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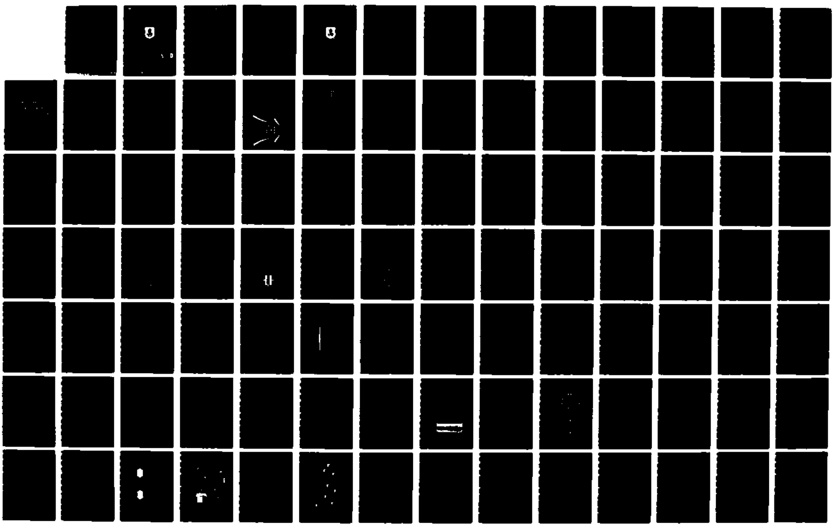

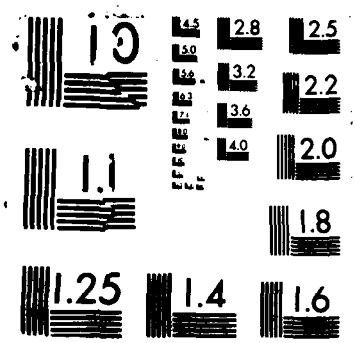
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INDUSTRIAL BASE ANALYSIS FOR SUPPORT EQUIPMENT

AIR FORCE SYSTEMS COMMAND

PHASE I FINAL REPORT

OCTOBER 1986

CONTRACT NO. F33657-85-D-0111

Task Order #0002

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The ability of the aerospace industry to provide fieldable weapon systems depends to a large extent on the manufacture of critical items of Support Equipment (SE) needed for maintenance and repair of those systems. Previous industrial base efforts have focused on improving the acquisition process of the weapon systems themselves. This initiative focused on improving the acquisition process of SE.

It was determined that there was a need for a system which SE personnel could access to gather pertinent data when making decisions throughout the weapon system life cycle. The right information must be identified, organized, and made available in a user-friendly manner. A solution is proposed which would aid SE managers with decisions regarding cost, planning, control and performance of SE. This methodology would identify and organize SE information to improve decision-making by both government and industry personnel.

Group Technology (GT) concepts do this in a relational database, word processing (over)

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system, and graphic databases so users can easily find and use relevant data. The total database would consist of numerous smaller databases, including industry and government information housed in different locations.

According to the GT approach, related items are grouped into families, and are differentiated according to specific distinctions. The organized information would be contained in a database where a Group Technology Support System (GTSS) would perform the basic functions of creating, accessing, modifying, and deleting information. Other user-friendly Decision Support Systems (DSS) could be developed to make the GTSS more accessible to the end user.

In manufacturing, aggregating SE into similar families could lead to the possible establishment of SE work cells or work centers. Since similarities are the basis for categorizing SE with this system, the use of flexible manufacturing systems are readily adaptable to making families of SE. GT codes could speed manufacturing planning and facilitate the use of automated process planning. Standardization of tools and equipment would be vastly improved.

In its final form, the proposed system must be capable of supporting all decision-making relative to the acquisition of SE, and cover all phases of the acquisition life cycle. The proposed system will cover all types of SE, but this study proposed a system for a single class of SE: special tools.

GT for SE can be cost effective if the attributes of parts, equipment, cost, processes and function can be rigorously captured in a standard form. With the application of GT principles and a well defined DSS to manage design, analysis, trade studies, manufacturing, inventory and use of SE, there is reason to believe that tremendous potential for cost savings exists.

INDUSTRIAL BASE ANALYSIS
FOR
SUPPORT EQUIPMENT

AIR FORCE SYSTEMS COMMAND

PHASE I
FINAL REPORT

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INDUSTRIAL BASE ANALYSIS FOR SUPPORT EQUIPMENT

PHASE I

CONTRACT NO. F33657-85-D-0111
Task Order 0002

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TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

Phase I of the Industrial Base Analysis for Support Equipment (SE) has as its objective to propose a **solution to the problems faced by SE managers who struggle daily with difficulties of price, cost, planning, control, and performance of SE without fast, easy access to useful information.** The solution we suggest for improving the technical aspect of the SE acquisition process uses **Group Technology** (GT) to identify and organize SE information in a way that will **improve decision making** by all personnel - in industry and in government - associated with the SE acquisition process.

The GT approach works by **grouping** related items into families based on similarities, and **differentiating** items according to specified distinctions. Once organized, the information can be loaded into a database and **made available to end users** in design, manufacturing, and management through user-friendly decision support systems (DSS). Users would be able to access and manipulate data as they need to, thereby improving the acquisition of support equipment throughout a weapon system's life cycle by the effective use of technical information.

o **Designers** could search a database for existing equipment to perform the function they need. Using GT codes consistent across military and contractor data, designers could identify Cost Driver Elements (CDEs) and use historical cost data to make valid design and cost tradeoffs.

o **Manufacturing** would be streamlined through the GT database approach by standardizing tools and equipment, significantly improving contractors' make-or-buy decisions, and by facilitating the use of Computer Aided Manufacturing (CAM) for SE.

o **Management** would be able to reduce necessary oversight of the SE acquisition process, without sacrificing confidence in the weapons systems being supported; allow SE cost comparisons across systems; and establish a corporate memory within the Air Force and the Department of Defense.

Building and demonstrating a prototype GT/DSS are crucial to the completion of the project, but **Phase I has focused on**

- identifying SE improvement requirements
- establishing GT/DSS feasibility
- studying other initiatives that may be related, in order to ensure that this work complements other efforts
- examining, as a starting point for the larger scope of the project, the interface between designer and SE specialist, specifically in the SE class of special tools.

At the close of Phase I, our conclusions and recommendations can be summarized with **cautious optimism:**

- Given the need to improve the SE acquisition process, GT/DSS will work as a technical solution. However, equal emphasis should be given to management issues as other approaches to a solution - from simplifying policy procedure and highlighting SE as an issue, to fostering cooperation among System Program Offices (SPOs) and improving manpower management.
- The information needed to support the implementation of GT/DSS will continue to be difficult to uncover. The best source for process information is not the literature but SE personnel, who must be given both motivation and a forum for discussing and documenting the details the project requires.
- GT/DSS is feasible. The concept should be planned top-down and implemented bottom-up as a series of decision support systems. The project's success will profit from the development of a prototype system in a chosen SPO which will branch out and connect to other program offices and their contractors.

- The project's success depends absolutely on support and endorsement from both industry and government members of the SE community.

As steps beyond Phase I, we recommend that the project

- establish an interest group closely interfaced with the Computer Aided Logistics (CALS) Program

- go on to develop a prototype GT/DSS, and then expand the prototype to propagate its benefits across other classes of SE and to other SPOs.

1.0 INTRODUCTION

This final report for Phase I of the Industrial Base Analysis for Support Equipment (SE) has been produced by Bernier & Associates, Inc. and the Center for Automated Engineering and Robotics at Arizona State University, under Contract No. F33657-85-D-0111.

This report includes an outline and example of the classification scheme we propose based on the problems and needs we discovered through the questionnaires, interviews, and review of the literature detailed in the Phase I Needs Analysis Document.

This report also identifies other government programs that directly or indirectly address similar issues, and other classification schemes in place or under development that are related to this effort. It contains our conclusions based on the work performed thus far as well as recommendations for a next step.

1.1 THE PROBLEM

Support Equipment (SE) managers, unable to get fast, easy access to useful information, daily face problems related to price, cost, planning, control, and performance. They have been forced to compensate by instituting procedures that are often inefficient and occasionally counterproductive.

There are many reasons - reflected in business and technical journals - for the current state of inefficiency, few of which are peculiar to Support Equipment. They include

- o inefficient management of acquisition process information
- o increasing sophistication of military systems
- o complex government procurement policies and regulations
- o current accounting practices in industry
- o an aging industrial base

1.2 THE SOLUTION

The Industrial Base Analysis for Support Equipment project is an attempt to identify and organize Support Equipment information in a way that will improve decision making by all personnel - in industry and in government - associated with the SE acquisition process.

Solving the Support Equipment information problem requires that the right information be identified, organized, and made available to management in a timely and user-friendly manner. Presumably Group Technology (GT) concepts will play a key role in organizing this database.

According to the Group Technology approach, related items are grouped into families based on similarities, and are differentiated according to specific distinctions. The organized information can then be loaded into a database where a Group Technology Support System (GTSS) can perform the basic functions of creating, accessing, modifying, and deleting information. Other user-friendly decision support systems (DSS) can be developed to make the GTSS more accessible to the end user. (See Figure 1-1 for the relationship between these major elements.)

Software development costs for the systems can be minimized and the probability of success increased by adapting approaches already proven for Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM).

The ideal system would improve the acquisition of Support Equipment throughout the system's life cycle.

Design

The SE designer, using a CAD terminal and appropriate GT codes, could search a comprehensive database to identify equipment for performing the particular function he wants. The GT codes would be consistent for both military and contractor data, so he could identify Cost Driver Elements (CDEs)

DSS: HIGHER LEVEL APPLICATIONS AIMED AT MAKING THE SYSTEM USER FRIENDLY

GTSS: USED TO PROVIDE THE BASIC DBMS FUNCTIONS

GT: USED TO STRUCTURE THE DATABASE

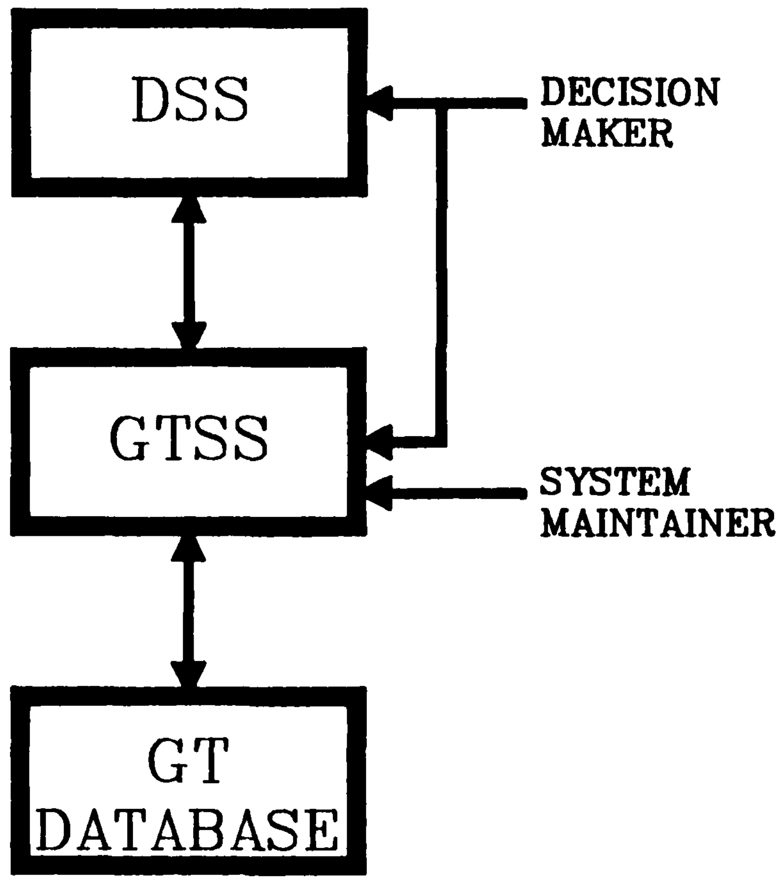


Figure 1–1: Group Technology Decision Support System (GT/DSS) Concept

and use historical cost data. These features would allow the designer to make meaningful design and cost tradeoffs. Standardization in the ideal system could be readily enforced by requiring the choice of an existing piece of Support Equipment with a GT match.

Manufacturing

In manufacturing, aggregating SE into families could lead to

- o the establishment of SE work cells/work centers
- o flexible manufacturing systems to make families of SE
- o the use of Computer Aided Manufacturing for SE.

GT codes could speed manufacturing planning by reducing the long lead time now needed for planning, and facilitate the use of automated process planning. Standardization of tools and equipment would vastly improve a contractor's make-or-buy decision.

Management

GT concepts could ease industry and Air Force management of the SE acquisition process and assure that SE is procured as carefully as basic weapon systems are procured. Equipment standardization would

- o reduce the amount of necessary oversight while increasing confidence in the system
- o allow comparison of SE costs across System Program Offices (SPOs)
- o ensure meaningful design/cost trade studies
- o enable the establishment of SE manufacturing work cells/work centers to more easily support surge production
- o establish a corporate memory within the Air Force and the Department of Defense (DoD).

1.3 PROJECT SCOPE

Building and demonstrating a prototype GT/DSS are crucial, but the thrust of Phase I of the project has been limited to

- identifying requirements for SE improvements
- establishing feasibility for the GT/DSS
- serving as a catalyst for increasing use of CAD in SE designs.

Accomplishing these initial objectives involved a number of interrelated activities as described in the following four steps:

Step 1: Ascertain the **need for a GT/DSS** by bringing to the surface current problems in the SE acquisition process and making a broad determination of the potential impact that a well-conceived information system might have on these problems.

Step 2: Establish that the **information required to populate the database** can be identified, collected, or organized in a way that will prove useful to SE managers.

Step 3: **Study other** efforts that may be related to the establishment of GT/DSS to reduce the possibility of duplication of effort, and to ensure that a course of action be pursued that complements, not duplicates the results of, similar initiatives.

Step 4: Explore the possibilities of **automating the information system** by postulating one or more conceptual designs of the proposed GT/DSS.

This report summarizes the progress made toward completing these four steps.

1.4 PROJECT FOCUS

Acquisition Life Cycle

In its final form, the system being proposed will be capable of supporting all decision making related to the acquisition of SE, and it will cover all phases of the acquisition life cycle. The initial effort, however, focused on defining the interface between the designer and the SE specialist. (See Figure 1-2.)

Support Equipment Type

The projected system will cover all types of Support Equipment. But the project's short-term goal is to develop such a system for a single class of SE: special tools. For our purpose special tools are defined as inexpensive, noncomplex SE that cannot be bought off-the-shelf, and simple off-the-shelf equipment that must be modified. (See Figure 1-3.)

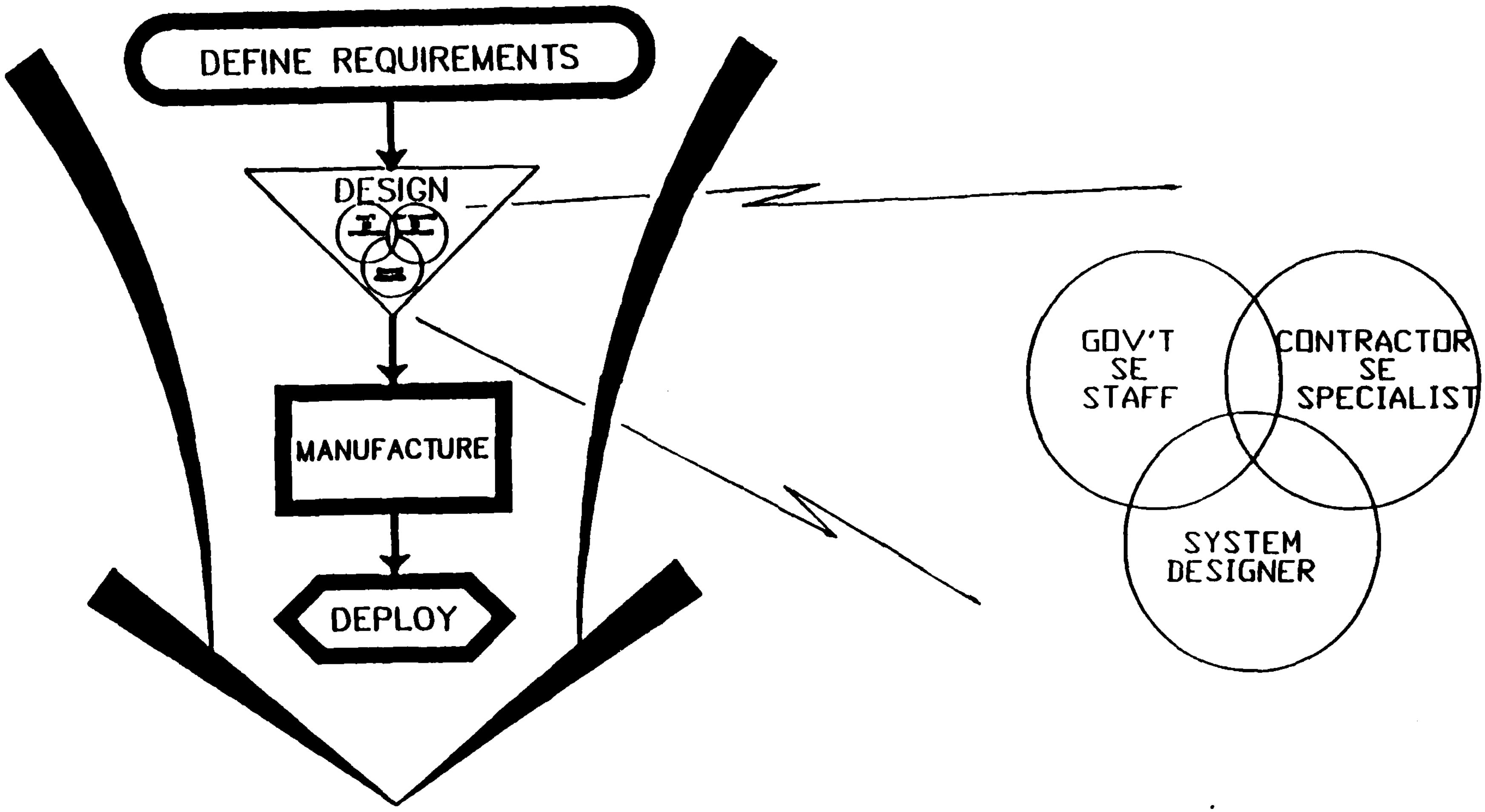
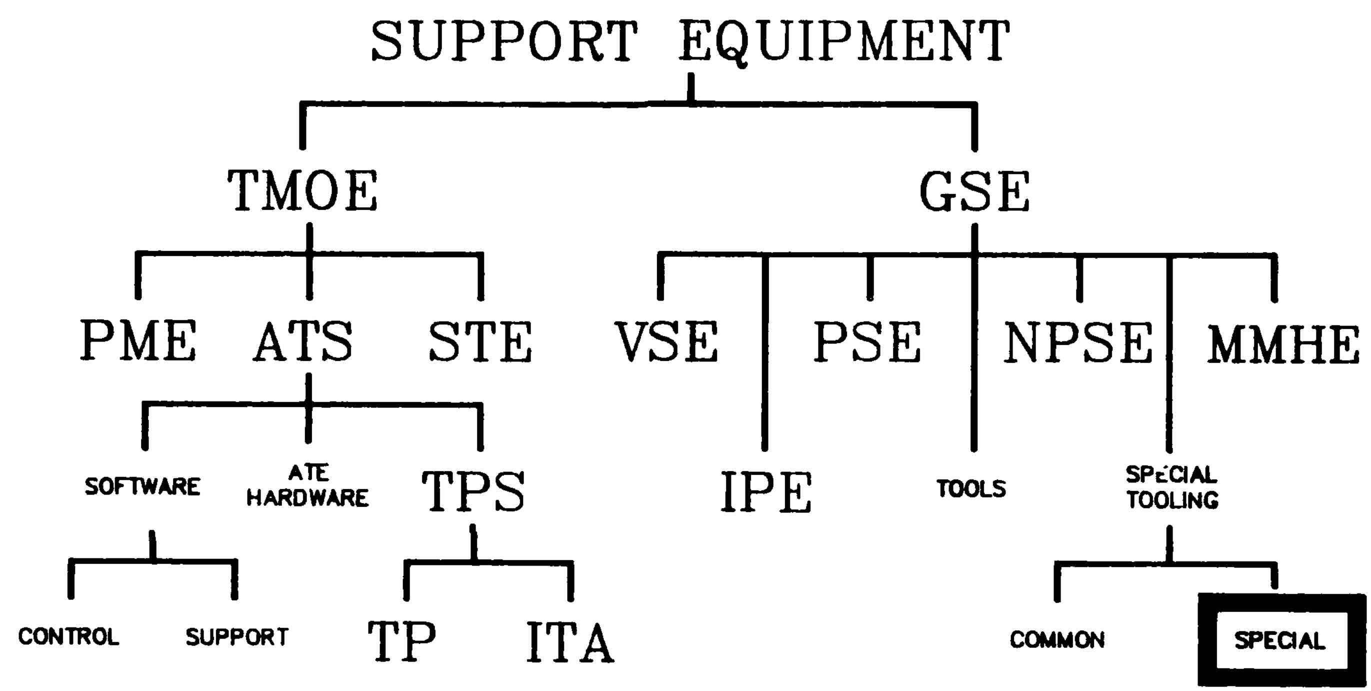


Figure 1-2: Support Equipment Acquisition Life Cycle



SOURCE: "Support Equipment Acquisition Review (SEAR) Group," Final Report, Air Force Systems Command, July 1984, p.7.

Note: Reference Glossary

Figure 1–3: Classes of Support Equipment

2.0 NEEDS ANALYSIS

2.1 DATA COLLECTION STRATEGIES

We used three different methods to collect information:

- A **questionnaire** structured to get an industry perspective on
  - the need for an information support system
  - the potential for using Group Technology as a baseline for creating such a system
  - the types of information to be considered.

Questionnaires were mailed to 77 companies chosen by the National Security Industrial Association (NSIA). Five responses were received. In some cases, interviews were used to supplement the industry questionnaire to help companies complete the form.

- **Interviews**, principally to establish need from a government perspective. We asked government personnel from various Air Force organizations
  - to discuss problems with the current acquisition process
  - to identify the types of information most useful in developing a GT/DSS
  - to estimate the impact of more easily accessible necessary information.

- An extensive **literature search** to
  - collect additional information
  - identify other programs related to this effort.

We analyzed and evaluated all the collected data and compiled the results in the **Support Equipment Needs Analysis Document**.

2.1.1 Industry Questionnaires and Interviews

In January 1986, we mailed questionnaires to 77 DoD Support Equipment contractors chosen by NSIA. The information the questionnaire requested was designed to

- o help formulate an initial **set of requirements** for a GT/DSS
- o identify families or **groups of SE** that have the greatest potential for demonstrating and implementing the projected GT/DSS
- o focus on **cost drivers** in the SE acquisition process
- o research the **benefits** of developing a support tool oriented toward SE costing less than $1000.

The questionnaire was organized into four parts:

Section I - Company Profile
Section II - Existing SE Classification Systems
Section III - Current Use of Group Technology
Section IV - Potential for Using GT to Support Design, Manufacturing, Procurement, and Logistics

2.1.2 Air Force Interviews

During February 1986, we interviewed a number of government SE personnel in order to

- o begin to identify government **information requirements** for a GT/DSS
- o assess the **potential impact** of the system on current SE problems
- o bring to surface the **most pressing needs** of the current SE acquisition process

- o develop a better understanding of two related efforts:
  - the automation of MIL-HDBK-300
  - the Air Force Logistics Command (AFALC) Support Equipment Master Plan (SEMP) initiatives.

Those interviewed included:

- o nine SE personnel at Wright-Patterson AFB
- o members of the F-15 and F-16 System Program Offices
- o Andrews AFB personnel involved with the automation of MIL-HDBK-300
- o a former F-15 SE specialist, now with Mitre Corporation.

The group represents a broad cross-section of Air Force organizations:

ASD/AEGA	ASD/YZEP	HQ AFSC/PLI
ASD/ALXA	AFALC/LSE	AFSC/PLL
AAD/YPLP	HQ AFLC/MAXF	

We asked each SE Specialist,

> "What information about Support Equipment must be shared between the system designer and manufacturer and the government SE specialists to assure the effective acquisition of the system's Support Equipment?"

We predefined the SE design, manufacturing, and acquisition processes to help the people being interviewed share a consistent focus. We asked the SE specialist to identify the major information flows for each activity, and we consolidated the findings into a single list.

Two of the SE specialists, interviewed further, agreed to assess the potential of a GT/DSS against the set of problems that surfaced during the literature search. They determined that a GT/DSS would indeed have a favorable impact on those problems.

2.1.3 Literature Search

The research team used numerous sources in a computerized literature search of Group Technology and Defense Support Equipment. They

- had immediate access to more than 40 million references, abstracts and full-text journal articles, technical reports, conference papers, patents, and government sponsored research.

- collated background information and analyses from on-line searching techniques of over 500 government, scientific, and industry databases.

- received from the Air Force Electronics Division and other appropriate government agencies the applicable Federal Procurement Regulations.

The search strategy consisted of identifying **key words, key programs, and associated acronyms** unique to:

- Department of Defense
- Support Equipment
- Coding and Classification Schemes
- Group Technology

These key words were then searched in all the available databases.

Of the many documents the research team reviewed, **seven stand out** as particularly useful[1]:

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[1] Numbers in parentheses indicate references in the Bibliography.

- o **The Support Equipment Acquisition Review (SEAR) Group final report**[10] and the **AFALC Lessons Learned database**[1] catalogue current SE problems and needs.

- o **MIL-STD-1388-2A**[3] represents the most complete set of SE attributes available today.

- o **MIL-HDBK-300**[12] is a database of aircraft- and missile-related SE currently in the Air Force inventory.

- o **MIL-STD-864B**[11] and the **FINDER documentation**[7] describe concepts that may prove useful in supporting our own coding and classification activity.

- o The **Computer-Aided Logistic Support (CALS) documentation** [9 & 13] suggests that CALS can provide a useful framework/context for this SE initiative.

SEAR Group Final Report

The Support Equipment Acquisition Review (SEAR) Group final report contains a **comprehensive and current description of SE problems and needs.**

Of the 107 recommendations made in the body of the report, these may be the most significant:

- o Develop a **Master Plan** for Support Equipment (SE)
- o Create an **SE Broker/Advocate**
- o Treat SE as a **hardware program**
- o Include SE considerations in **early program planning** and trade studies
- o Program **common SE funds the same way peculiar SE funds** are programmed
- o Include SE in the **Air Force Management Analysis Group (AFMAG) pricing recommendations**, with additions reflecting the peculiarities of SE.

The SEAR Group reported that all commands are experiencing SE shortages, with a cumulative value greater than $1.5 billion. Extensive workarounds and personal ingenuity are required to accomplish the mission in spite of the shortages. While this lack of SE is not preventing mission accomplishments during peacetime, they concluded, in times of stress - particularly if stress came from more than one direction at the same time - SE shortages could potentially hurt the mission.

AFALC Lessons Learned

The Air Force Acquisition Logistics Center (AFALC) maintains a database of lessons learned to provide feedback for improving its acquisition programs. The AFALC documentation is interesting insofar as it **constitutes the Air Force's effort to develop some corporate memory** concerning SE problems.

The AFALC has developed three primary methods to communicate with decision makers in current programs:

- The **Lessons Learned Abstract** is an interest-generating publication to acquaint people with AFALC services and to provide brief summaries of information

- **Lessons Learned Tailored Packages** - the primary reporting method - are prepared for individual programs. They are assembled as a program approaches a critical decision point, or on request from the program office, and focus on key decisions being made during an acquisition phase.

- **Bulletins** are a collection of lessons learned on specific problem areas common to most acquisition programs.

The appropriate action suggested in each lesson is AFALC's recommendation for methods to avoid problems in future programs.

MIL-STD-1388-2A

MIL-STD-1388-2A contains more SE information types than any other single document we reviewed. The CALS subcommittee recommended this military specification as **a starting point in creating a generic data dictionary** to support the Integrated Logistic Support (ILS) program.

MIL-STD-1388-2A's goal is to establish

- uniform requirements
- data element definitions
- data field lengths
- data entry requirements

for Logistic Support Analysis Record (LSAR) data. LSA documentation, including LSAR data, is generated by performing any of MIL-STD-1388-1A's specified analyses. This standard's requirements apply to major and lesser system/equipment acquisition programs, major modification programs, and applicable research and development projects.

MIL-STD-1388-2A is directed toward improving the cost effectiveness of the generation, maintenance, acquisition, and use of the technical data required to support an ILS program. This is accomplished by

- Standardizing LSAR data element definitions and formats between the services and industry

- Consolidating logistics-oriented technical information for the various engineering disciplines and ILS elements into one file to reduce redundancy, facilitate timely use, and heighten consistency between elements and disciplines o Maximizing use of industry-developed integrated data systems tied to engineering and manufacturing data bases as sources of LSA documentation.

The LSAR is intentionally structured to accommodate the maximum range of data potentially required by all services and all ILS element functional areas. At the same time, MIL-STD-1388-2A places responsibility on each service's requiring authority to tailor the total LSA documentation requirements for individual acquisition programs to prevent data overbuying.

MIL-STD-1388-2A allows for LSAR data delivery in manual, automated, or combined manual and automated modes. It does not prescribe Automated Data Processing (ADP) software for processing LSAR data. The use of cost effective LSAR ADP systems developed by industry is encouraged.

CALS Final Report

The Computer Aided Logistics Support concept is an effort aimed at integrating and automating logistics support for weapons systems. Our Support Equipment initiative falls within CALS's scope, but focuses on one aspect of the CALS effort - the creation of decision support systems for simple Support Equipment.

CALS was created as a task force of senior industry and government logisticians to address the problems faced by DoD in applying new and emerging computer technology to improve the logistics support process. The group was directed to "develop a strategy and a recommended master plan for computer-aided logistic support." - Under-Secretary of Defense DeLauer and Assistant Secretary of Defense Korb, 1984.

CALS, coupled with CAD and CAM data, is projected as a **comprehensive, manageable database containing all the essential elements for enhanced logistics support.** The CALS database is intended to become a "point of reference" for government, industry, and all acquisition and logistics support agencies.

The CALS objectives are to

- improve product reliability, maintainability, and supportability by influencing design through CAD and CAM interaction

- improve productivity by reducing manual logistics processes and thus reduce system flyaway costs

- increase the effectiveness of logistics planning by permitting early identification of logistics support needs

- improve the logistics support acquisition process and configuration management through CAD, CAM, and CALS information integration

- ensure continued availability of current product definition data for follow-on support, configuration management, spares procurement, and post-production support.

MIL-HDBK-300

MIL-HDBK-300 is a **technical information file of SE** for aircraft and missile weapon systems compiled and maintained by the Air Force Logistics Command Cataloguing and Standardization Center in Battle Creek, Michigan. The Handbook is meant to be the main source of SE selection by both acquisition program officers and government contractors.

MIL-HDBK-300 is complementary in purpose to our own effort; the major difference is in approach. MIL-HDBK-300 allows a wide range of freedom in the form and content of data within each major class of information; our effort differs in that is stresses the need for a more rigorously structured database. More structure would make it easier to add to and maintain the database, would give users more consistent information, would make item comparisons much easier, and would allow its data base to be used by a GT/DSS system.

MIL-HDBK-300 partitions SE into 17 functional classes, and documents for each piece of SE in the database

- o item name
- o date
- o type
- o functional class
- o dimensions
- o weight
- o National Stock Number
- o cognizant service
- o manufacturer identifying number
- o manufacturer name and code number
- o functional description
- o relation to similar equipment
- o technical description
- o reference data and literature

<u>**MIL-STD-864B**</u>

This standard lends itself as a possible starting point for our classification scheme. MIL-STD-864B was established to provide government personnel and contractors with a means of **comparing Support Equipment and Mission Equipment by functional and technical characteristics.** MIL-STD-864B provides the information for

- o categorizing by function the index of SE Illustrations (SEI) in MIL-HDBK-300
- o the Technical Information File
- o Air Force Logistics Command/Air Force Systems Command (AFLC/AFSC) Form 6 in the Air Force Standard/Preferred Item List (AFS/PIL).

The major functional classes found in the standard are

Group AA Measuring, Testing, Adjusting, and Indicating
Group BB Signal and Power Generating, Supplying, Storing, and Converting (excludes Transducers)
Group CC Communicating, Signaling, and Lighting

Group DD Engine and Missile System Checkout and Testing

Group EE Gas and Liquid Processing, Storing, and Shipping

Group FF Personnel and Solid Material Protection

Group GG Maintenance and Servicing

Group HH Handling, Moving, Stopping, Propelling, and Landing Aircraft Equipment and Solid Material

Group JJ Heating, Cooling, Ventilating, Humidity Control, Pressurizing, and Filtering

Group KK Fire Fighting, Rescue, and Survival

Group LL Training and Simulating

Group MM Detecting, Ranging, and Fire Control

Group NN Demolition and Destruction

Group OO Flight Control and Navigation

Group PP Ignition Systems

Group QQ Photographic

Group RR Data Processing and Storing

FINDER Documentation

The Functionally INtegrated DEsignating and Referencing concept, originated by Headquarters Air Force in 1984, is conceived as a universal coding system for documenting logistics technical data and providing engineering design referencing. The FINDER concept is designed to allow technicians in the field to identify easily and retrieve

- engineering drawings
- technical orders
- reliability and maintainability analyses
- logistics support analysis data

for weapons systems' operational and maintenance support. FINDER is seen as a flexible system applying Group Technology methodology to all required logistics data.

Two primary objectives for a universal numbering system were considered in developing the FINDER concept:

- o to provide a simple and easily used method for accessing all technical logistics information for operational and maintenance support of a weapon system
- o to provide a numbering scheme that would facilitate cost effective documentation of logistics data during design, development, and production of a weapon system.

The functional system and subsystem structure of FINDER offers a basis for satisfying both requirements.

2.2 FINDINGS

2.2.1 Description of the Support Equipment Acquisition Process

The proper introduction of Support Equipment into the Air Force inventory requires, according to our research, the careful coordination of two entities: the contractor and the government. The major roles and interactions of both groups during two interrelated processes, the Integrated Logistics System (ILS) and the Support Equipment Recommendation Data (SERD) procedure, are described here.

The ILS is the process of acquiring all logistic components for a particular system.

The SERD process, a subset of the ILS, is the procedure by which DoD reviews contractor recommendations for SE and determines how approved SE is procured. In order to follow DoD's information requirements for the acquisition of SE, one must understand the SERD review process. It also gives valuable insight into the DoD-contractor interface.

2.2.1.1 Integrated Logistics System Process[2]

2.2.1.1.1 Contractor Activities

Contractor SE personnel perform three important functions during the SE acquisition life cycle (See Figure 2-1):

- o management of the Support Equipment acquisition process
- o technical interaction with the system designer
- o provision of logistic resources.

Manage Logistics

The program/project manager is responsible for the **logistics function.** (In larger programs, this responsibility is frequently delegated to an ILS Manager). That manager's responsibilities normally include

- o dealing with contractual obligations
- o scheduling
- o budgeting
- o integrating activities
- o managing the logistics program's subtasks.

This function interacts with the comparable DoD manager's function and provides guidance and support to the two contractor technical functions:

- o technical interaction with design
- o provisioning logistics resources.

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[2] Source: Riddel, F.R., et. al., (Eds.), Report of the Joint Industry-DoD Task Force on Computer Aided Logistic Support (CALS), Vol. III Report of the Architecture Subgroup, Institute for Defense Analyses, Alexandria, VA, June 1985.

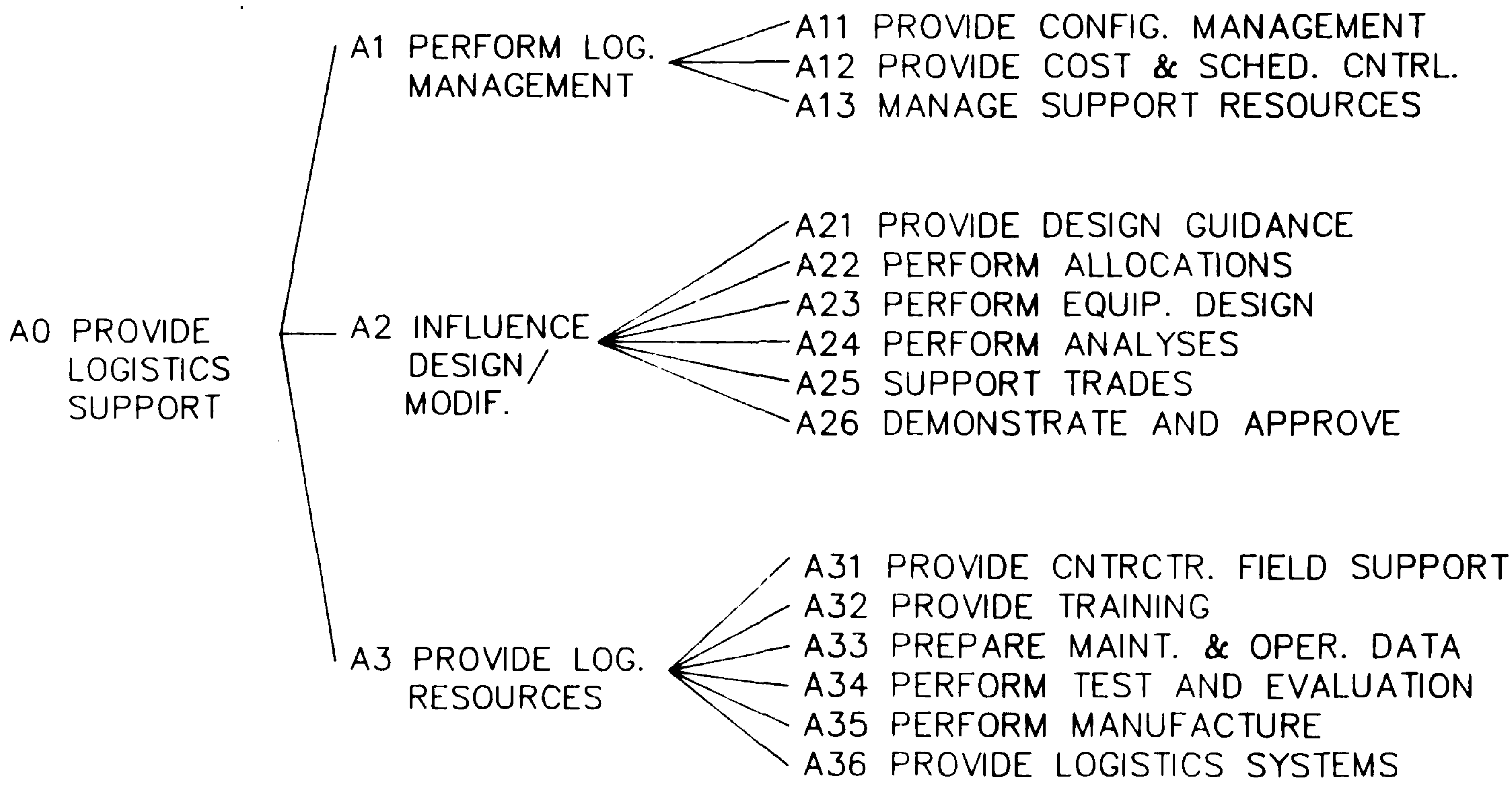

Figure 2-1: Contractor Logistics Support Functions

Technical Interaction with Design

The thrust of this function is to **influence the design/modification** of the major system under development and consists of five supporting activities.[3]

Design guidance is provided by translating Reliability, Maintainability, and Supportability (RM&S) requirements into terms the system's designer can use effectively. Its primary inputs are

- review of comparison systems
- lessons learned
- RM&S design rules
- feedback from the trade assessments

The activity's controls are

- performance requirements
- target support costs
- supportability specifications
- maintenance concept

which are usually communicated during the guidance conference. The activity's outputs are

- supportability requirements
- design features
- alternatives

expressed in terms that can support the allocation and design functions.

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[3] We are highlighting the "influence design/modification" function because the initial emphasis of our project is to investigate the information requirements most important to the interface between the designer and the SE community.

Perform Allocations partitions the system design and refines the RM&S requirements for each partitioned module. Its primary inputs are the design guidance outputs and the design analysis activities. Currently, the Optimum Repair Level Analysis (ORLA) technique and other manual techniques are used to perform this allocation function. Its major outputs are Figures of Merit (FOM) used to support design analysis and trade assessments.

Perform Equipment Design involves creating the design concept and gives design information to be analyzed. If the analysis results are positive, the design concept is documented. If not, the concept is modified.

Analysis involves conducting

- o reliability
- o maintainability
- o testability
- o human factors
- o safety
- o transportability
- o optimum repair level

analyses on the system design. The activity's primary inputs are design information and the FOMs developed during the allocation process. Its major outputs are the analysis results and recommendations, currently performed using a combination of computerized and manual techniques.

Trade-off assessments currently emphasize support cost alternatives using life cycle cost modeling and risk modeling. The CALS subcommittee anticipates that trades between other degrees of freedom - such as size, weight, and performance - will become more common. The trade assessments are used to design alternate design guidance which in turn supports the first activity, **Provide Design Guidance.**

The last activity involves the system's **validation/demonstration of compliance** with RM&S requirements. This activity requires

- development of test procedures
- actual validation/demonstration
- assimilation of test results.

Its primary inputs are the system design, performance information, and the system itself. Its output is approval or disapproval of the system.

Provide Logistics Resources

The thrust of this function is to help the government **identify, deploy, and apply the logistic elements needed to support a particular system** and is defined in terms of six related activities.

The contractor develops the support concept. The contractor prepares Logistic Support Analysis Records using

- the design concept
- design data
- support analysis results
- government-furnished inputs.

From the LSAR data, the contractor

- prepares a transportability plan
- establishes facilities design criteria
- develops an instructional system
- develops the Support Equipment specifications.

These specifications, documented as Support Equipment Recommendations Data, are forwarded to the government for review and approval.

The government determines, after deciding what SE is needed, whether to **procure the equipment** as Government Furnished Equipment (GFE) or Contractor Furnished Equipment (CFE). For other than off-the-shelf CFE, the contractor either off-loads the equipment or manufactures the equipment in-house. Traditional manufacturing activities are

- o plan for manufacture
- o make and administer schedules and budgets
- o plan production
- o provide production resources
- o obtain manufacturing materials
- o produce product.

The contractor performs an **independent test and evaluation** of the system and participates in the technical evaluation activities of the procuring agency, stressing functional and environmental testing.

The contractor **prepares maintenance and operations data** by developing, verifying, validating, and purchasing the data.

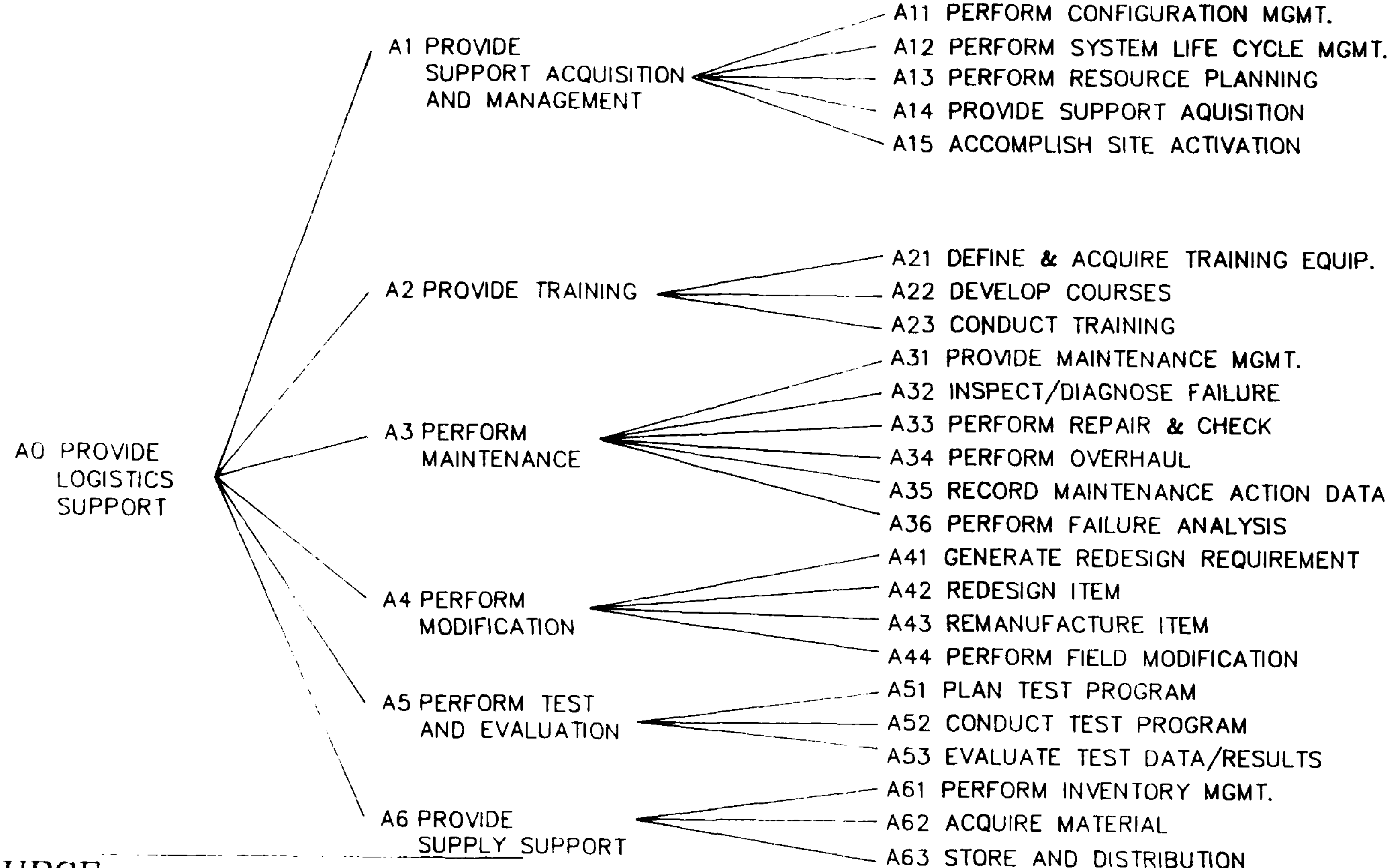
The contractor defines and acquires the requisite training equipment, develops courses and conducts **training.**

Finally, the contractor **provides required field support.** The contractor may provide

- o site activation
- o depot support/operation
- o production/post-production support
- o maintenance itself.

2.2.1.1.2 DoD Activities

Government personnel perform some activities that parallel contractor functions and some unique activities during the process of introducing Support Equipment into the Air Force inventory. (See Figure 2-2.) The dominant Air Force activities include



SOURCE: CALS FINAL REPORT, JUNE 1985

Figure 2–2: DOD Logistics Support Functions

- o providing support acquisition and management
- o providing training
- o performing maintenance
- o performing modifications
- o performing tests and evaluations
- o providing supply support.

Provide Support Acquisition and Management

The thrust of this activity is performing configuration management and systems life cycle management to acquire the necessary Support Equipment. The SERD review cycle is an important component of this process. Government personnel establish resource requirements, identify and allocate the required funding, and, with industry personnel, activate sites.

Provide Training

Government training parallels the contractor's training; both share the responsibility of defining training requirements, developing courses, and conducting maintenance personnel training.

Perform Maintenance

Responsibility for maintenance varies, although it is desirable to keep the contractor's involvement minimal. Major maintenance subactivities include repairing failures and scheduled overhauling. For failures, the process

- o distinguishes the failures
- o recommends a repair procedure
- o repairs the failure
- o records the maintenance.

Perform Modification

DoD's redesign requirements may call for equipment redesign, necessary remanufacture, and field modifications. Generally, DoD generates the requirements and performs the field modifications, while the contractor performs the redesign and remanufacture functions.

Perform Test and Evaluation

The government, like the contractor, prepares a test plan, conducts the test with - or without - the contractor's help, evaluates the results, and acts on the basis of the test results.

Provide Supply Support

DoD provisioning and supply activities include

- o providing for technical documentation acquisition
- o spare and repair part procurement/reprocurement
- o inventory management
- o storage and distribution

2.2.1.2 SERD Process[4]

Identifying Support Equipment requirements, an activity performed during the acquisition phase of a weapon system, is an integral part of the engineering process (See Figure 2-3). A Logistics Support Analysis (LSA) establishes SE requirements and the contractor documents them as Support Equipment Recommendation Data (SERD). The data is then submitted to the Air Force for review and approval.

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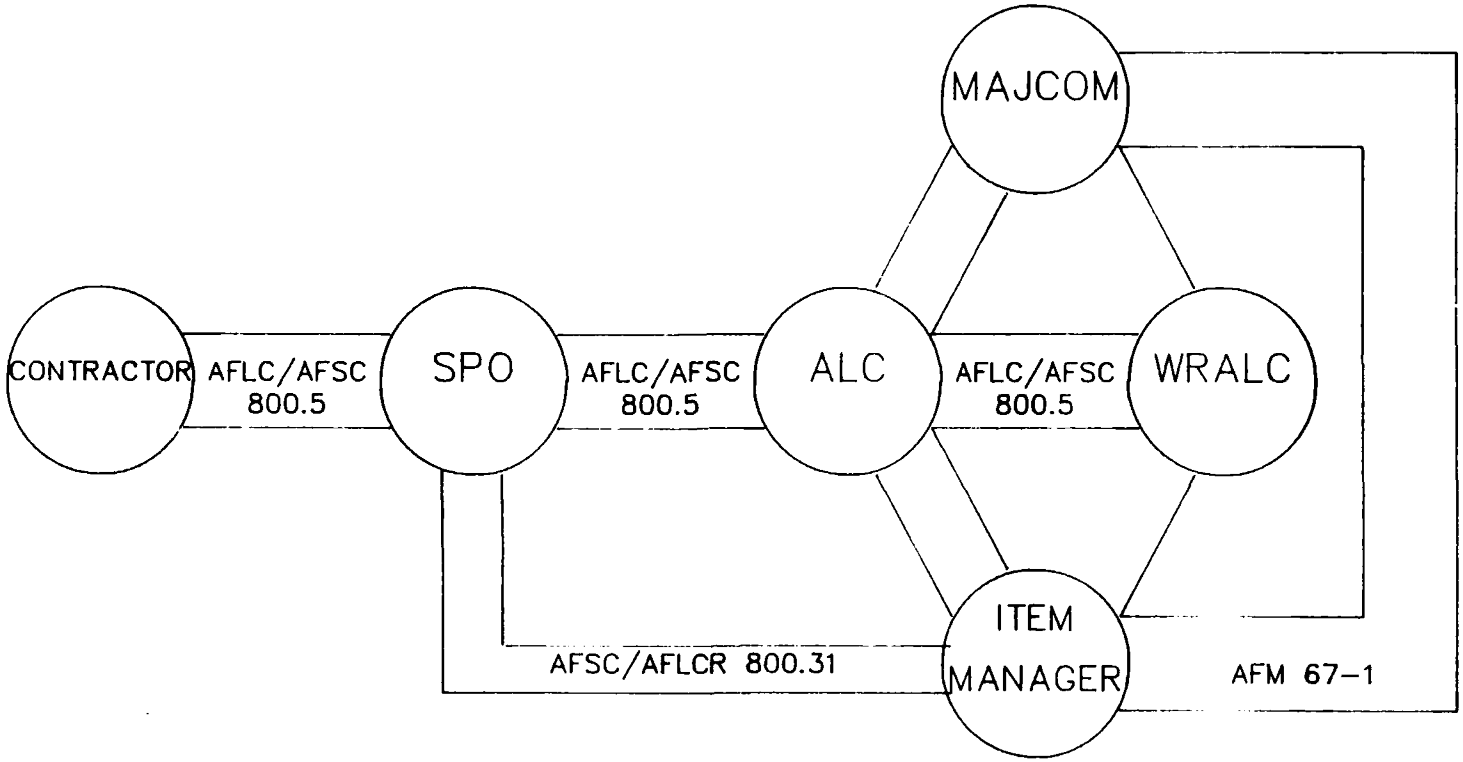
[4]Source: "Support Equipment Acquisition Review (SEAR) Group," Final Report, Air Force Systems Command, July 1984, pp. 8-9.



Source: "Support Equipment Acquisition Review (SEAR) Group", Final Report, Air Force Systems Command, July 1984.

Figure 2-3: SERD Review Process

Air Force policy defines two distinct classes of Support Equipment:

Common Support Equipment—SE in use, in inventory, or planned for use on other programs. Common Support Equipment can be further distinguished as

> **Standard Items**—those developed or acquired specifically to fulfill multiple AF requirements and designated "standard."
>
> **Preferred Items**—those not specifically developed or acquired to fulfill multiple requirements but which have been subsequently identified as having that potential (AFR-800-12).

Peculiar Support Equipment—SE not available from the inventory or by new purchase, as determined by the contractor.

In all cases, the Air Force can provide the items as Government Furnished Equipment (GFE) from inventory or by buying new Support Equipment from the manufacturer, or it can authorize the contractor to provide it as Contractor Furnished Equipment (CFE). The Air Force Equipment Management system (AFEMS) identifies the requirements for replacement SE and items required for a weapon system after initial SE acquisitions.

2.2.2 Problems in the Support Equipment Acquisition Process

Within the context of DoD's goals - acquiring high quality Support Equipment on time and at reasonable cost - we summarize documented problems associated with SE acquisition and highlight their impact on our target class of SE: simple, low-cost, peculiar SE.

Many of the problems associated with SE acquisition are common to other logistics elements as well, since the SE acquisition process is an integral part of the broader ILS process. We assume that there are also unique SE problems since there are ILS procedures - like the SERD process - unique to SE. We postulate that SE problems may vary according to the class of SE considered; it seems reasonable that complex, sophisticated, expensive Automatic Test Equipment (ATE) may present acquisition problems that common, simple, inexpensive SE does not.

The major classes of information examined here are

- o problems with the SE acquisition **process**
- o problems with process **output**
- o problems with process **inputs**
- o problems with process **controls**
- o problems with support processes **(mechanisms)**

There are problems inherent to the acquisition process itself, but there are also problems that can be attributed to the information and resources that support the process. Conversely, some problems associated with the process, inputs, controls, and mechanisms often are the root cause of problems we detect in the output of the process - in this case "deployed equipment." With this in mind, our review of the major problems starts with the output class.

Output: Deployed Equipment

Deployed SE problems generally involve several major issues. (See Figure 2-4.) Foremost is apparent **overpricing**, the result of the contractor's desire to maximize profit margins or to recoup margins sacrificed when pricing out the weapon system, and the high cost associated with the acquisition process. High costs can be traced to

- o major inefficiencies in the acquisition process itself
- o poor planning
- o lack of suitable resources
- o unstable system design and specifications
- o contractor and in-house SE personnel without meaningful incentive to keep costs low.

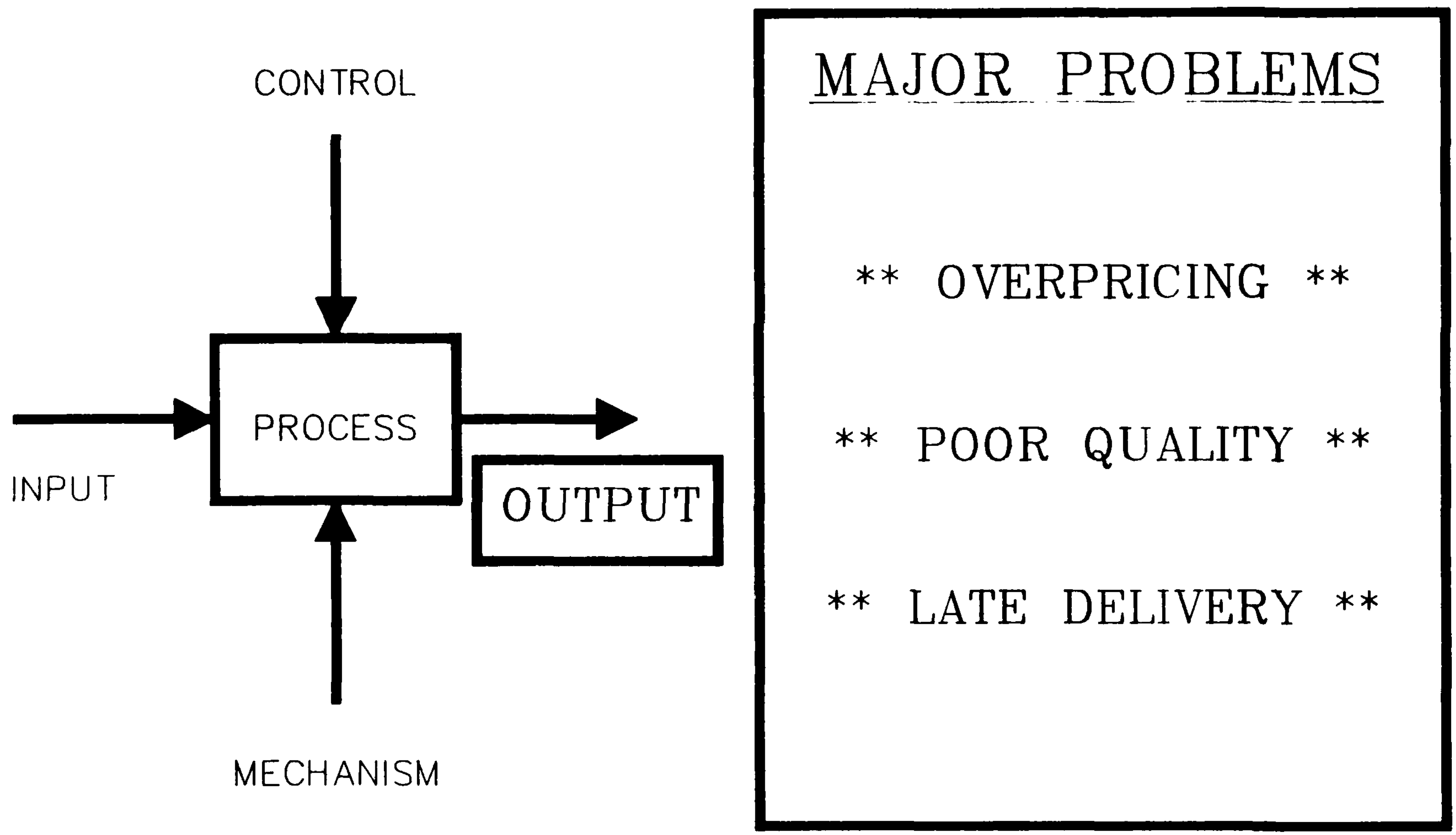


Figure 2–4: Problems with Deployed SE

Simple Peculiar Support Equipment is particularly prone to being overpriced because it has historically enjoyed a low profile - neither the contractor nor the government has been willing to spend much effort in this area trying to cut costs, or in the government's case, to verify costs. The result has been

- enormous duplication of effort and products
- inadequate accounting of existing SE
- proliferation of different but similar types of Peculiar Support Equipment

leading to unnecessary costs to re-invent tools, inappropriately high handling costs, and uncontrolled pricing.

Process: SE Acquisition Process

Aside from the problem of cost, problems of quality, flexibility, and scheduling can be traced in part to problems with the acquisition process itself. (See Figure 2-5.) The process is **unbalanced** in the sense that the operating requirements of the acquisition process often exceed the capabilities of those resources available to execute the process. Consequently, poor process contributes to poor product quality. The problem is compounded by DoD's inherent desire to operate on the frontiers of technology.

The SE acquisition process' **inflexibility** renders it unable to adjust easily to external changes, such as changes in the system acquisition cycle or the acquisition of different types of SE. Ineffective use of already scarce resources (e.g. the system has been known to acquire SE for obsolete system design concepts) and problems of synchronization result.

The acquisition process is too **slow.** Support Equipment, SE for SE, and supporting technical documentation are all prone to being late and uncoordinated unless extraordinary management effort is made.

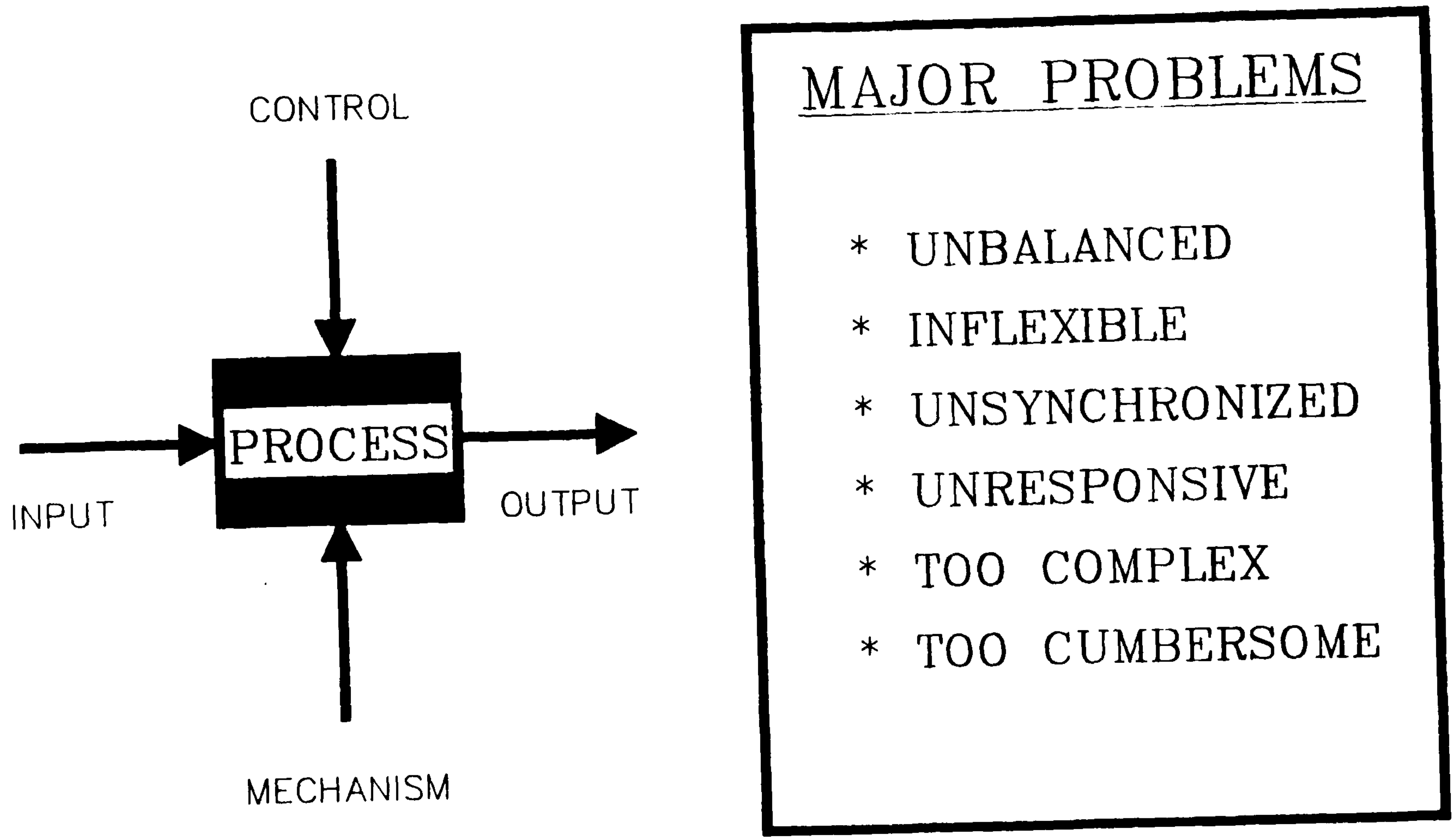


Figure 2–5: Problems with the SE Acquisition Process

Inefficiencies occur most often from the cumbersome nature of the acquisition process itself -

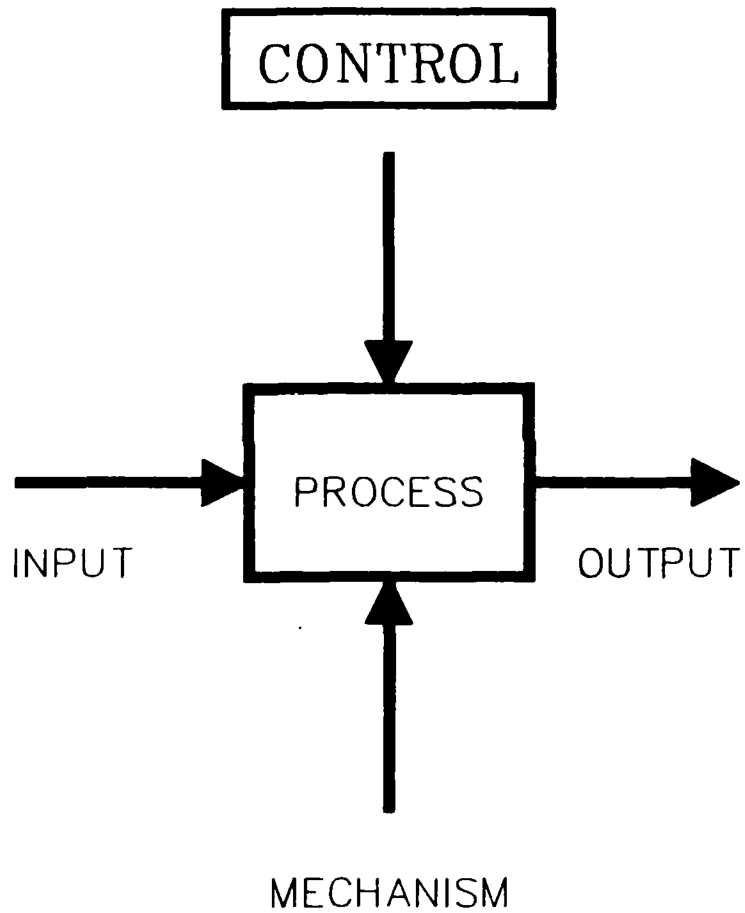
- o the difficulty of coordinating the numerous activities which, in turn, can lead to delays and loss of information
- o the surprisingly small amount of useful information easily available to support decision makers
- o the lack of useful systems for acquiring or generating this information
- o the generally low levels of productivity, measured in actual output, from the people who participate in the process
- o the profound lack of corporate memory other than in the minds of knowledgeable people.

Concerning only the acquisition of simple Peculiar Support Equipment, two problems predominate:

- o the acquisition process is overly complex for simple SE
- o required information for existing SE is unavailable - data sources like MIL-HDBK-300 try to bridge the gap, but the information is usually dated, incomplete, and inconsistent.

Controls: SE Plans and Constraints

Add to inefficiencies in the SE acquisition process problems of control. (See Figure 2-6.) The control structure includes a particular program's SE acquisition plan and constraints, including



MAJOR PROBLEMS

POOR PLANNING DUE TO:

1. LACK OF EMPHASIS
2. POOR TIMING
3. INADEQUATE PREPARATION
4. IMPROPERLY TRAINED STAFF
5. LACK OF USEFUL MODELS
6. LACK OF USEFUL INFORMATION

Figure 2–6: Problems Related to Control

- o DoD regulations and specifications
- o management constraints (scheduling, resource, and fiscal)
- o technical constraints
- o contractor company constraints

The clearest problem appears to be poor planning, which makes effective execution virtually impossible. Reasons offered for poor planning include

- o lack of emphasis on SE
- o poor timing
- o inadequate preparation
- o improperly trained staff
- o lack of useful models
- o lack of useful information

Many alternatives - organic vs. commercial acquisition, Economic Order Quantity purchase, use of existing SE, purchasing with guarantees - are not adequately explored during the planning process.

These problems apply to simple SE too, but problems with standardization, organic purchase, and using existing SE are particularly germane to our examination of Peculiar Support Equipment.

Input: System Design and Specifications

The instability of the system design, coupled with the inadequacies of the SE acquisition process, often provoke serious synchronization problems. (See Figure 2-7.) These problems manifest themselves in the wrong SE being purchased or the wrong SE being deployed.

In too many acquisitions, the system design has been not simply the first priority, it has been the only priority. Systems have been designed that cannot be manufactured or supported. Very high design priority has led to **unreasonable SE requirements.** Systems designers also tend to overspecify and overregulate their SE requirements. Together, these factors lead to exaggerated needs for peculiar SE.

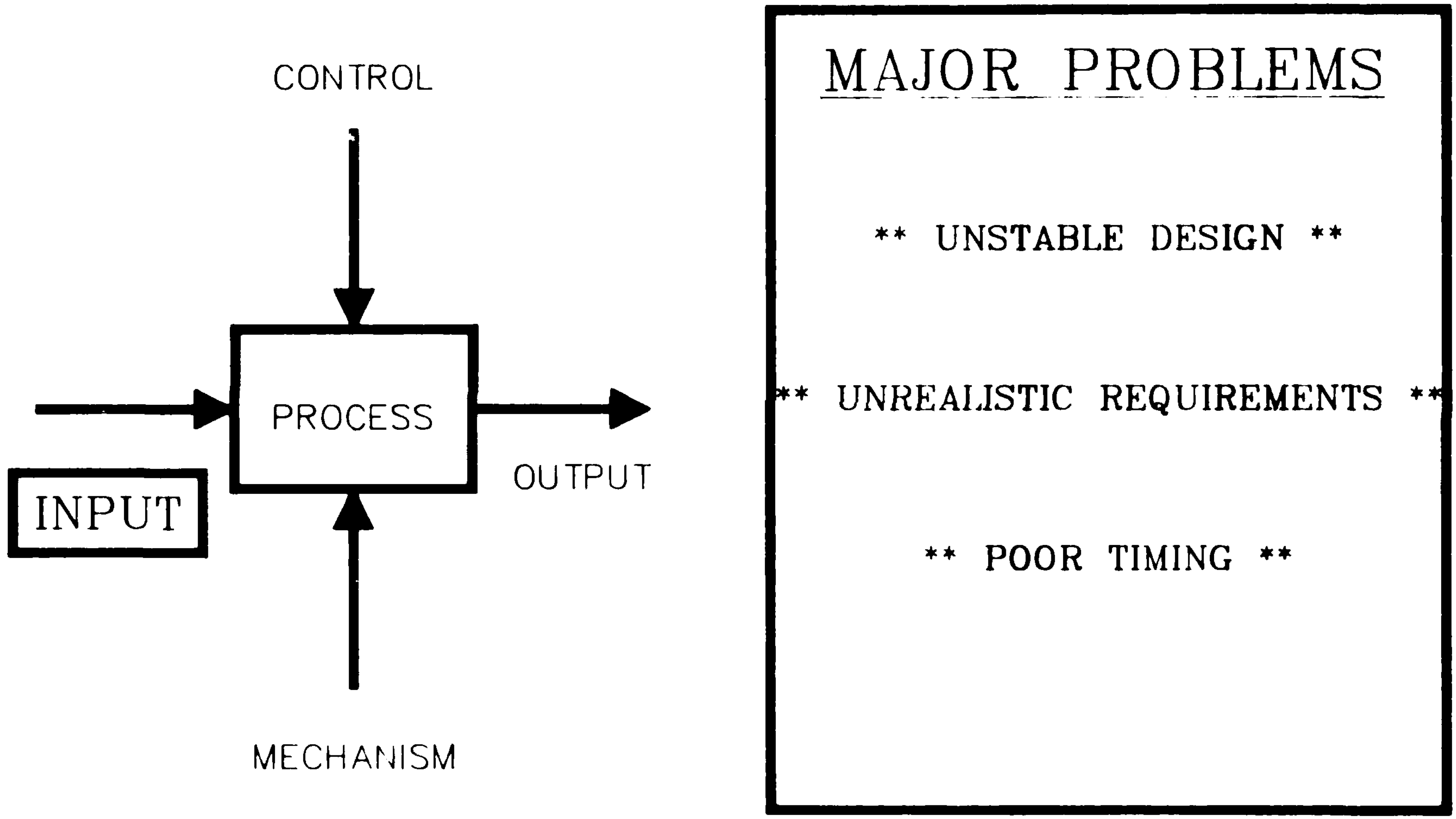


Figure 2-7: Problems Related to System Design Issues

Mechanisms: SE Personnel and SE Systems

Insufficient motivation and education are key problems of the SE work force. Contractors are not motivated to share cost, quality, and schedule goals beyond the point at which they affect profit. Government SE personnel are too often improperly trained, overwhelmed by their workloads, unclear about their roles and responsibilities, and - in their minds - unappreciated. (See Figure 2-8.)

SE support systems are alternately inadequate and overlapping. Hardware, systems, and databases are not integrated - returning us to the problem of inadequate planning.

2.2.3 Identified Needs

Support Equipment needs that surfaced during in-depth interviews with Air Force SE personnel correlated with and reinforced the problems identified in the literature search. These needs can be grouped as the SE problems were categorized - according to whether they stem from the SE acquisition process itself or are associated with the inputs, controls, or support mechanisms related to that process.

All the responses have an indirect bearing on the output of the process - deployed SE - but the specific needs identified focus on other factors in response to the structure of the question, which elicited descriptions of how to improve the overall acquisition process, not simply the product.

Process: SE Acquisition Process

The SE acquisition process is **complex and cumbersome**; the whole process needs major renovations to accomplish efficient fielding of SE:

- o process automation
- o shorter cycle time

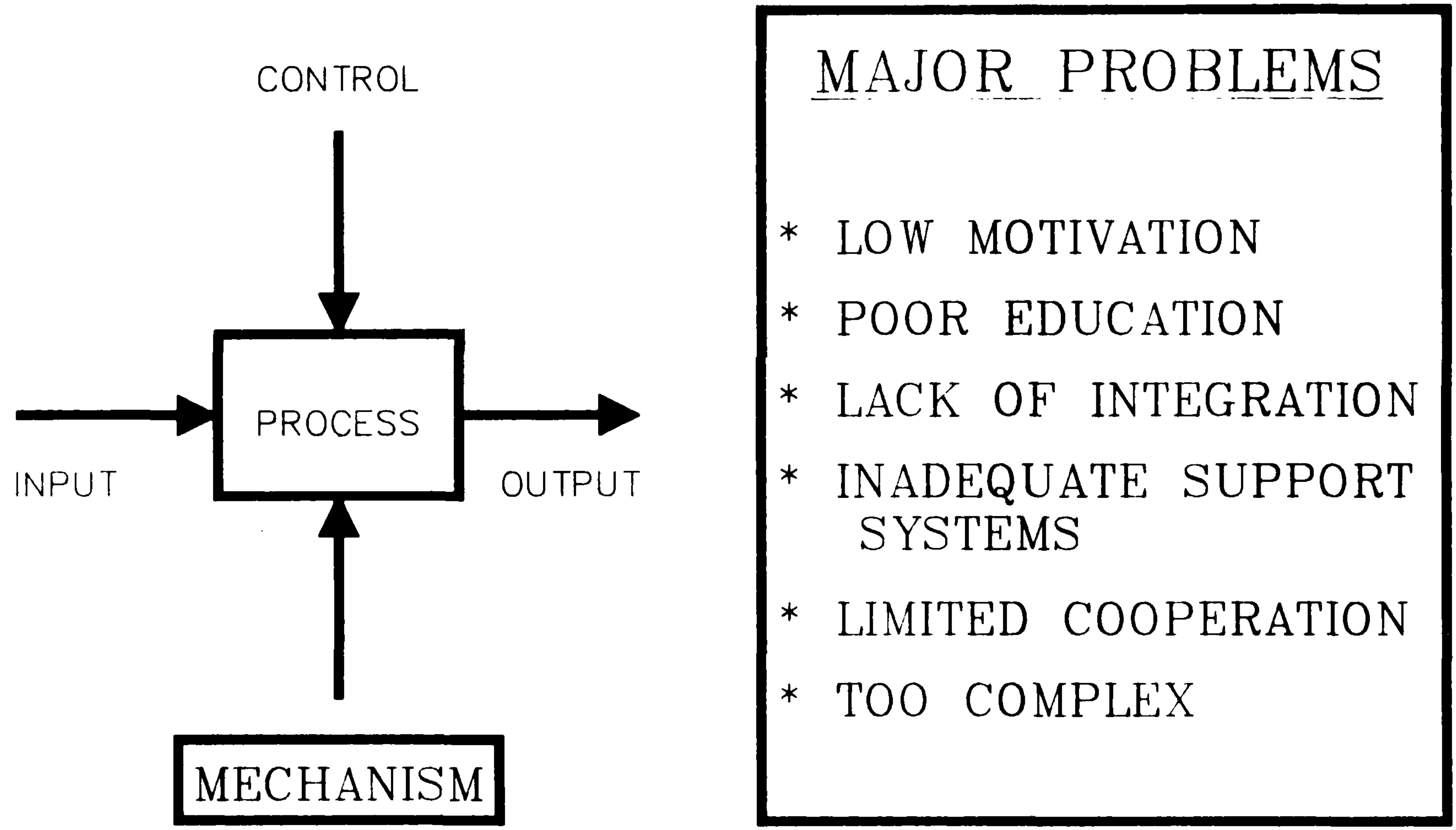


Figure 2-8: Support System Problems

- fewer delays
- simplified procedure for low-cost SE acquisition and/or low quantity SE acquisition

Controls: SE Plans and Constraints

The need for **more effective planning** was reiterated by the interview responses, specifically

- more emphasis on Economic Order Quantity purchases
- **establishing a cost baseline for SE similar to that for spares**
- providing incentives to encourage GFE

Input: System Design and Specification

The issues of **design instability and exclusive priorities** highlighted the need for

- earlier stable system design
- earlier consideration of SE in the system life cycle

Mechanisms: SE Personnel and SE Systems

Insufficient motivation, training, and involvement were the major personnel issues discovered, followed by the need for more adequate tools and information. These significant support requirements predominate:

- earlier SE personnel involvement in the system acquisition life cycle
- better defined roles, responsibilities, and procedures for SE support personnel
- more people to handle the SE workload, or fewer people and automated tools judiciously applied
- better SE personnel training
- better system to perform the SE configuration management function

- more timely information
- more useful information
- more effective SE information transition between AFSC and AFLC
- simple, straightforward description of the SE acquisition life cycle
- better tools to assess SE program requirements
- tools to identify GFE opportunities more easily.

2.2.4 Industry Questionnaire Results

Overview

The company questionnaire responses indicate that a Support Equipment classification system would be useful, even though we received too few responses to construct an industry profile.

We call our respondents Companies A, B, C, D, and E.[5] Their dominant product lines are

- Company A - automatic test equipment
- Company B - training and simulation devices
- Company C - helicopter support equipment
- Company D - gas turbine engine support equipment
- Company E - test fixtures and test sets

The questionnaire was organized in four parts:

- general information on the company for correlation of responses
- SE classification system currently used in-house, if any
- current use of Group Technology
- potential areas of use for a GT classification system.

[5] We use "company" as a generic term to refer to the division or organization responding to our questionnaire.

Here we highlight the responses most relevant to describing these companies' need for and uses of a Group Technology Decision Support System.

Advanced Technology Use

The companies showed some advanced technology use or intended use such as computer aided process planning or computer aided manufacturing, except Company C which used only numerical control. All companies described good product stability.

Support Equipment Families Classification

Responding to our request to identify the major families of SE their organization sells to the government, four listed special tools and equipment as the predominant families. The fifth company listed very different support: training and simulation devices.

Support Equipment Handbooks

No companies use the MIL-HDBK-300 classification system, though they are familiar with the handbook and use it to varying degrees. Only Company C reported that MIL-HDBK-300 had the benefits of being current and providing hard copy with illustrations. No companies use the MIL-STD-864 classification system, though two are familiar with the handbook. Three companies have internal SE handbooks, and Companies A, C, and E specified other SE handbooks that are peculiar to their products.

Group Technology Activity

Company B has a generic ATE development program begun internally for product design. They are also considering a GT system for manufacturing, purchasing, field support, classifying, and retrieving SE. Program benefits are expected to exceed costs for Company B in 1987. Company C is planning a GT system for manufacturing and expects to receive benefits in 1987-88. They are also investigating GT for design. Companies A, D, and E show no GT activity.

Projected Automated Decision Support System Impact

Three companies gave an extensive list of areas of work in the acquisition life cycle that would be affected by an automated decision support system:

- **design** was cited most frequently
- **field support** and **purchasing** had a strong showing
- **manufacturing** was mentioned least.

Company B said an automated decision support system would be useful to determine spares requirements and costs of replacement parts for Integrated Logistic Support.

On-Going Support Equipment-Related Projects

The companies' responses were considerably different from one another and closely tied to each company's product line. Nonetheless, for the most part they appear to be directed toward standardization and decreasing cost.

The Design Function

Section Four of the questionnaire - potential areas of use for GT - revealed a dramatic range of responses including the following for design:

- Company B averaged 20 products amounting to $75 million and employed 1500 people.

- Company C described 80% of their products as having a high degree of commonality.

- Company D shows an average of 450 products or components designed, amounting to $6.5 million and involving 20 people with 5% of their products having a high degree of commonality.

- Company E indicated 20 products, having little commonality, amounting to $2.5 million and 15 employees.

Company B, with its GT installation in the design function since 1985, has realized an estimated 25% time saving for a typical component. GT has been most useful, working in conjunction with CAD in designing new parts, in reducing the variety of designs produced.

Company D, which now uses no GT, perceives potential gains in reducing design variety, retrieving existing designs, and working in conjunction with CAD.

The Manufacturing Function

Two of the five companies said their approach to small cost (under $1000) SE items differed from their approach to higher cost items. Company A gave a detailed account of the driving forces, predominantly design and cost control. Company B looked at the difference as a practical matter of assigning expertise, given the low cost constraint.

Companies A and C report that 70% and 80%, respectively, of their products have a high degree of commonality. Companies B and E have only 20% and 10% respectively. Company C's high degree of commonality is especially important given that Company C manufactures an estimated 60,000 parts annually.

Company C plans to implement a GT system in manufacturing, and rates as the most important uses of the system

- computer aided process planning
- determining capital equipment needs
- common tooling
- sequencing

- o routing
- o quality improvement
- o job enlargement
- o cellular manufacturing

Asked to list the most useful subdivision of parts for the manufacturing function, the companies again chose **function** as important. They also mentioned

- o cost
- o performance capability
- o quality
- o shape
- o vendor
- o availability
- o size
- o complexity

The Field Support Function

Company B is the only company considering a GT system for field support; it now uses a non-military commodity code. Company B specified that it modifies a significant percentage - 10% and $33 million - of its products annually, all of which appear in MIL-HDBK-300. Company B considers only 10% of these products very similar and 60% not similar at all. Company B introduced only three new items in the past fiscal year and they had some degree of commonality with older products.

For classification purposes in the field support function, the only unique attribute mentioned was **time constraint.**

Types of Support Equipment Purchased

The types of SE purchased varied considerably across the companies, with only companies A, B, and E providing detailed information.

Company A bought 40 items for approximately $28 million, none of which came from MIL-HDBK-300. Most of the products Company A bought - 60% - were not similar. Company A uses about 20 different suppliers and 75% of them are single sourced.

Company B bought 5000 items for $36 million, less than 5% from MIL-HDBK-300. Roughly half of Company B's purchases were somewhat similar. Company B has over 2000 suppliers, fewer than 25% being single sources.

Even with so many source vendors, Company B has a GT-type system operational since 1980 that saves about 20% of the time required to perform the purchase function. The in-house system codes every item. Company B finds the system primarily useful for buying new parts and reducing the number of source vendors.

Company E bought 5000 items of which none were purchased under MIL-HDBK-300. Roughly 25% of the purchases were similar. Company E has 200 suppliers and sole sources for approximately 95% of its orders.

Among the information useful for classifying parts, companies chose only **delivery** as a category unique to purchasing.

Most Beneficial Classification Scheme

We asked which attributes of parts would be most useful for design purposes. Three companies said the most beneficial attribute would be **function.** Other attributes mentioned were

- performance capability
- availability
- shape
- part number
- cost
- vendor
- size
- data source

Summary of Information

Every company chose **function** as the most important attribute for classifying Support Equipment parts. They also frequently cited

- o cost
- o size
- o complexity
- o availability
- o shape
- o vendor
- o performance capability

as important attributes, and mentioned

- o time constraints
- o part number
- o delivery data
- o data source.

The one company that uses GT in the design function estimates a 25% time savings, primarily by reducing variety of design. The same company is considering using GT for field support and manufacturing. The company's internal coding system for purchasing, while not GT per se, saves approximately 20% of the time spent on the purchasing function.

2.2.5 Related Programs

The literature search revealed that all three services - Army, Navy, and Air Force - are currently engaged in Automated Technical Information (ATI) projects that may affect the development of a Group Technology Decision Support System (GT/DSS) for Support Equipment. Three additional related programs - Automation of MIL-HDBK-300, the Support Equipment Master Plan (SEMP), and the Integrated Design Support System (IDS) project - surfaced in the interviews with Air Force personnel.[6] (See Figure 2-9.)

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[6] An overview of current military initiatives in this area appears in the CALS Task Force final report. The initiatives are summarized here, and the complete CALS overview appears in the Needs Analysis Document as Appendix B.3.2 The SEMP concept is detailed more thoroughly in Appendix C.4 of the Needs Analysis Document.

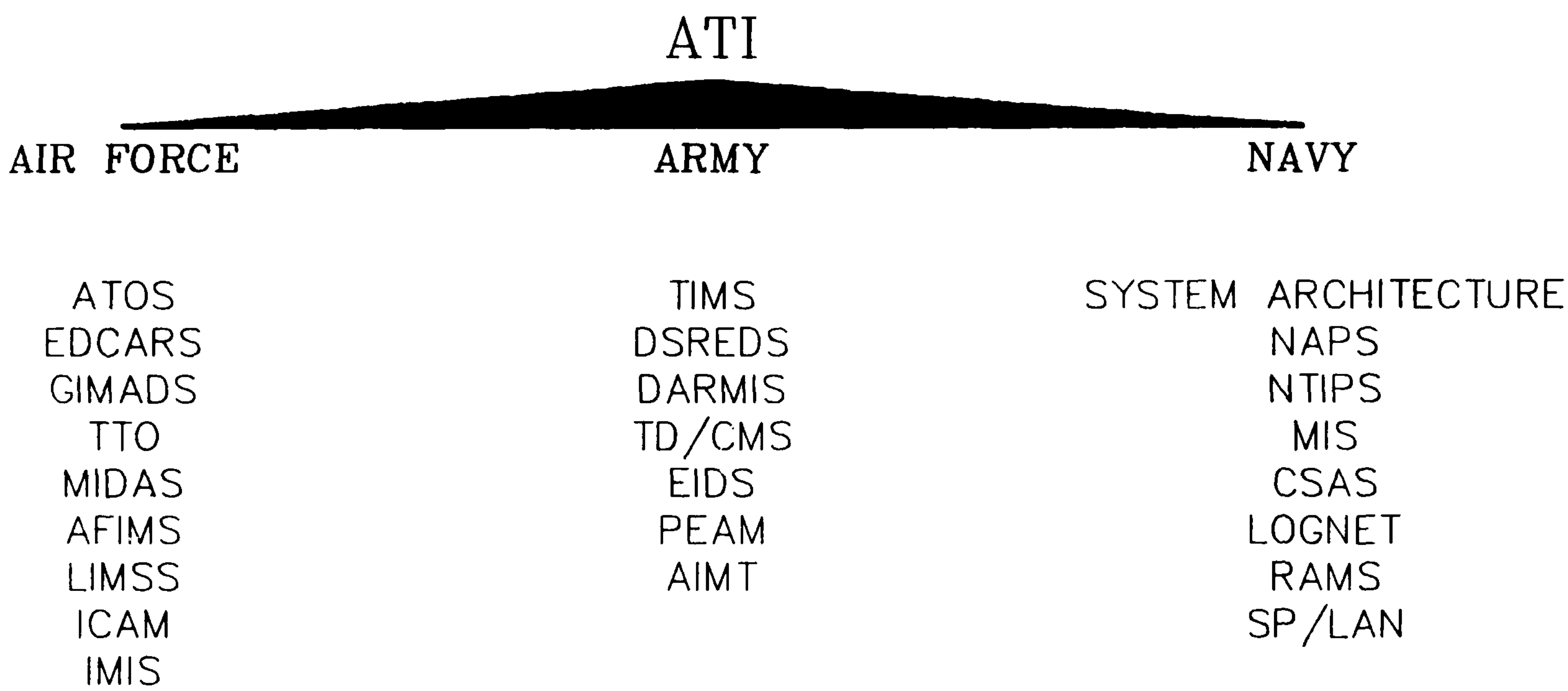

Figure 2–9: Related ATI Programs

2.2.5.1 Air Force Programs

The Air Force's ATI program goal is to establish the capability to accept, store, and retrieve - in digital form - technical information such as

- CAD, CAM, and Computer Aided Engineering (CAE) data
- technical drawings and specifications
- technical orders

The Air Force is specifically focusing effort on

- automated technical orders/technical data
- technical information display devices
- tailored technical orders
- coded maintenance data
- integrated technical orders/technical data/diagnostics

The Air Force will implement these priorities in the following projects:

ATOS The **Automated Technical Order System** is designed to accept and store, in digital form, technical order data from the contractor.

EDCARS The **Engineering Drawing Computer Aided Retrieval System** is being developed jointly with the Army's Digital Storage and Retrieval of Engineering Data System (DSREDS). Its purpose is to accept and retrieve engineering drawings in digital form. EDCARS will eventually be integrated with ATOS in a 3-D CAD/CAM system for digital data management in the Integrated Design Support System.

A project to develop equipment for integrating ATOS into the maintenance process will be initiated. The developed display devices will allow technicians on the flight line to interface with both on-board aircraft equipment and a mass data storage unit.

GIMADS The **General Integrated Maintenance Diagnostics System** is designed to integrate diagnostics, built-in test functions, and technical orders to improve fault isolation in equipment. The system interfaces with ATOS, TTO, EDCARS, and MIDAS.

TTO The **Tailored Technical Order** program will develop an interactive set of instructions to produce maintenance data tailored to the user's level of expertise. Inputs to TTO will be from ATOS and GIMADS. Technical information display devices present the data.

MIDAS The **Maintenance Information Data Access System** is a structured reference system that provides function correlation between work unit codes, technical orders, and engineering drawings. The system enables digital cross-referencing of the data across functional areas and among the various weapon systems.

AFIMS The **Air Force Information Management System,** one layer of the ATI system architecture, is designed to provide the logical framework for defining information system policies, standards, and guidelines.

LIMSS The **Logistics Information Management Support System,** a second layer in the ATI architecture, will define logistics system architecture standards and a logistics C^3 infrastructure that will be compatible with multiple user networks.

ICAM The **Integrated Computer Aided Manufacturing** program focuses on the complete integration of manufacturing functions. One project within the ICAM Program is particularly germane to our interest. The project is referred to as I^2S^2 (Integrated Information Support System). I^2S^2 is an attempt to develop a capability for integrating heterogeneous hardware and software environments. The value of having such a capability will become evident during the discussion of the GT/DSS design concept.

IMIS The **Integrated Maintenance Information System** is intended to enable maintenance technicians to interface with a weapon system at the job site.

2.2.5.2 Army Programs

The Army's objective is to develop an interconnected automated system that will ease the flow of technical information from source to user. The integration effort - **TIMS** - will be augmented by a variety of independent ATI projects.

TIMS The **Army Technical Information Management System** is designed to **automate and store Army weapon systems data. The project, using** state of the art commercial technology, will concentrate on training, maintenance, operations, and configuration management for those systems. TIMS will provide an interface between the supply, logistics, maintenance, and procurement functions. It will be supplemented by these projects:

A **CAD/CAM interface** with engineering drawings

A projected redesign of the processing of Provisioning Master Records (PMRs) and Logistics Support Analysis Records (LSARs).

DSREDS The **Digital Storage and Retrieval of Engineering Data** project is an on-going joint effort with the Air Force.

DARMIS The **Data Requirements Management Information System** is designed to automate the retrieval of requirements for specific contractual needs.

TD/CMS The **Technical Data/Configuration Management System** will integrate and manage all ATI within TIMS. The system is designed to interface directly with the automatic publication systems: Automated Printing and Publication System (APPS), Automated Technical Manual System (ATMS), and UPDATE (a new publishing process).

EIDS The **Electronic Display System** is designed to provide self-paced, individualized training. This basic system will be modified for the maintenance community as MEIDS and for Logistics personnel as LEIDS.

PEAM The **Personal Electronic Aid for Maintenance** program is a joint Army-Navy project to improve the quality management and delivery of technical information to the maintenance technician. The Navy project is AMIS.

AIMT The **Artificial Intelligence-based Maintenance Trainer** project is similar in intent to PEAM.

2.2.5.3 Navy Programs

The Navy's goal is threefold:

- to speed the transition to electronic technical information systems
- to reduce the cost of TI generation, data entry, reproduction, and distribution
- to control the proliferation of ATI systems.

The Navy is pursuing programs to develop an integrated ATI system that will support the whole Navy weapons systems acquisition cycle - requirements definition, system design, manufacture, deployment, operational support, and configuration management. These are the current Navy programs:

The **ATI System Architecture program** focuses on

- identifying and analyzing problem areas and deficiencies
- determining Navy ATI requirements
- assessing current and emerging ATI technologies

- o developing concepts and technical approaches for resolving identified problems and deficiencies
- o developing a top-down architectural design for a Navy-wide ATI system.

The effect of **on-going Navy programs in configuration control** (STEPS, NEDDARS) on the defined ATI architecture will be investigated and integrated within the ATI design architecture.

NAPS The **Navy Automated Publishing System** is a demand printing system being developed for test and evaluation.

NTIPS **The Navy Technical Information Presentation System** is a prototype operation for an automated electronic composition system. It will be developed in conjunction with NAPS.

MIS The Navy Publications and Printing Division Office will develop a **management information system** for integration with NAPS.

CSAS The Navy's **Configuration Status Accounting System,** which supports maintenance planning, will address some of the networking problems associated with ATI.

LOGNET The **Logistics System Information Network** initiative focuses on the broad networking aspects of ATI. This project will develop, test, and evaluate a Navy-wide information network concept for on-line access to the many logistics databases that support naval supply and maintenance operations.

RAMS The **Repairable Assets Management System** project uses LOGMARS and is intended to upgrade the repairable assets process by improved electronic interfaces and feedback to the Navy's Maintenance and Material Management (3M) System.

SP/LAN The **Stock Point/Local Area Network** program is designed to improve telecommunications at stock point locations within the ATI network area.

2.2.5.4 MIL-HDBK-300 Automation

Innovative Technology, Inc. (ITI) has developed MIL-300, an automated system that gives users easy access to SE technical information for aircraft and missile weapon systems contained in MIL-HDBK-300. MIL-300 allows a user to interface with ITI's host mainframe through TELENET. The user can request stock numbers on selected items by cross-referencing functional classes with MIL-HDBK-300 NSNs. The program shows all NSNs related to the functional classes chosen and the user selects NSNs for which he would like reports or technical information.

2.2.5.5 Support Equipment Master Plan (SEMP)

SEMP's objective is to provide the Air Force with an overall plan for acquiring, managing, and replacing Support Equipment. This master plan proposes to demonstrate new and projected SE requirements and point out deficiencies needing research and development. Planned as a dynamic document, SEMP is designed to reflect changes in deployment and support concepts and project new maintenance initiatives. SEMP will be implemented in four phases:

- Phase I — A feasibility study (the current effort)
- Phase II — Develop a prototype SE master plan
- Phase III — Distribute, update, and refine the SEMP draft and automate supporting databases
- Phase IV — Implement, maintain, refine, and update an operational version of SEMP

2.2.6 Support Equipment Information Requirements

Identifying, codifying and classifying information that should be considered in the design for a database for simple, low-cost SE will be performed later. We identified numerous data classes[7] to be considered and found the richest source of information in MIL-STD-1388-2A. That source was augmented with other classes of data identified in the CALS documentation, MIL-HDBK-300, the general literature, and interviews with SE personnel.

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[7] See the "Needs Analysis Document," Interim Report for the Phase I Industrial Base Analysis for Support Equipment, Appendix B.1.2, 3 July 1986.

3.0 RELATED CLASSIFICATION SCHEMES

3.1 SUPPORT EQUIPMENT CLASSIFICATION SYSTEMS

The approach used to develop the proposed system is based on the information necessary for the SE acquisition process uncovered in the literature search, Air Force interviews, and questionnaire responses. MIL-HDBK-300 and the FINDER concept are existing classification schemes we will examine here for their applicability to the problems of cost, quality, flexibility, and scheduling in SE acquisition we have discussed in Section 2.

3.1.1 Evaluation of MIL-HDBK-300

MIL-HDBK-300 is the main source supported by the federal government for SE selection by both acquisition programs and government contractors. The handbook holds documentation for SE according to these types of information:

- item name
- date
- type
- functional class
- National Stock Number
- cognizant service
- manufacturer name and code number
- manufacturer identifying number
- dimensions
- weight
- functional description
- relation to similar equipment
- technical description
- reference data and literature

Industry evaluation of MIL-HDBK-300

Industry responded negatively to questions about the utility of MIL-HDBK-300. The concept of a central source for SE acquisition and procurement is a good idea, but industry's consensus is that the equipment and information listed in MIL-HDBK-300 is **obsolete:** either the part is listed in MIL-HDBK-300 but no longer available, or the part is available but not listed in the Handbook.

Lack of configuration control contributes to engineers' reluctance to seriously consider using equipment listed in MIL-HDBK-300. One senior maintenance engineer pointed out that the government is not so much buying items of SE as it is buying the equipment's capability. The information on the capabilities of the equipment in MIL-HDBK-300 is so **untrustworthy** that few engineers or corporations are willing to risk specifying its equipment. This kind of criticism clearly and severely limits MIL-HDBK-300's usefulness.

Automated MIL-HDBK-300

Innovative Technology Incorporated of McLean, Virginia has designed Technical Logistics Reference Network, an online computer system linking **supply/logistics data from the Federal Cataloguing System and other related** DoD data bases. The system includes an electronic version of MIL-HDBK-300 as an attempt to make the Handbook's information accessible. Automating, however, does little to correct the user community's criticisms of the Handbook's shortcomings.

MIL-HDBK-300 and its automated version allow great freedom of form and content for data supplied in each major class of information. MIL-STD-864B, the apparent standardizing contributor to the Handbook, provides listings for categorizing Support Equipment Illustrations (SEIs) indexing by function only.

Inadequate Standardization

Consider, for example, the diversity of information and reporting practices in the category Hoisting and Lifting, which appears under class HH 1.1. The technical descriptions of the five cranes in this category

- vary from 14 lines to a full page
- are not standardized in informational form
- commonly address only two thirds of the information requested in MIL-STD-864B
- omit data on a number of items

- o sometimes contain unsolicited information
- o provide information on item characteristics in various forms.

Suppliers omit information on power consumption or erection capability, in some cases, but give extra information on boom length. Boom elevation or turning radii are given in degrees in some instances and feet and inches in others.

SE Classification Starting Point

MIL-STD-864B provides a starting point for an SE classification system. Standards can - and must - be imposed on the technical information requested by the regulation. (See Figure 3-1.) In our illustration, we have simply abstracted technical information categories from information given by movable crane suppliers. These technical categories are also applicable to other functional classes and so begin to form a standard that can be expanded.

Such a small point of improvement is representative of what, with very little effort, would constitute a significant step toward standardization. But to begin to be genuinely valuable, MIL-STD-864B would have to

- o contain a very precise dictionary
- o require rigorous reporting procedures
- o specify procedures to update information regularly
- o be expanded to include smaller budget items like special tools.

3.1.2 The FINDER Concept

The Functionally Integrated Designating and Referencing System (FINDER) was conceived as a universal coding system for documenting logistics technical data and providing engineering design reference. FINDER is an extension of the Maintenance Integrated Data Access System (MIDAS) architecture. Both FINDER and MIDAS use a system, subsystem, and sub-subsystem numbering scheme similar to the Air Transportation Association Specification Number 100 (ATA 100).

INPUT POWER CHARACTERISTICS

* VOLTAGE: 12 OR 24 VOLTS
* POWER CONSUMPTION: MILES PER GALLON
* POWER SOURCE TYPE: GASOLINE DEISEL, ELECTRIC
* POWER SOURCE RATING: <100 HP, >100 HP
* FUEL TYPE: GASOLINE,DEISEL,FUEL OIL
* FUEL TANK CAPACITY: IN US GALLONS

OUTPUT AND OPERATIONAL CHARACTERISTICS

* RATED CAPACITY: IN TONS
* MAXIMUM RADIUS: IN DEGREES
* BOOM TYPE: TELESCOPING OR FOLDING
* MAXIMUM BOOM ELEVATION: IN DEGREES
* ROTATION RANGE: IN DEGREES
* TYPE OF CONTROL: MANUAL, AUTOMATIC REMOTE
* PINTLE HEIGHT: IN FEET
* ROAD CLEARANCE
* TURNING RADIUS: IN DEGREES
* BRAKING SYSTEM: PNEUMATIC,HYDRAULIC, AIR, MECHANICAL
* STEERING SYSTEM: MANUAL, HYDRAULIC, POWER

Figure 3-1: Example Specifications for Technical Description

Members of Lockheed Georgia's technical staff evaluated FINDER and found it a simple and easy method for indexing all the technical logistics information needed for weapon systems' operational and maintenance support. FINDER as a numbering scheme could also track the cost effectiveness of logistics data during design, development, and production of a weapon system.

As a coding system, mapping the logistics information to the weapon system, FINDER is a useful concept for our work. We are concerned with a much broader issue of classification, but linking a particular piece of Support Equipment to its weapon system, so contractors can examine and build on similar systems characteristics, will be an important part of the coding effort.

3.2 PROPOSED CLASSIFICATION SCHEME

3.2.1 Classification System Overview

Solving the Support Equipment information problem requires that the right information be identified, organized, and made available in a user-friendly way:

- o An SE designer needs information across weapon systems to discover whether existing SE can be used on his current project in order to avoid duplicating existing designs, or, whether by modifying his current design he can make use of existing SE.

- o An SE manufacturing manager can use detailed information about SE characteristics for common tooling and to make efficient manufacturing runs rather than repeated small batch runs.

Group Technology (GT) concepts - classification and coding systems - can be used to **organize** this information in relational databases, word processing systems, and graphic databases so users can easily find and use relevant data.

Once organized, the information can be loaded into a database where a Group Technology Support System (GTSS) can be used to perform the basic functions of

- o creating
- o accessing
- o modifying
- o deleting

information in the database. User-friendly decision support systems (DSS) can be developed to make the GTSS **more accessible** to the end user.

Group Technology

Group Technology is an **operating philosophy** which recognizes that similarities occur in the design, manufacture, and deployment of discrete parts. It exploits the underlying sameness of things. A GT system's design objective is to establish families based on **specific similarities** and to differentiate things within families based on **specific differences.**

The key to a GT approach is implementing some kind of classification and coding system. Classification entails organizing related data in a logical and systematic order so that all like items are together. The goal of a GT approach is to develop an all-embracing, mutually exclusive classification of the permanent characteristics of a population of items while carefully considering the application of the information the system provides.

Central Principle of GT Classification

Classification, used in the GT context, relies on a basic principle: the system is developed from the user's point of view. We have concentrated, in our research, on identifying the broad decision junctions in the acquisition life cycle and thereby identifying the potential users of a Support Equipment data support system. Clearly, there is more than one user or group of users whose needs must be met for the system to be valuable. To satisfy the objective of our research, we have decided to formulate broad categories of information to reflect the depth and breadth of information required to support SE.

Two Types of Classification Schemes

Two types of classification schemes were of interest:

- o one that classifies Support Equipment per se
- o one that classifies the types of information each SE needs during the life of the weapon system.

Neither scheme is easily specified. Our approach was to use some well established classes for SE, like functional classes, and to build into them useful classes or categories of information, like supportability data. Some classes are amenable to coding, some are not.

Prototype System's Focus

In order to demonstrate the utility of our proposed system and the role of a GT structure, we have centered our efforts around the **Support Equipment designer's needs.** We identified **special tools,** a subset of SE, as the focus of our special attention because of the proliferation of special tools in the SE system and the notoriety of their relative cost.

For the purposes of this report, special tools are defined as

- o inexpensive, non-complex SE that cannot be bought off-the-shelf
- o simple off-the-shelf equipment that must be modified

A special tool used, for example, in assembly is considered Support Equipment only after it has been adapted and tested for field use.

The proposed classification scheme centers around the principal attributes of Support Equipment. The scheme's purpose is to provide a consistent communication tool for identifying parts. But the communication tool will differ from user to user: a design engineer requires different information in different form from that needed by a manufacturing engineer or a purchasing agent. So supplemental attributes that different users need should be stored in the database in such a way that each user would get only the information he needs in the form he can use.

The motivation to concentrate on the design aspect of small tools stemmed from the perceived cost benefits of applying a classification system here and the availability of data to do so. The system would help a design engineer discover whether a proposed design

- is redundant and thus unnecessary
- can be altered slightly to use an existing tool
- is indeed unique.

Database information about designed parts' producibility could be included to help the engineer adopt standards for non-critical differences among parts.

3.2.2 Proposed Classes

To provide a system that is flexible and expandable for both volume and application of information, we suggest a list of classes useful in characterizing SE that we call "cubby holes." The cubby holes draw heavily on the information already required by MIL-STD-864B and MIL-STD1388-2A.

Function is the major attribute used to subdivide all SE. The functional classification scheme proposed by the SEAR group should be considered as a starting point because it incorporates the MIL-STD-864B classes as well as smaller budget items, specifically special tools. We would include performance characteristics as subclasses of information under the function class. Depending on the function of the SE, the proposed system would further classify an item by part characteristics, and provide broad categories of information like supportability data. (See Figure 3-2).

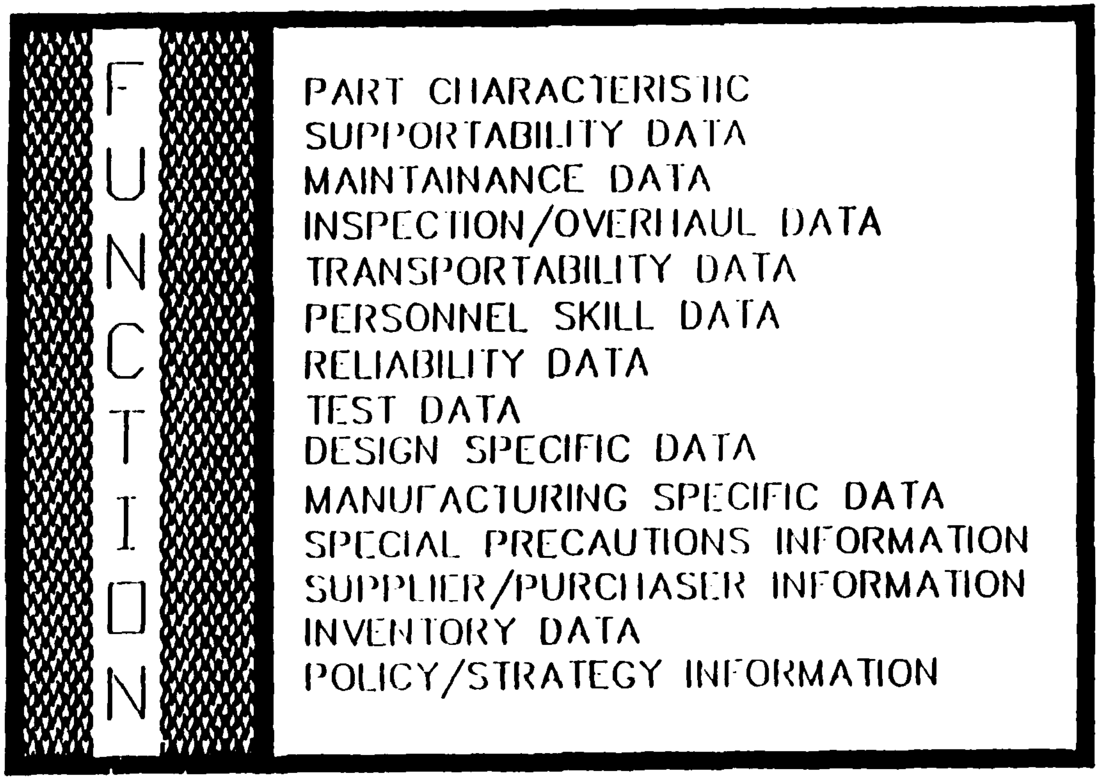


Figure 3-2: Support Equipment Classification

Relation of Weapon System Supported by SE to Class

Within a major weapon system, SE is used to support numerous subsystems like the engine or landing gear. Some of this SE may be common across the weapon system's subsystems, but much of it is unique. Therefore, we do not propose using the system supported by the SE as a class, but would list the supported system and subsystems in a trailer record within the function class coded by a concept like FINDER. (See Figure 3-3.)

Level of Detail in Classes

If one were to focus solely on special tools in the system, clearly some of the classes of information would not include much detail. A hand-held tool would probably not have any special supportability requirements, but it could have its part characteristics described in detail. (See Figure 3-4.)

System Size

Similarly detailed classes would need to be developed for every piece of Support Equipment. Clearly, the system would be enormous. (See Figure 3-5 for the general structure of the system, combining our proposed classes and those of the SEAR group. All SE is divided among the functions, then, depending on function and subfunction, is divided among classes. For instance, a subfunction under the special tool function might be adjusting tools.)

3.2.3 Information Representation

Coding

When the classes have been distinctly defined, a coding system would be assigned to individual categories. We anticipate that the system will combine monocode and polycode structures. **Monocode,** or hierarchical code, is made up of a series of digits in which each digit is dependent on the value of the preceding digits. **Polycode,** or chain-type code, is made up of digits independent of every other digit.

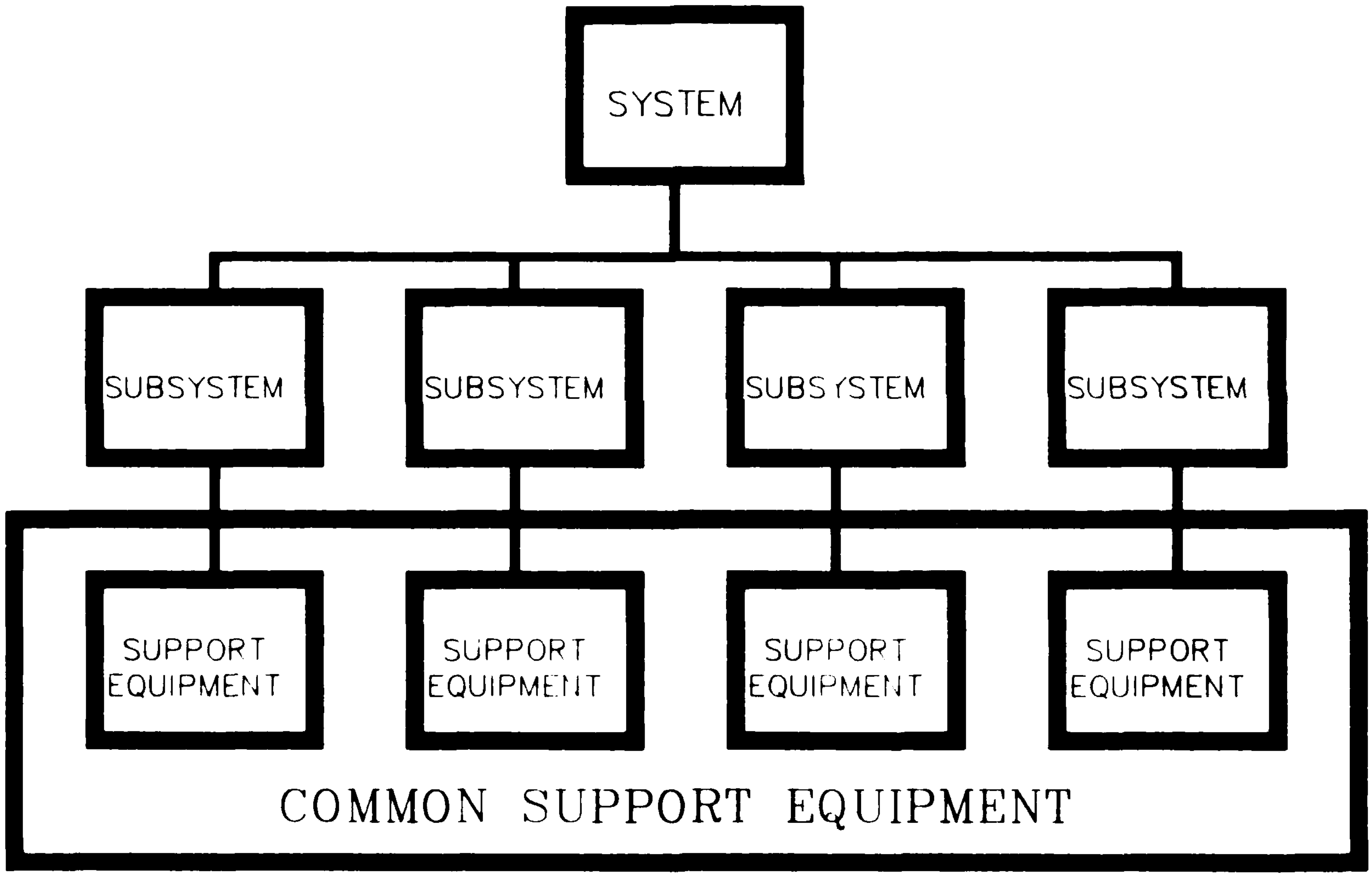
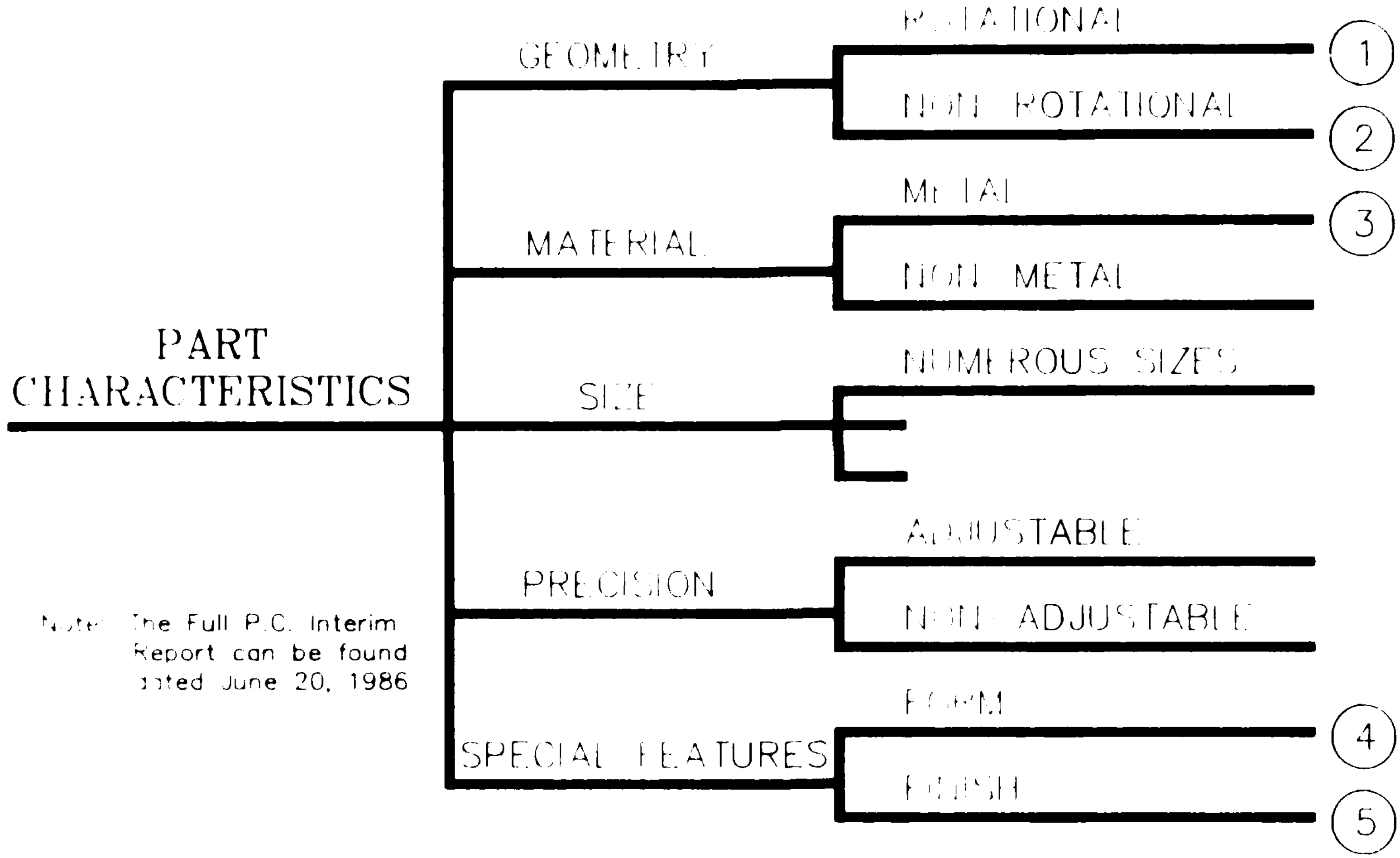
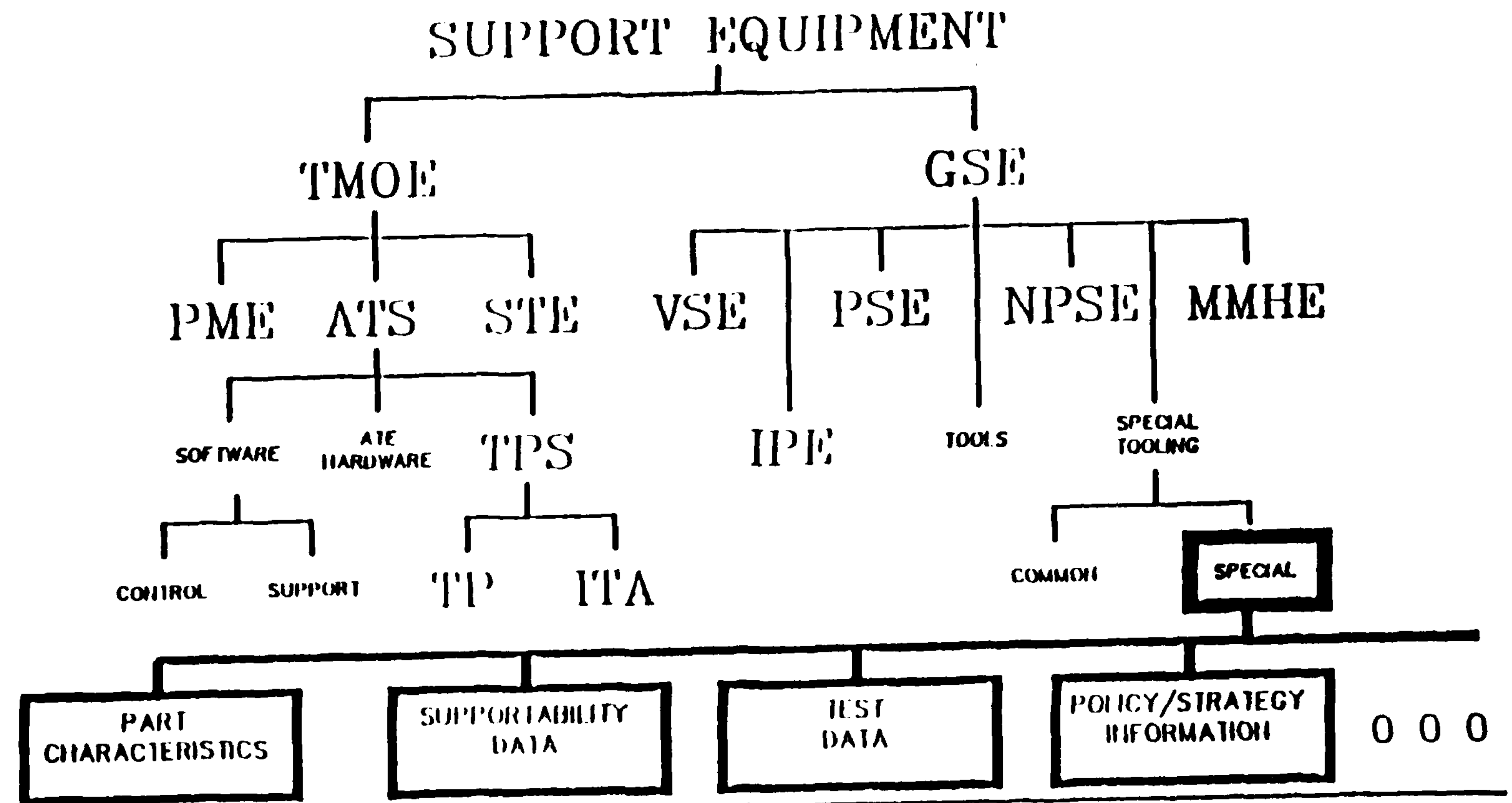


Figure 3-3: SE Relationship to Weapon System



Note: The Full P.C. Interim Report can be found dated June 20, 1986

Figure 3 4 Example GT Scheme for Part Characteristics



SOURCE: "Support Equipment Acquisition Review (SEAR) Group," Final Report, Air Force Systems Command, July 1984, p.7.

Note: Reference Glossary

Figure 3-5: Classes of Support Equipment

This coding structure is not unique to GT. MIL-STD-1388-2A provides a good starting point for creating a generic data dictionary and coding system. The goal of this standard is to establish

- o uniform requirements
- o data element definitions
- o data field lengths
- o data entry requirements for Logistics Support Analysis Record (LSAR) data.

Narrative and Graphic

The system would be designed to accept information for classes in a narrative or graphic form. Narrative would be essential for providing reasoning, policies, and special information. A graphics database would include engineering drawings and other figures of merit.

3.3 COST BENEFIT ANALYSIS

Group Technology for Support Equipment can be cost effective if the attributes of

- o parts
- o equipment
- o cost
- o processes
- o function

can be rigorously captured in a standard form. To support GT more extensively and to pinpoint the cost benefits comparing one part to another using currently available mediums, we would need to collect and analyze data from several standards, handbooks, and various SE personnel.

"For every $1 billion the country spends on a weapon, approximately $3-5 billion is spent supporting it."[8] With the application of Group Technology principles and a well-defined Decision Support System to manage design, analysis, trade studies, manufacturing, inventory, and use of Support Equipment, we have reason to believe that tremendous potential for cost saving exists.

Through our case study analysis we have found that

- SE parts range in commonality from 5%-80%
- SE design time can be reduced by 25%
- SE manufacturing is common in 20%-80% of parts produced
- SE purchasing time can be reduced by 20%

In each case we analyzed, a Group Technology scheme and culture was introduced into one area alone. To synergistically apply GT principles across all SE equipment would produce staggering cost savings. However, for the purposes of our study of the effect of GT on SE, we should temper the results shown here by the variety of SE produced and the relatively low importance given SE in the life cycle of a weapon system.

Design Cost Reduction

The central importance of GT for design is its ability to relate similar parts to a conceived need for a new part and fill the new need with an existing or slightly modified part. When a designer can identify a part that may be adapted from an existing part, considerable savings may be realized.

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[8] Walter Peterson, Advanced Program Development, Hughes Aircraft Co., Conference Chairman, 1984 National Conference on "Supporting Weapon System Technology Through the 1990's," Denver, Colorado, August 14-16, 1984.

One of our questionnaire respondents wrote that design time can be reduced 25% by using GT. From that, we extrapolate that the number of new SE parts can be reduced, tightening the whole system and increasing the benefits of GT on the number of parts that are developed.

The general industry standard for original equipment drawings considered necessary in a year indicates that 5-15% are exact duplicates and another 10-20% require only minor modifications to distinguish them from similar equipment. Although the breadth of SE is great, the savings may not be as consistently high because of their lower relative cost. For SE costing less than $1000, the functionality of GT may be quite similar but the anticipated savings percentages may be low. We need to do more specific data gathering to pinpoint the cost savings for design.

Manufacturing Cost Reduction

The savings from GT cascade from SE design to manufacturing. Given fewer unique SE parts, manufacturing can be streamlined. Companies can adjust their process to produce SE in cells that make families of parts in near-continuous flow layouts. Savings here can be astounding - a company producing electronic components saved 28% of the total fabrication budget by applying GT principles first in design and then in manufacturing.

Purchasing Cost Reduction

The leverage in purchasing is in knowing that a part with similar attributes costs $xxx. Knowing that at negotiations gives the buyer an effective advantage. When, during the design analysis phase, companies and the government review "Should Cost" and "Make-Buy" figures, there is a consistent dollar value for each standard SE part. GT principles increase the proportion of standard to unique parts and, in some cases, have been found to save a full 5% of the total purchasing budget.

4.0 SYSTEM CONCEPT

Creating a system designed to serve all our identified users and including all the information outlined would require a massive technological and human undertaking. It would need solid support from government and industry personnel. The following sections describe our system concept in terms of technology and people.

4.1 TECHNOLOGICAL REQUIREMENTS

The system would be a distributed system by nature. (See Figure 4-1.) The total database would comprise numerous databases, including industrial and government databases like the LSAR and Lessons Learned databases, housed in different locations. The user would have access to the system's information at his work location - certainly at a central location within the corporation/facility, preferably at his individual work station. (See Figure 4-2.)

The system design would rely heavily on state-of-the-art computer communication technology. The system database would consist of four types of database linked together:

- o GT-type
- o relational
- o graphic
- o word processing

These databases would be heterogeneous within themselves - each may comprise numerous databases joined together, and among themselves - different types of database may be on different systems. Some of these may have to be built from the bottom up, while others could use existing databases.

Accomplishing communication among these components would require linking heterogeneous databases across millions of miles of communication lines. The communication linkages themselves would make use of state-of-the-art

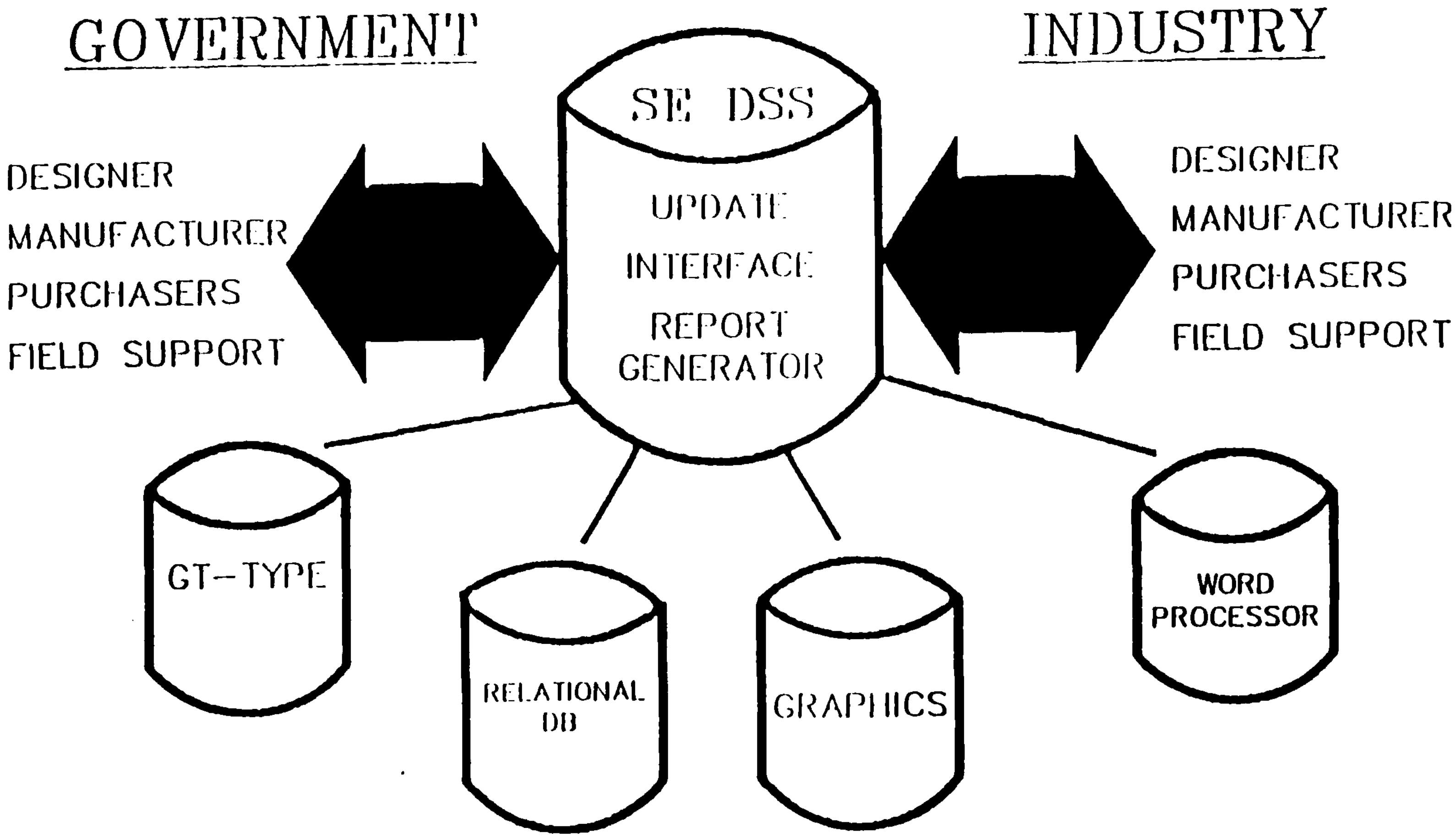

Figure 4-1: GT/DSS - A Distributed System

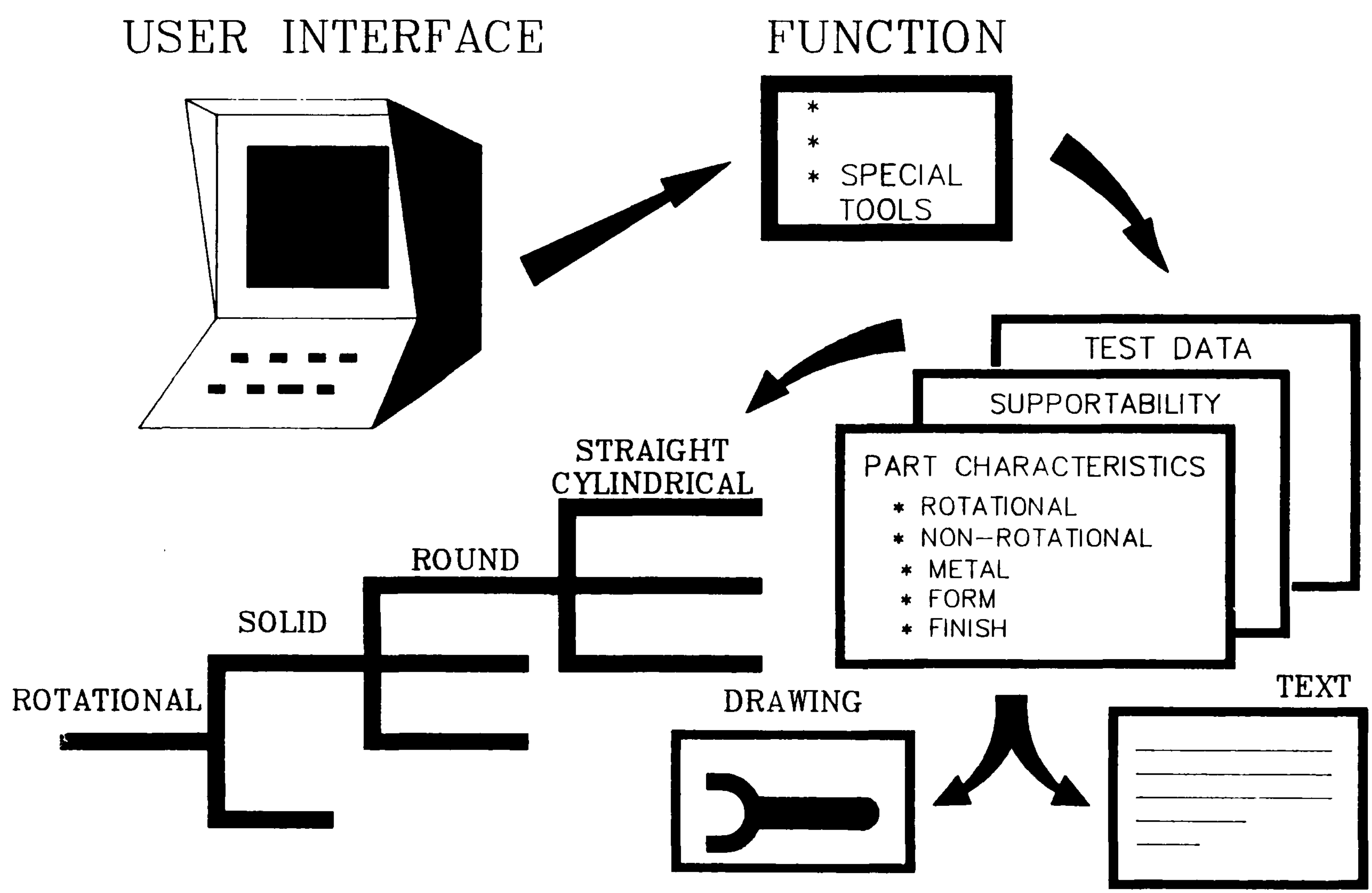

Figure 4-2: GT-DSS - A User Perspective

communications standards like Manufacturing Automation Protocol (MAP) and would need similar standards for graphics communication. (See Figure 4-3.)

The communication link would have to ensure both data integrity and reliable delivery of information in a timely fashion. The communication network would have to link each user or group to every other to optimize information utility, and it would have to be very reliable and respond rapidly. It should be able to accept read access and write access to make retrieving and updating information easy. A complete security system for accessing information would have to be established because some of the databases may be part of a corporation's information system or may include proprietary data.

Ideally the system would be independent of the users' computer equipment. The system would be user-friendly, requiring minimal computer literacy. The system might be menu driven with multiple forms of output.

4.2 HUMAN REQUIREMENTS

Specifications for human interface with the system extend to every critical stage of the process, from design specifications to system maintenance. The easy issues may be the technological ones, and the hard ones the human. But a parallel may be drawn between the technological and the human requirements.

Open communication in the system design would be essential. Industry representatives we interviewed agreed that the party responsible for the system should be an independent agent to

- o ensure that all lines of communication are kept open
- o alleviate suspicion that some players receive more consideration than others.

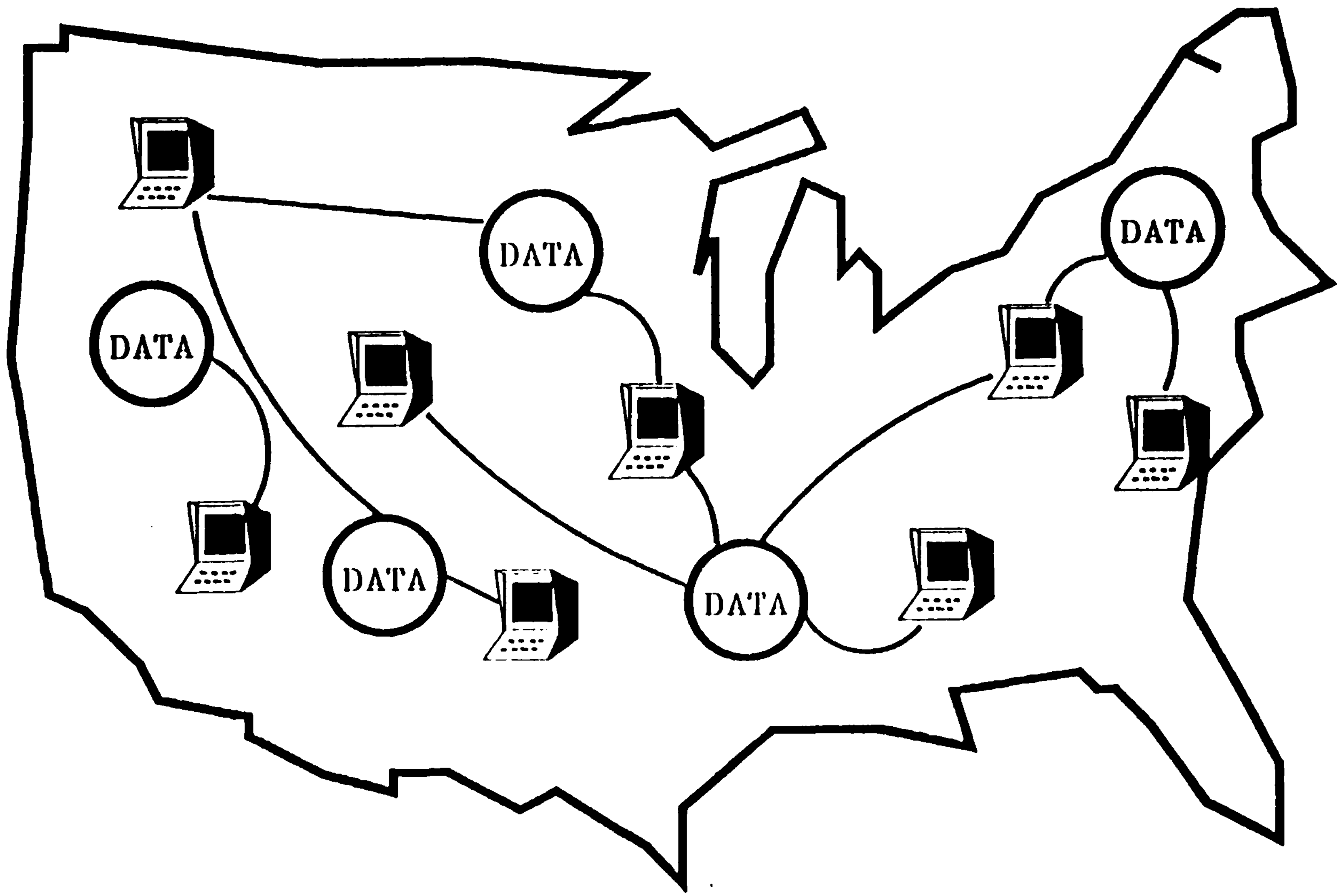

Figure 4-3: GT/DSS – A Networking Concept

Support from the top down - enforcing communication - would be necessary. Currently, communication is too formal, too stilted, and too bound by paper to be effective as a model for the communication this project would need.

Procedures would have to be developed to keep the system current with additions, deletions, and updates. The critical questions - who will do maintenance, how will the function be performed, when will it be performed - would all need to be addressed. The individuals responsible would have to have some kind of accountability, in parallel with the data integrity issue discussed above.

4.3 STANDARDS

Creating standards would be a critical ingredient of this effort. The Air Force MATE system is a good example of the system and infrastructure types that can be constructed to implement and maintain standards when motivation and support exist.

4.4 APPROACH

The GT/DSS, as its final form is currently envisioned, is easily classified as a large and complex system. A strategy for developing such systems is to **plan top-down and implement incrementally bottom-up.**

Top-down planning involves the systematic evolution of requirements and designs progressing from the abstract to the concrete. **Bottom-up implementation** involves a piecemeal, incremental development of individual components to make up the total design concept.

The **major benefit** of top-down planning is a coherent plan that assures that all the design elements are needed and that they will work when assembled in the total system. Bottom-up implementation lowers the overall development risk and allows the user community to enjoy the benefits of the system early.

4.5 EXAMPLE

To demonstrate the approach to prototyping the GT/DSS we propose, let us

- o Set as our goal: **Minimize use of peculiar low-cost Support Equipment**
- o Choose as our activity: **Initiate Diagnostic Procedures**
- o Establish as our **Activity Lineage:**

  A_0 Provide Logistics Support

  A_2 Influence Design Modification

  A_{22} Perform Allocation

  A_{221} Initiate Diagnostic Procedure

- o Postulate the major **information flows** for the activity we have chosen: Initiate Diagnostic Procedures (See Figure 4-4).

Potential Decision Points

For the major activity of interest (A_{221} Initiate Diagnostic Procedure) and from a Peculiar Support Equipment perspective, we must identify the dominant decisions that must be addressed within the activity and establish the relationship between these decision points in the form of a network diagram. (See Figure 4-5). For example, the major decision points for this activity might be as follows:

1. **Has similar equipment been designed before?**
   - 1.1 For the same or similar requirements?
   - 1.2 For a different set of requirements?

2. **Do similar diagnostic procedures currently exist?**
   - 2.1 For the same or similar equipment?
   - 2.2 For the same or similar requirements?

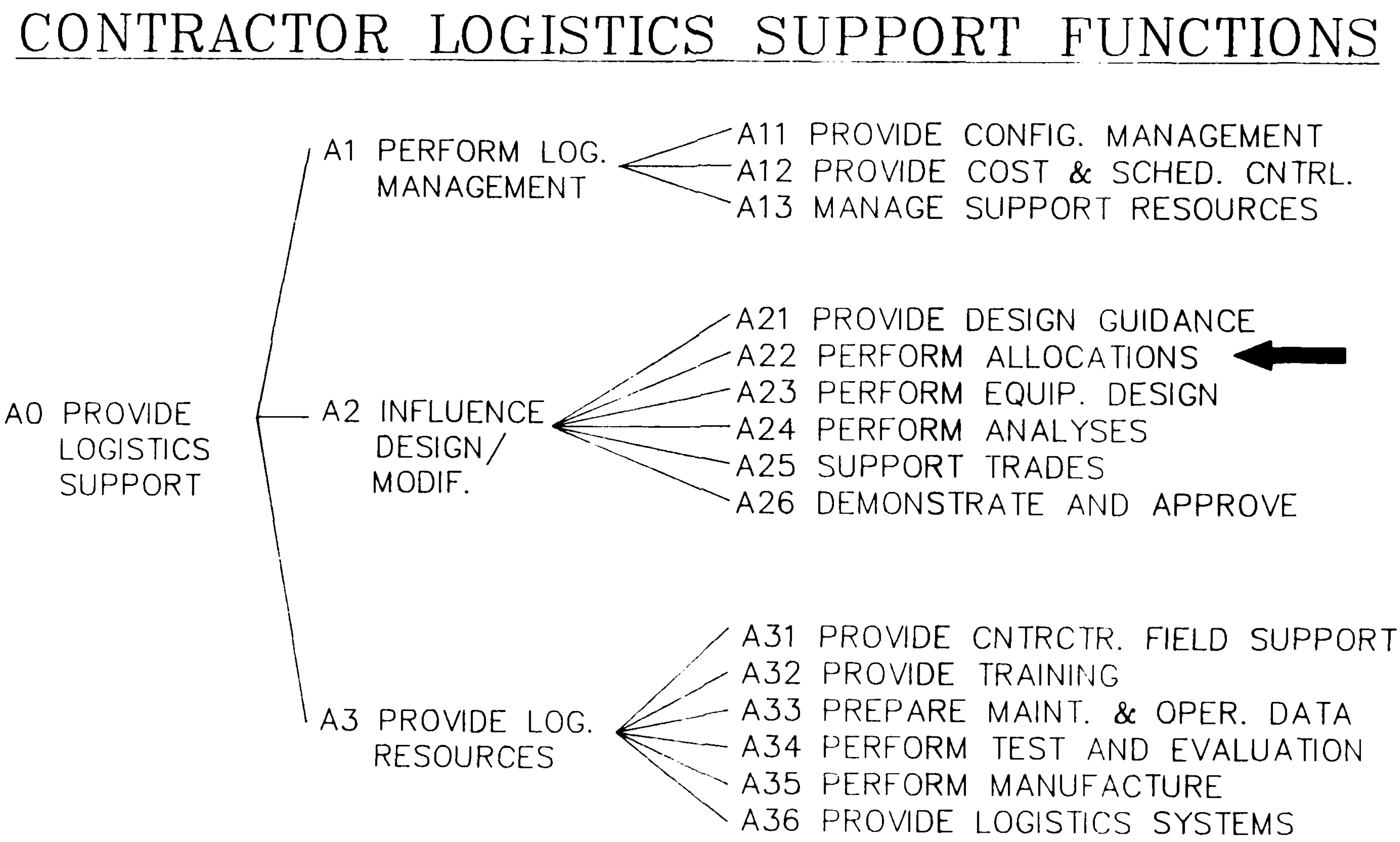

Figure 4-4: Example – Target Function

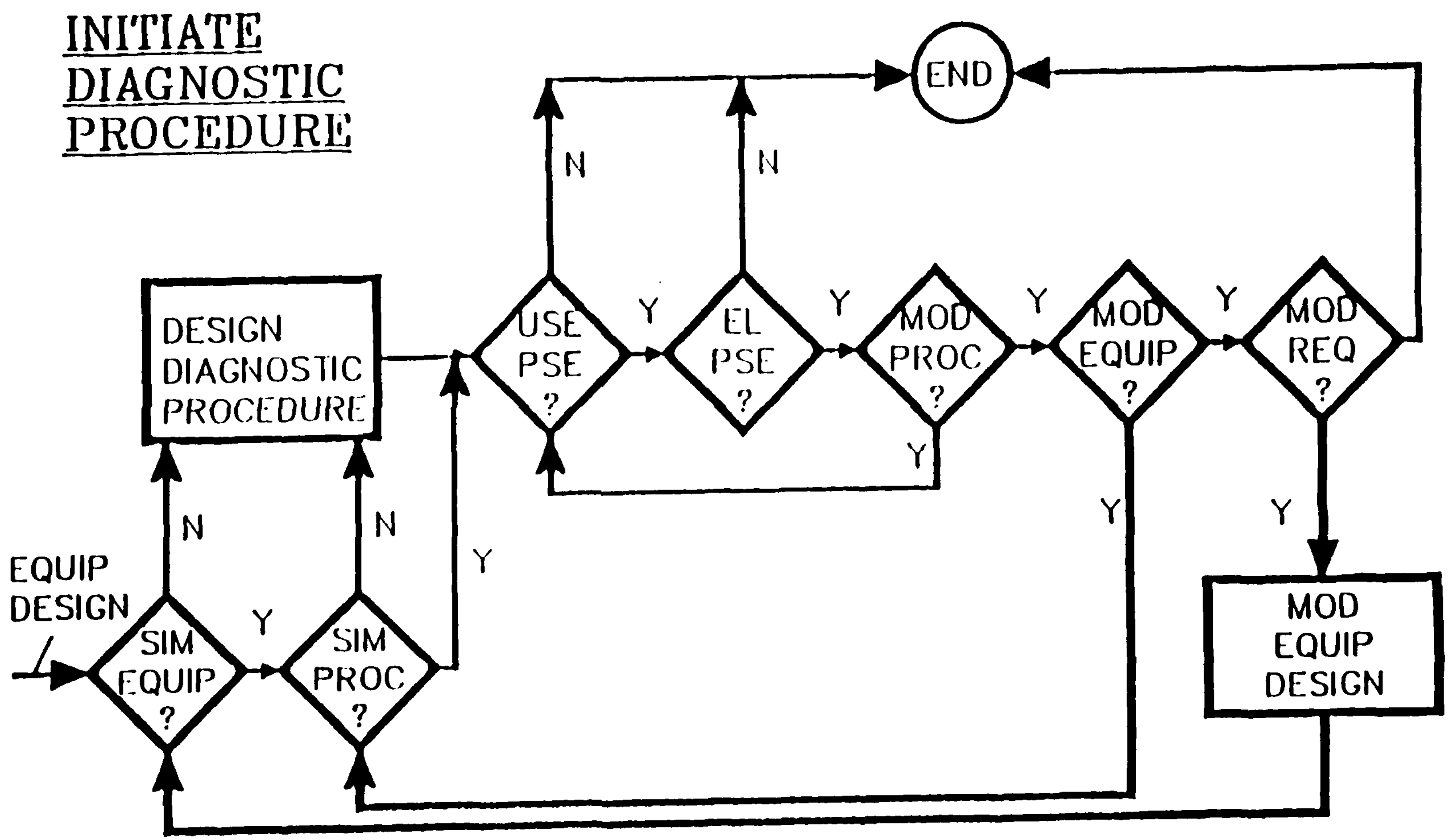

Figure 4–5: Example – Network Diagram

3. **What type of SE is required for each identified/acceptable procedure?**

   3.1 What Common SE?

   3.2 What Peculiar SE?

4. **Can the Peculiar SE be eliminated?**

   4.1 Are there any standard items that can be substituted?

   4.2 Are there any preferred items that can be substituted?

5. **Can the procedure be modified?**

6. **Can the equipment be modified?**

7. **Can the requirements be modified?**

Sub-Questions from Different Viewpoints:

Next, we must detail each of the decision points defined above from the perspective of players in the process, such as

1 Equipment Designer
2 SE Designer
3 Equipment Manufacturer
4 SE Specialist (Contractor)
5 SE Specialist (DoD)

The numbers in the columns below identify the players from the list above for whom each sub-question is pertinent.

Decision Point #1: Has similar equipment been designed before?

Purpose: To determine what constraints may be critical to developing the diagnostic procedures and to surface strategies that may have been used previously.

Has our company developed the same/similar equipment in the past?	4
What lessons have we learned in developing diagnostics for such equipment?	4
Have other companies developed the same/similar equipment in the past?	4
What lessons have they learned?	4
Does DoD have any experience with the same/similar equipment?	4
What are DoD's lessons learned?	4
What SPO experience can we share?	5
What Air Force experience can we share?	5
What DoD experience can we share?	5

Decision Point #2: Do similar diagnostic procedures currently exist?

Purpose: To determine what strategies are most likely to yield a good set of diagnostic procedures.

Has our company developed the same/similar equipment in the past?	4
What lessons have we learned in developing such diagnostic procedures?	4
Have other companies developed the same/similar diagnostics procedures in the past?	4
What lessons have they learned?	4
Does DoD have any experience with the same/similar diagnostic procedures?	4
What are DoD's lessons learned?	4
What SPO experience can we share?	5
What Air Force experience can we share?	5
What DoD experience can we share?	5

Decision Point #3: What type of SE is required for each identified/acceptable procedure?

Purpose: To establish which diagnostic procedures are best from the view of minimizing peculiar SE requirements.

What diagnostic procedure requires the least amount of peculiar SE?	4,5
What is the probability it will work?	4,5

Does it violate company policy?	4
Does it satisfy all contract requirements?	4,5
What about the other acceptable procedures?	4,5
What is the preferred ranking?	4,5

Decision Point #4: Can the Peculiar SE be eliminated?

Purpose: To determine if requirements can be altered to support our desire to minimize peculiar SE.

What are the functional constraints?	2
Can they be modified?	1,3,5
What are the geometric constraints?	2
Can they be modified?	1,3,5
What are the material constraints?	2
Can they be modified?	1,3,5
What are the: reliability, maintainability, safety, human factors, packaging, handling, storage, and transportability requirements?	2
Can they be modified?	[illegible],[illegible],4
How do these considerations affect the ranking of acceptable procedures?	[illegible]

AD-A182 194 INDUSTRIAL BASE ANALYSIS FOR SUPPORT EQUIPMENT PHASE 1 2/2
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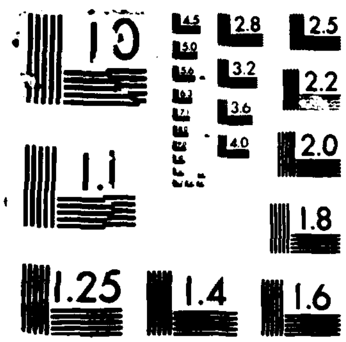
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Decision Point #5: Can the procedure be modified?

Purpose: To determine acceptable changes to the more attractive diagnostic procedures.

In light of the flexibility in constraints and available non-peculiar SE, can the procedure be modified to eliminate any peculiar SE?	4,5
Who could modify?	4,5
Can the procedures be modified to use less complex, less expensive peculiar SE?	2,4,5

Decision Point #6: Can the equipment be modified?

Purpose: To determine what flexibility there is in the equipment design concept.

What are the functional constraints?	2
Can they be modified?	1,5
What are the geometric constraints?	2
Can they be modified?	1,3,5
What are the material constraints?	2
Can they be modified?	1,3,5

What are the: reliability, maintainability, safety, human factors, packaging, handling, storage, and transportability requirements?	2
Can they be modified?	1,3,4,5
How do these considerations affect the ranking of acceptable procedures?	4,5

Decision Point #7: Can the requirements be modified?

Purpose: To determine what flexibility there is in requirements.

What is the equipment mission profile?	4,5
What are the performance requirements?	1,5
Can they be adjusted?	5
Can any of the subordinate requirements be adjusted?	5

Information Requirements

Understanding the detailed questions that must be addressed is only a partial solution to defining the GT/DSS. It is also necessary to understand what information is needed to answer each question. The following are typical of the types of information needed to support our decision structure for the activity of interest. This information would drive the details of a classification scheme, while the automated procedure necessary to assist the decision maker in using the information would constitute the Decision Support System.

Typical of the classes of information that might be needed to support our example are the following:[9]

- Diagnostic Procedures Supported
- Lessons Learned
- Functional Characteristics
- Material Characteristics
- Geometric Characteristics
- Reliability Characteristics
- Maintainability Characteristics
- Safety Characteristics
- Human Factors Characteristics
- Packaging Characteristics
- Handling Characteristics
- Storage Characteristics
- Transportability Characteristics
- Manufacturing Characteristics
- Supplier/Purchaser Information
- Performance Characteristics

[9] There is a significant amount of non-SE type information needed to support this process.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

There is a need to further improve the SE acquisition process. GT/DSS is one possible solution.

Both the literature and our interviews support this conclusion. GT/DSS is correctly seen as a technical solution. Equal emphasis should be given to management issues as approaches to the solution:

- o simplify policy procedure
- o make SE a prime-time issue
- o foster cooperation among SPOs
- o improve manpower management.

Surfacing the information needed to support the development and implementation of GT/DSS will continue to be a difficult task.

The literature is limited in its ability to satisfy this need. Information types seem to be more easily available in the literature than process information is, but neither is adequately documented.

We believe that SE personnel are the richest source of necessary information. It is essential that this group be properly motivated and given a forum for describing and documenting the details needed to support this project.

Group Technology/Decision Support System is feasible.

GT/DSS is a viable concept if we plan for the system top-down and implement it bottom-up as a **series** of decision support systems. Our probability of success will be considerably enhanced if we develop the prototype system of a particular SPO in piecemeal fashion and then propagate the results to other program offices and other aerospace companies.

The success of this project is directly related to the degree to which the SE community, both industry and government, is willing to endorse it.

The recommendations of this report should serve as the basis for a Statement of Work for Phase II.

5.2 RECOMMENDATIONS

Initiate an interest group closely interfaced with the Computer Aided Logistics (CALS) Program.

This group would

- define a more **general set of requirements** for a comprehensive GT/DSS. As a minimum, the group would develop function, information, and user requirements for such a system.
- examine and document the **interface requirements** between the SE activities and other ILS activities
- assure that SE requiremetns are properly considered **within the CALS effort**
- participate in the creation of an **ILS data dictionary**
- assist in creating **standards** that would influence the design, development, and implementation of GT/DSS
- assure that **related programs,** such as the MIL-HDBK-300 and SEMP, are properly considered in the formulation of the GT/DSS concept and the timing of the GT/DSS activities
- formulate a total GT/DSS **design concept**
- serve as a **technology transfer agent** for the prototype GT/DSS(s) being developed

- serve as a steering committee to the group developing the prototype GT/DSS(s)

- prepare an easy-to-understand handbook that explains the SE acquisition process and can be used as a reference to guide the activities of SE specialists.

Develop a Prototype GT/DSS

A prototype is needed to demonstrate the concept and is desirable in that it can lead to tangible results early. These significant activities should also be scheduled:

- identify a SPO. The SPO must be willing to participate in order to realize the significant benefits from the proposed system, and must be at a point in the SE acquisition life cycle to be able to realize them. The prime contractor must also be a willing participant.

- focus the prototype GT/DSS on some subset of SE

- review the SPO SE acquisition goals

- develop and document the SPO SE acquisition process

- identify critical decision points within the process and rank them

- determine which points in the acquisition process could most benefit from a GT/DSS

- detail the function, information, and user requirements for a subset of the ranked decision points

- formulate a design concept for a GT/DSS that will support the requirements as they are defined

- implement the design concept, choosing a design strategy that will allow **rapid prototyping**. Rapid prototyping is possible in most areas using fourth-generation languages and tools.

- feed results to the **CALS SE interest group**.

Expand the prototype GT/DSS to propagate the benefits of the prototype across other classes of SE and make the benefits of the system available to other SPOs.

These are the significant activities:

- modify the prototype GT/DSS to accommodate **other classes of SE** for the same decision points in the same SPO

- expand the prototype to accommodate **other decision points** in the same SPO

- repeat the prototype systems **in other SPOs**.

APPENDIX A

Glossary of Acronyms

ADP	Automated Data Processing
AFALC	Air Force Acquisition Logistics Center
AFEMS	Air Force Equipment Management System
AFIMS	Air Force Information Management System
AFLC	Air Force Logistics Command
AFMAG	Air Force Management Advisory Group
AFSC	Air Force Systems Command
AIMT	Artificial Intelligence-based Maintenance Trainer
ALC	Acquisition Life Cycle
ATA	Air Transportation Association
ATE	Automatic Test Equipment
ATI	Automated Technical Information
ATOS	Automated Technical Order System
ATS	Automatic Test System
CAD	Computer Aided Design
CALS	Computer Aided Logistics Support
CAM	Computer Aided Manufacturing
CFE	Contractor Furnished Equipment
CSAS	Configuration Status Accounting System
DARMIS	Data Requirements Management Information System
DoD	Department of Defense
DSREDS	Digital Storage and Retrieval of Engineering Data System
DSS	Decision Support System
EDCARS	Engineering Drawing Computer Aided Retrieval System
EIDS	Electronic Display System
FOM	Figures of Merit

GFE	Government Furnished Equipment
GIMADS	General Integrated Maintenance Diagnostics System
GSE	Ground Support Equipment
GT	Group Technology
GTSS	Group Technology Support System
ICAM	Integrated Computer Aided Manufacturing
ILS	Integrated Logistics System
IMIS	Integrated Maintenance Information System
IPE	Industrial Plant Equipment
ITA	Interface Test Adapter
ITI	Innovative Technology, Inc.
LCC	Life Cycle Costing
LIMSS	Logistics Information Management Support System
LOGNET	Logistics Systems Information Network
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Record
MAP	Manufacturing Automatic Protocol
MATE	Management of Automatic Test Equipment
MIDAS	Maintenance Information Data Access System
MIS	(Navy) Management Information System
MMHE	Munitions Material Handling Equipment
NAPS	Navy Automated Publishing System
NPSE	Non-Powered Support Equipment
NSIA	National Security Industrial Association
NSN	National Stock Number
NTIPS	Navy Technical Industrial Presentation System
ORLA	Optimum Repair Level Analysis

PEAM	Personal Electronic Aid for Maintenance
PME	Precision Measurement Equipment
PSE	Powered Support Equipment
RAM CAD	Reliability And Maintainability Computer Aided Design
RAMS	Repairable Assets Management System
RM&S	Reliability, Maintainability, and Supportability
SE	Support Equipment
SEAR	Support Equipment Acquisition Review
SEI	Support Equipment Illustrations
SEMP	Support Equipment Master Plan
SERD	Support Equipment Recommendation Data
S/PIL	Standard/Preferred Items List
SP/LAN	Stock Point/Local Area Network
SPO	System Program Officer
STE	Special Test Equipment
TD/CMS	Technical Data/Configuration Management System
TIMS	Technical Information Management System
TMDE	Test Measurement and Diagnostic Equipment
TP	Test Program Software
TPS	Test Program Set
TTO	Tailored Technical Order
VSE	Vehicular Support Equipment

APPENDIX B

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