Data Center (LDC) in support of TAMMS.

g) Detects input errors close to the source and advises originator of corrective action required.

h) Prepares reports covering maintenance management activities including:
   (1) Maintenance workload
   (2) Equipment availability
   (3) Repair parts usage
   (4) Repair frequency
   (5) Modification work order status
   (6) Equipment density
   (7) Manhours expended
   (8) Unit equipment readiness profiles

(9) Excessive equipment in red category

(10) Deadlined equipment

(11) Equipment improvement recommendations

(12) Equipment age/usage

(13) Equipment float status

(14) Equipment requiring most maintenance effort.

4.3.5 CS_3/AIDAPS Interface

An in-depth analysis of potential AIDAPS application to the CS_3 functions outlined in the previous section and restated below, indicates consideration should be given during Phase C to the following:

1) CS_3 Supply subsystem function, "Maintains records of storage activity assets by processing transactions that change quantity, conditions, locations, or other identification of items".

2) CS_3 Maintenance Reporting and Management subsystem functions, "Maintains records of gains, losses and transfers of equipment" and "Prepares records to satisfy the requirements of the Logistics Data Center in support of TAMMS".

The AIDAPS printout format and detail described in Section 4.2, envisions use of Army unit identification codes and the serial number of selected major components on the printout as a means of reducing the paper (TAMMS) workload on the aviation mechanic. These data which could be produced automatically on the printout will provide source data for the CS_3 subsystem functions outlined above. A recurring problem in Army aviation logistics is keeping track of serviceable and unserviceable components and end items. A frequently used technique in the past to attempt to resolve this problem has been the "one time" report. This technique has worked to a limited degree but creates a sizeable administrative burden on Army units. In addition, attrition including combat losses, and aircraft transfers, quickly makes the one-time report data invalid. The AIDAPS printout data which will be generated at the aircraft would provide current, factual data on the aircraft system. It merits restating that Northrop understands the Army position that an AIDAPS is primarily a maintenance system as outlined in the QMR. The additional uses described here will not detract from that concept.

4.3.5.1 AIDAPS/CS_3 Point of Interface

The point was previously emphasized that CS_3 has only been tested in the division/corps role. The Computer Systems Command personnel at Fort Belvoir cautioned that an enormous amount of work lies ahead in developing a viable CS_3 system. In view of this consideration, the AIDAPS/CS_3 interface point reflected in Figure 4.1-3 for a three division corps may change somewhat during Phase C. The changes, however, will probably be organizational (intra-division or corps) and not appreciably affect the broad CS_3 concept.

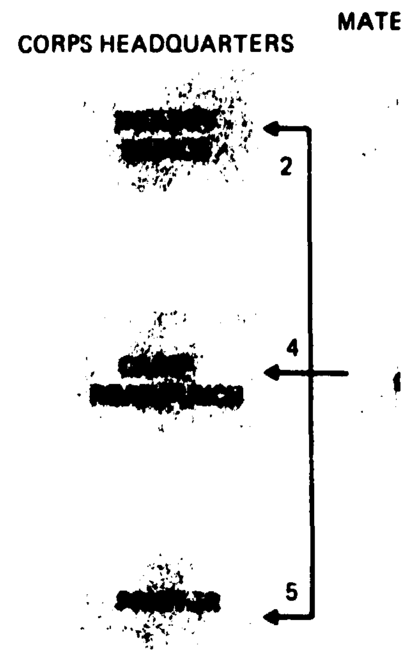
The AIDAPS printout data for divisional units could be fed into the transceivers located in the Brigade or Division Trains Area for subsequent forwarding to corps and/or higher levels of the Army. Non-divisional units might directly input into the corps transceivers. Precise interface details of this broad approach, subject to the limitations outlined below, will be addressed during Phase C of the study effort.

4.3.5.2 CS_3 Limitations

As indicated previously, CS_3 will be the standard ADP system for Administration, Financial, Logistics and Medical services for the Army in the Field. CS_3 is responsive to The Administrative Support, Theater Army, 1970 (TASTA-70) concept. TASTA-70 envisaged the usage of computer-to-computer techniques for accomplishing selected logistical functions by units of the Army-in-the-Field during the 1970-75 time frame. Coordination with personnel from the Computer Systems Command indicates CS_3 anticipates system loading problems. Based on the best estimates currently available, CS_3 computers will be operating at maximum capability for the next 5 to 8 years accomplishing the functions described above and displayed in Figure 4.3-2. This dictates consideration of dedicated computers for an AIDAP system for existing aircraft.

4.3.5.3 Dedicated Computer Impact on AIDAP System Design

The previous section indicated that the CS_3 system is presently operating at its capability with no planned (short term) expansion. Thus, a design consideration for an AIDAP system must plan for usage of dedicated computers where appropriate. The dedicated computers as described in Section 3.1.7 for reducing the airborne data to meaningful maintenance information will be located at the organizational level of maintenance. These on-site dedicated computers are envisaged as low cost, highly mobile, rugged units which live and function reliably alongside the combat soldier. This approach will provide inspection, diagnosis, short term trend analysis, and long term trend analysis based on time-function integration. Upon expansion of the CS_3 system and to accommodate future aircraft systems, it may be desirable to provide an AIDAPS interface with the expanded CS_3 system at levels of maintenance to provide a data base for support of long term trend analysis based on extrapolation of failure curves.



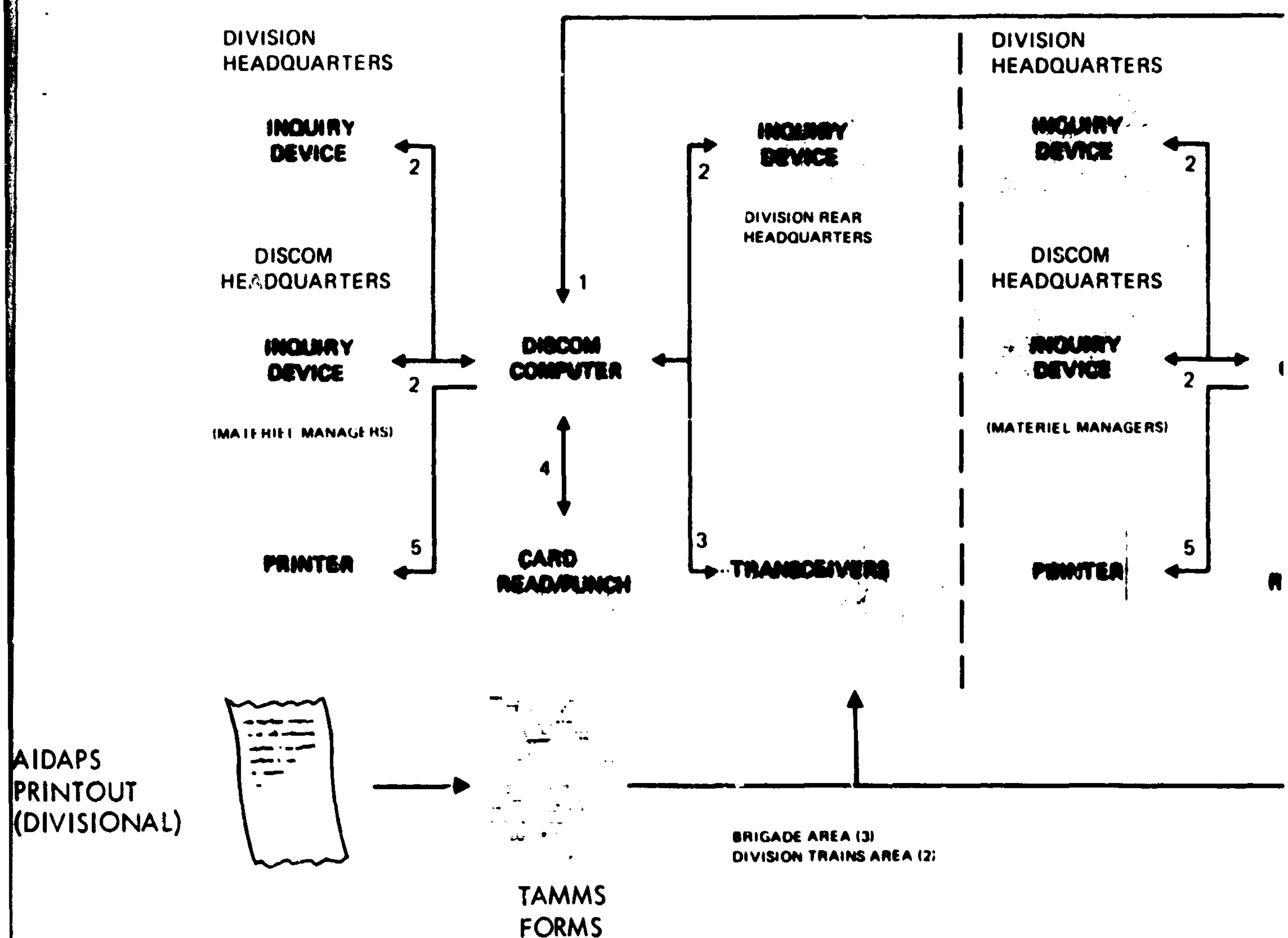
LINE 1 REPRESENTS COMPUTER-TO-COMPUTER CONNECTIONS

LINE 2 REPRESENTS THE REMOTE INQUIRY DEVICES THAT ARE LINKED TO THE COMPUTER

LINE 3 REPRESENTS THE PUNCH CARD TRANSCEIVERS THAT ARE LINKED TO THE COMPUTER CENTER

LINE 4 REPRESENTS THE COMPUTER'S PERIPHERAL PAPER TAPE OR CARD READ/PUNCH

LINE 5 REPRESENTS THE HIGH-SPEED PRINTERS TO BE LOCATED AT BOTH COSCOM AND DISCOM



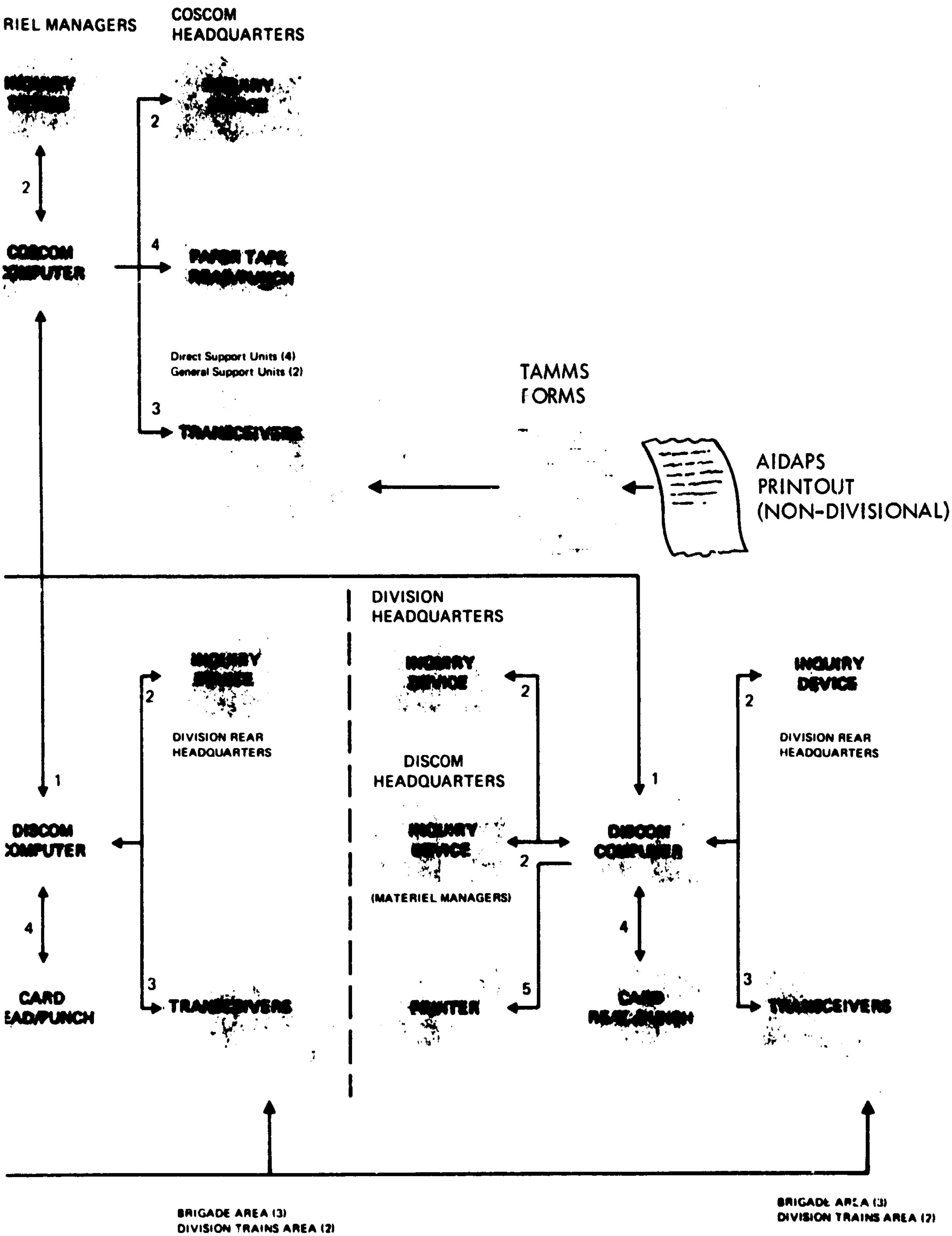


FIGURE 4.1-3 CS_3 SYSTEM COMMUNICATIONS INTERFACE FOR A THREE-DIVISION CORPS

SECTION 5

5.0 AIRCRAFT MAINTENANCE AND LOGISTIC DATA

The application of an AIDAP System to tactical aircraft is primarily directed toward improving aircraft availability and reducing aircraft maintenance and logistic support requirements. Therefore, the requirements for the system must reflect the maintenance, logistic, and operational problems presented in the maintenance, logistic, and operational data. The analysis of these data provides two major outputs. These are:

1. It guides the AIDAP System conceptual approach efforts to provide conceptual system configurations directed toward solutions to major problem areas.
2. It provides the data base necessary for calculating the economic impact upon Army maintenance and logistics and for evaluating the impact upon aircraft effectiveness.

Guidance of the system conceptual approaches was provided by broad examination of the data received to provide data applicable to all Army aircraft irrespective of type. Concurrently, a program is being pursued to develop, through computer processing, more precise and detailed data pertaining to aircraft grouped according to complexity. These data will be used for the economical effectiveness analysis and tradeoffs to be conducted during phase C.

5.1 DATA RECEIVED

Data analyzed during this phase consisted of reports generated by the Reliability and Maintainability Management Improvement Techniques (RAMMIT) System. These included a limited number of The Aircraft Life Cycle Maintenance and Ownership Records (TALCMOR), Aircraft Component Time Since Installation, Overhaul or New (ACTION), Crash Fact Reports, Quarterly Record of Equipment Improvement Recommendations, AVSCOM M&R Summaries, and Quarterly Records of Depot-Level Maintenance -- Cyclic Overhaul. In addition, flying hour data was received from the DA 1352, Inventory and Flying Time Status Reports. Finally, magnetic tapes were received containing TAMMS information keyed to DA Forms 2407, 2407-1, 2408-3 and 2410. It should be noted that Form 2408-3 is no longer used in the TAMMS system, but was being used during the time frame (FY '70) selected for the data base. In addition, the Army Aviation Test Activity at Edwards Air Force Base, AVSCOM, and elements of the Combat Developments Command, Army Materiel Command and Continental Army Command were visited to obtain aircraft operational data.

5.2 AIRCRAFT RELIABILITY, MAINTAINABILITY AND ACCIDENTS

Table 5-1 shows a preliminary rank order list of the aircraft systems based on their significance from a maintenance and logistic standpoint. Although the component data show large variations from aircraft to aircraft, an AIDAPS possesses the flexibility to adapt to these differences. During phase C, the precise lists will be generated for each aircraft or group of aircraft. These lists will be rank ordered by maintenance frequency, maintenance manhours, component cost, and accident hazard potential. The relative importance of the systems based on a scale from 1.0 to 10.0 is also shown. Although the engine and related systems are more significant than the power train, they were both given a rating of 10 since they were both considered mandatory for AIDAPS application.

Table 5-2 shows similar data for components. The relative significance of the components was derived by first listing the replacement rates of each component and assigning a value of 10.0 to a group of components with extraordinarily high replacement rates. The lowest replacement rate of this group was then used as the basis for determining the relative maintenance frequency of the remaining components. This was accomplished by dividing their maintenance frequency by the basis and multiplying by 10.0. To achieve the relative logistic significance, the relative maintenance frequency was then adjusted upward for those components which are difficult to remove and replace or represent significant packaging, shipping or overhaul problems.

Table 5-3 shows similar data for aircraft accidents and aborts. The relative frequencies were obtained from Monthly Aircraft Crash Messages Summaries. The engine and related systems were given a relative significance of 10.0 and the remaining significance ratios were determined by dividing the number of accidents or aborts attributable to the system or component by the number of accidents or aborts attributable to engines, and multiplying by 10.0.

5.3 LOGISTIC FACTORS AND HANDLING EFFECTS

The primary effect of AIDAPS on logistics costs is the reduction of handling and shipping necessary to support the tactical units. This reduction occurs because there are less unwarranted removals and because scheduled overhauls can be extended to an "on condition" basis. Some reduction in overhauls and checkout of no-defect removals will also be achieved. Table 5-4 is a preliminary list of the logistic factors which can be used in determining the savings in packaging, shipping, overhauls, and no-defect bench checks.

TABLE 5-1

RANKING OF AIRCRAFT SYSTEMS BASED ON LOGISTIC SIGNIFICANCE

RANK	SUBSYSTEM	RELATIVE LOGISTIC SIGNIFICANCE
I	Engine and Related	10.0
II	Power Train	10.0
III	Rotor Group	9.5
IV	Flight Control	6.0
V	Hydraulic System	5.0
VI	Instruments	4.0
VII	Electrical System	3.5
VIII	Fuel System	2.0
IX	Utility System	2.0
X	Cooling System	1.0

TABLE 5-2 LIST OF HIGH EMPHASIS COMPONENTS
(Logistics)

ITEM	RELATIVE LOGISTIC SIGNIFICANCE
ENGINE	
INLET SECTION	
Bearings	4.5
Accessory Gear Box	0.6
COMPRESSOR/DIFFUSER	
Actuator	3.0
Bearings	6.0
COMBUSTION/EXHAUST	
Fuel Vaporizors	9.0
TURBINE SECTION	
Turbine	4.0
Nozzles	9.0
LUBRICATION SYSTEM	
Oil Pump	7.0
Oil Tank	1.0
Seals	8.0
Oil Cooler	1.0
Oil Filters	2.0
FUEL SYSTEM	
Fuel Control	10.0
Main Manifold	4.5
Starting Manifold	1.2
Fuel Filters	1.0
Boost Pump	1.8
Distributor Valve	9.0
Governor Assembly	10.0
ELECTRICAL SYSTEM	
Ignition Assembly	1.0
Exhaust Thermocouple Harness	2.0
POWER TRAIN SYSTEM	
Main Transmission(s)	10.0
Intermediate Gear Box	10.0
Tail Rotor Gear Box	10.0
Combining Transmission	10.0
Oil Reservoirs	1.0
Oil Coolers	2.0
Bearings	3.0
Quill Assembly	2.5
Oil Pump	6.0
Oil Filters	2.0
ROTOR GROUP	
Main Rotor Hub	3.0
Scissors & Sleeve Assembly	2.0
Swashplate & Support Assembly	1.5
Tail Rotor Hub & Blade Assembly	3.0
Tail Rotor Gear Box Quills	2.5
Tail Rotor Drive Shaft Hanger	5.0

TABLE 5-2 LIST OF HIGH EMPHASIS COMPONENTS (Logistics) -- (Concluded)

ITEM	RELATIVE LOGISTIC SIGNIFICANCE
HYDRAULIC SYSTEM	
Pump	1.0
Reservoir	1.0
Cylinders	1.0
Accumulator	1.0
Filters	2.0
Servocylinder	2.5
INSTRUMENTS	
Fuel Quantity Indicator	1.0
Airspeed Indicator	1.0
Torquemeter	1.0
Temperature Indicators	1.0
Oil Indicator Assembly	2.0
RPM Indicators (Engine and Rotors)	1.0
ELECTRICAL SYSTEM	
Inverter	1.0
Starter Generator	2.0
Generator	2.0
Electro-Mechanical Actuators	1.0
FUEL SYSTEM	
Pumps	1.0
Filters	2.0
Valves	1.0
FLIGHT CONTROL SYSTEM	
Elevator Assembly	2.5
Elevator Horn Assembly	2.0
Stabilizer Damper	3.0
Stabilizer Bar Assembly	2.7
Pitch	1.0
UTILITY SYSTEM	
Anti-Icing System	1.0
Hot Air Valves	1.0
Heating & Vent System	1.0
COOLING SYSTEM	
Fan Assembly	1.0

TABLE 5-3 LIST OF HIGH-EMPHASIS SYSTEMS AND COMPONENTS (Aborts and Accidents)

RANK (SYSTEM)	SYSTEM/COMPONENT	RELATIVE ABORT FREQUENCY SYSTEM	RELATIVE ABORT FREQUENCY COMP.	RELATIVE ACCIDENT FREQUENCY
I	ENGINE & RELATED	10.0		10.0
	Oil Cooler Turbine Fan		2.0	
	Lubrication System		2.0	
	Oil Pump		1.0	
II	HYDRAULIC SYSTEM	8.0		3.0
III	ELECTRICAL	7.0		
	Transformer		1.0	
	Exciter Box		1.0	
[illegible]	FLIGHT CONTROLS	3.0		6.0
V	INSTRUMENTS	3.0		
	EGT Gauge		2.0	
	Altimeter		1.0	
VI	LANDING GEAR	3.0		2.0
	OTHER (Unidentified Warning Lights)	7.0		3.0

TABLE 5-4 LOGISTIC FACTORS*

Category	Total
Depot Labor Rate Per Manhour (Direct and Indirect)	$11.50
Preparation for Shipping Rates	
ConUS	
Labor per pound	$ 0.14
Material per pound	0.05
Total per pound	$ 0.24
Overseas	
Labor per pound	0.23
Material per pound	0.23
Total per pound	$ 0.46
Ratio of Packaged Weight to Component Weight	
ConUS	1.3
Overseas	1.4
Shipping Rates Per Pound	
Organizational to GS or Depot (ConUS)	$ 0.04
Organizational to Depot (Overseas)	$ 0.43

*Approximate

5.4 SCENARIO DEVELOPMENT

Formal scenarios containing details of the military situation, geographical deployment of opposing forces, force strengths, etc. are not required for the AIDAPS cost effectiveness analysis. Only four highly important operational parameters are involved. These are: aircraft utilization, distribution of the fleet overseas vs. ConUS, the quantity of aircraft of each type in the future inventory, and the aircraft system predicted life.

Of these parameters, aircraft utilization and distribution appear to be the most subject to prediction errors. Table 5-5 shows aircraft status and distribution data based on the period from April 1969 through December 1970. The average percentage of aircraft operationally ready, not operationally ready-(supply), and not operationally ready (maintenance) are also shown.

The above data was generated during a period when our overseas forces were withdrawing from a major counterinsurgency activity. During this period utilization of ConUS equipment was restricted due to the necessity of repairing equipment returned from overseas and because of the priority on support of the overseas forces with spare parts and ground support equipment. Since the AIDAPS study considers that the AIDAPS equipment will become available in the 1970 to 1980 time period, these operational data must be modified based upon a projection of assumed political, economic, and military situations for that time period.

The quantity of aircraft in the future inventory will be predicted from army phaseout and procurement plans. These data also determine the system life for those aircraft planned for phaseout. The basic cost period for other aircraft will be 10 years, although this may be extended or reduced depending upon how soon the costs expended for AIDAPS development and procurement are recovered through cost savings and benefits.

Some additional operational factors affect the analysis implicitly. Chief among these are the mission characteristics of the aircraft. Combat, including command and control, have great urgency, particularly in regard to meeting the exigencies of combat, including surprise attacks and ambushes and for attacking targets of opportunity, The most important aircraft characteristics for meeting these situations are availability and reaction time.

Combat support missions have slightly less urgency since some preplanning can be accomplished and reaction time may not be as important in certain situations.

TABLE 5-5 ARMY AIRCRAFT AVERAGE DISTRIBUTION, UTILIZATION, AND STATUS

DATA	UH-1 (1)		AH-1		OH-6		OH-58		CH-47 (2)		CH-54	
CATEGORY	OS	US	OS	US	OS	US	OS	US	OS	US	OS	US
INVENTORY DISTRIBUTION %	76%	24%	81%	19%	72%	28%	77%	23%	79%	21%	75%	25%
FLIGHT HOURS PER VEH PER MO	58 Hrs	40 Hrs (4)	57 Hrs	23 Hrs	56 Hrs	40 Hrs (4)	45 Hrs	40 Hrs (4)	50 Hrs (4)	19 Hrs	37 Hrs	19 Hrs
% OR	70%	71%	74%	72%	74%	69%	80%	83%	70%	67%	68%	66%
% NORS	6%	11%	7%	9%	7%	19%	5%	7%	7%	18%	12%	21%
% NORM	24%	18%	19%	19%	19%	12%	15%	10%	23%	15%	20%	13%
	U-21		OV-1 (3)									
INVENTORY DISTRIBUTION %	71%	29%	70%	30%								
FLIGHT HOURS PER VEH PER MO	64 Hrs	40 Hrs	38 Hrs	15 Hrs								
% OR	74%	75%	78%	73%								
% NORS	5%	7%	8%	9%								
% NORM	21%	18%	14%	18%								

(1) UH-1 B, C, D, H Total Deployment; (2) CH-47A, B, C Total Deployment; (3) OV-1A, B, C Total Deployment
(4) Estimated

On the other hand, larger payloads may be required. In this case, the missions are generally of shorter duration and cover shorter distances. The major aircraft characteristics for meeting these mission requirements are availability, payload and sortie capability. Combat service support missions require larger payloads, longer ranges, and high sortie capabilities.

The above discussion does not consider aircraft characteristics such as speed and vulnerability, which are not affected by an AIDAP System.

Aircraft safety, availability, and sortie capability are the most important mission characteristics which are affected by AIDAPS. Thus, AIDAPS may provide significant contributions across the entire spectrum of Army aircraft missions.

The Army mission requirements are keyed to aircraft types. These are discussed in paragraph 2.3.4, but Table 5-6 presents a summary of the aircraft/mission interfaces and the primary AIDAPS capability affecting mission effectiveness.

TABLE 5-6

AIRCRAFT PRIMARY MISSION AND AIDAPS APPLICABILITY MATRIX

AIRCRAFT	COMBAT: COMMAND CONTROL	COMBAT: OTHER	COMBAT SUPPORT	COMBAT SERVICE SUPPORT
OH-6	X	X		
OH-58	X	X		
OV-1	X	X	X	
CH-47			X	X
CH-54			X	X
UH-1	X	X	X	
U-21			X	
AH-1		X		
UTTAS		X	X	
HLH			X	X
PRIMARY AIDAPS CONTRIBUTION	More Aircraft Available	More Aircraft Available	More Aircraft Available & Sortie Rate Increases	More Aircraft Available & Sortie Rate Increases

SECTION 6

6.0 SUMMARY

The objective of this phase of the AIDAPS study was to identify a number of technical system approaches and hardware techniques congruous with feasibility limitations delineated in Phase A. In accomplishing this objective, the following related tasks were completed.

A review of the total Army aviation logistical environment was accomplished with the view of identifying those areas where the introduction of an AIDAPS might effect significant improvement. The scope of this task included an assessment of the differences between existing and future Army aviation logistical systems, with emphasis on AIDAPS correlation to the "management tools" used or envisaged in the systems. These tools include the Maintenance Allocation Chart (MAC); the Technical Manual (TM) system; the TAMMS system; Table Organization Equipment (TOE); Table Distribution Allowances (TDA); Military Occupational Specialties (MOS), and aircraft inspection requirements.

Analysis of these areas which is presented in depth in Section 4.1, indicates the most significant envisaged AIDAPS impact on the Army logistical system will be its capability to diagnose subsystem/component maintenance problems, and by trend analysis, to predict impending component failure. This capability dictates consideration of the addition of two new maintenance functions to the approved list in the MAC which are diagnosis and prognosis. In addition, a new MOS may be needed to provide an individual with diagnostic/prognostic training, at selected levels of maintenance. These considerations will be addressed during Phase C of the study, and could be implemented by the Army as a routine MAC change, with MOS decision action during the Provisional Qualitative and Quantitative Personnel Requirements Information (PQQPRI) input phase (Block 34) of the Army Life Cycle Management Model for Army Systems.

During the course of Phase B, visits were made to selected operational and logistical activities of the Army Materiel Command, Combat Developments Command, and the Continental Army Command. The purpose of these visits was threefold: to secure personnel opinions concerning AIDAPS data format, system configuration detail, and to determine the possible interface with Army field computers. The Army personnel interviewed were knowledgeable and enthusiastic about an AIDAP system. In discussing the desired AIDAPS data format and detail, three data format concepts were presented. These are: an alphanumeric code; a printout in the English language, and a printout of numerical parameter values. It also was recommended that the data printout be correlated to the MAC, TMs, and the TAMMS system. A recurring plea was voiced to consider replacing selected TAMMS forms with the AIDAPS printout as a means of reducing the paper workload on the aviation mechanic. This appears to be feasible and will be considered during Phase C. The data elements (with rationale for selection) deemed desirable on the printout, are presented in subsection 4.2.2.6, and summarized below.

a) Date (Julian, Table 9, TM 38-750)

b) Unit Identification Code (AR 18-50 and AR 18-50-10)

c) Aircraft Type, Model and Series (TMS)

d) Aircraft tail number

e) Major component serial number

f) Identification of selected (MAC) faulty LRUs and/or malfunctioning subsystems (abbreviated English language or alphanumeric code, and parameter value where appropriate printout coupled with failure codes used in TAMMS).

g) Technical Manual reference by chapter number applicable to item f) above.

h) Time correlation to events including: start, liftoff, hover (rotary winged aircraft), malfunction, landing and engine coastdown.

i) Record of accomplishment of AIDAPS feasible portion of scheduled inspections, servicing entries, time to next scheduled inspection (PMI or PMP).

j) Record of any pertinent prognosis including description of predicted failure parameter values and the computed time to that event.

The conclusion reached concerning Army computer interfaces for AIDAPS was that field computers in the CS_3 system could interface with AIDAPS at the Army Division Transceiver level, but will be utilized to maximum capacity for the next 5 to 8 years; therefore, consideration should be given to the usage of dedicated computers for an AIDAPS. Additional details concerning this topic and other Army ADP systems considered during Phase B are presented in subsection 4.3.

In order to ensure continuity and correlation of study effort between Phases A and B, the data derived from the Phase A review of contract appendices were used as guidelines for system selection. Thus, the hardware techniques and technical system approaches were selected in congruity with the AIDAP requirements outlined in Appendices A and B to the study contract. In addition, the documents listed in Appendix C were reviewed to ensure incorporation of the salient features of historical AIDAP effort in the future AIDAPS. Finally, the guidelines established in Appendices D and E were used to provide direction (stated Army desires) in the selection of the technical approaches which were considered.

Aircraft malfunction, maintenance and logistical data supplied by AVSCOM, and listed in Section 5.1, was analyzed to determine the most maintenance significant items for the study aircraft currently in the inventory. The aircraft subsystems were then rank ordered as to their relative logistical significance as displayed in Table 5-1. Selected samples of these data will be used to project maintenance characteristics for the developmental aircraft. The information gained from this preliminary data evaluation was used as a guide in the selection of AIDAP system conceptual approaches which will provide solutions to the identified problem areas. A secondary purpose was to provide the data base necessary for calculating the economic impact upon Army maintenance and logistics, and for evaluating the impact on aircraft effectiveness. Precisely calculated data of this same nature will be used as a major input for the Phase C tradeoff analysis model.

One of the major tasks accomplished during Phase B was development of a Plan of Analysis which will be used in performing tradeoff analyses during Phase C (submitted under separate cover as NORT 71-229, April 1971). This Plan of Analysis contains a description of the computer models and procedures which will be used in conducting cost/effectiveness tradeoffs.

The overall cost/effectiveness model consists of four sub-models which are:

a) AIDAPS/Aircraft Maintenance Analysis Model
b) AIDAPS System Procurement Cost Model
c) SOURCE Model
d) AIDAPS System Cost Benefit Model

Inputs required by the cost/effectiveness model include AIDAP system characteristics, and study aircraft component maintainability characteristics without AIDAPS. The outputs derived from the model are aircraft maintenance and operations cost savings, AIDAPS system life cycle costs, and aircraft effectiveness benefits. These outputs are summed to permit determination of net benefits.

Accomplishment of the tasks described above facilitated the selection of practical technical system approaches and hardware techniques. The selection process was executed with constant consideration given to the mission constraints of the Army logistical environment. In addition to the mission constraints, a number of technical constraints were developed which permitted the application of a scientific method of elimination of impractical system approaches. An in-depth discussion of all these technical constraints is presented in subsection 2.2. Application of these constraints resulted in selection of 10 recommended system configurations. Three of the 10 configurations are basically ground based systems; six are ground/airborne hybrids, and one is essentially airborne.

The 10 systems are identified and expressed as follows:

$$S_1 = A/B \left[(I)S \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$$

$$S_2 = A/B \left[(I)S \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$$

$$S_3 = A/B \left[(I)M \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$$

$$S_4 = A/B \left[(I)M \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$$

$$S_5 = A/B \left[(I)C \cdot (C')C \cdot (A)S \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$$

$$S_6 = A/B \left[(I)C \cdot (C')C \cdot (A)M \cdot (D)S\right] \cdot G/B \left[(A)C \cdot (D)M\right]$$

$$S_7 = A/B \left[(I)S + S + M + C \cdot (C')C \cdot (A)C \cdot (D)M\right]$$

$$S_8 = A/B(I)S \cdot G/B \left[(C')C \cdot (A)C \cdot (D)M\right]$$

$$S_9 = A/B(I)M \cdot G/B \left[(C')C \cdot (A)C \cdot (D)M\right]$$

$$S_{10} = A/B(I)C \cdot G/B \left[(C')C \cdot (A)C \cdot (D)M\right]$$

(Symbols and operators are defined in paragraph 2.4.1.)

An example read-through of the above system expressions is described as follows: S_1 equates to an AIDAP System consisting of airborne (A/B) simple sensing (I)S, and complex data collection (C')C, and simple analysis (A)S, and simple display (D)S in conjunction with ground based (G/B) complex analysis (A)C and medium display (D)M.

An ancillary task to the system(s) selection was to develop groupings for the ten study aircraft. This was achieved by comparing the significant features of each aircraft affecting AIDAPS design, such as mission, weight, cost, parameter list, density, utilization rate, maintenance manhours/flight hour, fixed vs rotary wing, number of engines, crew size, and attrition rates. Analysis of all these variables permitted assignment of the 10 study aircraft into the following 5 aircraft groups.

Group 1	OH-53 OH-6
Group 2	UH-1 AH-1
Group 3	U-21
Group 4	OV-1
Group 5	CH-47 OH-54 UTTAS HLH

The final task was to assess each of the 10 recommended system configurations relevant to constraints based on the aircraft group characteristics. This assessment resulted in 16 tradeoffs applicable to the 5 aircraft groups. The aircraft groups and applicable tradeoffs are listed below:

A/C GROUPS	SYSTEM CONFIGURATION TRADEOFFS
1 (OH-6 and OH-58)	S_1, S_2, S_7 and S_8
2 (UH-1 and AH-1)	S_3, S_4, S_7 and S_9
3 (U-21)	S_3, S_4, S_7 and S_9

4	(OV-1)	S_5, S_6, S_7 and S_{10}
5	(UTTAS, CH-47, CH-54 and HLH)	S_5, S_6, S_7 and S_{10}

In conclusion, the system configurations selected will be subjected to extensive computer model tradeoffs during Phase C for selection of the optimum system(s) approach.