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DESIGN DISCLOSURE FORMAT (DDF) AND DATA MANAGEMENT

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TECHNICAL COMMUNICATION

The development efforts of diverse complex Navy systems and equipments require diverse acquisition-management structures. Consequently, technical communications must be geared to accommodate these diversities. NAVMAT P3941* states: "technical communications probably form the most important requirement for a successful system development program." As early as concept formulation and contract definition, formal outputs such as GOR's, TSOR's, SOR's, PTA's and TDP's are based upon the dialogue between the user and the producer.

Technical communication, effectively keyed to acquisition-management structures requires that the presentation of information have a high degree of commonality at all system levels in order to form hierarchical subsystem organizations for management use. Since system acquisition is time dependent, technical communication must also be tied to the development life cycle and must grow with the system. Additional need for commonality and the time dependent updating of information is reflected in the fact that many operating systems do not experience finite phase-in phase-out increments, but rather grow and change with changing requirements.

*NAVMAT P3941 Navy Systems Performance Effectiveness Manual May 1967, Headquarters, Naval Material Command

A technical communication scheme must also serve as a reference for other system documentation. This not only allows change to be reflected throughout the organizational structure but also allows the program manager to be selective in terms of his documentation needs. The scheme must also have a data capability which provides critical inputs to the system modeling effort. A system analytical model relies on such information to enable calculation of reliability and maintainability in terms of system needs. Figure 1 summarizes the aforementioned needs of a technical communications scheme.

In order to bridge the technical communication gap between the many people involved in a system acquisition program and to meet the constraints set forth above, the U.S. Naval Applied Science Laboratory developed the Design Disclosure concept. Formally the Design Disclosure Formulation (DDF) is defined as a technical communication system that links Navy program managers, review teams and contractors by means of lucid, comprehensive and timely design disclosures.

Four basic disclosures comprise the DDF set, varieties of which are keyed to specific points in a system life cycle and to specific levels in a system hierarchy. They are Blocked Text, Detailed Block Diagram, Blocked Schematic and Design Outline.

<u>Blocked Text</u>

The Blocked Text technique is used during all acquisition phases and at all system and equipment levels. It combines functional blocks, hardware, and text on one diagram. The blocks represent system and equipment functions and the text within each block describes the function, its operation and associate reliability, maintainability, logistic and human factors information. With all text presented within the blocks, there is no loss of orientation between descriptive material and physical and functional relationships. The text material for the hardware and functional blocks will vary in accordance with data requirements for the different life cycle stages. During early phases of a weapon system development, for example, the information echelon includes performance, reliability, maintainability, logistics and human factors goals for each subsystem block of the alternately proposed system schemes. During later design states, at equipment and lower levels, text includes predicted reliability and maintainability figures, calculated failure and repair rates and detailed design information. As indicated in Figure 2, solid lines enclose the functions and subfunctions while a broken line represents hardware boundary. This technique is useful in disclosing the ways subfunctions cut across hardware boundaries such as racks and cabinets.

Detailed Block Diagram

In order to overcome the extreme difficulty in locating circuit functions and components within system hardware, the Detailed Block Diagrams is prepared during the preliminary design phase of the system life cycle. These diagrams show the basic mechanisation scheme and are updated at later design stages as more detailed circuit information becomes available. The functional echelons covered by the Detailed Block Diagrams range from equipment to circuit functions. As indicated in Figure 3, the use of solid lines to enclose functional elements and broken lines to enclose hardware boundaries allows for precise definition and identification of circuits and components. The broken line consisting of a long line and a single dash represents the highest level of hardware for a particular diagram. A broken line separated by two dashes indicates the next lowest level and so on. The functional levels consist of solid blocks within solid blocks. This technique provides a program manager or design reviewer with a variable focus allowing him to scan the big picture or to examine any level of detail. The lowest functional level on the Detailed Block Diagram is described by standard symbols such as gates, amplifiers, etc. In addition to precise functional and hardware definition, these diagrams show interconnection data, packaging data, test points and front panel markings. Signal lines are also coded to separate primary, secondary, feedback and reference paths.

For each Detailed Block Diagram, a Blocked Text Diagram is drawn on a facing page so that the design representation and the description of its operation are together.

Blocked Schematics

Blocked Schematic diagrams represent the most detailed level of disclosure and is prepared during the latter stages of the design cycle. As shown in Figure 4, the difference between this type of schematic and conventional schematics lies in the way that circuits are presented. Instead of symmetric layout, each set of circuit elements is grouped by functional entity. Each functional entity enclosed in a solid block, is located in a functional stage which is also enclosed in a solid block which is located in an functional assembly, etc. The functions are located within hardware boundaries in the same manner as Detailed Block Diagrams whereby a line broken with a single dash may represent a rack, a line with two dashes a drawer, three dashes a module, etc.

In order to relate various blocked Schematics to their higher order Detailed Block Diagram identical codes are used. A Blocked Text Diagram is drawn for each Blocked Schematic. Diagram with descriptive text in each functional block replacing the circuit symbols on the Blocked Schematic. See Figure 5. The text describes the operation of each functional element and includes reliability and maintainability calculations in terms of failure rates and restore times.

Design Outlines

The most significant design disclosure is the Design Outline which depicts system and equipment operation in terms of inputs, functions and devices, and outputs. This diagram is used during all phases of the acquisition cycle and at all system levels.

Figure 6 shows that three basic symbols represent complex information and signal dependency chains in a clear and concise manner. The result is a logical model of a system-equipment design which serves as an extremely valuable tool for Navy review teams, designers and analysts who are charged with the responsibility for design assurance and optimization.

The outline body contains the dependency chains constructed from three symbols: a triangle is used as a proof marker to indicate dependence on a previous event; a dot is used to indicate a functional element; and a rectangle is used to indicate an action, or availability of a signal or data, resulting from the proper operation of the preceding functional elements.

Thus, in Figure 6, the availability of output event V_1 depends upon the proper operation of element S and the availability of an event at R. Similarly, the availability of output event V_2 depends upon the proper operation of element T and the availability of the event at R. R, in turn, is an "and" circuit, because it depends on the availabilities at X and Y and the proper operation of element Z. The input block diagrams of Figure 6 illustrate that this simple method of representation is applicable to both electronic and mechanical devices. The situation depicted could be a speaker system, where a degraded operation would occur with a failure of either speaker (S or T), or it could be a gasoline engine, where a degraded operation, or missing engine, could occur with a failure of either cylinder (again, S or T). Without resort to complicated mathematical formulas, the use of these three basic symbols to logically depict design dependencies may be extrapolated to much more complex situations, such as typically found in sonar beam-forming functions, involving alternate signal-path switching and multiple channel flows and beam elements.

In support of the Design Outline body which depicts the logical design model, there is a procedure column on the left, a data heading row across the top, and referenced performance specifications (usually in the right-hand column). Figure 7 depicts a complete Design Outline structure. The logical model integrated with procedures, data headings, and specifications in a single format adds many dimensions to design clarity and understanding. For example, during early system level design the procedures contain the conditions for evant availabilities in the form of missions, operational modes and subsystem submodes; the headings contain reliability, maintainability, and performance goals for each of the system and subsystem functions; and the specifications contain either system performance characteristics or operator task requirements specifically keyed to respective event headings. Similarily, during detailed equipment design, the procedures could contain technician tasks, with the headings giving calculated repair and failure rate data, and the specifications containing waveform and signal characteristics. It is particularly noteworthy that the Design Outline precisely shows the involvement of operator and technician functions in the evolving design.

DDF, DATA MANAGEMENT AND EFFECTIVENESS

The essence of an effective system development program lies in better understanding of the crosscurrents between three fundamental functional areas of effectiveness. They are design technology, data management, and analytic techniques. DDF serves as a mechanism which interrelates these areas and thus provides a tool for improving design decisions. The previous descriptions of the four basic formats showed that the functional and hardware entities are specifically related to design, performance, reliability, maintainability, human engineering and logistics information and data. The development of disciplined analytic techniques are based upon the information presented on design outlines. As a decision making tool for program managers, review teams and designers, DDF complements other management schemes which include the 3M program and others:

Management Control

The following list includes those who utilize DDF for information and data to enable decision making and performance of analytic techniques during system development.

- Program Managers
- Prime System Designers

- Sub-System Designers
- Support System Designers
- Systems Analysts
- Reliability, Maintainability and Human Engineering Groups
- Work Study Analysts
- Design Review Teams
- Value Engineering Groups
- Technical Manual Writers
- Personnel Training Groups
- Logistics Planners
- Secondary Procurement Groups

The techniques used in all the formats allow these people to direct and oversee the system design. All too often, in complex developments, managers follow rather than lead the design at significant milestones. As described in Figure 8 management control is effected in the areas of design, support documentation, coordination and computer usage by using DDF.

Management control within the design is possible because of greatly improved technical interface control down to the lowest part level. Precise definition of boundaries and locations, such as components within circuits, circuits within assemblies, assemblies within units, etc., enable any design change covering the spectrum from overall system design approaches to circuit field changes, to be correctly made, reviewed, and then measured for impact on the system.

Management control of other supporting documentation is possible by simple coded references to the design disclosures. At this point it should be emphasized that the DDF is not a substitute for other important system support documentation, such as detailed engineering drawings, ship's installation drawings, interface or configuration control documents, production drawings, and technical manuals. DDF is a central control which enable management to recognize and act on deficiencies and omissions and evaluate them in a system context. There is a similar relation between the DDF and supporting material normally required in a design disclosure package from contractors, such as costs, scheduling, PERT, R/M predictions, work study, etc.

Management control in terms of coordination with other government and industry organizations can be started early enough in design to avoid later time and cost penalties. For example, the complete definition of input and output characteristics at equipment level terminal events, developed by the designers themselves, is of extreme interest to the Navy's Electronic Interface Management Office (EIMO). If coordinated early enough, this office could exercise a true birth to death configuration control of Navy equipment. Another example is the technical manual area. The Naval Ships Engineering Center (NAVSECNORDIV) of Norfolk, Virginia is vitally aware of technical manual deficiencies, a large percentage of which is due to the lack of diagnosis information. In preparation of technical manuals, the publication people could utilize a DDF data package for this purpose.

Modern management control of complex operations is looking more and more for computer assistance for storage, updating and retrieval of data and information. The DDF techniques are uniquely compatible with computer operations.

System Modeling For Analysis

The dependency chains of the Design Outline represent logical models of evolving designs and thus become system models at high system levels. Complex system models described via Design Outline can be mapped directly into computers. The computer model equivalent of the DDF logical model can be used to store system designs in network library banks for later modification and computer aided analysis. Because Design Outlines are in a form for easy translation into a computer, preliminary studies indicate the feasibility of automatic scanning to input system models. Given additional system data, information, computer capability to handle the time parameter and mathematical functions for reliability distributions, meaningful analysis can be performed. For example, mission profiles and their relationships to alternate and degraded modal dependencies, combined with functional element failure rates can yield print-outs of time dependent reliability per mission duration. Such mission oriented calculations would increase the management evaluation confidence level of proposed system designs.

Design Analysis

A general listing of DDF design review and analytic uses is given in Figure 9. These uses will meet development cycle requirements prescribed in DoD and Navy directives, including the OPNAV 3910 instruction series and DoD 3200 directives. Therefore, maintenance concepts and plans are reviewed in light of requirements during concept formulation and definition stages. R/M equipment allocations are reviewed during preliminary design, and so on down to detailed engineering design where R/M analyses for optimizing design are performed. Specific illustrations of the use of the DDF as a design analysis tool are given in the following paragraphs for each of three areas:

- System level analyses,
- R/M analyses, and
- Design-support interface.

System level analyses are performed during concept formulation and contract definition phases to support technical decisions. Decisions at this time are, perhaps, the most critical in designing for cost/effectiveness. In addition to the time-dependent reliability printouts of computers discussed above, the high-level design outlines are useful for other important analyses. Figure 10 shows a simplified system design outline. The heading contains effectiveness data summaries. Specific performance characteristics or man decision points are related to the events and mean time to failure (MTBF), mean active repair times (MTTR) and estimated inactive repair times (Logistics Time) are related to the functional entities. Valid and applicable data sources must be carefully considered for the inclusion of the data. Documents such as

MIL-HDBK-472 and NAVSHIPS 93820 contain techniques for prediction of maintainability and reliability indices.

The integrated design information contained in system Design Outlines allows for various types of analysis. One is analysis of the man/machine interface. The performance description of an event may be a complex analog display which would require interface with a well trained operator. The program manager may wish to relieve the operator of decision-making responsibility by replacing the display with a go, no-go, light, or two displays which would require two less skilled operators. Another type of analysis is the machine/machine interface. The performance description of an event may cover the interface with a data processor. For example, event descriptions may indicate that range, bearing, heading and speed information are all available at this point for processor mating. Excessive conversion requirements or the inability of a central processor to receive the digital data format required by this design allows the program manager to make changes which will meet the demands of the interface.

The accurate display of each functional element (with respect to individual as well as all modes) and the inclusion of the data heading allows sensitivity analyses to be performed. Reliability and maintainability analyses are performed during the design phases of an equipment or system life cycle. The data base developed for use with the Design Outline during the detailed design phases is shown in Figure 11. Cost data is given in the supporting material and is code-referenced to the Design Outlines.

The impact of DDF as an R/M analytic tool is demonstrated by synthesis of repair and failure time distributions from the design. Analyses from the synthesized distributions serve as the foundation for improvement in maintainability predictions, assurance and overall design. The payoffs include: better R/M design assurance through meaningful requirements, identification of R/M problem areas, and identification of the most effective remedial actions to be taken to improve designs.

The success of a sophisticated automatic test system is dependent on the completeness and accuracy of the information concerning the prime design to which it is mated. The DDF has a significant impact on the design/support interface because it represents the complete software package of design information and requirements. Figure 12 summarizes the DDF software package. The disclosures are the controlling and coordinating mechanisms for designing and developing hardware to provide optimum machine/machine and man/machine features in the test system. Optimum design support interface provides successful maintenance without interfering with operational performance. The controlling software delineates the hardware and software support needed to assure the optimum design/support interface.

DDF IMPLEMENTATION

In order to provide cognizant Navy people a reference for inclusion of DDF in their development activities, a Proposed Design Disclosure Standard has been prepared and is currently undergoing coordination and administrative action. For maximum flexibility to managers and engineers, this Proposed Standard is focused on formating requirements and guides. Left to their discretion, are particular data requirements in performance, reliability, maintainability etc., and any particular utilization in management control, system modeling and design analysis. Two broad categories of DDF implementation are being pursued over and above the Proposed Standard, one covers implementing documentation (Specs, Stds, guides etc) for specific technical areas of DDF utilization, and the other covers specific development programs which calls out the use of all or some of the DDF formats by contract.

Implementing Documentation

Design Disclosure techniques are presently being incorporated into various documents. One such document is the Automatic Test System Interface specification initiated by NAVSEC (Code 6181D). The specification requires prime system information to be presented via Design Disclosure so that optimum interface can be effected with automatic test systems.

Negotiation is presently being made to incorporate the DDF concept into an Integrated Logistics Support guide. This guide will be a product of a NAVSEC 4814 effort in ILS which also includes development of a Shipboard Maintenance Management plan. The guide will aid the System Acquisition Manager in agreements to provide total Integrated Logistic Support for ships systems. The use of DDF will allow the acquisition manager to have maximum visibility and control of the system development in terms of design and data accumulation to enhance total ILS.

Negotiation is also being made to include the DDF package in the development of a DoD Design Review Standard presently being coordinated by NAVSEC (Code 6037). The benefits realized by requiring DDF packages at specific design review points in the system life cycle have been mentioned earlier in this paper.

Program Developments

In total, DDF techniques for design disclosure are in use in about ten going Navy programs encompassing total ship as well as subsystem levels, and the development cycle phases of concept formulation through design. A brief summary of the major Navy applications to date follows in tabular form below. The overall approach in these programs has been to first validate, by usage, selected portions of the developments before employing across-the-board implementation.

	System Modeling and Analysis	Design Review and Analysis	Prime/Support Interface
Conformal Planar Array Sonar	Used by G/D & GE on Transmit beam former during concept formulation		

	System Modeling and Analysis	Design Review and Analysis	Prime/Support Interface
ICS	Used by G/D during ICS Contract definition		
Variable Depth Sonar		Used by Tracor for R/M design review and analyses	
NIXIE Acoustic Counter-Measures		Used by Aerojet for R/M analyses	
MASWT			Contract under negotiation, to be used by Nortronics for TEAMS/ASW torpedo /Target Interface
TPX-28 IFF		Used by NASL in-house for Micro-electronic/ packaging re-design of transponder section	

Of particular significance is the application to the Conformal Planar Array Sonar, wherein results indicated by G/D of Rochester showed that using the DDF decreased design time and improved technical communications between G/D design engineers. Based on these results, the DDF technique will be broadened in the program to serve as a tool for overall management control.

As a further indication of potential utilization of the DDF concept, examples of benefits which would have been derived if DDF was used for the design review of the AN/SQS-26CX sonar are described in a paper delivered at SPECON 3* by V. Iacono of the U.S. Naval Applied Science Laboratory. A few examples are summarized as follows:

*Naval Material Command Third
System Performance Effectiveness Conference, May 17,18, 1967
Washington, D. C.

(1) DDF would have immediately shown what data was missing at design review points. Time, effort and money would have been saved in gathering the data. (2) DDF would have allowed more inherent maintainability by making the designer aware of the techniques for predicting down-time via design outlines. (3) The overall system representation with the variable focus capability of DDF would have enabled test point selection on the basis of system status; thus avoiding redundant selection of test points based on individual cabinet design.

Conclusion

Extensive research shows that the Design Disclosure Formulation is the only current means of collecting system oriented data and information, in functional logic form, prior to hard design. This fact makes the DDF a pertinent Tool for concept formulation and contract definition activities. The logical commonality of DDF provides a means for analysis reference and integration of information within complex systems for management and design review purposes over the entire development cycle. Since it is expected that specific requirements for each procurement will be generated as a normal consequence of the contracting process, flexibilities have been built into the structure of DDF to permit adaptation of the techniques to a wide variety of applications.

TECHNICAL COMMUNICATION TO SYSTEM DEVELOPMENT

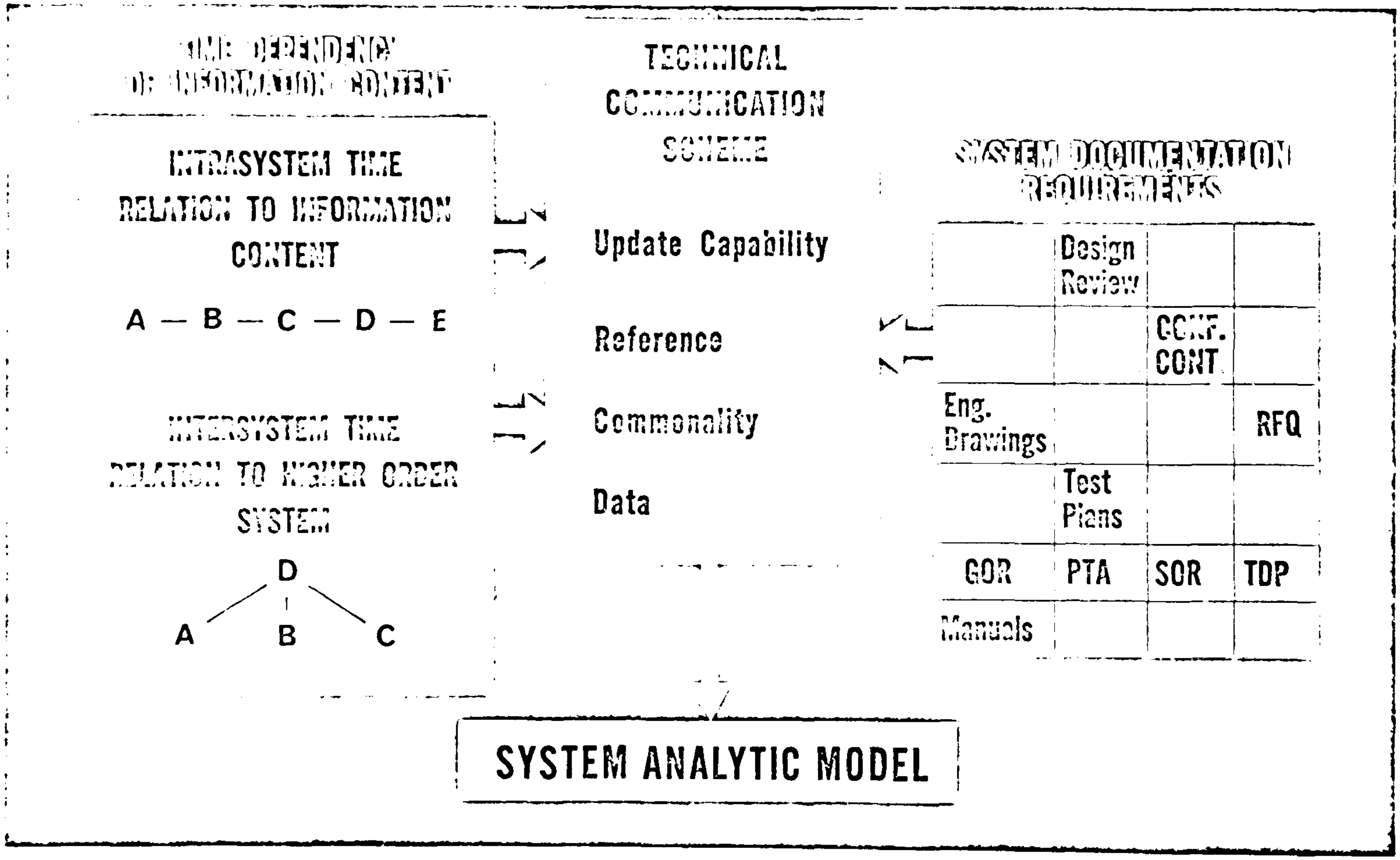

FIGURE 1.

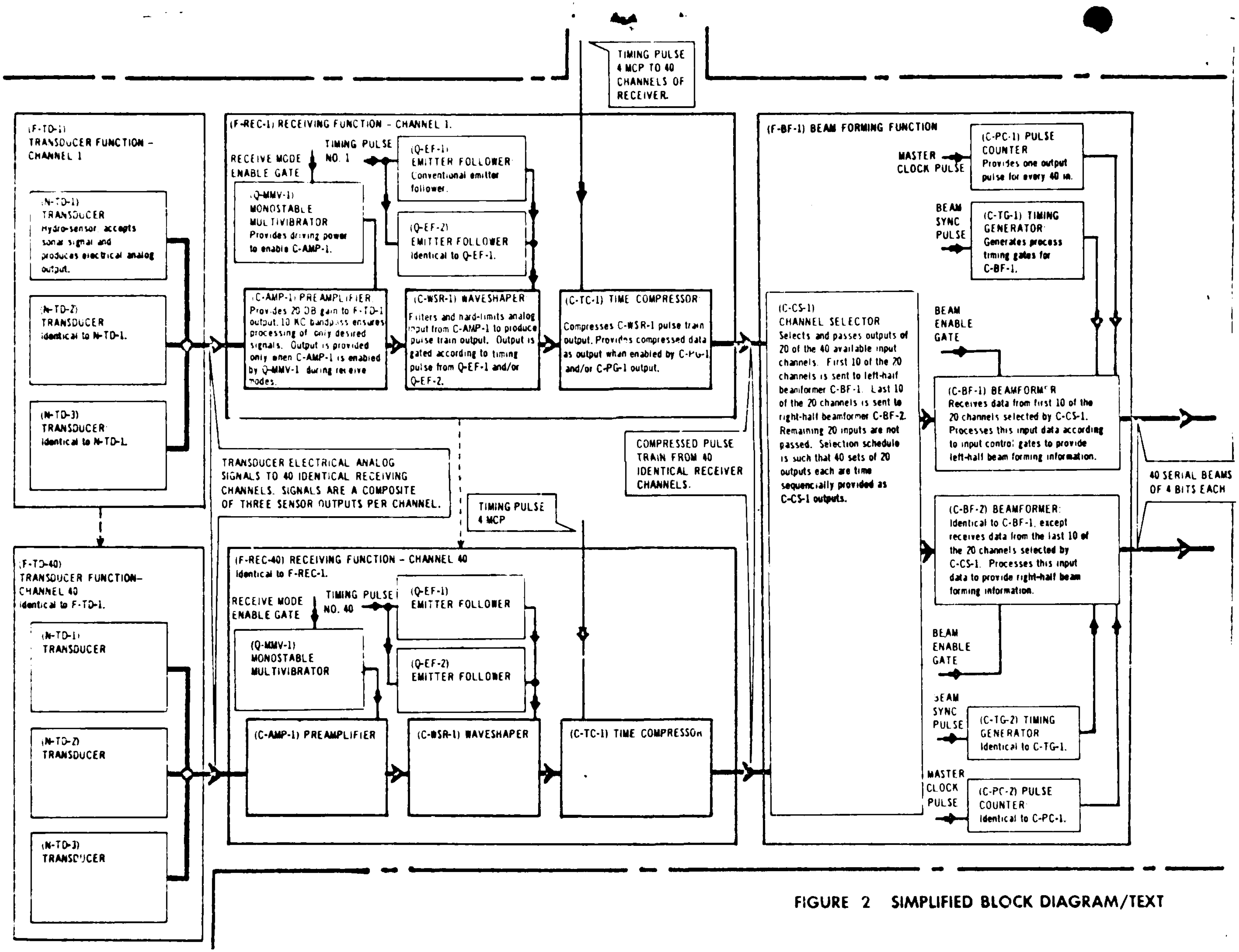

FIGURE 2 SIMPLIFIED BLOCK DIAGRAM/TEXT

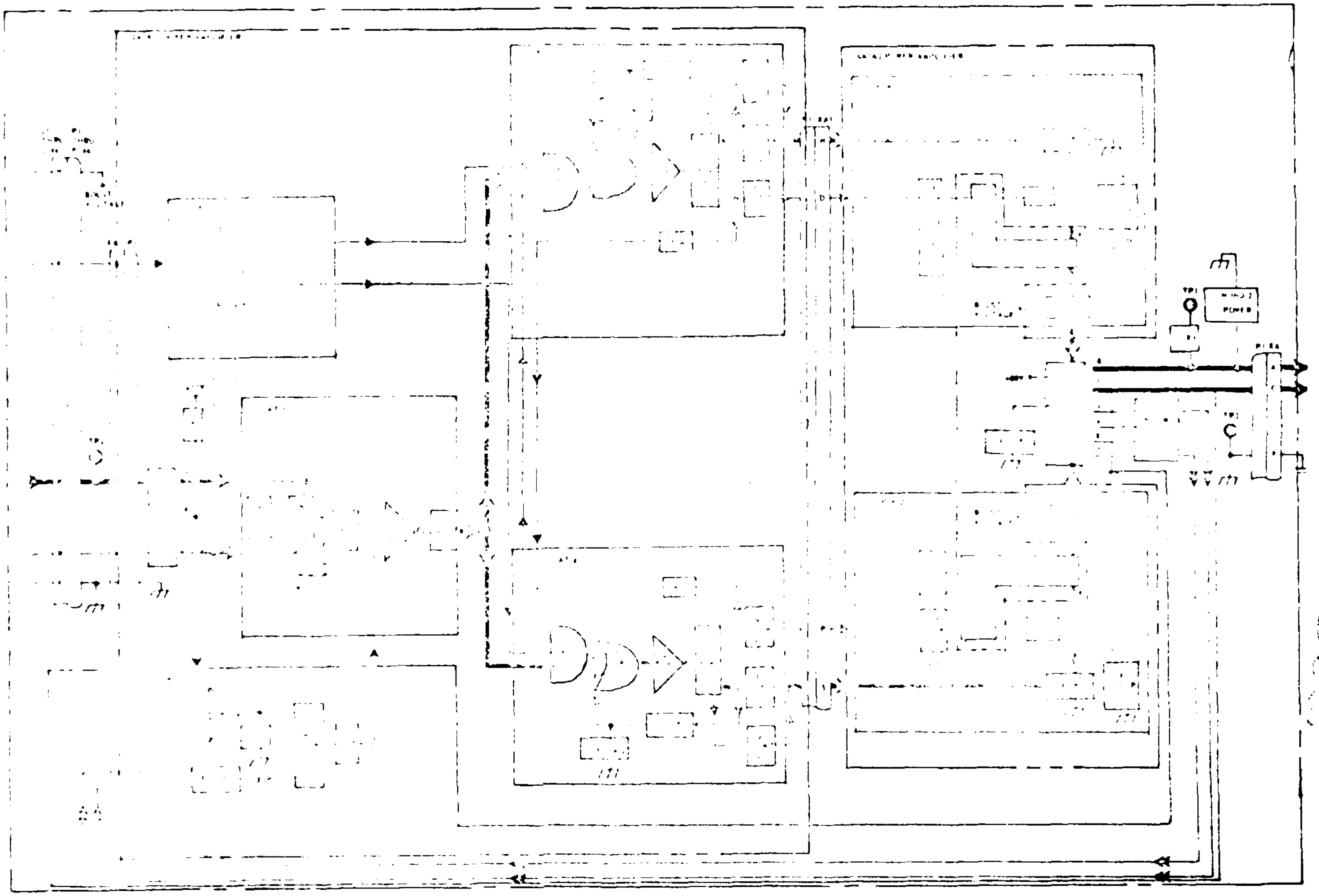

Figure 3. Detailed Block Diagram

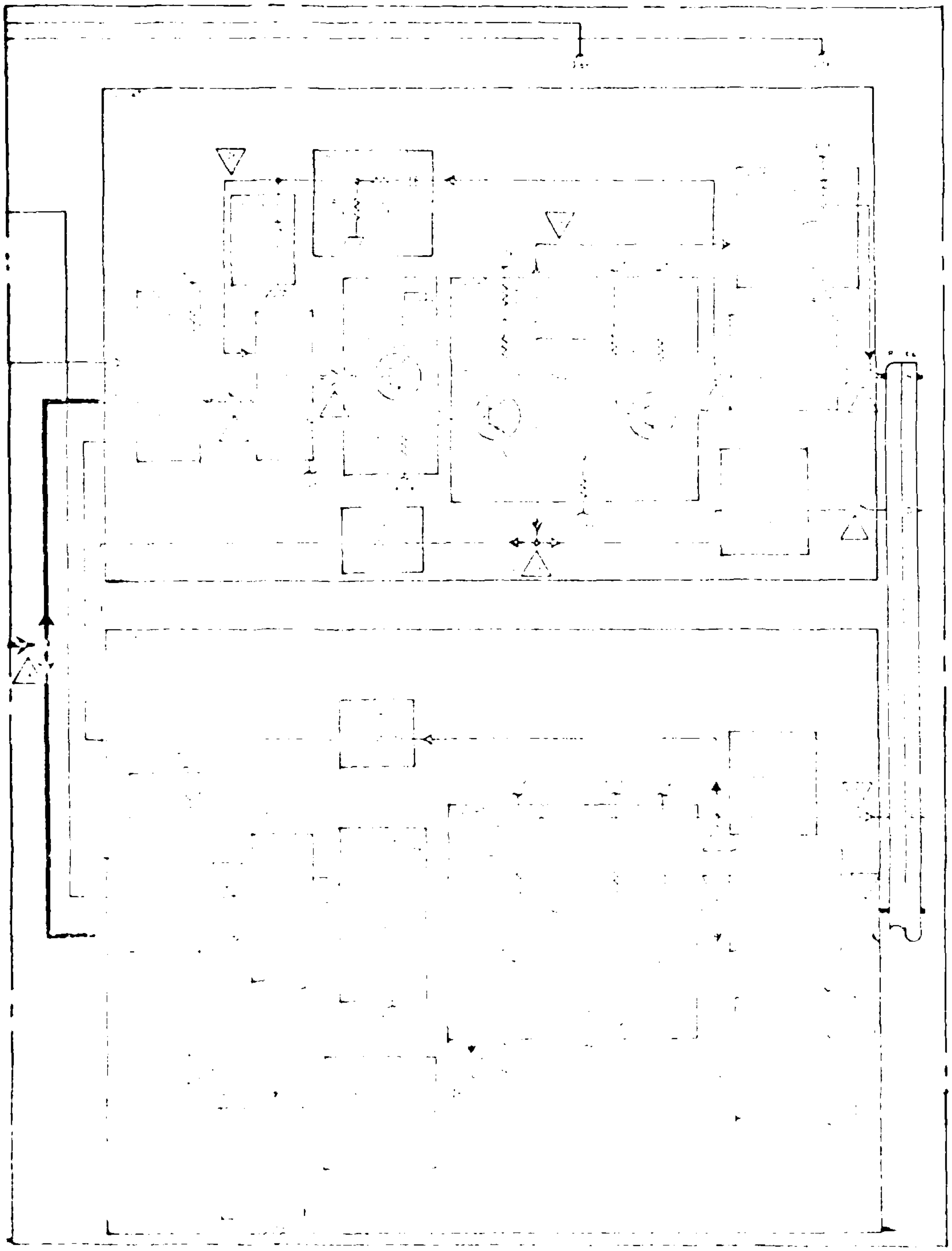

Figure 4. Blocked Schematic

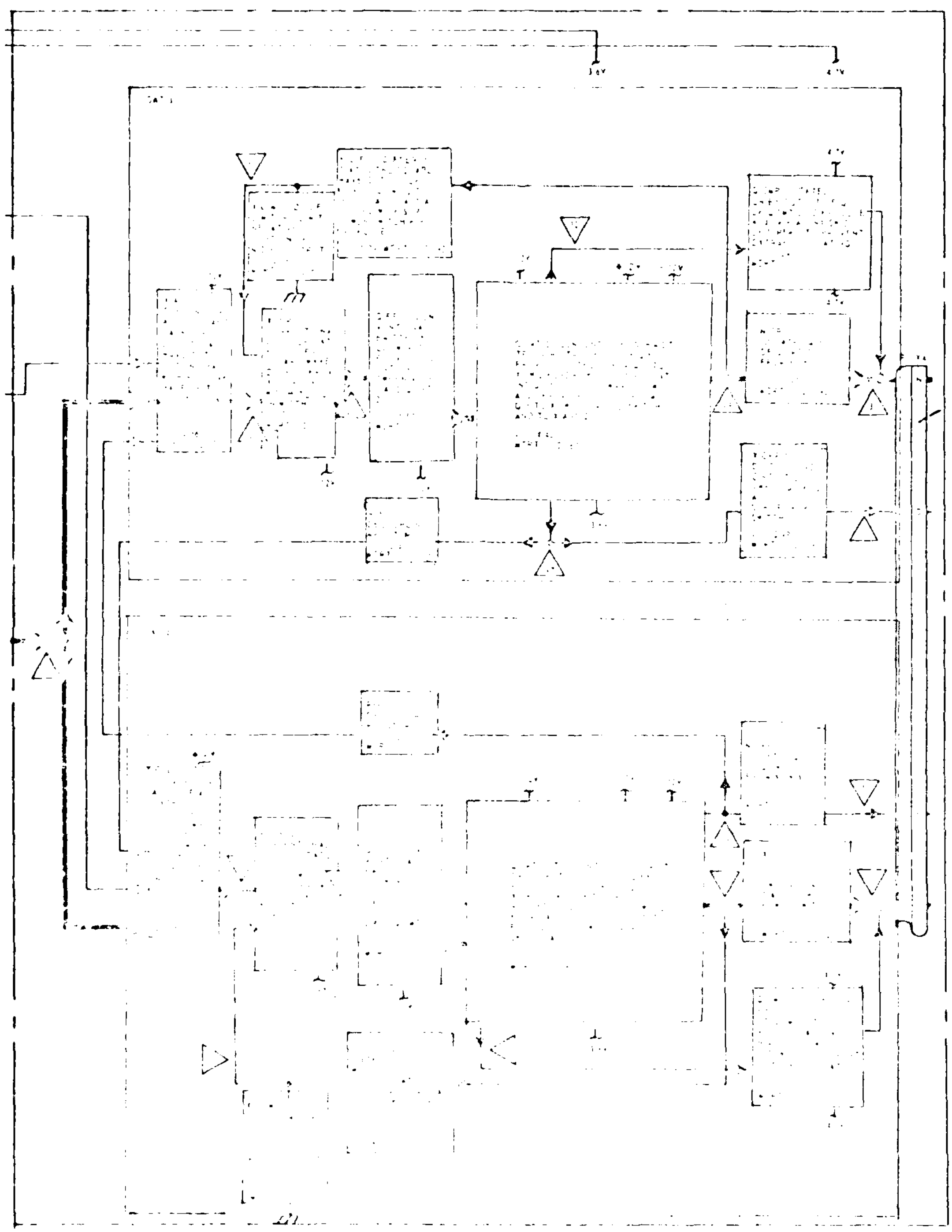

Figure 5. Blocked Text

DDF DESIGN OUTLINE (BODY)

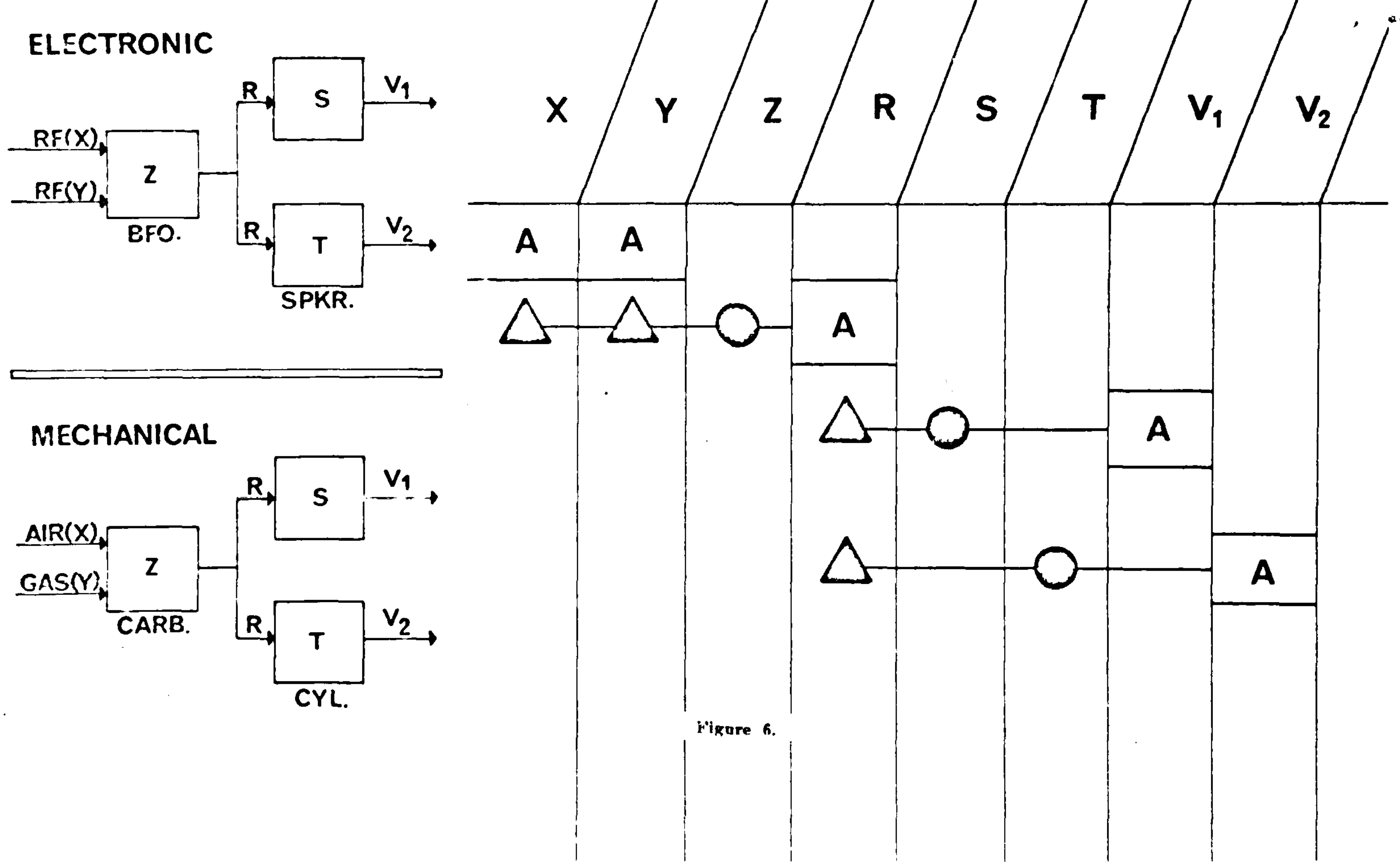

Figure 6.

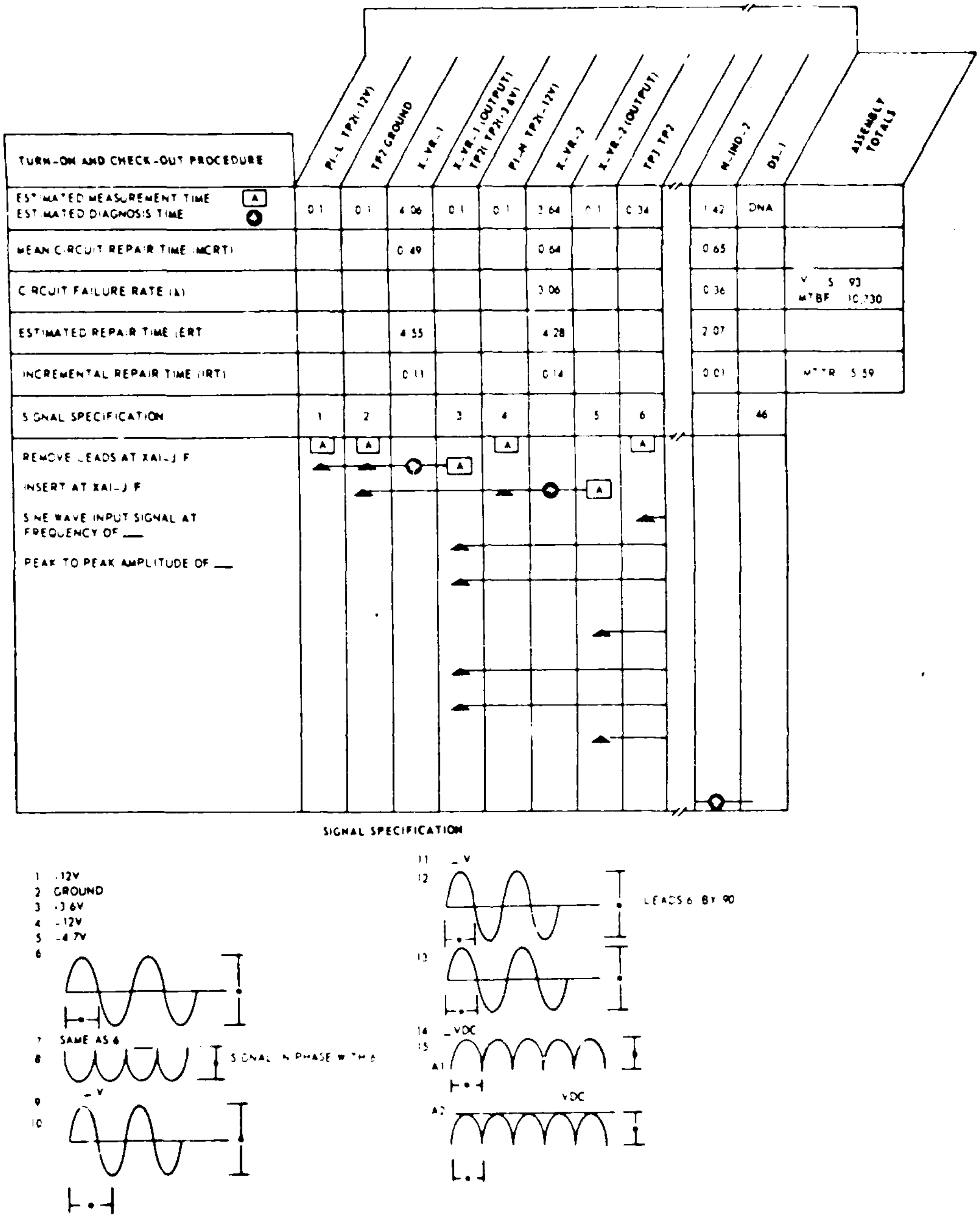

Figure 7. Design Outline, Sample

DESIGN	SUPPORTING DOCUMENTATION	COORDINATION	COMPUTER USE
• Total interfaces	• Engineering production & installation drawings	• Interface management (EIMO)	• System information storage & retrieval
• Function boundaries	• Configuration control documents	• Technical manual preparation (EMEC)	• System updating
• Hardware boundaries	• Technical manuals	• Training (BUPERS)	• Design modifications & re-procurement control
• Design changes	• DDF supporting material	• Support hardware specialists (NEL)	
• System evaluation			

Figure 8. DDF for Management Control

BLOCKED TEXT	DESIGN OUTLINE	DETAILED BLOCK DIAGRAM	BLOCKED SCHEMATIC
• System maintenance concept	• Logical models	• Mechanization schemes	• Complete review of design
• Interfaces	• R/M analyses	• Interconnections	• Complete function description review
• Performance goals	• Test point analyses	• Monitoring and adjustment points	• Complete mechanization review
• R/M goals	• Support system interfaces		
	• Modal sensitivity analyses		

Figure 9. DDF for Overall Design Analysis

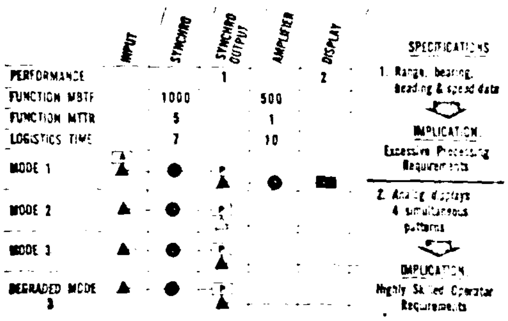

Figure 10. DDF for System Analysis

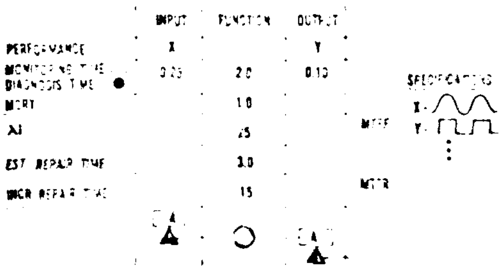

Figure 11. R/M Analysis Data Base

Complete Software Package For Test Systems

PRIME MAINTAINABILITY DESIGN	SUPPORT T.E. DESIGN	TECHNICIAN SUPPORT
• T.P. ALLOCATION	• COMPUTER TEST PROGRAMS	• TECHNICAL MANUAL DATA PACKAGE
• OPTIMUM DIAGNOSTIC ROUTINES	• STATUS MONITORING REQUIREMENT	• DEPENDENCY CHARTS AS MAINTENANCE AIDS
• SENSOR PLACEMENT	• TEST PARAMETERS	• SKILL LEVEL REQ.
• SENSOR DESIGN REQ.	• T.E. REQ. & PRIORITIES	

Figure 12. Prime/Support Interface