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SPACE STATION COMMON MODULE POWER SYSTEM NETWORK TOPOLOGY AND HARDWARE DEVELOPMENT

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Figure

1.0 INTRODUCTION

Martin Marietta will perform the Space Station Common Module Power System Network Topology and Hardware Development program in full accordance with the request for proposal (RFP) with no exceptions taken to the statement of work (SOW).

This study plan contains Martin Marietta's approach to performing the proposed program. Performance of the tasks described will assure systematic development and evaluation of program results, and will provide the necessary management tools, visibility, and control techniques for performance assessment.

The plan is submitted in accordance with the data requirements given in the RFP and includes a comprehensive task logic flow diagram, time-phased manpower requirements, a program milestone schedule, and detailed descriptions of each program task.

The study plan, when approved by Marshall Space Flight Center (MSFC), will become the basic guideline document for this program and will serve as the primary program control document for the MSFC contracting officer representative (COR) and the Martin Marietta program manager. Should changes result from progress reviews by the National Aeronautics and Space Administration (NASA), the work plan will be updated to reflect the new program baseline.

The overall objective of this program is to define and develop candidate power system network topologies for the Space Station common module and to provide the necessary hardware for test and evaluation.

2.0 PROGRAM TASK FLOW

Our program task flow logic (Fig. A-1) provides fundamental insight into our plan for total compliance with the SOW and indicates the relationship between all tasks and subtasks, including requirements. Each major program task is shown as a boldly outlined box. Each box shows the sequence of subtask activities and the interrelationships with other tasks, subtasks, and other related activities. The flow also shows required MSFC COR approvals. The task number and work breakdown structure (WBS) reference are shown in each block.

The project inputs--which include the RFP, NASA Space Station design, and analysis data--will feed program Task I. Task I will include requirements definition, network concept development and selection, and the detailed evaluation of selected concepts. This task will also benefit from the ongoing Martin Marietta Independent Research and Development Project D-47S, "Space Station Subsystem Integration," and the planned NASA/MSFC Common Module Power Management Automation Study. Our IR&D project will aid the requirements definition and provide supplementary information on control system options and a power quality assessment for the various input power types. This will enhance the concept definition and selection process. Interaction with the MSFC Common Module Power Management Automation Study will aid in the definition of sensor and power control devices and their interfaces. The hardware defined in Task I will be assessed for technology readiness in Task II. Our ongoing Martin Marietta IR&D Project D-30D, "Advanced Power System Technology," will benefit both this task and Task III. That project includes the testing and evaluation of solid-state and electromechanical switchgear and the development and test of high-frequency ac power coverters, both ac-ac and ac-dc types. Task III will prepare and implement advanced development plans and procure the hardware necessary for verification and test at MSFC. In Task IV, we will develop recommendations for system testing, prepare test procedures and other test documentation, install hardware at MSFC, and perform initial system testing. Task V will include contract reporting tasks.

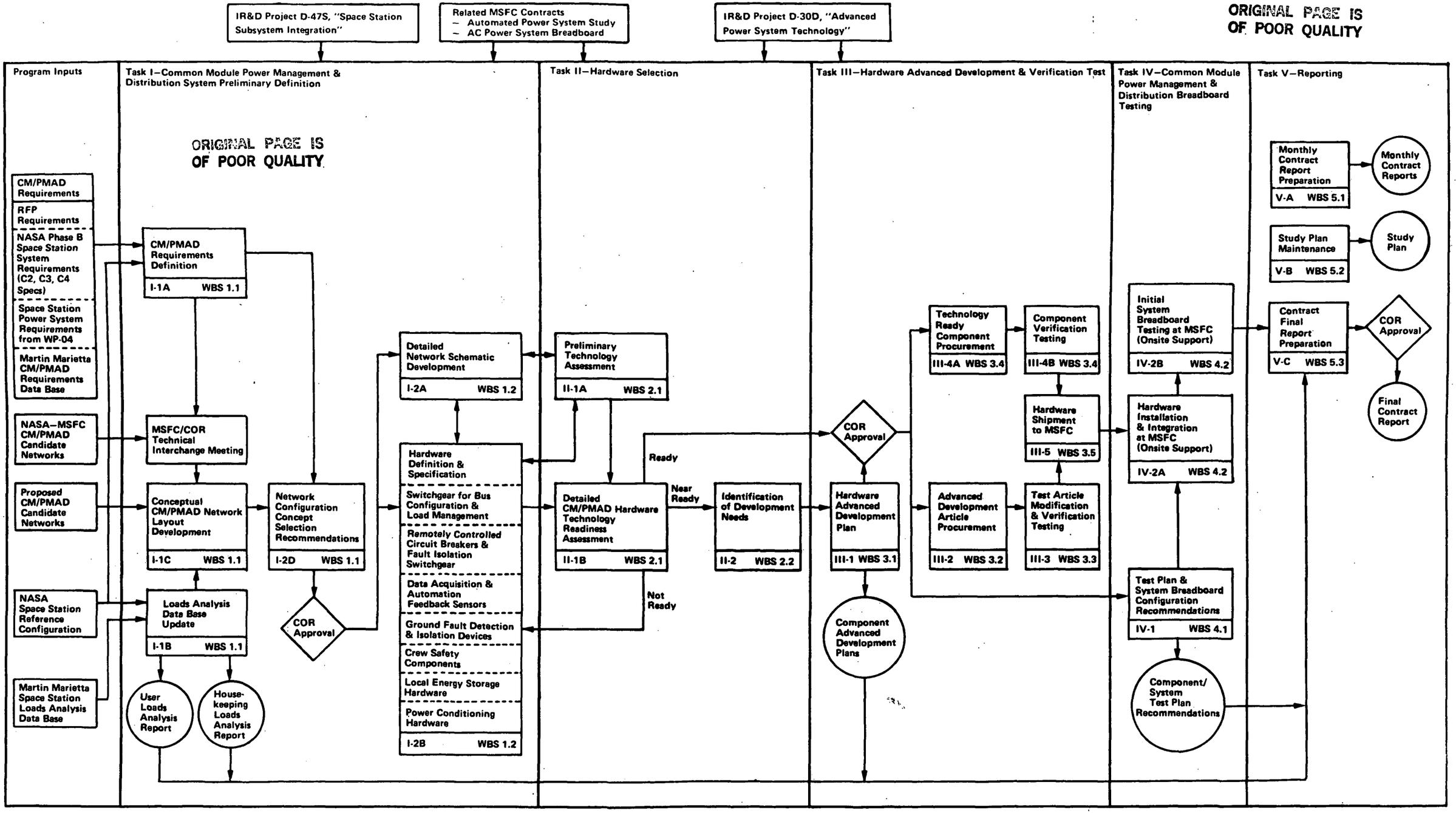


Figure A-1 Program Task Flow

FOLDOUT FRAME

FOLDOUT FRAME

3.0 PROGRAM MASTER SCHEDULE

The program master schedule (Fig. A-2) includes the major program milestones, the overall program sequencing, start and stop dates, and the duration of each program task. This schedule reflects our total responsiveness to the RFP SOW with no exceptions or deviations in a 24 month technical effort.

The schedule has been organized to present a complete program picture by presenting significant program milestones and reviews, and tasks and their phasing.

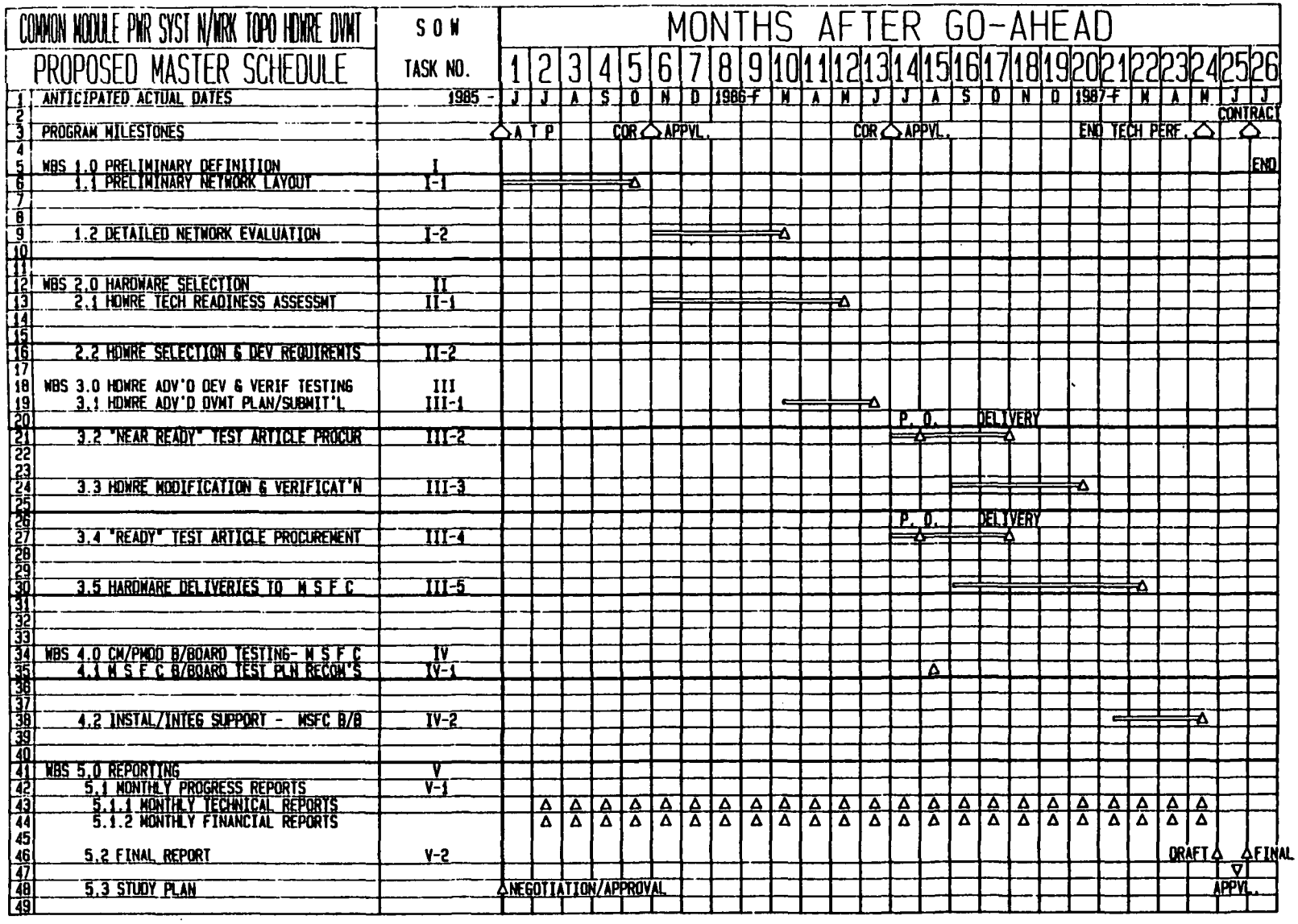


Figure A-2 Program Master Schedule

4.0 STUDY TASK DESCRIPTION AND APPROACH

We have prepared a detailed task plan for each of the tasks identified in the SOW. Each task plan is identified by title and SOW number and referenced to the WBS. The task description is directly quoted from the SOW. The approach section describes the task approach in detail and, in some cases, further divides the task into subtasks. These plans describe subcontractor activities as required. A detailed task schedule is shown by subtask with inputs and outputs identified. The task plan also identifies the technical lead for each task and shows the engineering labor and subcontract cost by month.

SOW: I-1	TITLE: CM/PMAD NETWORK CONCEPTUAL LAYOUTS	WBS: 1.1

SOW DESCRIPTION:

1. The contractor shall perform a preliminary conceptual lay-out of candidate common module power management and distribution (CM/PMAD) system network configurations which have a likelihood of fulfilling the following criteria and requirements:

a. Capability to accept probable primary power types including: (1) high frequency 3ϕ AC; (2) low frequency (<1 khz) single or multi-phase AC at >150 v AC (RMS); and (3) >150 VDC.

b. The ability to accommodate user power needs regarding type and quantity as practical. The contractor shall provide the assumed user needs and the source/rationale for same as a separate report.

c. The ability to accommodate housekeeping and other subsystem power requirements, the contractor shall provide the assumed user needs and the source/rationale for same as a separate report.

d. The capability for common module power growth commensurate with station growth from 75kw to 300kw.

e. The transparency of the network configuration to Space Station energy conversion and energy storage technologies selected.

f. The capability for a high degree of autonomy as dictated by Space Station guidelines.

g. The adequacy of technology readiness of required hardware, either as presently available or as anticipated to be available with appropriate advanced development effort through FY87 consistent with funding under this contract.

h. The on-orbit maintainability through repair or replacement resulting from either the configuration and/or specific hardware used.

SUMMARY OF APPROACH:

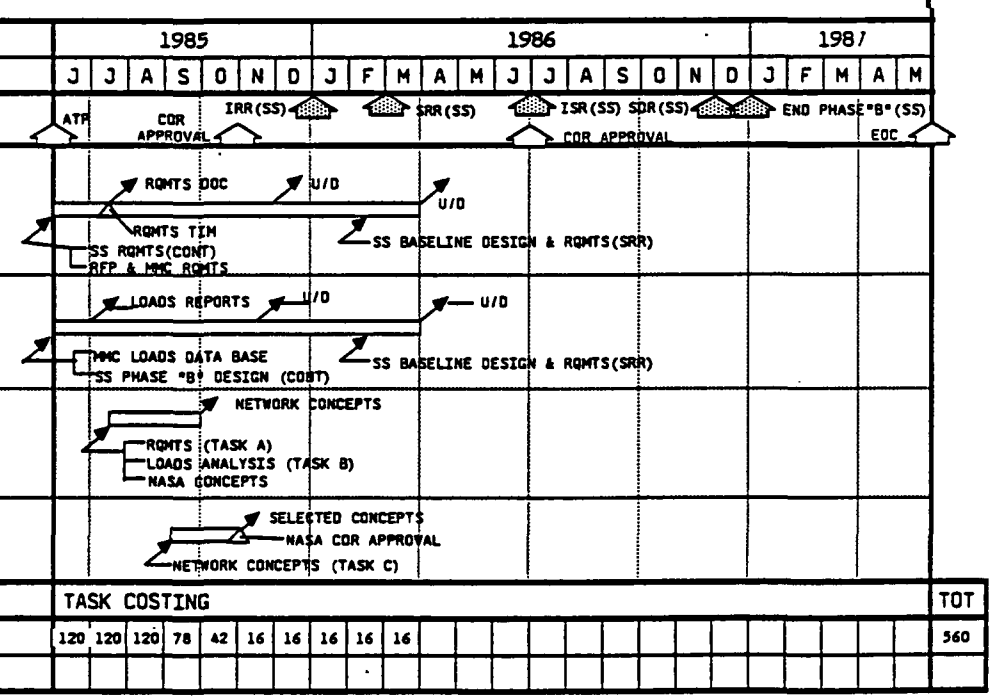
The objective of this task is to develop a set of conceptual CM/PMAD system network layouts capable of meeting the criteria and requirements of the SOW. The effort is described in the following subtasks:

Task A. Requirements Definition—The requirements in the SOW, the Martin Marietta CM/PMAD requirements, the current revision of the Space Station Reference Configuration Description, and the Space Station system requirements as defined in the C2, C3, and C4 specifications will be analyzed and used to develop a set of baseline CM/PMAD requirements. These requirements will be reviewed with the MSFC COR early in the program.

Task B. Loads Analysis—We will use our existing space station loads analysis data base as a point of departure to provide a user loads report and a housekeeping/subsystem loads report. We will maintain the data base throughout the program and provide updates as the design activity in the Phase B Space Station program progresses. The loads data will be provided in report format and will also be available as an "RBASE" data file.

Task C. Conceptual Network Layouts—We will develop conceptual network layouts based on the functional, configuration, and energy storage options described in Part 1 of this proposal and on candidate networks supplied by MSFC. Each network will be described in block diagram form. Input and output capabilities and functional characteristics of each will be described. Representative candidates for each of the three major power input types will be included.

Task D. Network Concept Selection—Based on the requirements from Task A, a set of concept selection criteria will be developed. The criteria will be weighted based on relative importance and applied to each of the concepts developed in Task C. At least three of the most promising candidates will be recommended to MSFC for further study.



CATEGORY	TASK COSTING																								TOT
ENGINEERING HOURS	120	120	120	78	42	16	16	16	16	16															560
SUBCONTRACT & MTL K$																									

SOW: I-2	TITLE: NETWORK EVALUATION AND HARDWARE DEFINITION	WBS: 1.2

SOW DESCRIPTION:

2. On approval of the NASA COR, the contractor shall perform a detailed analytical evaluation of at least 3 of the network configurations which appear most promising for consideration as a common module power management and distribution system (CM/PMAD).

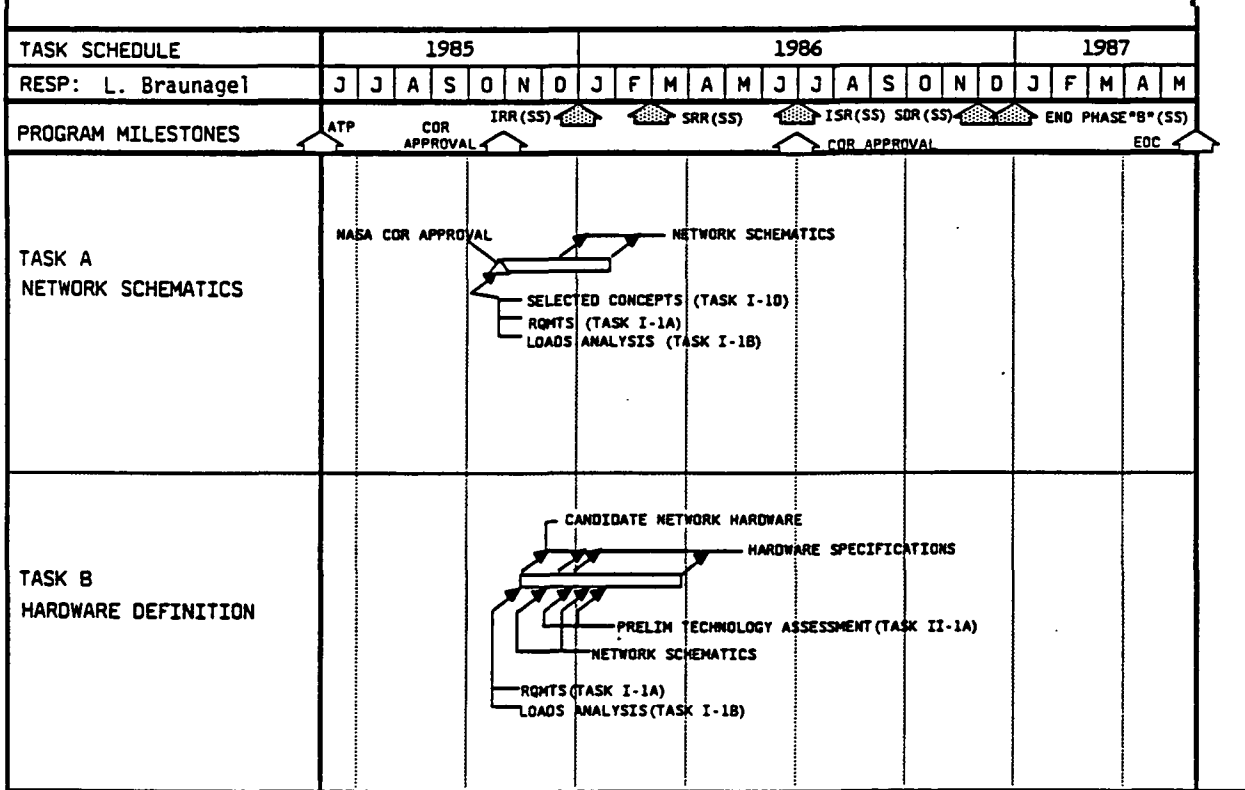
This evaluation shall expand on the preliminary network configuration layout to provide specific definition of all hardware needed. This hardware shall include all switchgear for bus configuration and load management both remotely and locally controlled; all remotely controlled circuit breakers and other fault isolation switchgears for bus and load protection; all sensors for data acquisition and/or automation feedback; all ground fault detection and isolation devices; all crew safety components; all local energy storage hardware for use as an uninterruptable power source or as a safe haven power source.

SUMMARY OF APPROACH:

The objective of this task is to perform a detailed evaluation of the concepts selected in Task I-1 and to define the hardware required. The effort is described in the following subtasks:

Task A. Network Schematics—Each concept selected in Task I-1 will be expanded into a system schematic. The schematic will identify power and control interfaces at the system, assembly, and component level. Particular emphasis will be placed on power distribution components such as load management and bus configuration switchgear; circuit breakers and other fault isolation switchgear; sensors; ground fault devices; crew safety components; and energy storage hardware. Power conditioning hardware and control equipment will be represented in block form with the interfaces identified. The schematic will identify quantities and locations for each component. Each drawing will be assigned a number with configuration controlled by the program manager.

Task B. Hardware Definition—We will analyze selected designs required to provide a specific definition of the hardware components. Specifications will be prepared for each component identified. The specifications will be in sufficient detail to allow technology assessment and supplier quotations.



CATEGORY	TASK COSTING																								TOT
ENGINEERING HOURS						128	140	140	60	60															528
SUBCONTRACT & MTL K$																									

SOW: II-1	TITLE: TECHNOLOGY READINESS ASSESSMENT	WBS: 2.1

SOW DESCRIPTION:

1. In the course of the detailed evaluation described in Task I-2 the contractor shall assess the technology readiness of all hardware which might be considered for use in CM/PMAD system under evaluation. In carrying out this assessment, both hardware from commercial or industry sources as well as hardware under development by NASA and/or other government agencies and their contractors shall be considered.

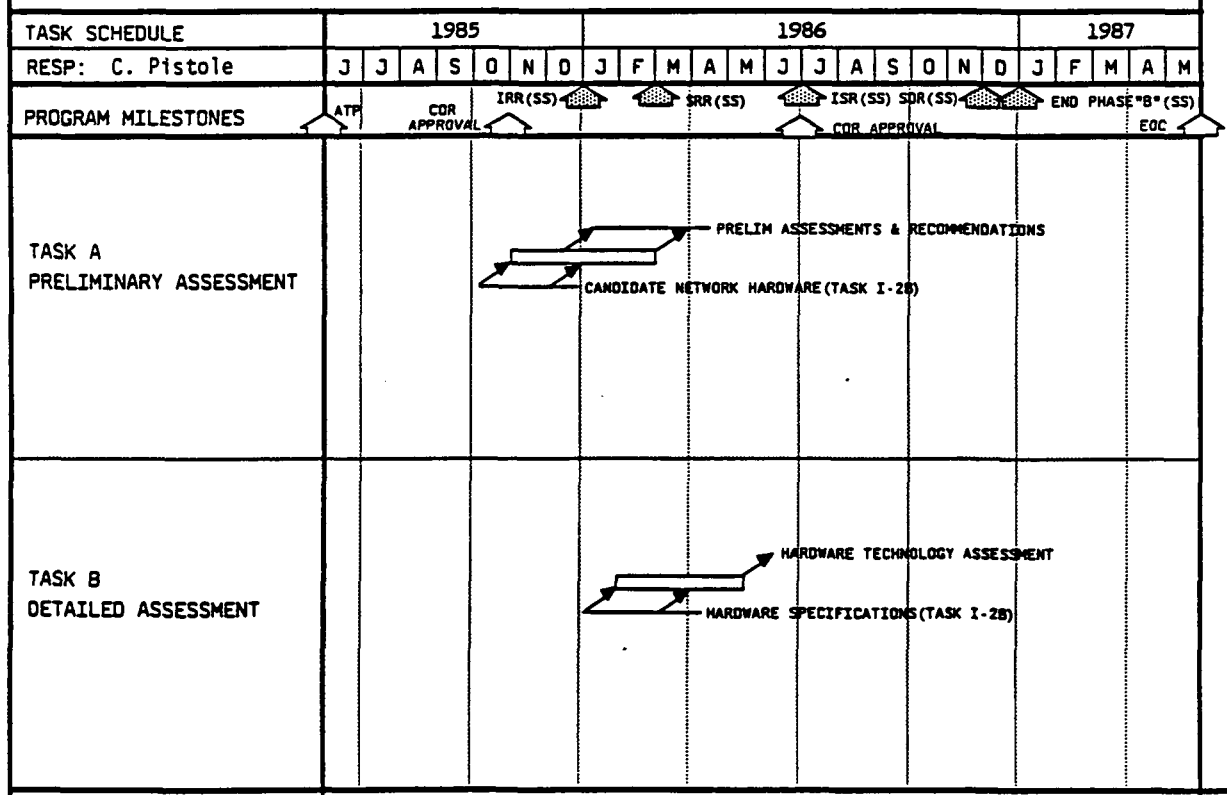
The technology readiness of a piece of hardware shall be judged on the basis of the amount of development and/or qualification effort needed to be expended prior to a phase C/D authority to proceed (ATP) in order to allow selection and use of that hardware by a Phase C/D contractor with minimal risk. If normal effort is needed then the hardware can be considered technology ready. If accelerated advanced development effort consistent with the Space Station power advanced development program is adequate augmentation of normal effort, then the hardware should be considered technology near-ready and can be assumed to be available to a Phase C/D contractor in a technology ready state by a Phase C/D ATP. If the accelerated advanced development effort consistent with the Space Station advanced development program is judged to be inadequate to sufficiently reduce risk associated with using certain hardware, then the hardware shall be judged technology not-ready.

SUMMARY OF APPROACH:

The objective of this task is to assess the technology readiness of the hardware that might be considered for use in the CM/PMAD system. The effort is described in the following subtasks:

Task A. Preliminary Assessment—This task is highly interactive with Task I-1, network evaluation, and hardware definition. Candidate hardware for the networks under evaluation will be assessed as to the general technology level to preclude the selection of technology "not-ready" components. Where appropriate alternative hardware approaches will be recommended for incorporation into the designs. We will review the latest published papers, technical reports, and vendor data as they apply to the components of interest. In addition, we will contact other NASA centers and DOD agencies, as well as suppliers as appropriate.

Task B. Detailed Assessment—This task will provide the detailed hardware assessment from the specifications generated in Task I-2B. We will visit appropriate hardware suppliers and other agencies to review available technical data and for indepth discussions of the hardware components. Each component specified will be categorized as ready, near-ready, or not-ready as defined in the SOW.



CATEGORY	TASK COSTING																								TOT
ENGINEERING HOURS						40	40	80	80	60	60	40													400
SUBCONTRACT & MTL K$																									

SOW: II-2	TITLE: IDENTIFICATION OF DEVELOPMENT NEEDS	WBS: 2.2

SOW DESCRIPTION:

2. The contractor shall identify hardware to be used in each of the CM/PMAD systems identified in Task I-2. For those hardware components which are judged technology near-ready the contractor shall identify the specific features or capabilities which must be further developed to upgrade the hardware to technology ready.

SUMMARY OF APPROACH:

The objective of this task is to identify the development needs for hardware categorized as near-ready. In this task we will review, in detail, the specifications for each hardware component categorized as near-ready in Task II-1B. The required characteristics and features of each component will be compared against existing technology items to specifically identify the development needs. This effort will parallel the assessment of Task II-1B.

TASK SCHEDULE	1985							1986											1987				
RESP: C. Pistole	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M.
PROGRAM MILESTONES	ATP		COR APPROVAL		IRR(SS)					SRR(SS)			ISR(SS)			SDR(SS)			END PHASE "B" (SS)				EOC
													COR APPROVAL											
IDENTIFICATION OF DEVELOPMENT NEEDS																								
													DEVELOPMENT RECOMMENDATIONS											
													HARDWARE SPECIFICATIONS (TASK I-2B)											

CATEGORY	TASK COSTING																							TOT
ENGINEERING HOURS									20	32	23	20												95
SUBCONTRACT & MTL K$																								

SOW: III-1	TITLE: ADVANCED DEVELOPMENT PLANS	WBS: 3.1

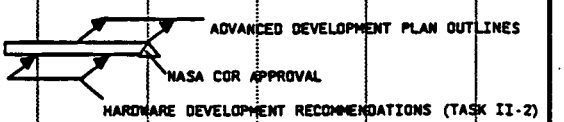
SOW DESCRIPTION:

1. For each hardware component identified as technology near-ready, the contractor shall outline and submit to MSFC an advanced development plan needed to upgrade the hardware component to technology ready status, and to verify through test the attainment of the technology ready status.

SUMMARY OF APPROACH:

The objective of this task is to develop and submit advanced development plan outlines for technology near-ready hardware. The effort will use the development recommendations from Task II-2 as input. An individual plan will be prepared for each component identified and presented in a concise, one-page outline format. The proposed format is shown in Section 1.6.1 of the proposal. The plan outline will identify the specific component and clearly state the advanced development goal. The performance section will quantify the performance requirements, referenc ing appropriate specifications, and will summarize the development and verification approach. The plan outline will specifically identify the hardware types and quantities that will be fabricated and tested and the fabrication and test facilities used. Cost, schedule, and subcontractor involvement will also be defined. The plans will be reviewed with MSFC with plan implementation contingent on MSFC COR approval.

TASK SCHEDULE	1985							1986											1987				
RESP: D. Landis	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
PROGRAM MILESTONES	ATP		COR APPROVAL		IRR(SS)					SRR(SS)			ISR(SS) COR APPROVAL		SDR(SS)				END PHASE "B"(SS) EOC					
ADVANCED DEVELOPMENT PLANS																								



CATEGORY	TASK COSTING																							TOT
ENGINEERING HOURS										40	40	40	40											160
SUBCONTRACT & MTL K$																								

SOW: III-2	TITLE: ADVANCED DEVELOPMENT ARTICLE PROCUREMENT	WBS: 3.2

SOW DESCRIPTION:

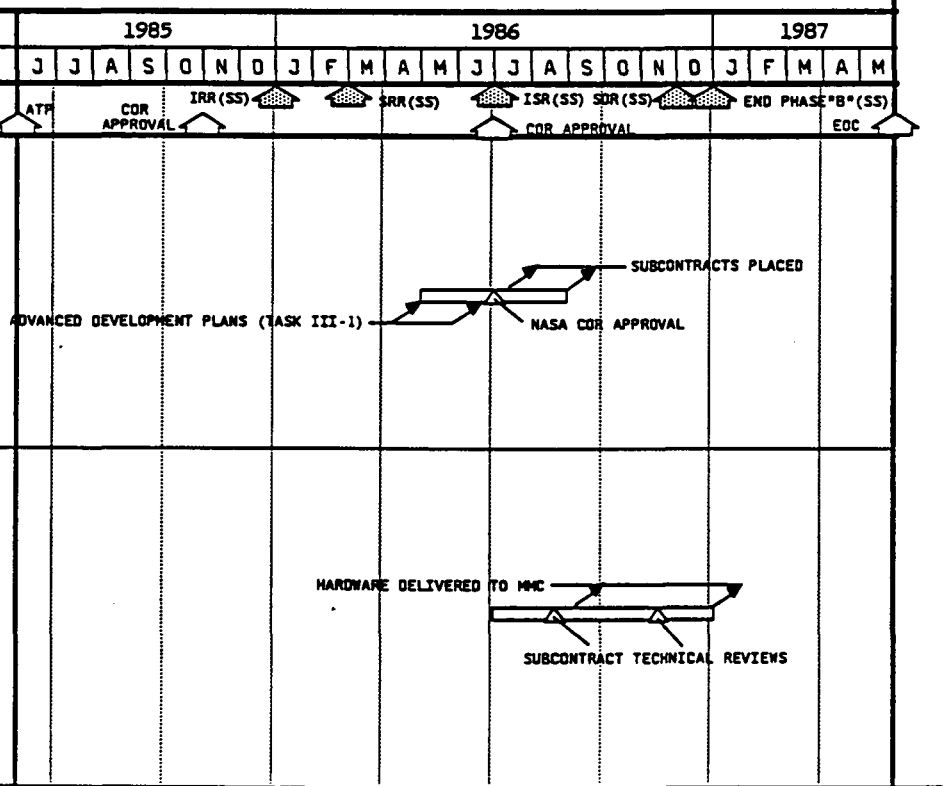
2. On approval of the outline plan of Task III-1 by the MSFC COR the contractor shall procure the necessary test articles in quantities sufficient to execute the outlined advanced development and verification testing and subsequently verify CM/PMAD systems operation through breadboard testing at MSFC.

SUMMARY OF APPROACH:

The objective of this task is to implement the subcontract advanced development activity and procure test articles for component verification and use in the MSFC breadboard. The effort is described in the following subtasks:

Task A. Subcontract Implementation—For each advanced development activity requiring subcontract effort, statements of work will be prepared detailing the required activity. This task includes RFP preparation, subcontractor selection, negotiation, and the placement of orders. While this effort will parallel the advanced development plan preparation, no purchase orders will be placed until MSFC COR approval is granted.

Task B. Procurement and Hardware Delivery—This task includes the technical monitoring and subcontract management for the subcontracts placed in Task A. Periodic, informal reviews will be held with each subcontractor to review design, fabrication, and test results.



CATEGORY	TASK COSTING																								TOT
ENGINEERING HOURS												20	20	20	20	10	10	10	10						120
SUBCONTRACT & MTL K$														113	10	9									132

SOW: III-3	TITLE: ADVANCED DEVELOPMENT HARDWARE MODIFICATION & TEST	WBS: 3.3

SOW DESCRIPTION:

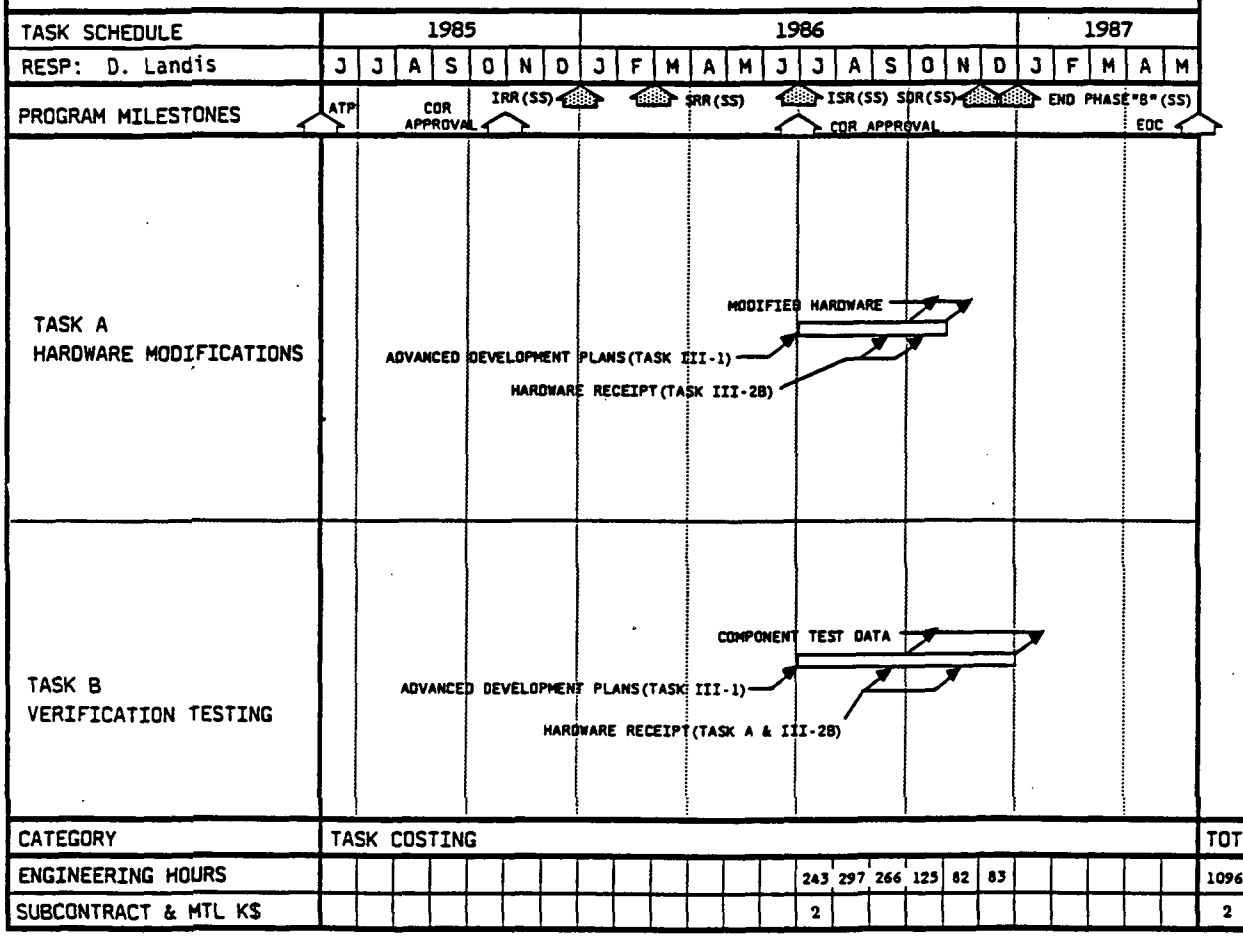
3. The contractor shall implement the outlined plan, performing and verifying all necessary modifications to the hardware needed to allow for systems breadboard testing at MSFC.

SUMMARY OF APPROACH:

The objective of this task is to perform required hardware modifications and verification testing in accordance with the advanced development plans. The effort is described in the following subtasks:

Task A. Hardware Modifications—It is anticipated that in some cases advanced development hardware procured under Task III-2 will be modified by Martin Marietta. This may include the addition of some electrical circuitry or the integration of several components into an assembly. This task includes the design of those modifications and the preparation of drawings and implementation procedures. This task also includes the procurement of piece parts and materials required to implement the modification.

Task B. Verification Testing—All hardware procured under the advanced development activities of Task III-2 and the hardware modified in Task A will be subjected to verification testing at Martin Marietta. This effort includes the design and fabrication of required test tools or fixtures. Verification test procedures will be prepared based on the advanced development plans and testing will be conducted in accordance with the procedures. Test data will be documented in a form suitable for incorporation into the final report.



CATEGORY	TASK COSTING																								TOT
ENGINEERING HOURS													243	297	266	125	82	83							1096
SUBCONTRACT & MTL K$													2												2

SOW: III-4	TITLE: READY COMPONENT PROCUREMENT & TESTING	WBS: 3.4

SOW DESCRIPTION:

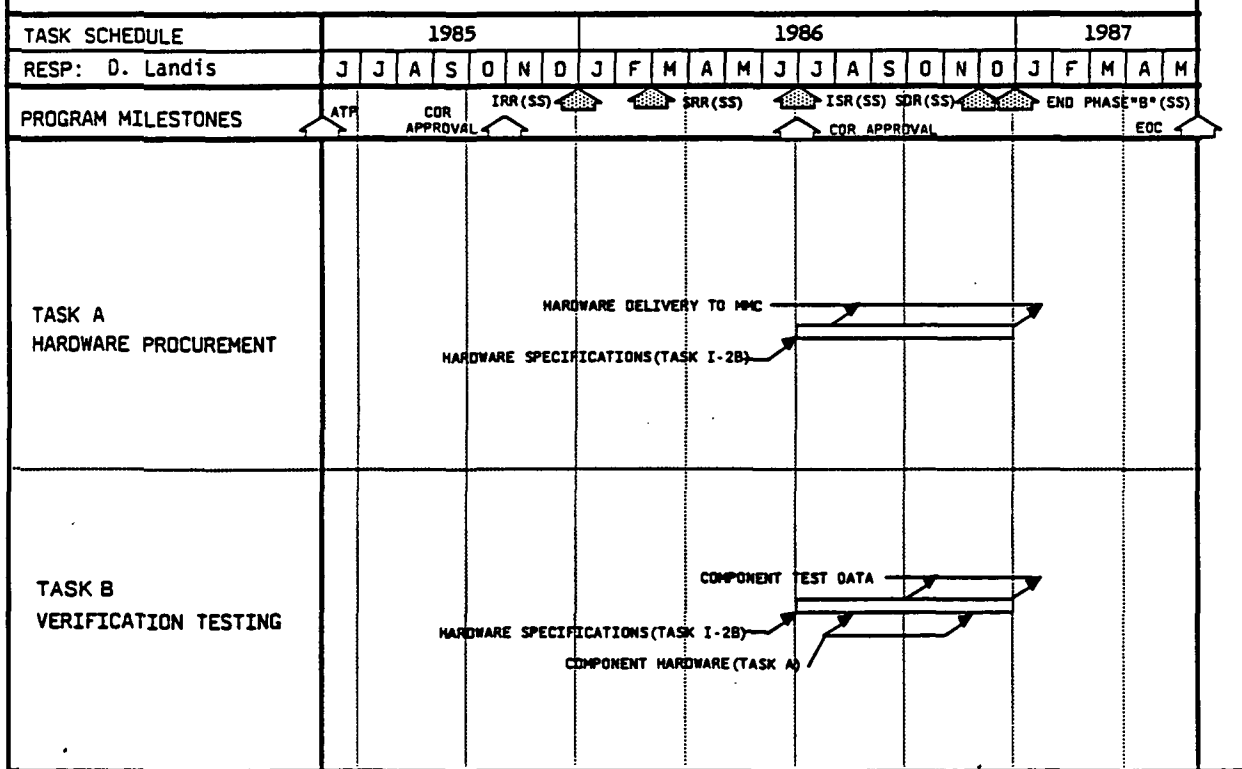
4. On approval of the outline plan of Task III-1 by the MSFC COR, the contractor shall procure necessary hardware components identified as technology ready, in quantities sufficient to verify CM/PMAD systems operation through breadboard testing at MSFC and implement any verification testing identified in the outlined plan.

SUMMARY OF APPROACH:

The objective of this task is to procure technology ready components and perform required verification testing. The effort is described in the following subtasks:

Task A. Hardware Procurement—Hardware identified as technology ready in Task II-1B, and approved by the MSFC COR, will be procured in accordance with the hardware specifications from Task I-2B.

Task B. Verification Testing—All procured components will be delivered to Martin Marietta. The components will be subjected to verification testing. This effort will include the preparation of test procedures and the design and fabrication of test tools and fixtures. Procedures, tools, and fixtures from Task III-3B will be used where possible. Verification test results will be formatted for incorporation into the final report.



CATEGORY	TASK COSTING																								TOT
ENGINEERING HOURS														8	68	98	38	38	38						288
SUBCONTRACT & MTL K$														10	7										17

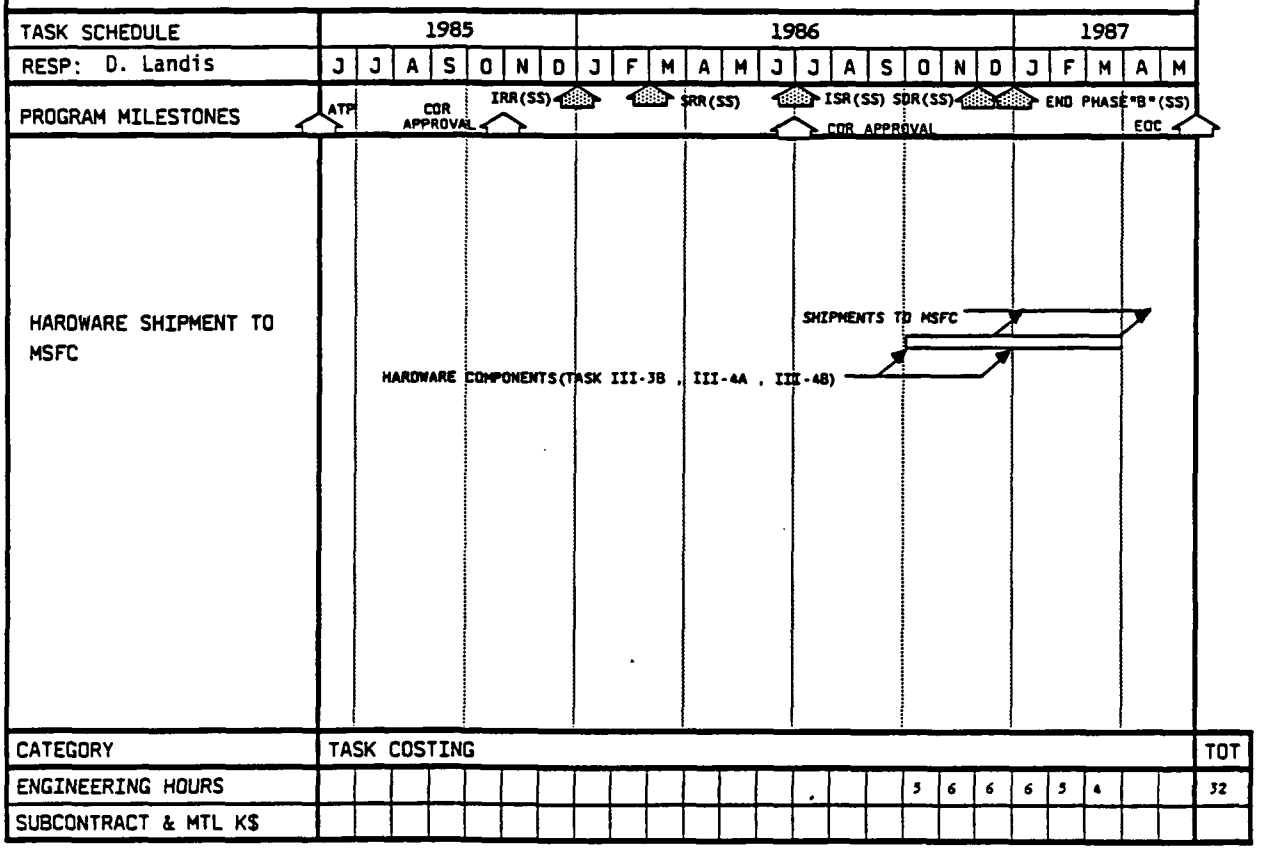
SOW: III-5	TITLE: HARDWARE SHIPMENT TO MSFC	WBS: 3.5

SOW DESCRIPTION:

5. As testing of components is completed under this Task, the hardware components shall be forwarded to MSFC for testing in the CM/PMAD breadboard.

SUMMARY OF APPROACH:

The objective of this task is to forward hardware components to MSFC for system breadboard testing. This effort includes the packing, inspection, and shipment of hardware to MSFC.



CATEGORY	TASK COSTING																							TOT
ENGINEERING HOURS																5	6	6	6	5	4			32
SUBCONTRACT & MTL K$																								

SOW: IV-1	TITLE: TEST PLAN & SYSTEM RECOMMENDATIONS	WBS: 4.1

SOW DESCRIPTION:

1. The contractor shall submit recommendations as to the systems breadboard configurations and test plan which best evaluate the hardware and network configurations identified and delivered in Tasks I, II and III.

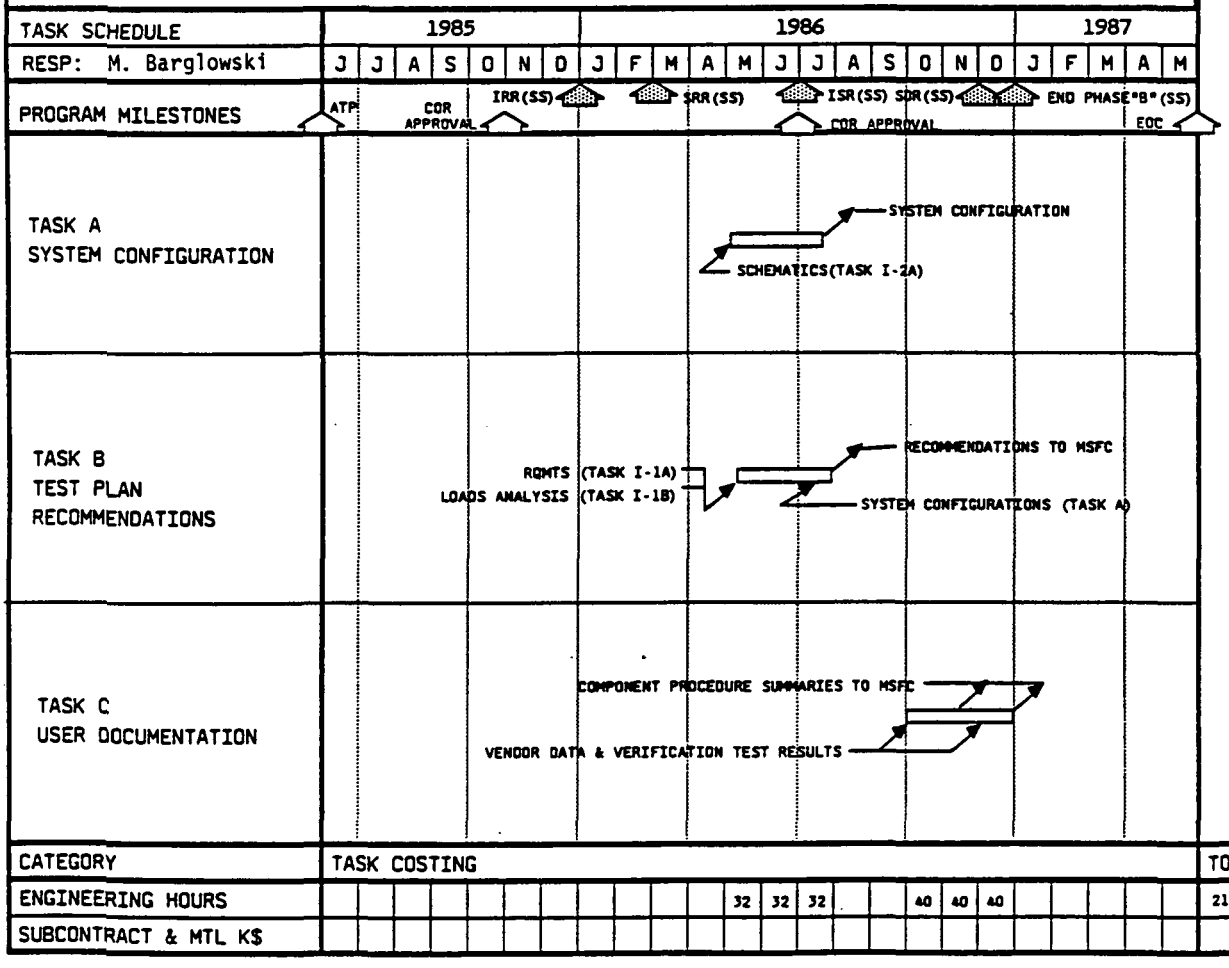
SUMMARY OF APPROACH:

The objective of this task is to prepare and submit a recommended test plan and system breadboard configurations for testing at MSFC. The effort is described in the following subtasks:

Task A. System Configurations—Candidate system breadboard configurations will be developed that are capable of verifying the operation of the CM/PMAD system designs developed in Task I as well as verifying component performance. These configurations will be developed based on the system schematics from Task I-2A, the component hardware availability, and the characteristics and limitations of the MSFC test facility.

Task B. Test Plan Recommendations—Test plan recommendations will be developed to verify the operation and performance of the CM/PMAD system designs relating to the requirements and loads data from Task I. Recommendations will be prepared for each of the three (or more) selected designs and will incorporate the system configurations developed in Task A.

Task C. User Documentations—We will develop a component checkout procedure summary for every component forwarded to MSFC. The sheet will include a simplified electrical schematic, interface definition, operating instructions and restrictions, and a component checkout procedure.



CATEGORY	TASK COSTING																									TOT
ENGINEERING HOURS												32	32	32			40	40	40							216
SUBCONTRACT & MTL K$																										

SOW: IV-2	TITLE: INTEGRATION & BREADBOARD TESTING	WBS: 4.2

SOW DESCRIPTION:

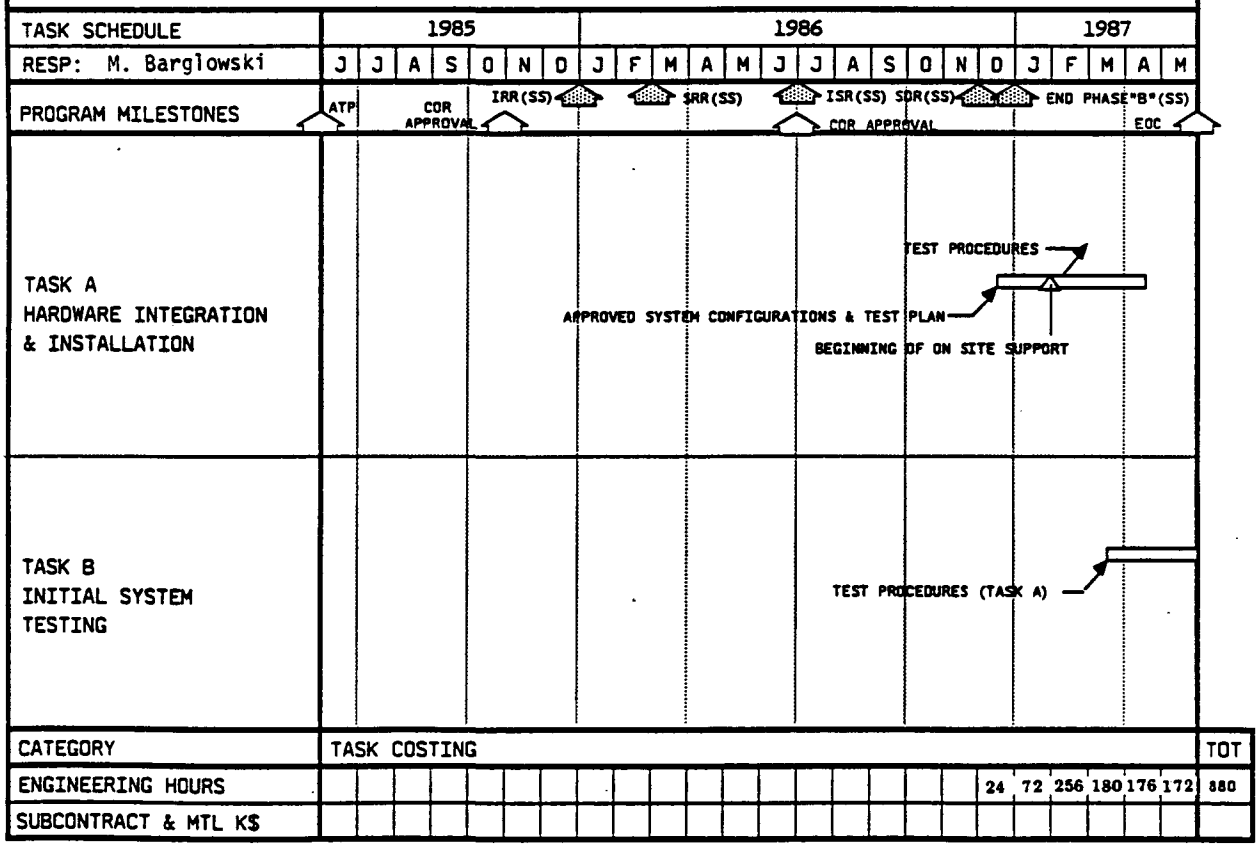
2. The contractor shall provide personnel support at the MSFC site for installation and integration of contractor provided hardware into the MSFC CM/PMAD systems breadboard and conduct initial testing.

SUMMARY OF APPROACH:

The objective of this task is to install the test hardware into the MSFC breadboard and perform initial testing. The effort is described in the following subtasks:

Task A. Hardware Installation and Integration—The components forwarded to MSFC after verification testing will be installed in the system breadboard in accordance with the system configurations approved by MSFC. We will develop detailed hardware installation and test procedures based on the approved test plan. This task includes engineering and technician support at MSFC.

Task B. Initial Systems Testing—Initial system testing will be conducted in accordance with the test procedures from Task A. This task includes engineering support at MSFC.



CATEGORY	TASK COSTING																						TOT
ENGINEERING HOURS																			24	72	256	180	176	172	880
SUBCONTRACT & MTL K$																									

SOW: V	TITLE: REPORTING	WBS: 5.0

SOW DESCRIPTION:

1. The contractor shall furnish monthly contract technical and financial progress reports in accordance with Attachment J-2 *Reports Requirements*. The milestones for Tasks I through IV and for the reports required by this task are shown in Figure 2.

2. In addition to the above reporting requirements the contractor shall also furnish as part of the proposal, a study plan to define the contractor's planned method and approach for accomplishing the objectives set forth. This plan will be updated at contract negotiations and informal working sessions may be held to discuss the study plan during the course of the contract. The plan will include as a minimum:

a. Complete description of the tasks (time phased and costed) in the effort and how they are to be accomplished.

b. Subcontractor effort, if applicable, shall be summarized. Identify the subcontractor who will participate and include a brief scope of responsibility for each.

c. The individual responsible for lead of each task shall be named.

The plan shall be updated to reflect changes resulting from program reviews and direction by NASA.

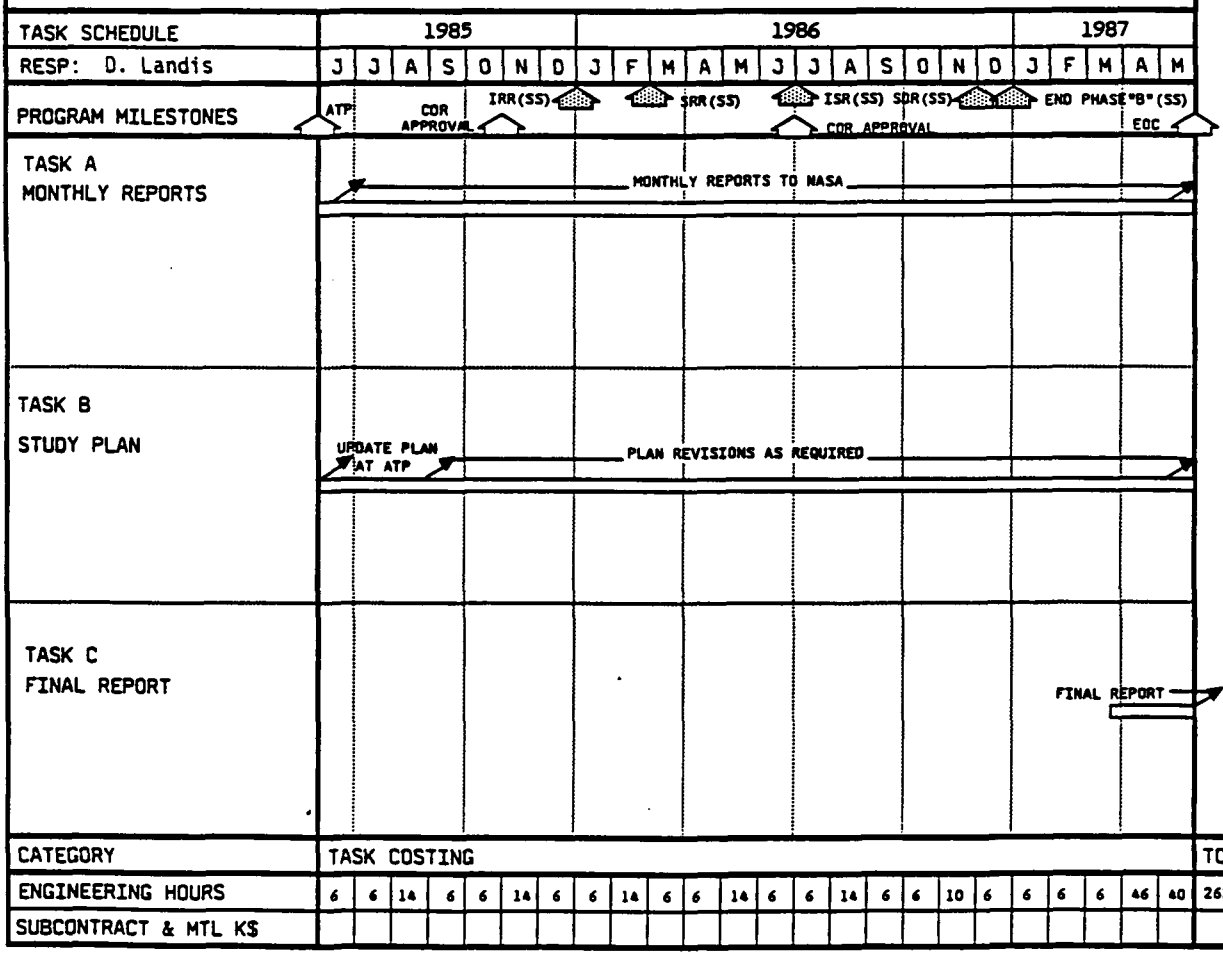
SUMMARY OF APPROACH:

The objective of this task is to report the program status, document and control the study plan, and to provide a final technical report. The effort is described in the following subtasks:

Task A. Monthly Reports—Progress reports will be prepared and submitted monthly, and contain a description of work performed, identification of problems, description of work to be performed, and monthly cost data.

Task B. Study Plan—This study plan will be updated during negotiations and maintained for the duration of the contract.

Task C. Final Report—A final technical report will be prepared and submitted. It will document and summarize the results of the entire contract work, including recommendations and conclusions based on the experience and results obtained.



CATEGORY	TASK COSTING																							TOT
ENGINEERING HOURS	6	6	14	6	6	14	6	6	14	6	6	14	6	6	14	6	6	10	6	6	6	6	46	40	262
SUBCONTRACT & MTL K$																								