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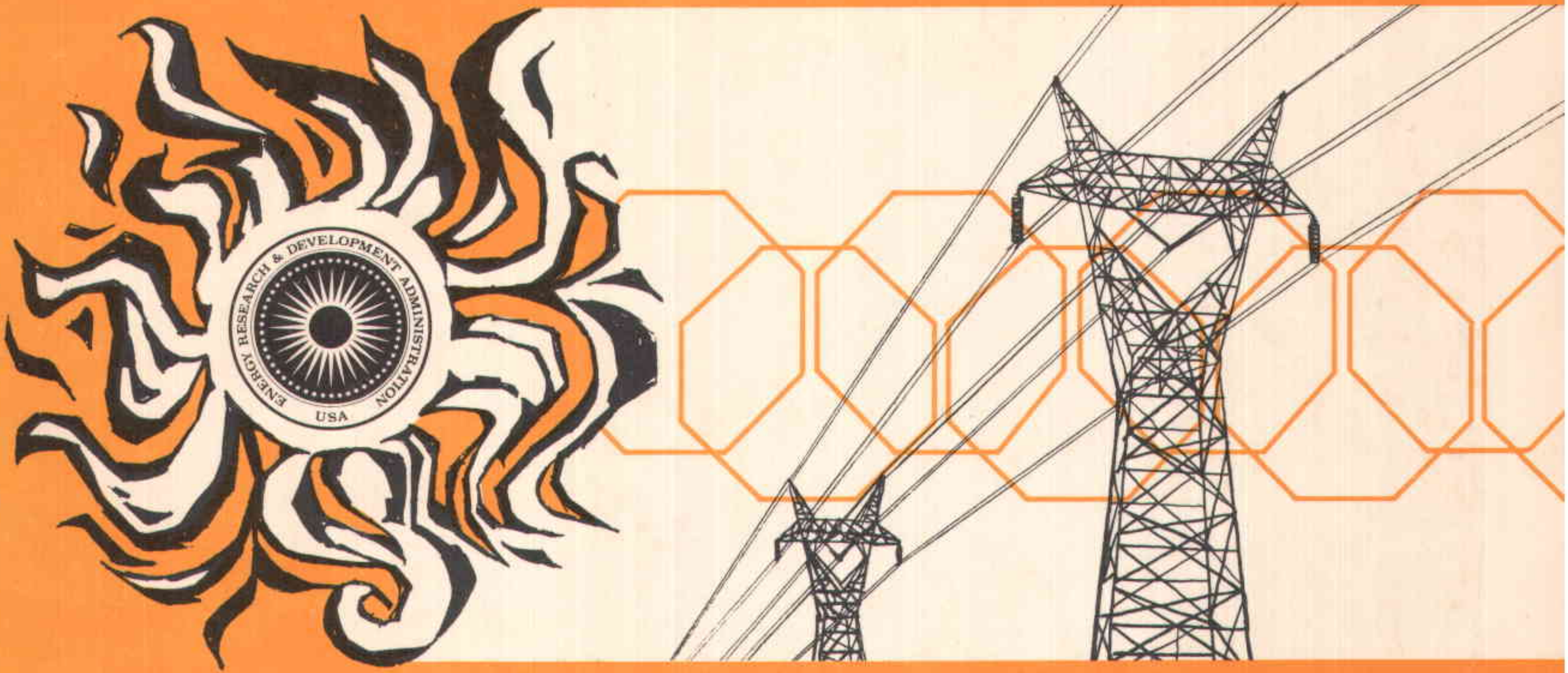


CENTRAL RECEIVER SOLAR THERMAL POWER SYSTEM, PHASE I

Volume 4 Program Plan

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS
CORPORATION

MDAC □ Rocketdyne □ Sheldahl □ Stearns-Roger □ University of Houston

MCDONNELL
DOUGLAS

CENTRAL RECEIVER SOLAR THERMAL POWER SYSTEM, PHASE 1

VOLUME 4

Program Plan

APRIL 1975

MDC G5942P

74W-005Q

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-WEST

5301 Bolsa Avenue, Huntington Beach, CA 92647

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

5301 Bolsa Avenue, Huntington Beach, CA 92647 (714) 896-3333

R. L. JOHNSON
PRESIDENT

28 April 1975

Mr. Vito Magliano, Chairman
Proposal Evaluation Board
Central Receiver Solar System Project
Energy Research and Development Administration
1333 Broadway
Oakland, California 94612

Dear Mr. Magliano:

In response to ERDA's solicitation for a preliminary design and major subsystem testing of a Central Receiver Thermal Power System, McDonnell Douglas Astronautics Company respectfully submits the attached proposal for your consideration. As prime contractor and system manager, we have emphasized the following major objectives: (1) the necessity to develop a commercially competitive design at least technical risk and at minimum cost, and (2) to provide the total technical and management expertise capability for carrying Phase I as well as subsequent program phases to successful completion.

To satisfy these objectives we have assembled a team of companies representing a broad spectrum of capabilities. The experience of this team qualifies it to perform the required tasks not only of this first phase of this program but for all subsequent phases.

Our qualifications to serve as prime contractor for this project are supported by past and currently demonstrated capabilities in managing major operational systems for both DOD and NASA and, most significantly, by our experience in nuclear plant management for the AEC at Hanford, Washington. In addition, we believe our background in designing, construction and operation of many of our major facilities and test sites is particularly applicable to the successful development of the proof-of-concept pilot plant and subsequent power facilities.

We view this program to be a major endeavor for this company as well as for the nation. It will report directly to my office and will be supported by all available resources of this company as well as the McDonnell Douglas Corporation.

Sincerely,

R L Johnson

MCDONNELL DOUGLAS
CORPORATION

Rocketdyne Division
Rockwell International

6633 Canoga Avenue
Canoga Park, California 91304
Telex: 651488

24 April 1975

In reply refer to 75RC2934

Mr. Robert L. Johnson, President
McDonnell Douglas Astronautics Company
5301 Bolsa Avenue
Huntington Beach, CA 92647

Dear Bob:

We at Rocketdyne have been working closely with your Energy Systems personnel in preparation for the Central Receiver Solar Thermal Power System program. The working relationships and enthusiasm demonstrated by the team has impressed me deeply. I am sure much of the success of the program team is due to our past and very successful associations on the Thor-Delta and Saturn-Apollo programs. We are looking forward to working with you again on this new and important energy development program. We expect this program to demonstrate how our aerospace technology can be utilized to solve the pressing energy problems that our nation currently faces.

Rocketdyne has committed a number of our key management and technical personnel to the program team. I plan to personally review program progress on a regular basis, and I sincerely hope that both of us can participate in joint reviews to ensure that the program receives proper management support and resources to achieve optimum performance.

Very truly Yours,

ROCKWELL INTERNATIONAL CORPORATION
Rocketdyne Division

Brennan

W. J. Brennan
President

Stearns-Roger
INCORPORATED

D. E. PROVOST
CHAIRMAN OF THE BOARD
PRESIDENT

April 24, 1975

Mr. R. L. Johnson, President
McDonnell Douglas Astronautics Company
5301 Bolsa Avenue
Huntington Beach, California 92647

Dear Mr. Johnson:

I wish to express to you, on behalf of Stearns-Roger Incorporated, my sincere support in placing a high degree of urgency on the timely completion of our input for the Central Receiver Solar Thermal Power System, Phase I.

Stearns-Roger will support this project in whatever manner necessary to insure the effective and efficient completion as required by the Energy Research and Development Administration. As you may appreciate in an organization of our size, we have resources of qualified personnel to perform all of the various engineering tasks required in our phase of the program, even in the event that the scope of work is increased.

It is indeed a pleasure to be a member of such an impressive team on such an important project.

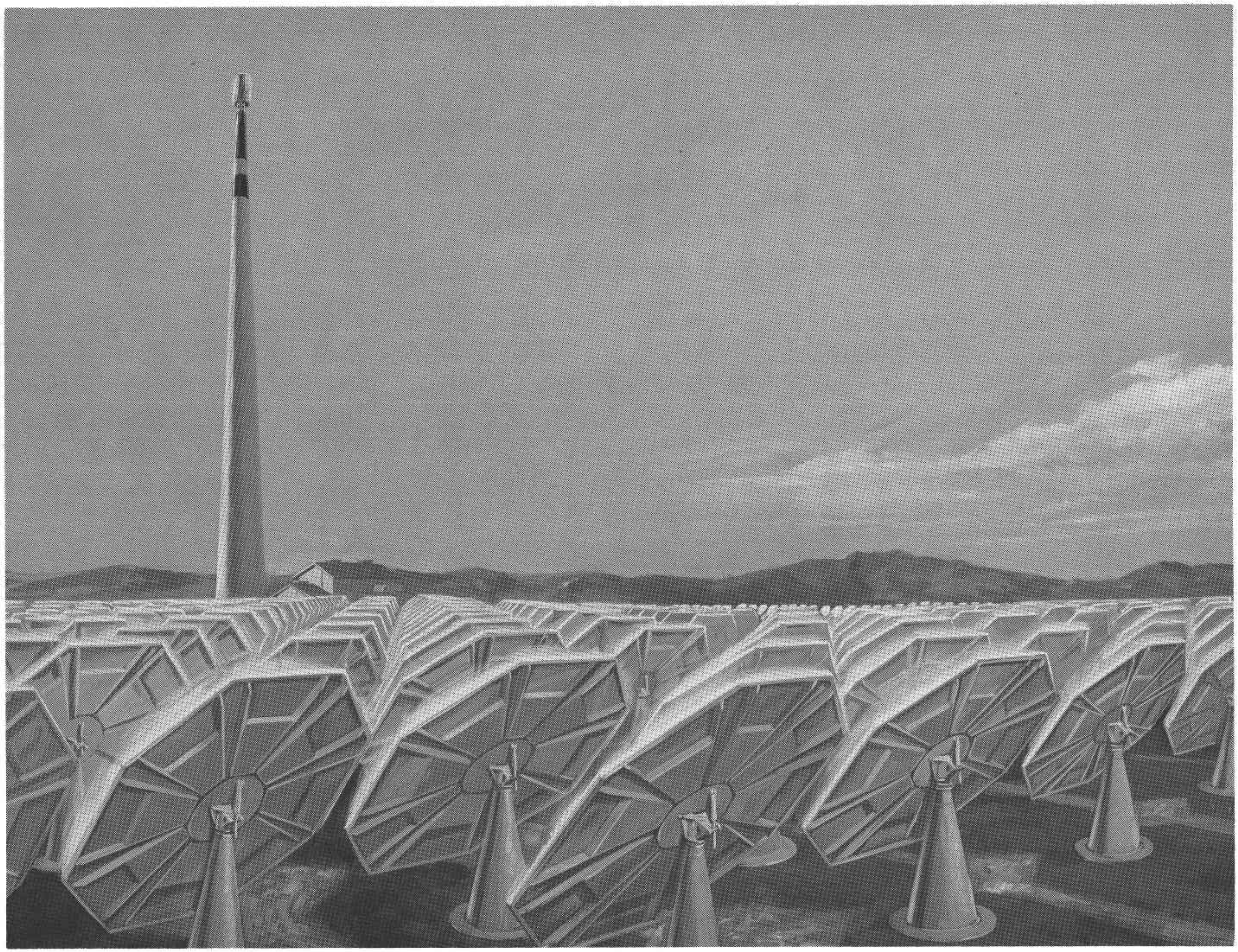
Very truly yours,

STEARNS-ROGER INCORPORATED

D E Provost

D. E. Provost
President

DEP/pk



PREFACE

This proposal is submitted to the Energy Research and Development Administration in response to Request for Proposals No. 75-124. It presents a plan by the McDonnell Douglas Astronautics Company to perform Phase 1 of the Central Receiver Solar Thermal Power System Program. The proposal is submitted in five volumes:

Volume 1	**Technical Proposal**
Volume 2	**System Requirements Specification**
Volume 3	**Subsystem Research Experiments Test Plan**
Volume 4	**Program Plan**
Volume 5	**Cost Proposal**

Recognizing that the technical demands of the program cover a broad spectrum of expertise, we have assembled a team we believe to be best suited to conduct Phase 1 and to carry on throughout all subsequent phases as well.

THE TEAM

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

System integration
Collector subsystem design, fabrication, and test
Thermal storage subsystem integration

ROCKETDYNE DIVISION OF ROCKWELL INTERNATIONAL

Receiver assembly design, fabrication, and test
Thermal storage unit design, fabrication, and test

STEARNS-ROGER, INC.

Tower and riser/downcomer design
Electrical power generation subsystem design
Environmental impact data

UNIVERSITY OF HOUSTON

Collector field optimization

SHELDAHL, INC.

Heliostat reflective surface

WEST ASSOCIATES

Utility consultant

Requests for further information will be welcomed by the following McDonnell Douglas representatives:

- R. W. Hallet, Jr., Program Manager
  Huntington Beach, California
  Telephone: 714-896-3664

- R. L. Gervais, Deputy Program Manager
  Huntington Beach, California
  Telephone: 714-896-3239

- G. M. Jones, Contract Administrator
  Huntington Beach, California
  Telephone: 714-896-2795

- N. P. Shyken, Field Office Representative
  Washington, D.C.
  Telephone: 202-446-4544

CONTENTS

INTRODUCTION

This volume presents the Mc Donnell Douglas Astronautics Company's plan for satisfying all requirements of the Energy Research and Development Administration's Phase 1, Central Receiver Thermal Power System Program.

To successfully accomplish Phase 1 program objectives and establish a strong basic organization with capability to conduct the total multiphase program, MDAC has formed a contractor team. This arrangement combines MDAC's own technical resources with those of other companies in an effective, complementing fashion. The other principal team members are the Rocketdyne Division of Rockwell International, Sheldahl, Inc., Stearns-Roger, Inc., and the University of Houston. West Associates, an association of western utility companies, supported by personnel from Southern California Edison, will serve as advisors.

The MDAC integrator role includes overall management and the total system integration, collector subsystem tasks, and integration of the thermal storage subsystem.

Successful management of the Phase 1 program requires, in addition to the obvious need for understanding the required technologies, in-depth experience in total system development and management with integrated, multicompany program activities. MDAC has gained such experience on many major aerospace programs, and is currently exercising this resulting expertise as the prime contractor/system integrator on the Site Defense program. Supporting MDAC's system development capability is the Company's capability for designing, developing, and operating large complex system and subsystem test facilities. Examples include the Saturn S-IVB test center at Sacramento, the Thor-Delta test complex at Cape Canaveral, and the Spartan test facilities at White Sands and Kwajalein.

OMITTED
IN
JUNE 1975
PUB.

In 1965, MDAC was awarded, in partnership with the United Nuclear Corporation, the prime contract to manage the Hanford fuel fabrication facility and production reactors including the "N" reactor which generated approximately 800 megawatts of electrical power. The operation of this reactor gave MDAC personnel valuable experience in working with utility companies and the Bonneville Power Administration.

These examples of MDAC's total system operation experience combining the management of people, money, and materials highly qualifies MDAC for the Central Receiver Program integrator position.

The other team member assignments include Rocketdyne's design, fabrication, and test responsibility for the receiver assembly and thermal storage subsystem. The POCE receiver tower and riser/downcomer design, electrical power generation subsystem design, and environmental impact data will be provided by Stearns-Roger, Inc. Collector field optimization will be achieved by the University of Houston. Sheldahl will support the POCE heliostat reflective surface design and provide the protective coating for the SRE mirrors.

An additional assurance of program success is the basic technology capabilities that exist in depth within all team members' engineering and development organizations. This reserve capability, which contains essentially all scientific and engineering disciplines, is available to supplement that of Phase 1 organization members in any way required. It also constitutes a strong base upon which to later build a full-scale development program.

The MDAC program plan presented here is consistent with the outline established by the RFP proposal preparation instructions. Section 1, Program Task Plan, describes in WBS format the approach to be taken to perform all statement of work tasks. Team members have been identified in the tasks to which they will contribute. All program schedules are presented in Section 2, Program Schedules, with the exception of the Executive Summary Schedule and the Subsystem research experiment schedules, which have been located with their task descriptions in Section 1.

Plans for integrated technical, cost, and schedule management as well as control and reporting are included in Section 3, Performance Management Plan. Section 4, Material and Subcontract Plan, provides descriptions of the material procurement and control policies established for the program. The rationale for selection of subcontractors and the management systems to be used by the MDAC team is also described.

The team assembled for the Phase 1 program is described in Section 5, Organization and Key Personnel. The responsibilities and authorities of the team managers are defined, and the key supporting personnel of all member organizations are identified and their qualifications described.

PROGRAM TASK PLAN 1

Section 1

PROGRAM TASK PLAN

The approach planned by MDAC and its team members to successful performance of all statement of work tasks for Phase 1 of the Central Receiver Program is described in this section. This task plan conforms completely to the Energy Research and Development Administration (ERDA) work statement and work breakdown structure, and is consistent with the Cost Proposal, Volume 5. The program schedules, presented in this section and Section 2, follow the same task breakdown. Management and organization approaches described in Sections 3, 4, and 5 have been carefully selected for optimum support of these tasks and to provide the base for subsequent program phases.

SC000* CENTRAL RECEIVER SOLAR THERMAL POWER SYSTEM

The objective of the Phase 1 effort defined in this task plan is to accomplish preliminary designs of the proof-of-concept experiment (pilot plant) system with the design feasibility of critical subsystem technology areas verified by results of subsystem research experiment (SRE) testing. The definition of task plans and schedules and the MDAC team resources allocated to these tasks have been carefully planned to provide high confidence of meeting technical goals while staying within budgets and schedules.

The program executive summary schedule, Figure 1-1, gives an overview of the task phasing. Our program plan has been constructed to meet the ERDA schedule milestones given in the RFP since detail

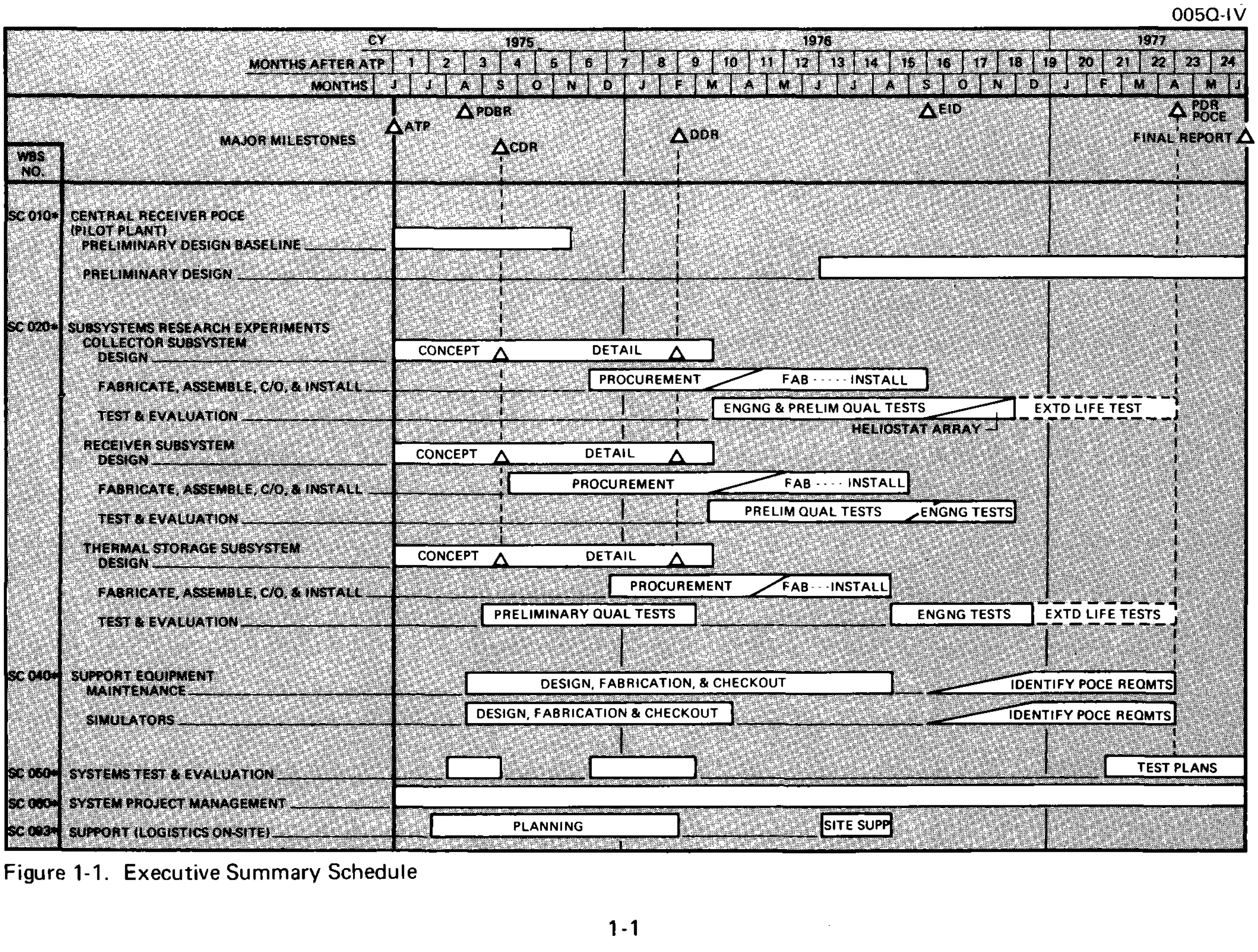


Figure 1-1. Executive Summary Schedule

planning has shown these time spans to be reasonable for performance of program tasks. In addition to those milestones, the following principal schedule dates have been defined:

- Test hardware preliminary operating instructions (month 14)
- Completion of SRE hardware fabrication, assembly, and checkout (month 14)
- Initiation of subsystem testing (month 15)
- Completion of major subsystem testing (month 18)
- Completion of life testing (month 22).

The MDAC and subcontractor technical team that has been working on this proposal and on other solar energy tasks is ready to initiate Phase 1 activities. Immediately upon receipt of authority to proceed, the contract work will begin based on existing planning. Concurrently with the start of program tasks, the program plan will be updated for ERDA review and approval 10 days after Phase 1 start (CDRL item 9).

The proof-of-concept experiment (POCE) and SRE design and analysis tasks will be performed primarily at MDAC in Huntington Beach, California and at Rocketdyne, Canoga Park, California with support provided by Stearns-Roger, Denver, Colorado; the University of Houston, Texas; and Sheldahl, Northfield, Minnesota.

Collector SRE heliostats will be fabricated at MDAC with mirror material protected by a special acrylic coating applied by Sheldahl. Final assembly and on-site testing of the heliostats are planned at the Naval Weapons Center, China Lake, California where MDAC has already conducted similar testing. An alternate test site is the MDAC Microwave Test Site at Grey Butte, California, on the Mojave desert. Transportation of reflector segments and other materials has been investigated and does not pose significant problems.

Receiver and thermal storage SRE hardware will be fabricated by Rocketdyne at Canoga Park. The receiver will be tested at Rocketdyne and in the Rockwell International Thermal Laboratory at El Segundo, California. Thermal storage system research experiment installation and testing will be done at Rocketdyne test facilities at Santa Susana, California.

The management and coordination of procurement, transportation, and testing at these diverse locations has been thoroughly analyzed and planned. While care must be exercised to avoid problems, there are no inherent program risks in this minimal geographic dispersal.

A flow chart of program activities is shown in Figure 1-2 which illustrates the sequence of activities and flow of data. A summary of planned manloading for the major program tasks which provides an overview of the distribution of resources is presented in Table 1-1. Detailed manloading of all tasks is contained in the Cost Proposal, Volume 5.

Our program task plan constitutes an integrated program consisting of:

- An efficient design approach
- MDAC team members with unique technology capabilities to support this approach
- Test facilities that are suitable for satisfying the specific SRE requirements

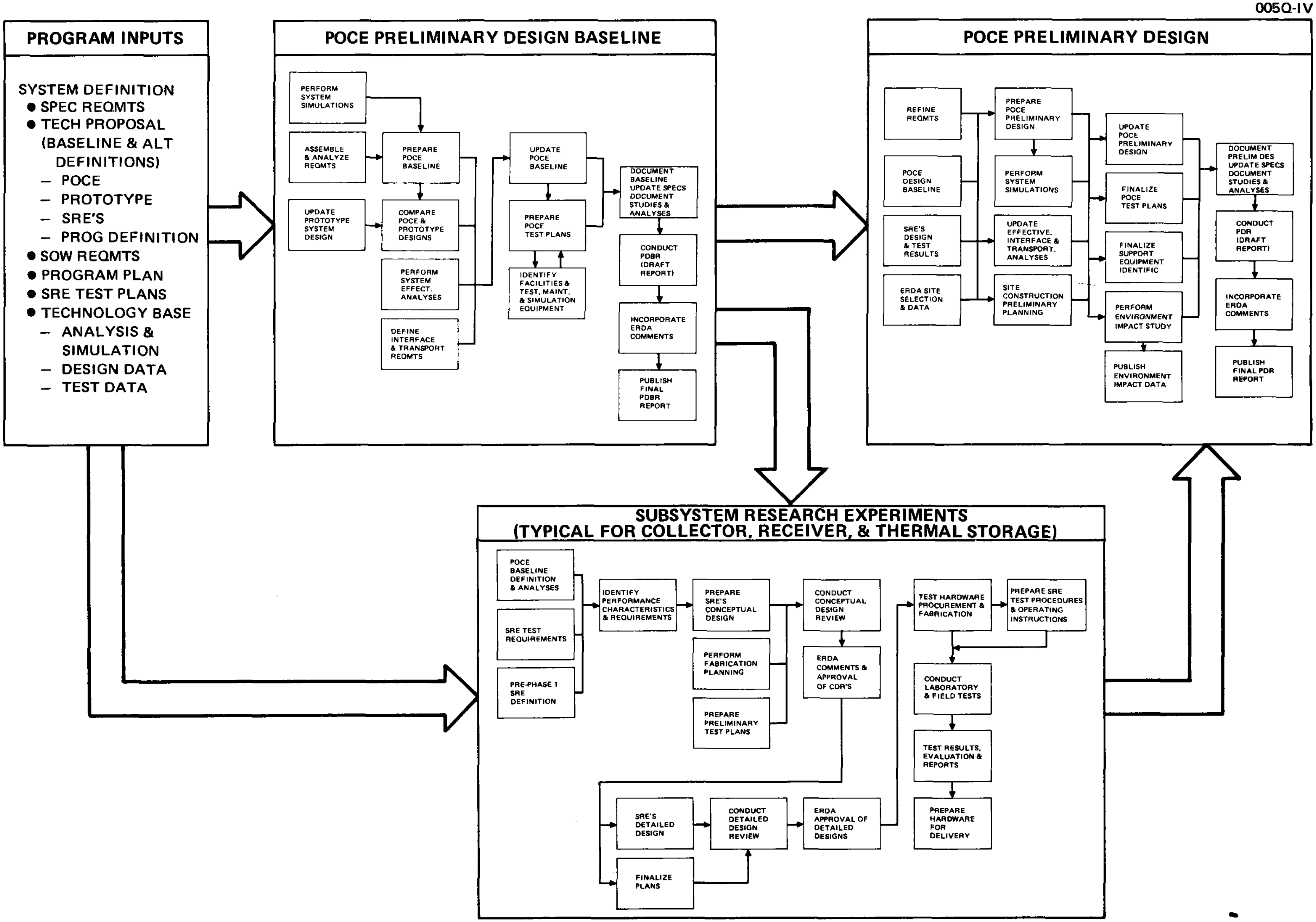


Figure 1-2. Central Receiver, Phase 1 Program Task Flow

- Applicable hardware fabrication experience in critical areas
- Schedule and resource planning tailored to program needs.

The management and key personnel identified in Section 5 are available and ready to perform these tasks. They will maintain close coordination with ERDA throughout the Phase 1 program by means of design reviews, project reviews, CDRL reports, and frequent personal contact.

Table 1-1. PROGRAM MANLOADING BREAKDOWN

	MONTHS AFTER ATP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
	MAJOR MILESTONES	ATP		PDBR POCE	CDR SRE					DDR SRE							EID POCE							PDR POCE		
WBS TASKS	CALENDAR MONTHS	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
SC 010*	CENTRAL RECEIVER POCE PRELIMINARY DESIGN	29.9	31.9	14.8	9.9	4.2	2.6	0.9	0.8	1.1	0.6	0.6	0.6	0.3		1.0	14.3	14.5	15.6	11.5	15.1	15.8	18.0	8.9	7.4	7.3
SC 110*	INTEGRATION & ASSEMBLY	4.5	5.2	3.5	2.6	0.9	0.3	0.3	0.5	0.3	0.3	0.3	0.3				1.9	0.8	1.1	0.8	1.1	1.3	1.5	2.1		
SC 210*	COLLECTOR SUBSYSTEM	9.1	10.5	5.9	5.0	1.0	0.3	0.3	0.3	0.8	0.3	0.3	0.3	0.3		1.0	1.8	1.0	1.0	1.8	2.0	2.5	2.8	0.8	0.8	
SC 310*	RECEIVER SUBSYSTEM	2.0	2.9	1.8	1.7	1.5	1.4	0.3										1.7	1.8	2.0	3.1	3.1	4.5	2.9	2.9	3.5
SC 410*	THERMAL STORAGE SUBSYSTEM	5.3	4.3	2.4	0.6	0.8	0.6										0.6	1.0	1.7	1.7	3.9	3.9	4.2	2.6	3.2	3.8
SC 510*	ELECTRICAL POWER GENERATION SUBSYSTEM	9.0	9.0	1.2													10.0	10.0	10.0	5.2	5.0	5.0	5.0			
SC 220*	COLLECTOR SUBSYSTEM RESEARCH EXPERIMENTS	1.1	3.2	6.4	8.0	12.1	13.8	12.1	9.5	18.6	22.7	36.1	32.8	21.2	18.2	14.0	9.5	6.9	6.1	4.4	4.6	3.1	2.9	2.9	2.8	0.7
SC 320*	RECEIVER SUBSYSTEM RESEARCH EXPERIMENTS		1.0	2.9	4.1	3.7	3.5	5.8	7.9	8.0	11.4	11.1	12.0	12.8	11.8	6.3	9.6	9.6	7.6	0.9						
SC 420*	THERMAL STORAGE SUBSYSTEM RESEARCH EXPERIMENTS	0.2	0.5	1.5	4.1	6.0	5.3	7.2	7.8	6.9	8.5	3.1	3.7	5.0	5.0	5.3	10.3	9.4	5.0	4.1	1.9	1.8	0.2	0.2	0.2	
SC 040*	SUPPORT EQUIPMENT				0.4	0.4	1.2	1.2	1.3	1.5	0.4	0.4					0.6			0.2	0.2	0.9	1.0	0.4	0.4	
SC 050*	SYSTEM TEST & EVALUATION	0.5	1.3	0.4				1.0	2.2	1.0												1.9	4.0	4.0	2.9	1.1
SC 060*	SYSTEM/PROJECT MANAGEMENT	4.1	6.2	6.3	4.6	4.4	3.8	3.9	4.5	3.1	3.3	4.1	4.3	5.3	5.3	4.5	6.2	5.5	6.1	6.9	5.8	5.3	7.5	3.9	3.6	2.3
SC 070*	DATA	0.1	1.7	2.7	3.0	0.6	0.1			2.1			0.1		0.8	1.1	2.4	0.6	0.1			0.1	3.6	1.0	0.7	0.6
	TOTAL MANLOADING	36.0	45.7	35.0	33.9	31.5	30.3	32.4	34.0	42.1	46.9	55.4	53.7	44.4	41.1	32.2	52.9	46.4	40.5	27.9	27.4	28.8	36.9	21.4	17.8	12.1
	MDAC	19.6	22.5	17.8	15.9	15.9	16.8	15.0	14.1	20.9	25.0	32.5	25.2	18.4	17.0	13.2	10.2	7.0	9.2	9.8	10.6	11.2	16.8	5.2	4.1	0.3
	ROCKETDYNE	5.0	6.6	6.6	10.5	13.6	11.5	14.8	16.7	17.6	21.6	15.7	17.3	20.1	19.0	13.1	23.3	21.0	14.5	7.4	7.7	8.7	12.4	10.5	10.0	11.1
	STEARNS-ROGER	9.0	9.9	3.2	1.8	1.0	1.0	1.4	2.2	1.0		1.0	1.0	1.0	1.8	1.8	11.2	12.9	13.8	9.1	7.4	7.4	5.8			
	UNIVERSITY OF HOUSTON	0.5	3.3	5.0	4.5			0.2		2.0		1.0	1.0			1.5	4.9	1.5						3.0	1.0	
	SHELDAHL	1.9	3.4	2.4	1.2	1.0	1.0	1.0	1.0	0.6	0.3	2.3	3.9	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.5	0.6	0.7	0.7

*In addition to the MDAC direct manloading shown in this table, MDAC management has committed a total of approximately 100 man months of engineering indirect support for program management functions.

SC010* CENTRAL RECEIVER POCE (PILOT PLANT)

A preliminary design baseline (PDB) of the POCE (pilot plant) will be developed in accordance with the system and subsystems requirements specifications. This system engineering task will be initiated by first assembling and ordering all available and applicable input data and requirements definitions. These data are presently identified in the Technical Proposal, Volume 1 and System Requirements Specification, Volume 2. Subsystem Research Experiments Test Plan, Volume 3 is an indirect contributor. Using these documented data, as modified by any ERDA direction after program ATP, the system analyses and design activities will commence. Requirements will be analyzed for consistency, desirability, and attainability with respect to technological, cost, and schedule goals. The development of a system definition will consider system operational modes and costs projected through the various program phases to the commercial application. Elements of the system not specifically covered by the SRE's (e.g., master control unit) will also be introduced into the studies.

Documentation of this effort in the form of preliminary layout-type drawings, updated specifications, and analyses will be submitted to ERDA per the requirements of CDRL item 1. This draft submittal is scheduled at the preliminary design baseline review (PDBR) which will be conducted at the end of the second month of the contract. The data will be applied to the SRE design and test planning activities (Task SC020*) in an iterative process. Also, the conceptual design activities in support of the SRE's may perturb the POCE definition and precipitate changes which will then be incorporated. After receipt of ERDA comments on the draft material approximately 30 days after submittal, changes will be incorporated. A final issue will be submitted five months after contract initiation.

Upon completion of the SRE's in approximately the 18th month, the results and data obtained will be applied to update the preliminary design baseline and provide a preliminary design report, documented as specified in CDRL item 2. This report will contain updated preliminary design drawings, analyses, and specifications. Additional documentation available at this time will be the preliminary POCE test plans and support requirements developed under Task SC050*. The SRE test results and evaluation, developed in Task SC020*, will also be provided. This activity will culminate in the POCE preliminary design review 22 months after ATP. After receipt of ERDA comments, changes will be made and a final report submitted at the end of the 24th month. (The schedule for all SC010* tasks is presented in Figure 2-3 in Section 2, Program Schedules.)

The following tasks, which define this effort in detail, have been divided into subtasks describing separately the initial preliminary design baseline effort and the final preliminary design output after completion of SRE testing.

SC110* Integration and Assembly

This task serves as a focal point for all POCE system-level design activity and provides integration of all activities conducted in Tasks SC210*, SC310*, SC410*, and SC510*. In addition to reviewing and expanding system requirements and preparing a system design, this task provides for technical review and direction of SRE activity as it relates to the POCE system. The task also integrates non-SRE design requirements into the POCE. Interface requirements definition at the subsystem level is performed concurrently in Task SC061A.03.

This task is the primary responsibility of MDAC but support will be provided by Rocketdyne, Stearns-Roger, and the University of Houston, and consultation by West Associates.

SC110A Preliminary Design Baseline – The objective is to provide integration and assembly functions required for a preliminary design baseline of the POCE system and to verify design scalability to a prototype power plant. The following principal activities are included:

- POCE scalability
- Requirements analyses
- System design and supporting analyses
- Master control unit definition and design.

SC110A.01 POCE-to-Prototype Power Plant Scalability – The design of a prototype (100- to 300-MWe) central receiver solar thermal power plant developed under previous NSF and MDAC studies will be upgraded with the results of pre-Phase 1 in-house studies and analyses and any ERDA redirection. This design will be utilized to verify the scalability of POCE design approaches to a 100- to 300-MWe commercial plant.

SC110A.02 Requirements Analysis – All POCE system-related requirements contained in System Requirements Specification, Volume 2; any additional requirements imposed by ERDA, and those recommended by West Associates and Stearns-Roger specifically related to utility interfaces and electrical generation equipment characteristics will be analyzed for consistency, desirability, and attainability with respect to technology, cost, and schedule goals. System-level cost and performance studies related to the collector/receiver interface (e.g., tracking accuracy, receiver size, and trades related to temperature and pressure as they impact the steam/water loop) will be conducted to expand design requirements. Additional studies related to the collector/receiver interface requirements will include the effect of collector field startup and shutdown strategies on system operation, the impact of heliostat focusing on POCE operation, and emergency heliostat defocusing and receiver self-protection provision tradeoffs. The receiver, thermal storage, and electrical power generation subsystem interface requirements will be investigated to ensure compatibility from an operational standpoint. Intersubsystem operational requirements will be identified. Existing performance, design, support, and operational requirements will be continuously reviewed to ensure compatibility and traceability. The resultant POCE system requirements specification will be presented at PDBR. These requirements will also serve as a base for Tasks SC210*, SC310*, SC410*, and SC510*.

POCE support requirements will be analyzed to develop a support data base fundamental to the tasks of maintenance, planning, spares provisioning, transportation, and the identification of other support resources. The support requirements analyses will parallel hardware design and development to ensure early recognition and resolution of system support requirements and maintenance problems.

POCE system functions will be analyzed on the basis of system requirements and schedules. Each function will be described in terms of inputs, outputs, and interface requirements. Operational alternatives will be identified. These data will be used to define the master control unit, establish interface definition in support of the interface requirements engineering task (SC061A.03), and establish a basis for the system effectiveness task (SC061B).

SC110A.03 System Design and Supporting Analyses – The baseline POCE system configuration along with alternatives adaptable to larger demonstration plants will be modified while satisfying receiver-related requirements. A POCE system sizing effort will be conducted which will determine heliostat quantity and spacing requirements for subsequent installation, maintenance, and wind-loading evaluations. The University of Houston will support MDAC in this activity.

Subsystem and master control/subsystem control interfaces will be defined based on system requirements. Design alternatives related to the water/steam loop will be identified and resulting trade studies will be conducted addressing capital and life-cycle costs and schedule impacts. Plant operational characteristics will be identified with the aid of West Associates. System effectiveness factors (Task SC061B), including maintainability, transportability, safety, supportability, and survivability, will be considered for resultant designs. Subcontractor designs for the receiver (SC310*, Rocketdyne), thermal storage (SC410*, Rocketdyne), and electrical power generation (SC510*, Stearns-Roger) subsystems will be managed through scheduled design reviews (Task SC061C) to ensure compatibility and consistency with POCE system requirements.

With the aid of West Associates, the resulting system configuration along with the subsystem designs developed in Tasks SC210*, SC310*, SC410*, and SC510* will be assembled into a preliminary baseline POCE system, presented at PDBR and subsequently refined per ERDA review. This design will be the basis of all requirements for the SRE test program.

The SRE activities will be continuously monitored to ensure technical compatibility with the POCE system requirements. Test data will be reviewed and redirection will be given based on system and cost-effectiveness analyses consistent with POCE objectives. The definition of non-SRE items (tower, riser/downcomer, electrical power generation subsystem, and master control unit) will be maintained and monitored to ensure consistency with the SRE areas at the start of the preliminary design activity (month 16).

SC110A.04 Master Control Definition – The objective of this task is to establish a preliminary design baseline for the master control functions required for the POCE. The top-level requirements (SC110A.02) imposed by the POCE concept, ERDA, and the baseline subsystems will be analyzed and master control system requirements generated. Overall system sizing will be determined by selecting and sizing the operational conditions which represent the "worst case operations per second" that the master control must be capable of handling.

System architecture will be defined which satisfies the generated requirements. Criteria for trades such as plant safety, reliability, flexibility, and automation will be established and trades performed to compare the defined architecture. With the basic architecture established, detail hardware, system software, and application software implementations will be established and trades performed using the general criteria established for the architecture trades and projected life-cycle costs. The outputs of this task include a system description, a definition of system operating concepts, a preliminary description of each hardware item, preliminary flow diagrams of critical performance portions of the system software, and a preliminary description of each application program.

SC110B Preliminary Design – The results of the SRE test programs and site-specific data will be utilized to initiate this task which will update and expand the POCE baseline system configuration. All system requirements will be reviewed and updated as a result of these data. The impact of these modifications will be accommodated through the refinement of appropriate earlier trade studies to update the system specification. The system design will be expanded to permit the detailed design and fabrication of a complete POCE system to be initiated at the end of this phase. Plans related to a total plant operation and network integration will be expanded with the aid of West Associates.

Detailed subsystem designs will be monitored for compatibility with system requirements and the results of this effort will be incorporated into the preliminary system design. All system operational modes will be defined. Hardware and software descriptions of the master control unit will be updated to reflect requirement changes. Adequacy and compatibility of all physical and functional interfaces will be assured. The completeness of the design in response to the specification will also be verified as part of this preliminary effort. The subtask outputs will include all the drawings, schematics, block diagrams, functional flow diagrams, hardware/software descriptions, and updated specifications required to define the preliminary POCE system design.

Design refinements and SRE test results will be reviewed for impact on system support analysis and system support planning. Specifications will be revised to be compatible with system requirements and incorporated in the preliminary design report specified in CDRL item 2.

SC210* Collector Subsystem

The POCE collector subsystem will be designed to satisfy all requirements and specifications while maximizing cost effectiveness. This philosophy provides direction and focus for all analyses, trades, and design efforts conducted. The program team members assisting MDAC in this task include Sheldahl, Stearns-Roger, and the University of Houston.

SC210A Preliminary Design Baseline – The objective of this task is to develop a baseline POCE collector subsystem design which satisfies the subsystem technical and economic requirements. Activities conducted will include requirements analysis, and collector design and supporting analysis.

SC210A.01 Requirements Analysis – A detailed definition of the collector subsystem performance, design, manufacturing, operational, logistics, effectiveness, and environmental survival requirements will be developed from the system requirements analysis of Task SC110*. These requirements will be expanded through appropriate trade studies, including:

- Required reflective surface performance, durability, and life
- Adhesive bond requirements
- Structural support rigidity
- Combined load requirements
- Drive unit performance
- Control sensor characteristics
- Pedestal/foundation rigidity, tilt, and sinkage requirements
- Controls performance requirements.

Detailed requirements will be established for the collector preliminary design baseline.

Collector subsystem functions will be defined. Each function will be described in terms of the inputs, outputs, and interface requirements. Operational alternatives will be identified and investigated from a cost-effectiveness and performance standpoint. Task results will be an updated requirements specification for the collector subsystem and a functional description of the subsystem operation which will be presented at PDBR.

SC210A.02 Collector Design and Support Analysis – The objective is to conduct the supporting analyses and trade studies required for POCE collector subsystem definition. These activities will be conducted for the field layout, the heliostat assembly (including reflective surface, structural support, drive unit, control sensors, and pedestal/foundation), and the field controller assembly. The results of previous and continuing MDAC analytical, design, and test efforts, including the design, fabrication, and field test of a full-scale heliostat, will be utilized.

Heliostat Assembly – The following reflective-surface trade studies will be refined, utilizing data from continuing Company-sponsored testing efforts:

- First versus second surface mirrors
- Standard versus low iron float glass
- Chemical versus vapor deposition (silver and aluminum)
- Surface geometry, glass cutting costs
- Bond materials and methods.

Candidate protective coatings developed by Sheldahl are also included in this effort. Projected costs of the candidate reflective surfaces for commercial quantities will be related to degradation rates based on test data for abrasion, hail, solar exposure, and chemical attack effects versus time. Projected life estimates will be determined, candidate bond materials for adhesive bond of the reflective surface to the structural support will be evaluated, and bond methods defined.

Heliostat Structural Support – Design trades will be conducted including adhesive types, manufacturing methods, configuration, and costs. Load and stress analyses will be conducted to determine critical loading conditions, structural design loads, stress distribution, and deflections. Structural dynamic analysis will be conducted to define unsteady loading conditions and predict structural responses. Analyses will be performed using simple structural models and MDAC computer codes including P0730.

Drive Mechanism – Heliostat drive configuration, components, and mechanisms will be evaluated as a function of performance, integrity, life, producibility, maintainability, and cost. The impact on the heliostat of varying emergency defocusing timelines will be determined for interface trades. The baseline drive will be sufficiently analyzed and defined to allow design factors such as compliance, backlash, friction, mass, and moments of inertia to be utilized in the MDAC servodynamic computer program.

Aerodynamic wind load effects will be analyzed, including the influence of wind velocity and gust frequency for induced loads and dynamic performance. Total energy consumption of the drive will be determined along with the impact of power consumption costs on drive system design. Component selection and variations in arrangement and configuration will be investigated to optimize the baseline design for durability and long life.

Control Sensors – Analyses and trades will be performed to select the appropriate control sensors and components, including the motor tachometer, position potentiometers, and beam sensor, on the basis of performance and cost.

Pedestal/Foundation – Cost trades of the pedestal/foundation baseline design will be performed on the basis of structural loads, assumed site conditions, cost, rigidity, and life considerations. With the aid of Stearns-Roger, configurations, materials, and fabrication and/or installation techniques will be evaluated. Static and dynamic structural analyses will be applied, including MDAC structural computer programs (P0730). The impact of long-term environmental degradation due to installation will be included. An optimum design will then be defined. Estimates of beam sensor support pedestal shift due to thermal gradients, wind loads, and soil property variations (e.g., moisture) will be determined.

Collector Controls Definition – The object of this task is to establish the preliminary baseline design of the POCE collector controls. This task will verify the baseline definition or identify areas to be changed. The requirements for the collector controls are contained in the POCE specification, the collector subsystem specification, and the master control definition. Control requirements from these sources will be verified and alternate collector control architectures defined which satisfy these requirements. The alternate architectures will involve different allocations of control functions than those selected for the baseline. Detail cost data for each implementation will be generated and the optimum architecture established. As the varying architectures are defined, hardware and software items will be defined to satisfy the functional requirements.

Hardware/software trades will be performed for each functional implementation. Cost trades on hardware implementation will be performed for packaging and environmental parameters in conjunction with system-level cost trades to establish hardware repair levels, maintainability techniques, self check techniques, and electronic piece part reliability levels. The outputs of this task are a preliminary collector controls block diagram and operating descriptions, preliminary design descriptions and a block diagram/ circuit schematic for each hardware item and a preliminary description of each software element.

Collector Performance – A heliostat field layout optimization will be performed, with assistance from the University of Houston, for the POCE to maximize the average heliostat effectiveness factor (incremental cost of total system divided by incremental annual power collected) for the total field. The optimum field layout will be modified as required to eliminate severe receiver controls problems due to circumferential heat load distributions. Data required to support receiver design studies will be generated on receiver flux distributions. Aim-point strategy, temporal and geometric flux distribution, and total annual power collected will be determined considering collector field taper and trim as well as individual heliostat focusing. Temporal variations of the receiver flux distributions will be generated for morning startup and evening shutdown considering effects of heliostat shading on beam sensor acquisition. Programmed heliostat acquisition profiles will be generated as required.

The results of the above trade studies will result in the definition of a preliminary baseline collector subsystem configuration with corresponding specifications which will be presented at the PDBR and subsequently refined per ERDA direction.

SC210B Preliminary Design – The results of the collector SRE test program will be utilized to update and expand the POCE baseline collector subsystem configuration. In addition, data related to the selected POCE site, including the collector subsystem requirements specifications, will be incorporated. Computer models will be correlated to test data while site-specific parameters such as solar insolation, wind, rain, hail, soil condition, etc., will be incorporated into the site definition analysis. The collector subsystem design will then be revised and expanded to produce hardware descriptions and/or functional characteristics of the previously described collector assemblies. Collector subsystem manufacturing, transportation, assembly, installation, alignment, checkout, maintenance, and logistics aspects will all be considered. Required support equipment, facilities, and personnel will be identified.

The outputs of this subtask will include the drawings, schematics, diagrams, hardware/software descriptions, operating instructions, plans, and updated specifications required to define the collector subsystem as an integrable element of the POCE system design (CDRL item 2).

SC310* Receiver Subsystem

The POCE receiver subsystem will be designed for maximum reliability and cost effectiveness while satisfying all performance requirements. These objectives will guide all analyses, trade studies, and preliminary design. The subsystem is composed of three principal assemblies: receiver, riser/downcomer, and tower. This receiver assembly design activity will be the responsibility of Rocketdyne. Stearns-Roger will be responsible for the design of the riser/downcomer and tower assemblies. MDAC will maintain the interface definitions.

SC310A Preliminary Design Baseline – The objective is to develop a baseline preliminary design of the POCE receiver subsystem which satisfies the subsystem requirements and is responsive to the POCE system requirements. Activities will include requirements, receiver subsystem design, and support analyses.

SC310A.01 Requirements Analysis – Definition of the receiver subsystem performance, design, operational, reliability, and environment survival requirements will be expanded compatible with the system requirements analysis of Task SC110*. The detailed requirements will be refined through trade studies to permit a complete receiver and tower subsystem definition. These studies define requirements related to the following critical issues:

- Threshold power level for individual panel operation at both design and derated outlet steam conditions
- Flow control characteristics and the impact on outlet steam transient conditions
- The effect of various collector morning startup and evening shutdown operational schemes on the receiver operational conditions, including both the external heat flux distributions and the internal flow and steam state conditions
- The relationship between emergency heliostat defocusing and receiver self-protection measures such as short-term backflooding from a receiver-mounted water reservoir.

Similar studies conducted on the riser/downcomer to aid in defining requirements will include:

- The impact of thermal transients on the steam line and the possibility of using multiple downcomers
- Techniques utilized during startup and shutdown to withdraw and inject required amounts of feedwater
- The relationship between flow control characteristics and operational transients.

The functions of the receiver subsystem will be developed through system functional analyses of Task SC110* and by analyzing the appropriate subsystem requirements. Each function will be described in terms of inputs, outputs, and interface requirements. Operational alternatives including the impact of panel outage will be investigated considering cost, performance, and reliability. The results will be an updated requirements specification for the receiver subsystem and a functional description of the subsystem operation which will be presented at PDBR.

SC310A.02 Receiver Subsystem Design and Support Analysis – The objective is to design and conduct the supporting analyses and trade studies required for the POCE receiver subsystem. These activities will be conducted for each of the assemblies described below.

Receiver Assembly – Receiver design activities will address the absorber panels and required manifolding as well as the receiver structure and flow control. Heat transfer, thermostructural, and flow control analyses will be conducted. The thermostructural analyses will consider the interaction of static, dynamic, and thermally induced loads. Life-cycle and creep limits will be determined for critical components as affected by temperature, pressure, startup and shutdown rates, feedwater characteristics, and seasonal, diurnal, and cloud-induced cycles. Flow control analyses will be conducted to define safe, stable receiver operation for all potential operational modes and transient conditions.

Riser/Downcomer Assembly – The riser/downcomer assembly definition, including the boost pumps and flow control equipment, will be refined based on subsystem requirements. Design activity will be supported by thermostructural and flow control analysis. The effects of various operational modes on the design will be considered, including startup and both normal and emergency shutdowns. The effect of thermal growth and cycling will be included in all design and life-cycle analysis. Flow control analyses will be conducted to verify the operational characteristics of the design and satisfy the appropriate interface requirements.

Tower Assembly – The tower assembly will be defined to meet the receiver subsystem requirements. Trade studies related to cost and environmental resistance will be conducted. Subsequent design activities will be supported by structural and environmental analysis. Structural analyses will include the receiver and piping network weight as well as wind and seismic activity effects on the integrated tower and receiver. Natural structural frequencies will be identified to ensure that a nonexcitable condition exists. Environmental factors will be applied to tower components in conducting life analysis. Soil conditions and their impact on tower foundations will be assessed. The analysis of site-specific soil and environmental conditions will be deferred until the preliminary design effort following POCE site selection.

The results of the above definition, design, and analysis activities will be utilized to define the baseline receiver subsystem configuration and update corresponding specifications presented at the PDBR. With subsequent refinement, per ERDA direction, this baseline will become the initiation point for receiver SRE activity. Basic design and analysis activity will be continued on the riser/downcomer and tower assemblies to ensure that they remain current and are at a comparable state of development with the SRE components at the completion of SRE activity.

SC310B Preliminary Design – The results of the receiver SRE test program will be combined with the design activity related to the riser/downcomer and tower assemblies to update and expand the POCE baseline receiver subsystem configuration. Site-related data including wind, rain, cloud characteristics, soil conditions, seismic conditions, etc., will be incorporated and reflected in the receiver subsystem specifications. Hardware descriptions and functional characteristics will be further defined in the development of the receiver subsystem preliminary design. The preliminary design effort will include receiver subsystem manufacturing, transportation, assembly, construction, installation, checkout, and maintenance considerations. Required support equipment, facilities, and personnel will also be identified.

The output of this subtask will include updated specifications, drawings, schematics, diagrams, hardware/software descriptions, operating instructions, and plans required to define the receiver subsystem and its role in the POCE system definition.

SC410* Thermal Storage Subsystem

The principal goal of the POCE thermal storage subsystem design activity is to develop a cost-effective, efficient, reliable, and safe means of storing and extracting thermal energy. This goal will provide direction and focus for all the planned analyses, trade studies, and design efforts. This subsystem design will be developed jointly by MDAC and Rocketdyne.

SC410A Preliminary Design Baseline – The object is to develop a baseline preliminary design of the POCE thermal storage subsystem which satisfies the subsystem requirements. Activities will include requirements analysis as well as thermal storage subsystem design and supporting analyses.

SC410A.01 Requirements Analysis – A definition of the thermal storage subsystem performance, design, operational, reliability, and safety requirements will be developed as a result of the system requirements analysis of Task SC110*. These requirements will be expanded through trade studies to permit a complete thermal storage subsystem definition. The trade studies will include dynamic response characteristics of each component and the integrated subsystem, operational efficiencies associated with widely varying fluid-flow conditions, and resulting identification of operational thresholds. Thermocline storage characteristics as related to the storage unit and inlet/outlet flow rate, heat loss, and the impact of temperature and thermal cycling on subsystem life will also be investigated.

The functions of the thermal storage subsystem will be developed through the system functional analysis of Task SC110* and the appropriate subsystem requirements. Each function will be described in terms of the inputs, outputs, and interface requirements. Operational alternatives will be investigated considering cost effectiveness, performance, and safety. The results will be an updated requirements specification for the thermal storage subsystem and a functional description of the subsystem which will be presented at PDBR (CDRL item 1).

SC410A.02 Thermal Storage Design and Support Analysis – The object is to design and conduct supporting analysis and trade studies required for the POCE thermal storage subsystem. These activities will focus on the principal assemblies which are the storage unit, charging loop, energy extraction loop, and control.

Storage Unit – Storage unit components and designs will be defined in response to the above requirements. Thermodynamic, fluid dynamic, and heat transfer analyses will be conducted. Factors to be analyzed will include thermocline storage, tank charging and discharging efficiencies, and heat loss. Structural analysis will be conducted to ensure structural compliance with code requirements. Material compatibility analyses will be made to ensure complete compatibility of all container and thermal storage materials as well as predict fluid stability and its impact on subsystem life.

Charging Loop – Design and analytical studies will be conducted as required to define the thermal charging loop, including all heat exchangers, pumps, control valves, etc. Designs developed will satisfy all requirements identified in Subtask SC410A.01 including steady-state and dynamic conditions. The impact of steam flow rate transients will be defined to provide system trade data. Functional and physical interfaces with the receiver will be defined. Each component will be evaluated to verify adequate functioning of all parts at temperatures and pressures above and below operational values. The heat transfer film coefficients, particularly steam, for a variety of flow conditions will be analyzed. Potential overheat, safety, and reliability conditions will be addressed.

Energy Extraction Loop – Design and analytical studies will be performed as required to define the energy extraction loop including the steam generator, auxiliary feedwater heater, and the supporting circulation and flow control equipment. The designs will satisfy all requirements identified in Subtask SC410A.01 including steady-state and dynamic conditions for all operating modes and transitions. Functional and physical interfaces with the receiver and electric generating subsystems will be defined. The function of all components will be investigated at temperatures and pressures above and below anticipated operational values. The impact of varying flow velocities and pressure drops on component operating performance and heat transfer coefficients will be analyzed. Life and maintenance requirements of heat exchangers will also be investigated along with design safety and reliability aspects.

Control – Design and analytical studies will be performed to determine the control requirements compatible with subsystem requirements and the characteristics of the prevously discussed assemblies. The control requirements will be allocated between the master control and the subsystem controllers. A control concept design will be synthesized and analyzed to ensure stable, compatible operation. Consideration will be given to operating limits, response time, reliability, accuracy, switching sequences, actuation type, sensor type, and control mode. The interface between the subsystem controls and the master control will be defined for each operating mode and transition including the functions assigned to each.

The results of the above definition, design, and analysis activities will be utilized to define the baseline thermal storage subsystem configuration and applicable specifications presented at the PDBR. With subsequent refinement, per ERDA direction, this baseline will serve as the basis for thermal storage SRE activity.

SC410B Preliminary Design – The results of the thermal storage SRE test program will be utilized to update and expand the subsystem design. Subsystem requirements and specifications will be reviewed and revised per the experimental data. Computer analysis conducted in support of the preliminary baseline design will be correlated to test data and updated. Updated designs, hardware descriptions, and/or functional characteristics of the thermal storage subsystem will be developed. Thermal storage manufacturing, procurement, transportation, assembly, construction, installation, checkout, maintenance, and safety will be considerations in this activity. Requirements for support equipment, facilities, and personnel will be identified concurrently in Task SC050*.

The outputs of this subtask will include updated specifications, drawings, schematics, diagrams, hardware and fluid descriptions and functional descriptions required to define the thermal storage subsystem as an integral part of the POCE system preliminary design.

SC510* Electrical Power Generation Subsystem

An electrical power generation subsystem will be defined as part of the central receiver POCE effort. The subsystem design will be restricted to the utilization of proven, commercially available hardware to minimize the contribution of the electrical power generation subsystem to POCE program risk. The general approach to the performance of this task will be to synthesize a subsystem configuration from available equipment that will best accommodate the range of steam conditions and flow rates that are expected from the receiver and thermal storage subsystem of the POCE. Stearns-Roger will be responsible for this design activity. They will receive consulting support from West Associates in the areas of total plant operations, electrical power generation subsystem definition, and interfaces with the power transmission network. The specific subtasks are described below.

SC510A Preliminary Design Baseline – The objective of this subtask is to develop a preliminary baseline design of the electrical power generation subsystem for the POCE which satisfies the stipulated performance and operational requirements in the specifications. Major assemblies include the turbine-generator, condenser, heat rejection equipment, feedwater equipment, and water treatment facilities. The functional flow chart in Figure 1-3 identifies the interfaces between this subsystem and other POCE elements. Subtask activities will include equipment identification and characterization as well as integrated subsystem design and supporting analysis.

SC510A.01 Equipment Identification and Characterization – Candidate equipment capable of satisfying the subsystem requirements will be characterized as to performance, design, operation, cost, reliability, and availability and transformed in Task SC110* into system requirements and guidelines. Typical data include steam state condition and permitted rate of fluctuation, conversion efficiency, steam extraction for feedwater heating, equipment lead times, and cost.

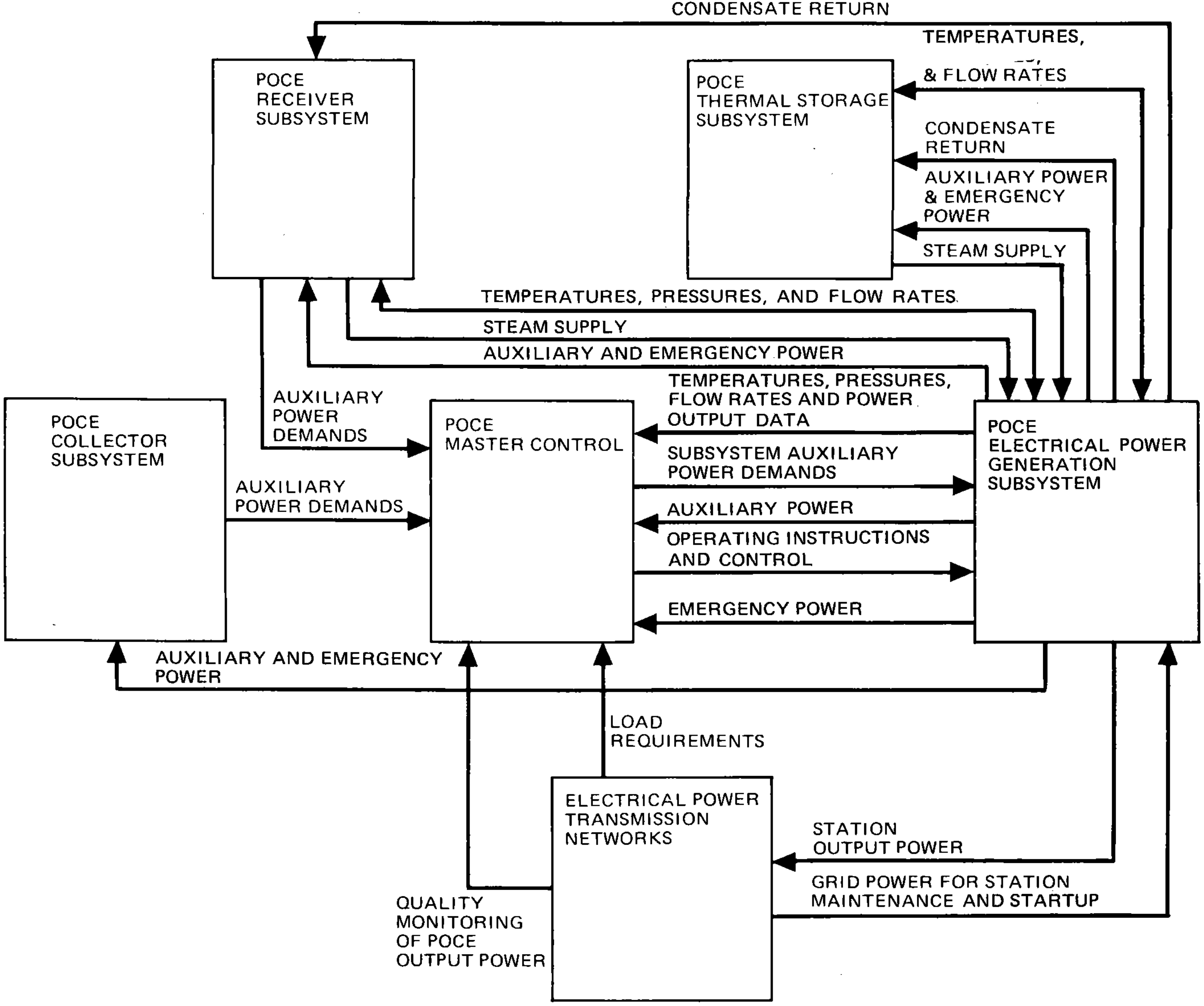


Figure 1-3. Functional Interfaces Between the Electrical Power Generation Subsystem and Other Operating Elements

SC510A.02 Baseline Design and Supporting Analysis – Candidate equipment satisfying the above requirements will be synthesized into integrated assemblies. Supporting analyses and trade studies will be conducted to further refine the designs of the major assemblies.

Turbine-Generator – A preliminary assessment of available turbine-generator equipment in the 10-MWe class, which has been performed by Stearns-Roger, will be refined to identify a complete list of candidate units for POCE application. The basic characteristics of these machines will be analyzed further in conjunction with the respective manufacturers to determine the impact of POCE requirements (e.g., multiple steam state operation) on the operations and design of the basic hardware. Additional analyses will consider the allowable variations in feedwater heating, effects of back-pressure variations on performance, startup, shutdown, and transitions among operating modes. The results of these analyses will be utilized to select a configuration and an operational philosophy that most closely satisfy the POCE requirements.

Condenser – Available condenser types will be assessed in the class compatible with 10-MWe units. Candidate units identified will then be sized to determine temperatures, pressures, and flow rates of circulating water required to be compatible with the turbine exit conditions.

Heat Rejection Equipment – Design and analytical studies will evaluate alternative heat rejection concepts and equipment, including the cooling tower and water circulation equipment. Material compatibility, water chemistry, lifetime, and maintenance analysis will be used to establish circulating water treatment and material requirements. Performance and structural analyses will assess the impact of environmental factors such as wet- and dry-bulb temperature variations, wind, water availability, and soil conditions on the design of the cooling equipment.

Feedwater Equipment – The number and types of feedwater heaters will be defined, considering the turbine capabilities versus thermal storage and receiver subsystem feedwater heating requirements and cycle efficiency implications. Functional relationships between feedwater heaters as well as fluid state points will be defined. This effort will be part of a preliminary energy balance for the entire POCE plant.

Water Treatment Facilities – Design and analytical studies will evaluate alternate water treatment facilities; factors will include capacity, inlet water quality, and both circulating and feedwater chemistry requirements. The impact of additional water requirements for other system functions such as heliostat cleaning, will also be assessed.

The results of the above evaluations will be utilized to define the preliminary baseline electrical power generation subsystem configuration which will be presented at the PDBR (CDRL item 1) and subsequently refined per ERDA direction. The design will continue during the SRE activity to ensure that a comparable state of development exists between this design and the SRE items at the end of the SRE program.

Subsystem Control – The allocation of electrical power generation control functions between the master control and the subsystem controllers will be defined.

SC510B Preliminary Design – The baseline design will be expanded and refined to reflect the revised requirements resulting from the SRE activity. Since the POCE site will have been chosen by this time, site-specific tasks for the electrical power generation subsystem will be performed during the preliminary design effort. Updated designs, including hardware descriptions, and/or functional characteristics of the previously described assemblies will be developed. Electrical power generation subsystem procurement, transportation, installation, construction, checkout, maintenance, and integration will be included in the considerations. Support equipment, facilities, and personnel requirements will also be identified.

The output of this subtask will include all drawings, schematics, diagrams, hardware descriptions, plans, operating instructions, updated specifications, and procurement schedules required to define the electrical power generation subsystem as an integrable element of the POCE system design.

SC020* SUBSYSTEM RESEARCH EXPERIMENTS

The MDAC team will design, analyze, develop, fabricate, test, and evaluate test results for the subsystem research experiments described below.

Collector Subsystem – One mobile and four stationary full-size heliostats will be designed, built, and field tested. The major elements of an additional heliostat will be fabricated and subjected to structural, life, and environmental tests. These tests will provide preliminary design data and confidence that the collector subsystem elements can eventually be produced, installed, and operated in a cost-effective manner.

Receiver – A full-length POCE receiver panel will be built and tested at peak heat fluxes with flows and thermal cycling equal to the POCE conditions to provide solutions for the high-risk technological issues of the receiver subsystem.

Thermal Storage – A 4-MW/hr thermal storage module configured for a 5-MW charge and extraction rate at actual temperature conditions will be built and tested to provide an efficient, economical thermal storage subsystem that will demonstrate the ability to smooth out system transients and extend power plant operation into periods of reduced insolation. The tests will be performed at up to 2-MW charge and 5-MW extraction rates thus meeting all SRE test objectives to simulate POCE operating conditions.

The subsystem research and test results will be evaluated, documented, and applied to the preliminary design definition of a 10-MWe POCE (Pilot Plant) in Task SC010*.

SC220* COLLECTOR SUBSYSTEM RESEARCH EXPERIMENTS

The collector SRE will provide the necessary research and test data to establish confidence that the collector subsystem elements can eventually be produced, maintained, and operated in a cost-effective manner. The SRE hardware will be representative of the subsystem hardware planned for the POCE program.

Conceptual and detailed designs for the SRE hardware will be prepared from POCE design and performance requirements and baseline designs approved by ERDA at the PDBR two months after start of contract. Three and eight months after start of contract, SRE conceptual and detailed design reviews will be conducted in accordance with the requirements of CDRL items 3 and 6, respectively. After ERDA approval of the SRE designs, hardware fabrication and test will comence to ERDA-approved test plans. The collector SRE schedule, Figure 1-4, illustrates these activities.

Five SRE heliostats plus additional test hardware, including the major elements of an additional heliostat (drive, mount, hub, segment, and sensors), will be fabricated and assembled. Testing of the hardware at both Huntington Beach and the Naval Weapons Center field test site at China Lake, California, will verify POCE requirements as well as operational procedures. Throughout the fabrication and test periods, results of all operations and tests will be documented for inclusion into project reviews (CDRL item 10) and the POCE preliminary design activity (CDRL item 2). Operating instructions for the heliostats will be provided ERDA before start of the field tests, in accordance with CDRL item 13. At the conclusion of the test program, the heliostats and other test hardware will be disassembled and packaged for shipment in accordance with ERDA direction.

SC221* Conceptual Design – The objectives of this task are to:

- Prepare conceptual designs and analyses of the collector subsystem from the design and performance requirements documented in the collector subsystem requirements specification for the SRE
- Identify long-lead procurement items

Sheldahl will support MDAC in the reflective surface design portion of this task. Documentation will include drawings, updated specifications, analyses, and hardware requirements (with special attention given to long-lead procurement items). They will be prepared in accordance with CDRL item 3 and presented at the collector CDR. Upon ERDA approval, comments to the conceptual designs and requirements will be incorporated and the detailed design task (SC222*) will proceed. Test planning activities will be performed concurrently with these design activities as part of Task SC224*. The following subtasks provide a description of the effort to be performed.

SC221A Performance Characteristics and Requirements Analysis – Requirements and characteristics of the SRE collector subsystem will be established and updated through analyses and tradeoffs of the SRE collector specification and the POCE collector subsystem specification design definitions, performance require-

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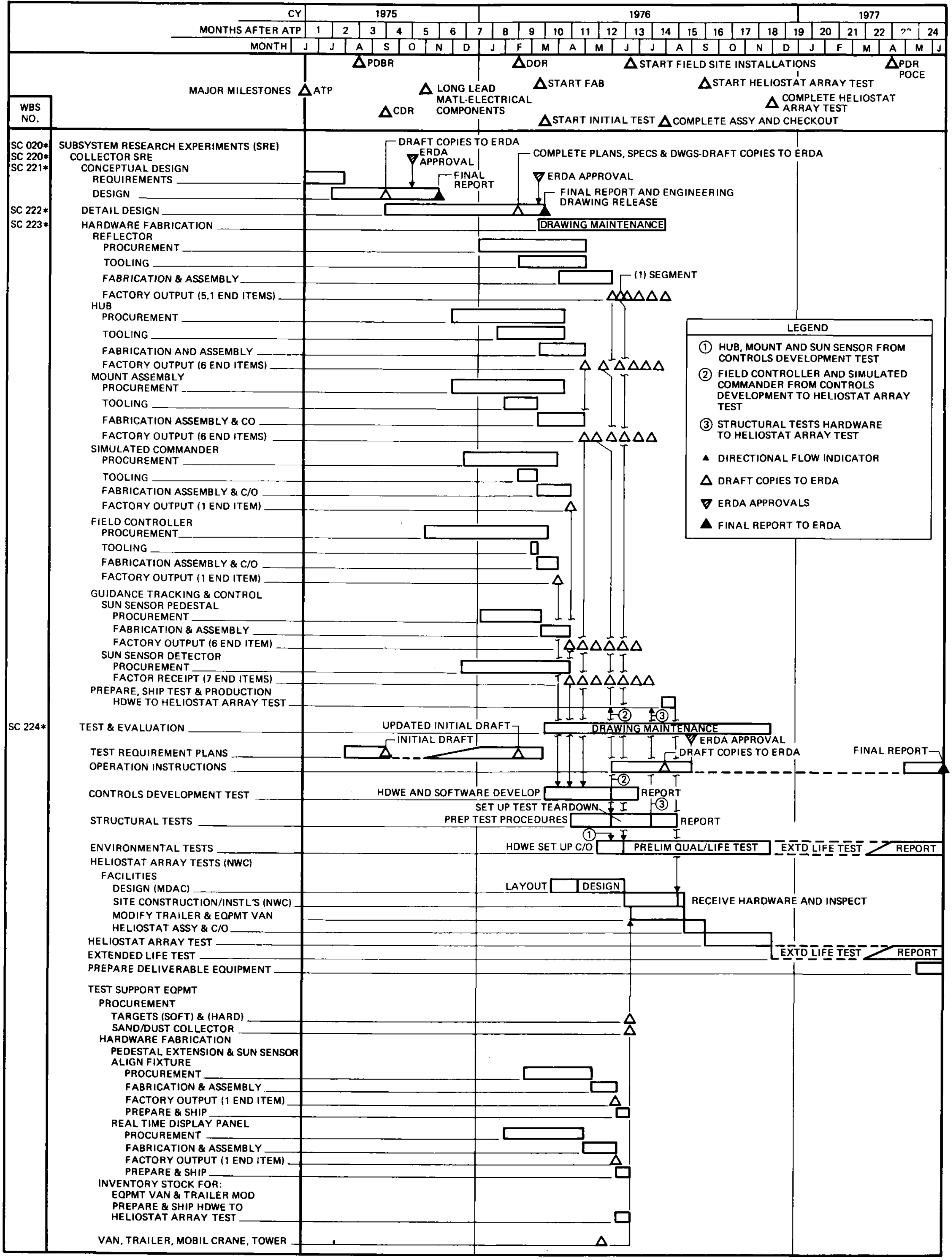

Figure 1-4. Subsystem Research Experiments – Collector System

ments, and operational modes as derived for Task SC210* and presented at the POCE PDBR. These analyses and trades will include tracking accuracy, control stability, slew rates, off-nominal operating requirements, aiming strategy, required flux pattern, and operational conditions. The number and location of test heliostats, instrumentation, reliability, cost factors, environmental survival, and test requirements will be considered. Wherever feasible, POCE requirements will be translated directly to SRE requirements to establish maximum benefits to the POCE preliminary design activity. The output of this subtask will be an updated SRE collector subsystem requirements specification.

SC221B Design and Analysis – Based on the design and performance requirements of the collector subsystem as defined in Subtask SC221A, conceptual designs and analyses will be performed for the collector subsystem hardware consisting of the heliostat assembly, field controller and ancillary equipment. These designs will duplicate POCE designs wherever feasible to maintain the benefits to the POCE preliminary design (Task SC010*) activities.

The field controller will be defined, considering effects of noise, and stability analyses will be performed on the control loops to assure stable heliostat performance. Structural deflections and errors resulting from sensors, controls, and other sources will be analyzed to define pointing accuracy and compared with pointing accuracy requirements. Off-nominal performance due to wind load, haze broadening of the sun's image, synthetic tracking, and other sources will be described. The impact of off-nominal performance on the receiver, including heat flux impinging on the support structure and tower and unusual receiver flux distributions, will be assessed to assure that no unacceptable conditions arise. Environmental survival of the reflective surface is being verified by Company-funded tests with results scheduled to be presented to ERDA at CDR.

Heliostat boresighting and alignment methods and control system loop analyses are typical of the functional analyses. Collector control equipment configurations (field controller, control sensors) required to satisfy the proposed test objectives will be analyzed and selections made. Detailed descriptions of a simulated master control and field controller, as well as control sensor equipment, will then be generated.

Specifications will be further developed for the collector subsystem research experiments by allocations of verification requirements and test definition to verify those requirements allocated to test, considering nominal operation and excursions so that both design and operating margins can be established. Planning will include identification of the cost and procurement schedules required for purchase of long-lead time hardware items such as bearings, drive trains, and electronic parts. Manufacturing, assembly, logistic support, and test techniques will be considered in all design activities. The outputs of this subtask will be

- Conceptual designs and analyses of the collector subsystem SRE hardware
- Identification of long-lead procurement items.

SC222* Detailed Design – The objectives of this task are to:

- Prepare detailed designs and analyses of the collector subsystem from the ERDA approved conceptual designs
- Prepare and issue procurement specifications for the ERDA-approved long-lead procurement items.

The documentation, such as drawings, updated specifications, analyses, etc., will be prepared in accordance with CDRL item 6 and presented at the collector DDR. ERDA approval to the detailed designs will be obtained before proceeding to hardware fabrications. Sheldahl will support the reflective surface design effort. The following paragraphs provide a detailed description of the subtasks to be performed.

SC222A Refine Design Requirements – Design requirements for all levels of collector subsystems hardware will be refined on the basis of technical, schedule and cost trades performed against the subsystem level requirements defined in Task SC221*. The outputs of this subtask will be incorporated in the collector subsystem specification.

SC222B Design and Analysis –From the ERDA-approved conceptual designs of Task SC221* and the approved, updated collector subsystem specification of Subtask SC222A, detailed layout and assembly drawings for all collector SRE hardware and software, including the reflective surface, structural support, drive, control sensors, foundations, field controller, etc., will be prepared. Detailed analyses pertaining to flux pattern, tracking performance, loads, stresses, deflections, dynamic characteristics, aeroelastic effects, seismic effects, weight, etc., will be made. Static and dynamic analyses will incorporate finite elements, idealizations of the structural elements using operational MDAC computer codes (PO730, ANSYS). Vibration model analysis and generation of dynamic loads will be performed using codes such as PO730, SA49, DA20, and CA28.

The normal requirements for detail electronic design, such as parts stress, standard parts identification, hardware quality grade, etc., will be determined. The detailed design activity will consist of both hardware and software design for the field controller and hardware design of the heliostat control sensors. The field controller design will take advantage of a Company-funded design effort and will include the digital processor, motor drive amplifier, multiplexer, and A/D conversion and interfacing circuitry. Software design will include basic field controller operation, self-test routines, and interfaces with the master control simulator. Certain aspects of the system will be breadboarded and checked out to further assure a sound design. Planning of manufacturing, assembly, checkout, packaging, and transportation activities will be established. The outputs of this subtask will be:

- Detailed design drawings and analyses of the collector SRE hardware
- Procurement specifications for long-lead procurement items.

SC223* Hardware Fabrication – The objectives of this task are to procure and/or produce collector SRE hardware, representative wherever possible of the POCE hardware, which will meet the requirements of the SRE plans and also verify POCE manufacturing techniques, producibility, and operability in a cost-effective manner. SRE drawings will be released through the production planning department directly to the experimental shops where the close working relationships of fabrication and engineering will assure direct verification of detail design producibility. Purchased parts will also be procured in this task. Quality assurance personnel will verify by inspection techniques the conformance of this hardware to the design definition, as approved by ERDA, before the test operations commence. All hardware fabrication and subassembly will be performed at the MDAC Huntington Beach facility with final assembly and installation occurring at the field test location. The assembly sequence of a heliostat is shown in Figure 1-5.

SC223A Reflective Surface – Mirrors will be fabricated for five complete heliostats, an additional hub and segment required for laboratory tests, plus one hub and segment and two segment mirrors for spares. The fabrication process will be similar to that planned for the POCE. Due to the low number of mirror surfaces required for SRE, the first-surface silver will be applied at a qualified mirror supplier and then the mirrors will be vacuum bagged and purged for shipment to the Sheldahl facilities for application of the acrylic protective coating. The assemblies will then by shipped to the MDAC Huntington Beach facility where the mirrors will be bonded to the reflector structure as shown in Figure 1-5.

SC223B Structural Support – The reflector support structure consists of segmented assemblies. Five complete support assemblies will be fabricated together with the two additional hubs and segments for spares and test requirements. Manufacturing engineers and design engineers will work closely together to verify the design and hardware producibility. The segment framework will be fabricated with sheet metal parts and assembled. The segment attach fittings are machined and attached to the frame. A final machining processs of the segment attach fittings after assembly achieves the flatness required for the completely assembled structural support.

SC223C Drive – A drive mechanism is provided for each SRE heliostat. It consists of a fabricated support housing with a harmonic drive for azimuth and an electric screw drive for elevation positioning of the heliostat. The fabricated housing is a welded and machined assembly. Final assembly of the drive components will take place in the manufacturing experimental shops.

SC223D Field Controller – One field controller will be provided for support of the SRE. It will be a development model of a proposed POCE field controller. Wire-wrapped, plug-in, integrated circuit boards using commercial components will be assembled and installed in a rack mounting frame along with the required power supplies. Interconnecting wiring will use commercial terminal strips. The field controller will be fabricated in the electrical circuit laboratory and tested with the heliostat drive mechanism before delivery to the field site.

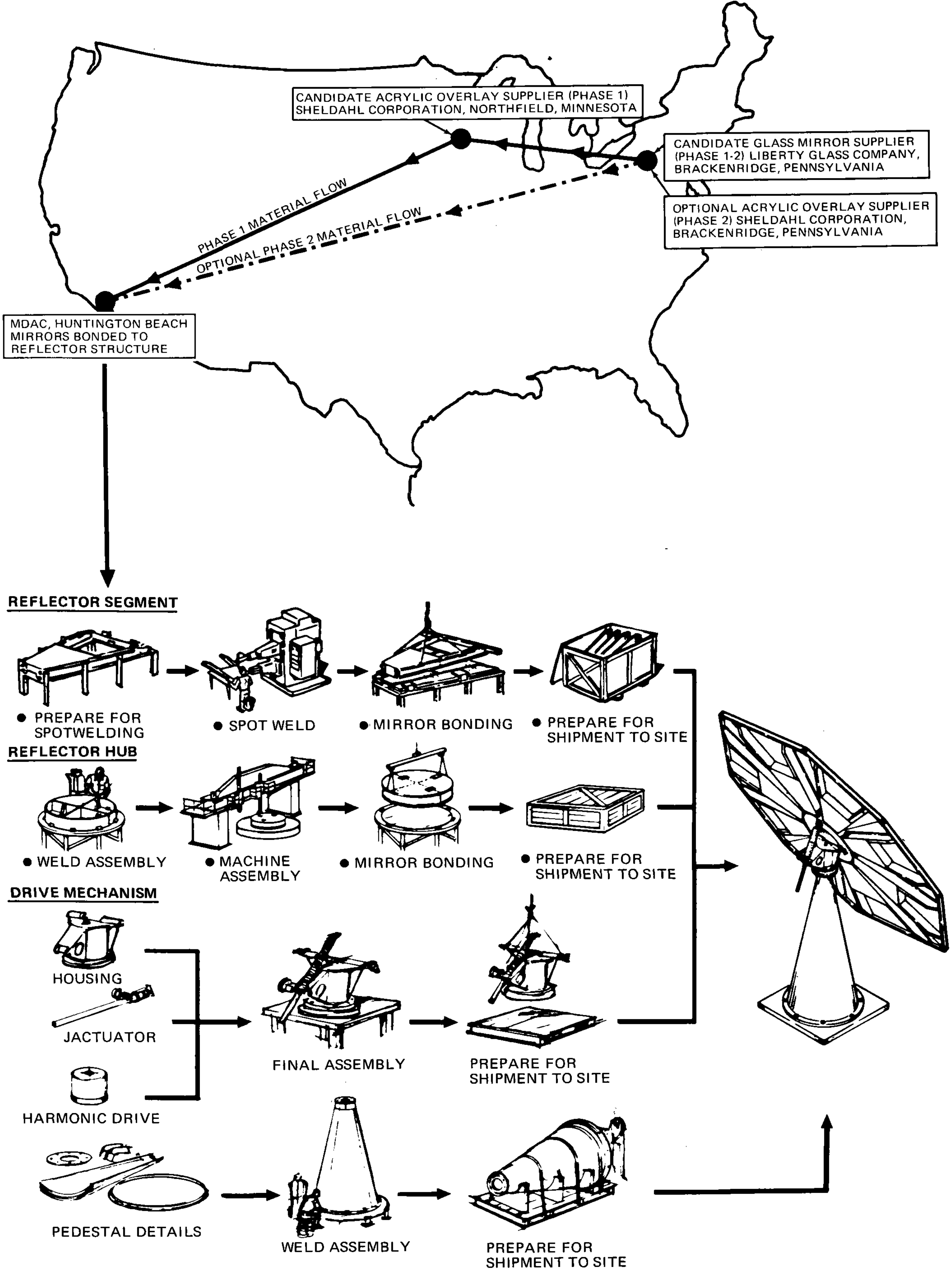

Figure 1-5. SRE Heliostat Fabrication and Assembly Approach

SC223E Foundation – Heliostat and sun sensor steel pedestals and concrete foundations will be provided. A foundation will also be provided for the sand and dust collection poles which gather airborne samples for environmental damage assessment. Following site selection and survey, a construction contractor familiar with the conditions and terrain at the site will be selected to install the concrete for the foundations. The contractor will be supplied with bolt locating templates so that the foundation bolts for the heliostat and sun sensor pedestal and dust collector base flanges will match the steel hardware assemblies.

The heliostat pedestals are formed and welded, low-carbon, sheet-steel cones with foundation and drive-mounting flanges. The sun-sensor pedestals are welded, low-carbon and steel pipe assemblies with foundation and sun-sensor mounting flanges. The sand and dust collectors are formed steel cones welded to the supporting, vertical pipe.

Four fixed heliostat pedestals and foundations, five fixed sun-sensor pedestals and foundations, and two fixed sand and dust collectors and foundations will be installed. One heliostat pedestal and one sun-sensor pedestal will be trailer-mounted and mobile. All fixed units will be bolted to the concrete foundations and the four heliostat pedestals will be filled with sand to increase their mass and consequently their stability.

SC223F Checkout and Installation – The heliostats will be assembled as units at the field test site using a trailer and a crane to lift completed assemblies into place on the pedestals. The one mobile heliostat will be assembled and installed on the trailer. The sun sensors will be attached to their pedestals after the heliostats are installed. Upon completion of the heliostat and sun-sensor installation, the array will be electrically connected to the field controller in the control and instrumentation van. Interconnecting cabling to the heliostat for control and instrumentation will be laid above ground using connectorless hard wiring. Operation checks will be performed as part of the engineering test plan described in Section 2 of Volume 3, Test Plan.

SC224* Tests and Evaluation – The objectives of this task are to plan, conduct, and evaluate the results of collector subsystem research experiments that will

- Verify the validity of the POCE collector subsystem design approach
- Provide an experience and data base for the establishment of POCE collector manufacturing, assembly, packaging, shipment, checkout, logistic support, and operational procedures.

All tests and operations conducted during the course of the SRE program will be documented and evaluated with the results integrated into the POCE preliminary design activity and the POCE (Pilot Plant) preliminary design report and review in accordance with CDRL item 2. Sheldahl and University of Houston personnel will assist MDAC in this task. Sheldahl will participate in all tasks; the University of Houston will assist in Subtasks SC224B and SC224D. The test flow diagram in Figure 1-6 identifies the proposed tests together with their general objectives. The following subtasks provide a description of the effort to be performed.

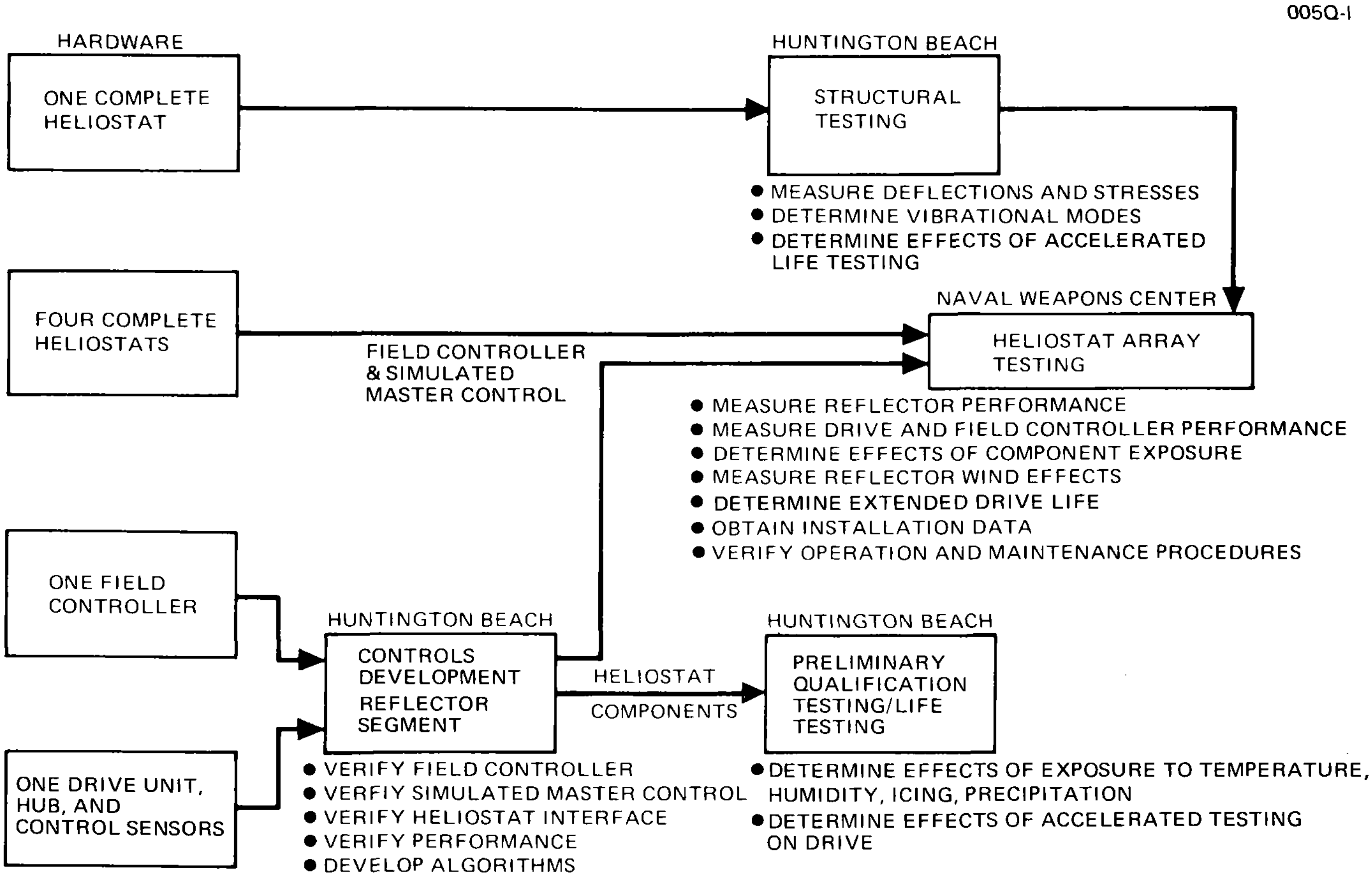

Figure 1-6. Collector SRE Testing Flow

SC224A Test Planning – An expanded version of the collector subsystem test plans presented in this proposal (Volume 3) will be prepared in accordance with the SRE collector subsystem requirement specification and the requirements of CDRL item 3. These plans will include the objectives and requirements for the MDAC Huntington Beach-conducted control development tests, the complete reflector surface/structural support structural static and dynamic tests, the environmental/extended-life tests of applicable collector subsystem hardware (including life-cycle testing of one segment of the reflector/structural support), and the heliostat array tests at the field site. Requirements for SRE test instrumentation will be analyzed and the number and type of measurements established. Available equipment items which satisfy existing requirements and a description of items to be built or purchased will be identified. These plans will be presented and discussed at the collector subsystem CDR scheduled for three months after start of contract. Subsequent to this review and approval, the individual test plans for each of the four major tests will be updated based on ERDA comments and the requirements of the updated collector subsystem requirements document (Task SC222*). These plans will incorporate the results of field site test planning discussions held with the Naval Weapons Center, China Lake. Detailed designs for the required test equipment identified within the test plans will also be accomplished during this period. At the collector subsystem DDR, the four test plans, prepared in accordance with the requirements of CDRL item 6 will be reviewed. The outputs of this subtask will be:

- Detailed test plans for the Huntington Beach tests
- Detailed designs of the required Huntington Beach and field site test equipment.

SC224B Test Setup, Installation, and Checkout – From the ERDA-approved test plans of Subtask SC224A, detailed test procedure drawings and operating instructions (CDRL item 13) will be prepared for conducting the Huntington Beach and China Lake tests.

Test preparation and operations for the Huntington Beach tests will include the assembly, installation, and checkout of the test hardware – reflector, structural support, drive, and control components. The test equipment (instrumentation, strip charts, support fixtures) and the facilities (circuit, structure, and environmental laboratories) will be scheduled and checked out. Total test coordination will assure readiness for the field controller development tests, structural tests, and environmental/extended life tests. Quality assurance personnel will verify the configuration of the test hardware.

Fabrication of steel targets required for receiver simulation during the heliostat field tests will be accomplished during this period. Preparations at China Lake for the heliostat array tests will include installation of the field controller, simulated master controller, target emplacement, equipment van modifications and emplacement, installation of communications and control cables, instrumentation of selective heliostats with strain gages and thermocouples, and placement of the heliostat/mobile trailer and mobile crane.

SC224C Test Operations – The objective is to perform the tests as planned, in accordance with the approved procedures, and obtain accurate, applicable test data. Complete operating instructions where applicable will be produced and submitted for ERDA approval at least six weeks in advance of testing. Four major tests will be conducted:

- The field controller assembly development tests will be a series of functional tests utilizing the heliostat mount, sensor, and a partial reflector with the field controller and a simulated commander. Tests will be performed to verify the field controller hardware and software, the field controller performance with the simulated master control, heliostat hardware interfaces, and overall operational performance. These tests will be conducted in MDAC laboratories.
- Structural tests will be performed to verify adequacy of the heliostat support design. A reflector surface, the structural support, and the drive and pedestal will be subjected to vibration and simulated wind load conditions. Deflection under load, strains, unit load influence coefficients, and vibration mode shapes and frequencies will be measured. These tests will be conducted in MDAC laboratories.
- Environmental/accelerated life tests will be performed on the heliostat mount, drive train, hub control, sensors, and a reflector segment. This equipment will be subjected to a variety of operations and environments over an extended test period. The drive train will be operated under

accelerated life conditions by slewing the hub in both axes so as to accumulate an equivalent operational life of 10 years or more, while simultaneously varying the environmental temperature and humidity. Combined thermal and simulated wind load cycles will be performed to verify the integrity of the reflection surface, structural support, and adhesive bond. The subassemblies will also be subjected to severe conditions of icing and rain. Simulated hail and sand/dust tests will be performed on the reflector segment. Tests will provide supporting data for wear rates, reliability, confidence level, MTBF and MTBR, mechanical integrity, and any degradation of the reflective surface and adhesive bond. These tests will be conducted in MDAC laboratories.

- Heliostat array tests will be the major SRE test activity for the collector subsystem. The five heliostat assemblies will be installed at the field test site. One of the five will be on a mobile trailer for operation at various locations relative to the target. Following verification of all operational and performance aspects of the heliostats during the active test program, the array will be placed in the "feathered" safe-stow position and monitored for an extended period to gain additional data on durability/life. The major objectives of this test series are an assessment of field layout, shading/blocking, multiple aim strategy, confidence level associated with calculating MTBF/MTBR, and reliability. Flux patterns for close up and far field positions with the mobile heliostat will also be obtained to verify the reflective surface performance. A digital image radiometer will be used to obtain near real time flux pattern, intensity distribution, and tracking accuracy data, and for automatic sensor realignment procedures. These tests are planned for the China Lake field site.

SC224D Test Data Evaluation and Documentation – Environmental, structural, and performance test data and verified test procedures from the Huntington Beach and China Lake tests and operations will be analyzed and the results integrated into the POCE preliminary design activities. As required, collector drawings will be upgraded to reflect required changes as a result of the tests. All test data analyses will be documented to support the project reviews (CDRL item 10) and the POCE PDR in accordance with the requirements of CDRL item 2. At the conclusion of the test program, the heliostat array and other SRE test hardware/ software will be disassembled and packaged for shipment in accordance with ERDA direction.

SC320* RECEIVER SUBSYSTEM RESEARCH EXPERIMENTS

The objectives of the receiver experiments are:

- Evaluate heat absorption capabilities of the absorber assembly
- Demonstrate the ability of the receiver control assembly to account for dynamically varying heat loads
- Demonstrate thermostructural interaction of the absorber with the receiver structure over repeated cycling
- Determine strain on the absorber assembly during repeated thermal cycles.

The required effort is described in Tasks SC321* through SC324*. An activity schedule for this task (Figure 1-7) shows the interrelationship of tasks and subtasks. This effort will be performed by the Rocketdyne Division of Rockwell International.

SC321* Conceptual Design – A conceptual design of the receiver subsystem will be prepared after establishing performance characteristics and requirements. The results will be reported to ERDA at the CDR per CDRL item 4. ERDA-requested changes will be incorporated for final approval before proceeding into the detailed design task. The University of Houston will assist in this design effort through the generation of receiver assembly flux distribution data.

SC321A Performance Characteristics and Requirements Analysis – Performance characteristics and requirements definition for the receiver SRE hardware will be obtained through analyses and tradeoff studies which have established the POCE receiver subsystem definition, operating modes, and requirements. Parameters such as absorber size, heat load, heat flux rates, and operating conditions will be selected to provide scalable engineering and lifetime data to the POCE system. Critical issues for POCE will be reviewed and related to the SRE design concept.

Overall receiver SRE performance will be analyzed with respect to absorption efficiency and pumping power requirements. SRE feedwater quality requirements will match those of the POCE pilot plant and commercial systems. These activities will include:

- Developing receiver flux profiles for all potential modes of operation and exposure of the POCE (Pilot Plant) and for all SRE test operations.
- Determining the receiver subsystem energy balance for critical and nominal receiver flux profiles, which considers all thermal losses, including the effects of variations in absorptivity and reflectivity of the receiver on the resulting steam quality. The optimum receiver geometry to maximize transfer of available incident energy to the working fluid will be identified.
- Analyzing energy availability and cycle life as affected by temperature, pressure, startup/shutdown rates, feedwater cycle characteristics and water quality, diurnal and cloud-induced cycles, elastic and inelastic deformations, the interrelationship of thermal storage/buffer requirements, and creep, fatigue, and other material properties.

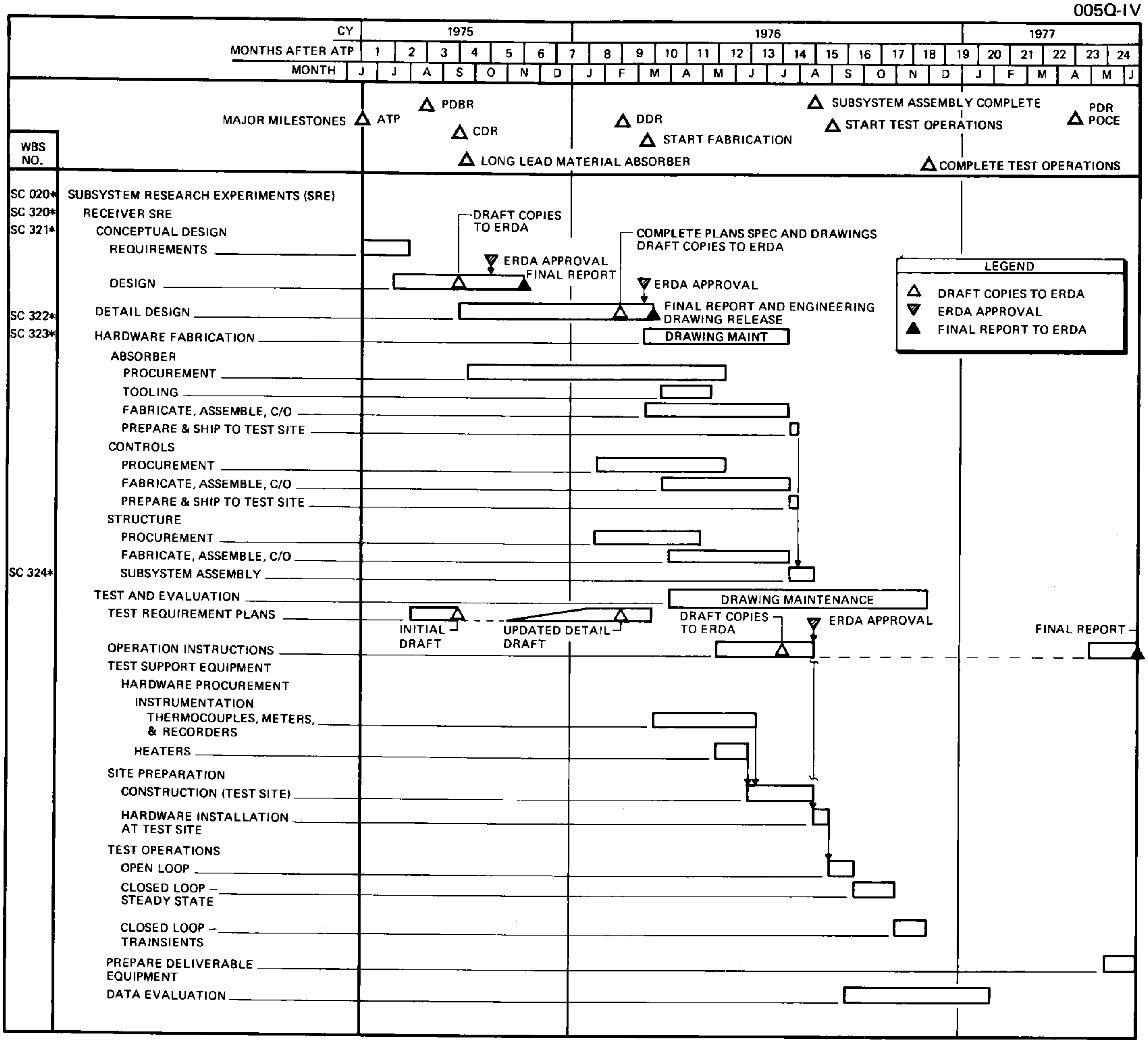

Figure 1-7. Subsystem Research Experiments – Receiver Subsystem

- Providing a structural analysis (static loads and stress analysis; dynamic loads, stress, and lifetime analysis) for operating conditions and specified natural environmental conditions, including the effects of dynamic wind and earthquake loads and of temperature and pressure cycling. Also, developing a nominal configuration to maximize cycle life.
- Developing flow control system design requirements in order to maintain the desired steam conditions within the absorber. Defining method of working fluid flow control in order to maintain the desired steam conditions.
- Identifying the cost and schedule of those long-lead time hardware material items (e.g., valves and boiler/superheater tubing) requiring procurement approval during the detail design period.

The results of these activities will be presented for review at CDR (CDRL item 4), for ERDA approval.

SC321B Design and Analysis – Studies and analyses will be performed to identify and establish detailed characteristics and performance requirements consistent with the subsystem requirements established in Subtask SC321A for the absorber, structure, and controls of the receiver subsystem. Heat transfer, stress, dynamics and functional analyses will be performed for the absorber to ensure compatibility with subsystem life and operational requirements. Components will be evaluated at temperature and pressure extremes to verify proper functioning.

The structural design effort will establish the method of attaching the absorber to the structure and the means of insuring structural compatibility between the hot absorber and the relatively cool structure. The method of providing for thermal expansion and the effects of the thermal stress and thermal cycling will be determined. The structural design will provide capability of operating the receiver with the specified wind loading from all quadrants.

The control system design effort will concentrate on definition of the method of maintaining the desired working fluid flow rates. This effort will include analyses and computer simulations to define stability characteristics, control system accuracy and response characteristics, and interactions among the controls and other assemblies.

A conceptual design will be developed for each of these subassemblies to satisfy the derived detail performance characteristics and requirements. The scaling relationships of the SRE and POCE and the prototype receiver subsystem will be established. Drawings and reports will be prepared to document the results of the analyses and conceptual design in accordance with CDRL item 4. Test planning activities will be conducted concurrently with these design activities as a part of Task SC324*.

SC322* Detailed Design – A detailed design of a receiver unit will be prepared for the SRE. After ERDA approval at CDR, detailed design requirements and performance characteristics will be established, and procurement of long-lead-time items will be initiated. The design will be presented to ERDA at the DDR in accordance with CDRL item 7. MDAC will incorporate ERDA corrections and submit the report for approval. The following subtasks provide further definition of the activities.

SC322A Refine Design Requirements – Detailed design requirements will be expanded including power levels, and component requirements other than those established for CDR, and will be sufficiently detailed that subsequent design descriptions will permit fabrication and assembly of all test hardware.

SC322B Design and Analysis – The conceptual designs of Task SC321* will be analyzed with respect to manufacturing techniques and processes, practical dimensional tolerances, and reliability, maintainability, and safety aspects. Detailed designs will be completed for the receiver unit, including the absorber, distribution and collection, structure, and controls subassemblies.

Documentation will be provided in the form of layouts and detail drawings for fabrication, processes, assembly, and installation.

SC323* Hardware Fabrication – The receiver test hardware will be fabricated to the detailed designs of Task SC322*. Manufacturing engineers will coordinate with design engineers to achieve producibility with minimum cost, and to assure that the SRE designs will verify POCE manufacturing processes and techniques. Quality of the test hardware will be verified by inspection. Coordination will be achieved by scheduled in-house reviews with MDAC representation. A fabrication flow sequence in Figure 1-8 illustrates initial planning for the receiver SRE hardware production.

SC323A Absorber Fabrication – Upon ERDA approval of DDR, SRE absorber hardware will be fabricated and assembled to the approved detail design. Tubes comprising the absorber surface are stacked and joined by brazing them to lateral supporting bands. These bands are then welded to the structural supports which provide a tie-in to the main receiver structure. The light-tightness of the absorber shall be guaranteed by providing a nonstructural backup to the panel of tubes. Subsequently, manifolds will be attached by welding together with supply and discharge lines.

SC323B Structure Fabrication – Upon ERDA approval of DDR, SRE structure hardware will be fabricated and assembled to the approved detail design. The structure is fabricated from structural steel on the test site where the basic structure already exists in the form of a tower. Structural adaptation to mount the

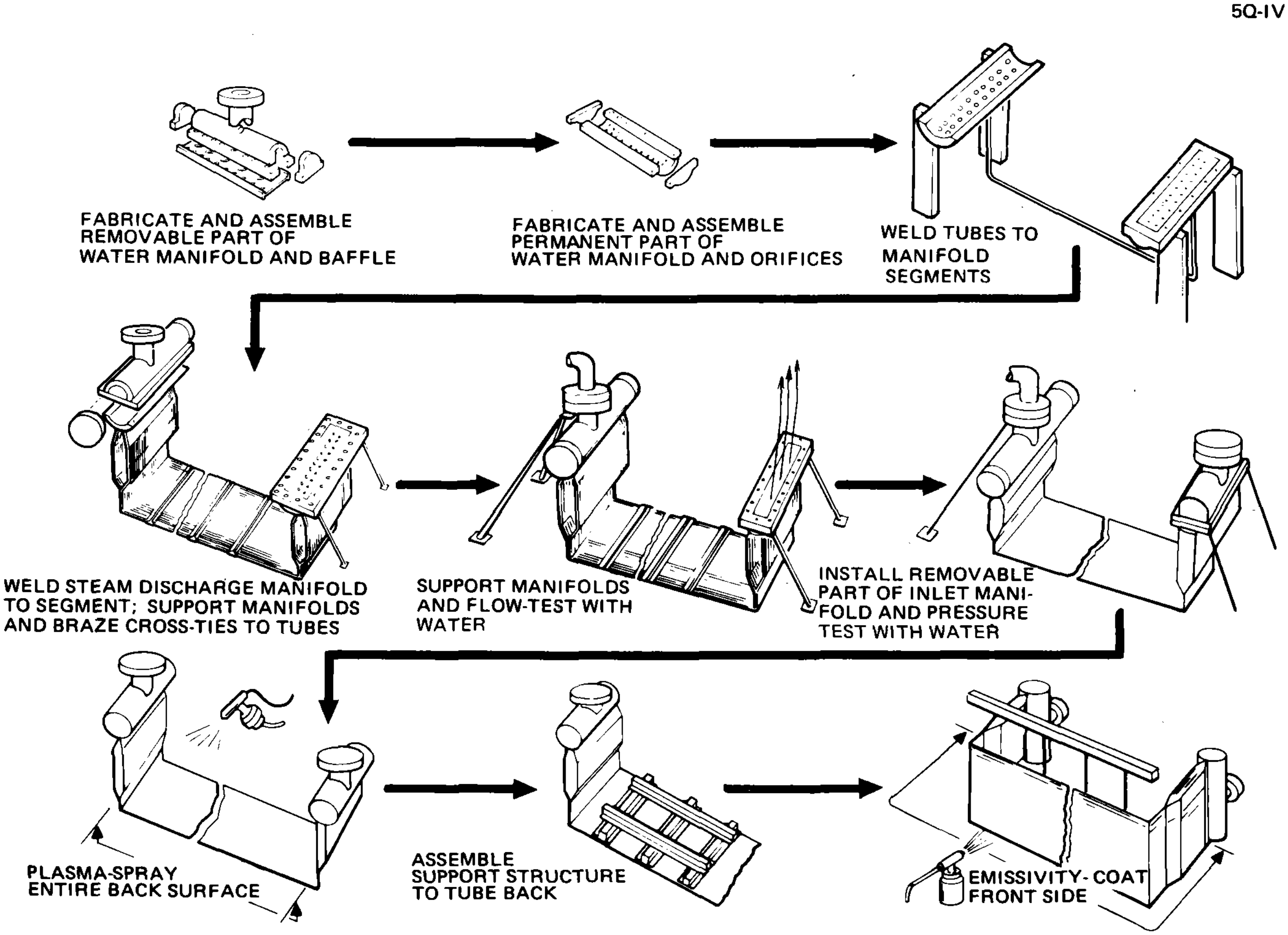

Figure 1-8. Receiver SRE Fabrication Flow

SRE receiver on the tower will be provided.

SC323C Controls Fabrication – Upon ERDA approval of DDR, the SRE controls hardware will be procured and assembled to the approved detail design. The controls will include commercial stop/check valves, a water flow control valve, controller, and the pressure, temperature, and flow instrumentation.

SC323D Checkout Tests and Coordination – Functional and structural checkout tests of the SRE receiver will be performed to ensure that the hardware is "test-stand worthy." These tests include checks for leakage, valve functions, electronics equipment functions, proof pressure and blockage in tubing and piping, and X-ray of welds and structure joints.

SC324* Tests and Evaluation – Receiver SRE hardware tests and evaluation will be conducted when ERDA approves the test plans, procedures, test sites, and configurations presented at the receiver CDR (CDRL item 4) and receiver DDR (CDRL item 7). Complete operating instructions will be generated for support of the tests and submitted to ERDA six weeks prior to start of testing (CDRL item 13). ERDA will be notified prior to each test so that representatives may attend. The results of each test will be documented for inclusion to the POCE preliminary design effort (CDRL item 2) and the project reviews (CDRL item 10). The proposed receiver SRE test program is presented in a flow diagram (Figure 1-9) where the tests and basic objectives are identified. The tests and evaluation will be accomplished under the following subtasks.

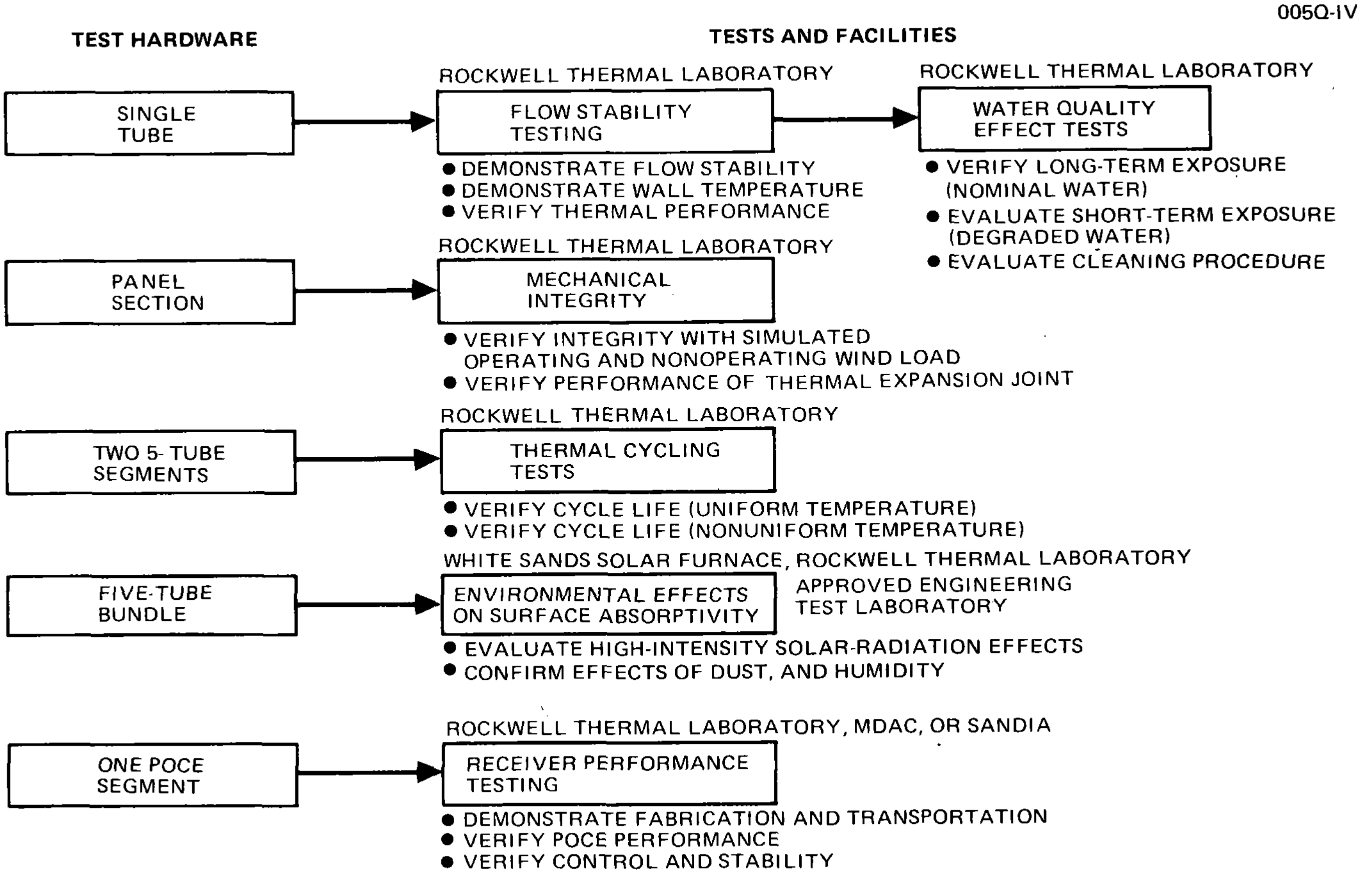

Figure 1-9. Receiver SRE Testing Flow

SC324A Test Planning – The proposal test plans (see Volume 3) for the receiver SRE hardware will be updated based on the test requirements established in the receiver specifications and design activities. The information will include detailed test objectives, test schedules, and equipment and facility requirements for each identified engineering, preliminary qualification, and extended life test. Test plans will include the results of the system effectiveness allocations and analyses as defined under Task SC061B. In accordance with CDRL items 4 and 7, these plans will be submitted to ERDA for review and approval prior to test initiation.

SC324B Test Setup, Installation, and Checkout – This task includes the test setup, installation, and checkout of the receiver hardware and supporting test hardware. From the ERDA-approved test plans, test procedure drawings detailing how the test is to be conducted will be prepared for each test. In addition to these drawings, operating instructions for the receiver will be provided in accordance with CDRL item 13. With ERDA approval, the receiver SRE hardware will be installed at the Rockwell International Thermal Laboratory and facility operational connections made. Additional facility equipment to provide a radiant heat source to achieve proper test conditions; 2.5 MWth heat load, 0.3 MW/m^2 peak heat flux and 1.5 kg/sec flow at absorber rated conditions will be installed and checked out. Complete facility checkout tests will be conducted prior to actual SRE testing.

SC324C Test Operations – The receiver SRE tests as approved by ERDA in the DDR, CDRL item 7, will be conducted in this subtask. All testing will be in accordance with detailed test procedures and, where required, operating instructions for the test specimen. The following tests will be conducted:

- **Flow Stability Tests** – A series of engineering tests will be performed with a single tube conforming to the POCE design. The flow stability tests will have the following objectives: demonstrate flow stability in a single tube, demonstrate safe tube wall temperature, and verify thermal performance.

A single full-size POCE tube will be tested. The surface will be coated to enhance absorptivity. A second tube (to be selected based on test results for the first tube) having a different inside diameter will also be tested. Each tube will be profiled with two different inlet orifices. All measured data will be correlated with the test conditions. Plots will be prepared of tube wall temperatures, heat-transfer efficiency, and the drop in pressure vs these conditions. Heat flux and flow rates will exceed POCE design conditions. Regions of stability will also be identified.

- **Water Quality Effects Tests** – The test setup used for the preceding tests will also be used for preliminary qualification tests to ensure that tube scaling does not occur at an excessive rate under POCE operating conditions. The water quality effects tests have the following objectives: determine effects of long-term exposure to nominal quality water, determine effects of short-term exposure to degraded quality water, and veryify cleansing procedure.

Tests will simulate actual operating conditions including the diurnal temperature cycling. Test data will be correlated to produce tube wall temperatures and fluid pressure drop vs operating time. Quantitative degradation in receiver performance and pumping requirements vs operating time will be calculated from these data. Flushing effectiveness will be established.

- **Mechanical Integrity Tests** – A series of engineering tests will be conducted on a section of the SRE panel which represents the basic POCE structural module. The mechanical integrity tests have the following objectives: verify the integrity of the panel under simulated wind loading for both operating and nonoperating conditions, and verify the adequacy of panel supports to accommodate thermal expansion.

Both test objectives will be met in one series of tests, with the panel in the loaded condition. A second series will be performed to verify the panel structural integrity to a higher simulated wind loading in the nonoperating condition. Test measurements will be correlated to provide data on panel deflections vs temperature under simulated wind loading. Temperatures will exceed those specified for the POCE receiver. The ability to accommodate thermal expansion with relative temperatures of the panel and support exceeding POCE conditions will be verified.

- **Thermal Cycling Tests** – A series of preliminary qualification tests will be conducted on sections of the SRE panel which are critical with respect to thermal fatigue life. The thermal cycling tests have the following objectives: demonstrate life of tubes under laterally uniform heat flux and/or flow condition, and demonstrate life of tubes under laterally nonuniform heat flux and/or flow conditions.

The test hardware consists of two segments of an SRE panel, identified with the POCE design. One segment consists of five POCE tubes joined together by bands of exactly the same configuration as in the POCE panel and plasma sprayed with Inconel.

The second panel is similar to the first except for the manifolding. In the second panel, the center of the five tubes is manifolded independently from the other four so that flow to the center tube can be controlled independently from the two tubes on either side of it.

A series of tests on the first specimen will verify the life of the tubes under laterally uniform conditions. The second specimen will be used to verify the tube life under laterally nonuniform conditions in another series of tests. Strains will be calculated from the temperature data. The actual failure point, if it occurs, will be compared with the predicted value for both specimens. The ability of the tube to survive up to 10,000 thermal cycles under both optimum and nonoptimum conditions will be demonstrated.

- **Environmental Effects on Surface Absorptivity** – Preliminary qualification and life tests will be performed on the receiver surface absorptivity coating. The absorptivity coating tests have the following objectives: determine the effect of high-intensity solar insolation on panel surface absorptivity, and determine the effect of dust and sand on panel surface absorptivity.

Two specimens each consisting of five POCE type tubes will be fabricated. The general procedure for these tests will be to measure the absorptivity, expose the sample to the specified environment, and then remeasure the absorptivity.

Pre- and posttest absorptivity measurements of coated and uncoated panel sections will be correlated with the actual test conditions to establish the ability of the surface to withstand the specific environments.

- **Receiver Performance Tests** – Engineering tests will be conducted with an absorber and controls that are identical to the POCE elements. The tests will be conducted over ranges of interfaces and operating conditions which equal or exceed POCE design values. The receiver performance tests have the following objectives: demonstrate POCE absorber fabricability, weight, and transportability, verify POCE receiver performance, verify control and stability of POCE segment, verify thermal stress and expansion provisions, and demonstrate preliminary receiver unit reliability.

The test hardware consists of a complete segment of the POCE receiver absorber and controls. Two orifice sets are included which are representative of maximum and minimum orificing for panels on the north and south sides of the receiver.

Fabricability and transportability will be demonstrated by making a full-scale POCE panel, including structural members and coatings, and transporting it to the test site. POCE absorber performance will be demonstrated by applying radiant heat flux profiles that simulate POCE conditions with diurnal, seasonal, and geometric (North-South orientation) variations. Stability and control of the POCE receiver segment will also be demonstrated during these tests.

The measured weight and dimensions of the absorber will be compared to design values. Dimensional variations will be used to establish tolerances for interchangeability of panels. Incident energy will be correlated with energy transferred to the water for all steady-state test conditions. The incident heat flux profile will be mapped at various power levels. Control valve position, steam flow rate and temperature, and tube wall temperature transients will be plotted vs heat flux transients. Maximum safe transients and steady-state operating conditions will be determined, based on tube wall and steam temperatures. Subsystem pressure drops will be correlated with operating conditions. Component dynamic characteristics will be determined. Regions of instability, if any, will be mapped.

SC324D Test Data Evaluation and Documentation – Test data collected from each test will be evaluated and documented to support the project reviews (CDRL item 10) and the POCE preliminary design activity (CDRL item 2). These data will also be presented to ERDA and program management at periodic intervals for assessment of overall receiver SRE status and progress. At the conclusion of the test program, the SRE test hardware will be disassembled and packaged for shipment as directed by ERDA.

SC420* THERMAL STORAGE SUBSYSTEM RESEARCH EXPERIMENTS

The basic objectives of the thermal storage SRE are:

- Evaluate charging and extraction capabilities of a scalable thermal storage unit (TSU)
- Obtain performance of the TSU over all ranges of operating conditions for the POCE
- Demonstrate stable operation for high, low, intermittent, and no insolation conditions
- Demonstrate changeover capabilities from one operating mode to another and emergency response modes
- Develop requirements and techniques for treating the heat transfer fluid to permit 30 year lifetime with make up
- Determine the additional strain on container walls during repeated thermal cycling.

Two preliminary qualification test series have been included in the thermal storage SRE plans as described in SC424C. These are laboratory experiments needed to substantiate the design and sizing of the SRE test hardware and do not involve any special equipment design. Approval will be requested for initiation of these special tests in the first month of the program.

The effort required for this SRE is described in the following tasks (SC421* through SC424*). The thermal storage SRE schedule in Figure 1-10 identifies the task breakdown and illustrates the interrelationship of the various activities. Rocketdyne will perform the major portion of this SRE design effort and all of the testing. The proposed test series for the thermal storage SRE program is presented in Figure 1-11. Test objectives and facilities are included.

SC421* Conceptual Design – The objective of this task is to establish the performance characteristics and requirements for the thermal storage unit upon which a conceptual design will be based. The results will be reported to ERDA at a CDR (CDRL item 5). Upon receipt of ERDA comments and approval, the detailed design task will proceed. A detailed description is provided in the following subtasks.

SC421A Performance Characteristics and Requirements Analysis – Performance characteristics and requirements definition of the thermal storage unit SRE hardware will be obtained through analyses and trades of the POCE thermal storage subsystem definition, operating modes, and requirements. Parameters such as unit size, charge and discharge rates, and operating conditions will be selected to provide engineering and lifetime data on the POCE system.

Overall thermal storage subsystem performance will be analyzed from the standpoint of heat absorption and transfer efficiency, charging and extraction performance, stable operation, and structural integrity. Heat transfer medium maintenance requirements for lifetime and temperature conditions of the SRE will be determined in a manner applicable to the POCE and commercial systems.

These activities will include but not be limited to the following:

- Development of a detailed analytical thermal and dynamic model, including transient conditions, capable of providing component operating and nonoperating temperature limits. The model will

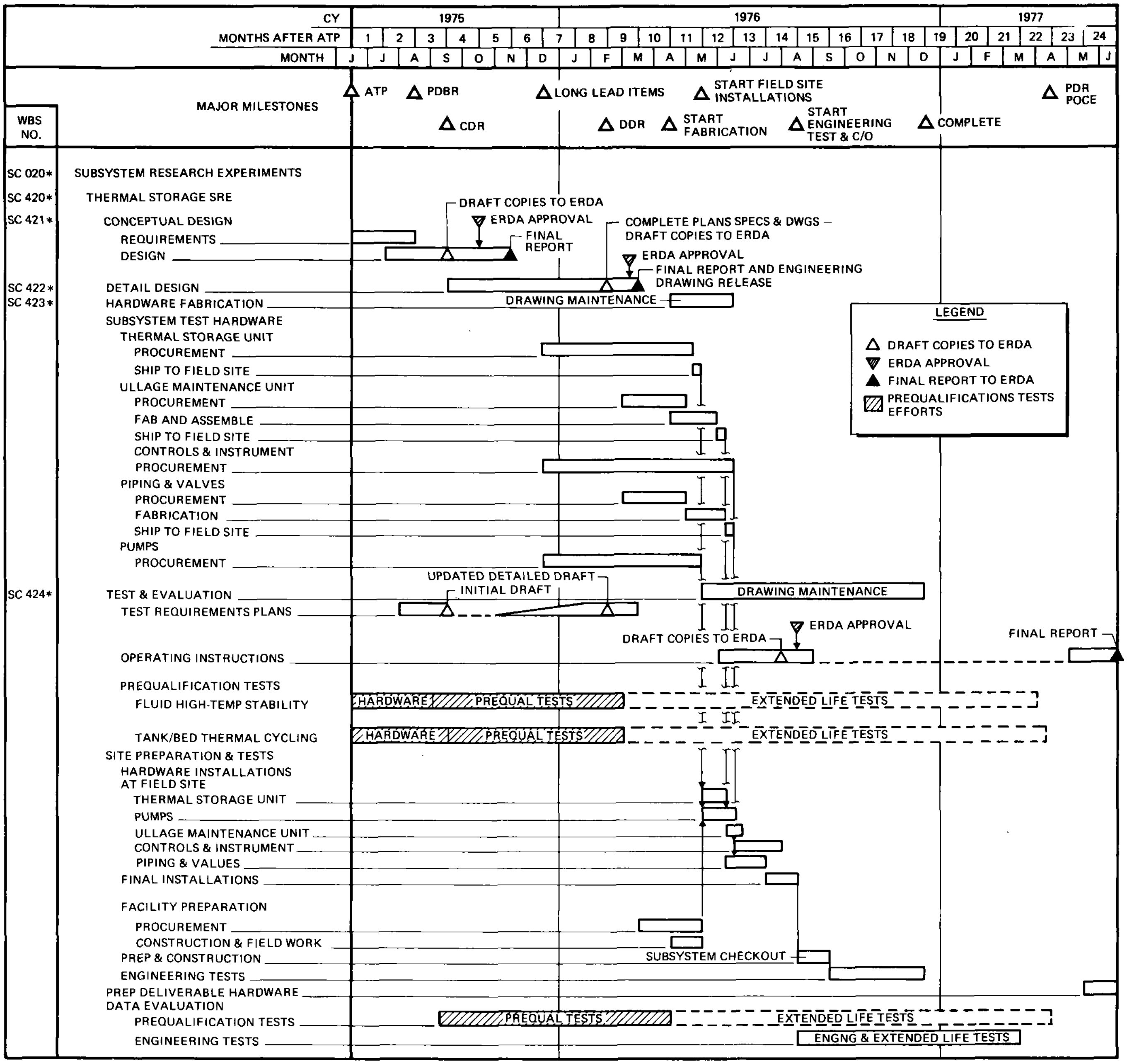

Figure 1-10. Subsystem Research Experiments – Thermal Storage Subsystem

include thermal energy balance considerations under nominal and extreme levels of operational and environmental conditions. All thermal energy losses and heat exchanger effectiveness will be defined. The model will be largely based upon an existing Rocketdyne model which has been programmed for a digital computer and used for parametric design calculations.

- Performance of stability analyses of the proposed control loop(s) for maintaining proper flow rates and heat exchange of operating fluids.
- Determination of the effects of all off-nominal operations of the thermal storage subsystem on the receiver and electrical power generation subsystem and that these effects are consistent with the POCE (Pilot Plant) requirements.

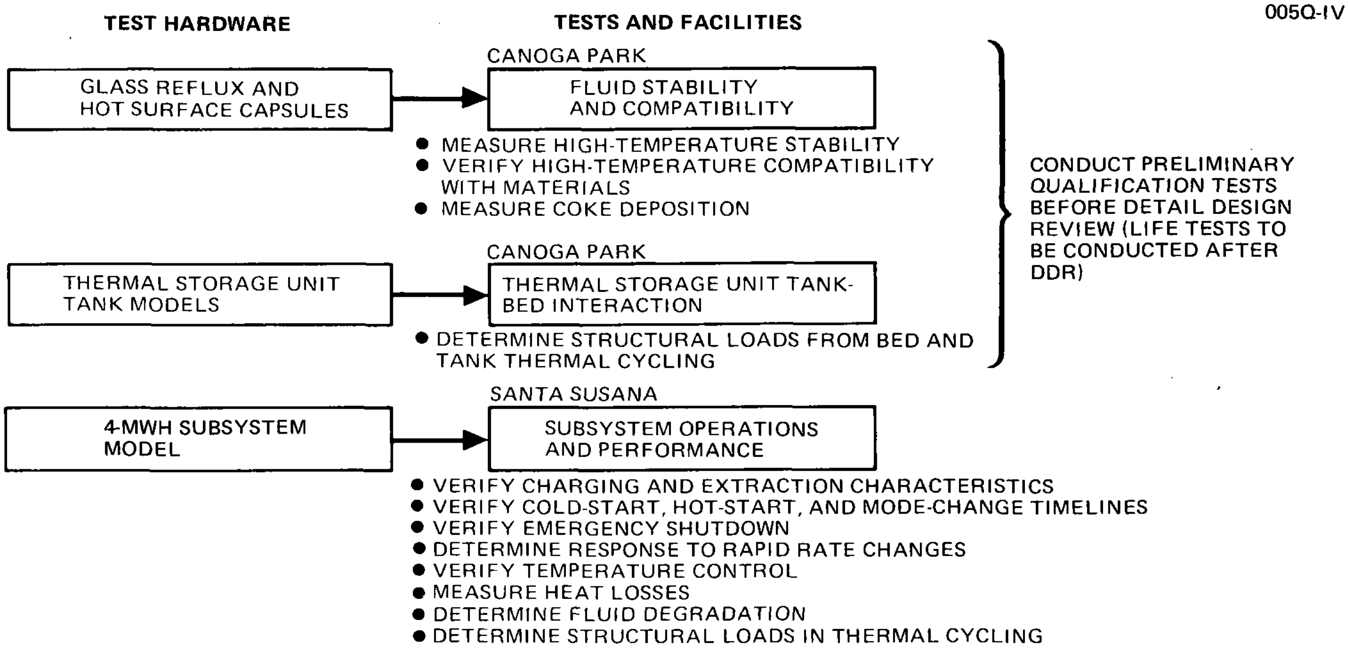

Figure 1-11. Thermal Storage SRE Testing Flow

SC421B Design and Analysis – Studies and analyses will be performed to identify and establish detailed characteristics and performance requirements consistent with the subsystem requirements established in Subtask SC421A for the following modules of the thermal storage subsystem – thermal storage unit, thermal charging loop, energy extraction loop, and controls.

For the thermal charging and energy extraction loops, structural and functional analyses will be performed to ensure compatibility with subsystem life and operational requirements. Components will be evaluated to verify proper functioning at temperature and pressure extremes. Long-lead-time materials or components and their cost and schedule impacts will be identified for possible early procurement action. MDAC recommendations on these items will be presented at the CDR for ERDA approval.

The controls analysis effort will define the method of maintaining the desired working fluid flow rates, pressures, and temperatures. The scaling relationships between the research experiment and POCE and the prototype thermal storage subsystems will be established.

For each of these modules, a conceptual design will be developed to satisfy the derived performance characteristics and requirements. Drawings and reports will be prepared to document the results of the analyses and conceptual design in accordance with CDRL item 5. Test planning activities will be conducted concurrently with these design activities as a part of Task SC424*.

SC422* Detailed Design – The objective of this task is the preparation of a detailed design of the thermal storage subsystem for the SRE. Detailed design requirements and performance characteristics will be established from the results of Task SC421*. Design activities and procurement of long-lead-time items will be initiated after ERDA approval at the CDR. These requirements and designs will incorporate all changes to the concepts required by ERDA. The detailed designs will be presented per the requirements of CDRL item 8 to ERDA at the DDR meeting eight months after ATP. MDAC will incorporate any ERDA comments and provide a final submittal within 10 months from ATP. The following subtasks describe the detail of this activity:

SC422A Refine Design Requirements – Detailed design requirements will be generated including lower level component requirements not established during conceptual design. These requirements will be sufficiently detailed to provide design definition permitting fabrication and assembly of all elements of the SRE hardware.

SC422B Design and Analysis – The conceptual designs of Task SC421 will be analyzed with respect to manufacturing techniques and processes, dimensional tolerances, and reliability, maintainability, and safety aspects. The results will be detailed designs for the storage tank, thermal charging and energy extraction loops, and controls.

Documentation will be provided in the form of a complete set of layouts, updated specifications, and detail drawings for fabrication, assembly, and installation. Test planning for this SRE will be a concurrent activity as part of Task SC424*.

SC423* Hardware Fabrication – The objective of this task is to produce the hardware required for the thermal storage subsystem model SRE. This activity will commence after ERDA approval at the DDR. Fabrication of all SRE hardware shall be in accordance with the approved detail design. Manufacturing planning will control fabrication and assembly of parts in accordance with the engineering design requirements. Hardware configuration and quality will be confirmed by inspection techniques.

SC423A Thermal Storage Unit Fabrication – Fabrication of the thermal storage unit by a qualified supplier will proceed in accordance with the approved detail design. Quality assurance will verify by inspection the conformance of this hardware to the design definition approved by ERDA. Following shipment to and erection of the tank at the test site, a final inspection will be performed and the tank then will be covered with an external insulation material.

SC423B Thermal Charging Loop Fabrication – The necessary fabrication related to the thermal charging loop comprises piping fabrication plus installation of the thermal charging loop pump. Thermal charging heating is provided by the facility; only connections to the facility equipment will be necessary. Pump installation, piping fabrication, and valve installation will be accomplished at the field site, except where specific piping spools can be more effectively prefabricated in the shop.

SC423C Energy Extraction Loop Fabrication – The necessary fabrication related to the energy extraction loop comprises piping fabrication plus installation of the energy extraction pump. Steam generation (heat rejection) is provided by the facility; only connections to the facility equipment will be necessary. Pump installation, piping, fabrication, and valve installation will be accomplished in the field as noted in task SC423B.

SC423D Control System Fabrication – The control assembly will be assembled from commercial components. Fabrication will consist of assembly and installation of the purchased components.

SC424* Tests and Evaluation – The tests and evaluation of the thermal storage SRE model hardware will be performed in accordance with SRE test plans as presented at the design reviews. No tests will be initiated prior to DDR approval by ERDA of the test plans, test sites, and configurations. Before each test is initiated, ERDA will be notified so that representatives may attend. The results of each test will be documented for inclusion in the POCE preliminary design report (CDRL item 2) and the project reviews (CDRL item 10). The tests and evaluation will be accomplished under the following subtasks.

SC424A Test Planning – The objectives of this subtask will be to produce engineering, prequalification, and life test plans for the thermal storage SRE hardware based on the test requirements established in the SRE specifications and design activities. Test plans will include complete definition of test objectives and descriptions, schedule, test support equipment, test facilities, and data requirements. Test objectives will also reflect the results of the system effectiveness allocations and analyses as defined under Task SC061B.

SC424B Test Setup, Installation, and Checkout – The objectives of this task will be to prepare detailed test procedures and prepare the test setup, installation, and checkout of the thermal storage subsystem hardware and supporting test hardware. The subsystem model SRE hardware for the major test series in this task will be installed at the Rocketdyne Santa Susana Field Laboratory subject to approval by ERDA. Complete facility checkout will be conducted prior to actual SRE testing commences.

Test procedures for each test will detail the step-by-step method by which each test will be conducted. In addition, operating instructions for the thermal storage subsystem hardware will be prepared and provided in accordance with CDRL item 13.

SC424C Test Operations – The objective of this subtask is to perform the test program comprising three sets of tests:

- Fluid stability and compatibility tests
- Tank/bed thermal cycling interaction tests
- Subsystem operations tests.

The first two test series are laboratory-scale prequalification and life tests. The third test series refers to the test program submitted at the DDR (CDRL item 8) and will be conducted in accordance with the detailed test procedures developed in Subtask SC424A.

Fluid Stability and Compatibility Tests – The objective of this test series is to provide the POCE design requirements related to thermal stability and fluid maintenance requirements. Twenty-four test setups will be run with overlapping scheduling for periods from 2 to 20 months. Each test setup will involve one of two candidate heat transfer fluids (Caloria HT43 and Therminol 55) held at a constant temperature and in contact with either an inert glass container, rock, construction materials, or a heated metal tube. Periodic sampling and measurements will be made to determine the stability of the fluid and its compatibility with the materials. The tests will be conducted in a chemical laboratory under controlled laboratory conditions at Rocketdyne.

Tank/Bed Interaction Tests – The objective of this test series, dealing with tank/rock bed stress interactions, is to support the development of a model for tank stresses which will be used for life design analysis. Two small-scale test tanks with rock beds will be fabricated and tested by thermal cycling over a temperature range of approximately 83°C (150°F). Caloria HT43 will be used to heat and cool the model tanks. The operation will proceed on a continuous basis with automatic control to provide the maximum number of thermal cycles during the program. These tests will be conducted in a Rocketdyne laboratory.

Subsystem Operations Tests – The objective of the subsystem model tests is to establish the thermal charging and heat extraction capability of a 4-MW-hr thermal storage subsystem. The proposed test facility setup is shown in Figure 1-12. The subsystem will be tested in various operating modes and with charging and extraction over a wide range of rates. These rates will correspond to a range of heat transfer fluid temperatures and flow rates. A cutaway illustration of the thermal storage test unit is presented in Figure 1-13.

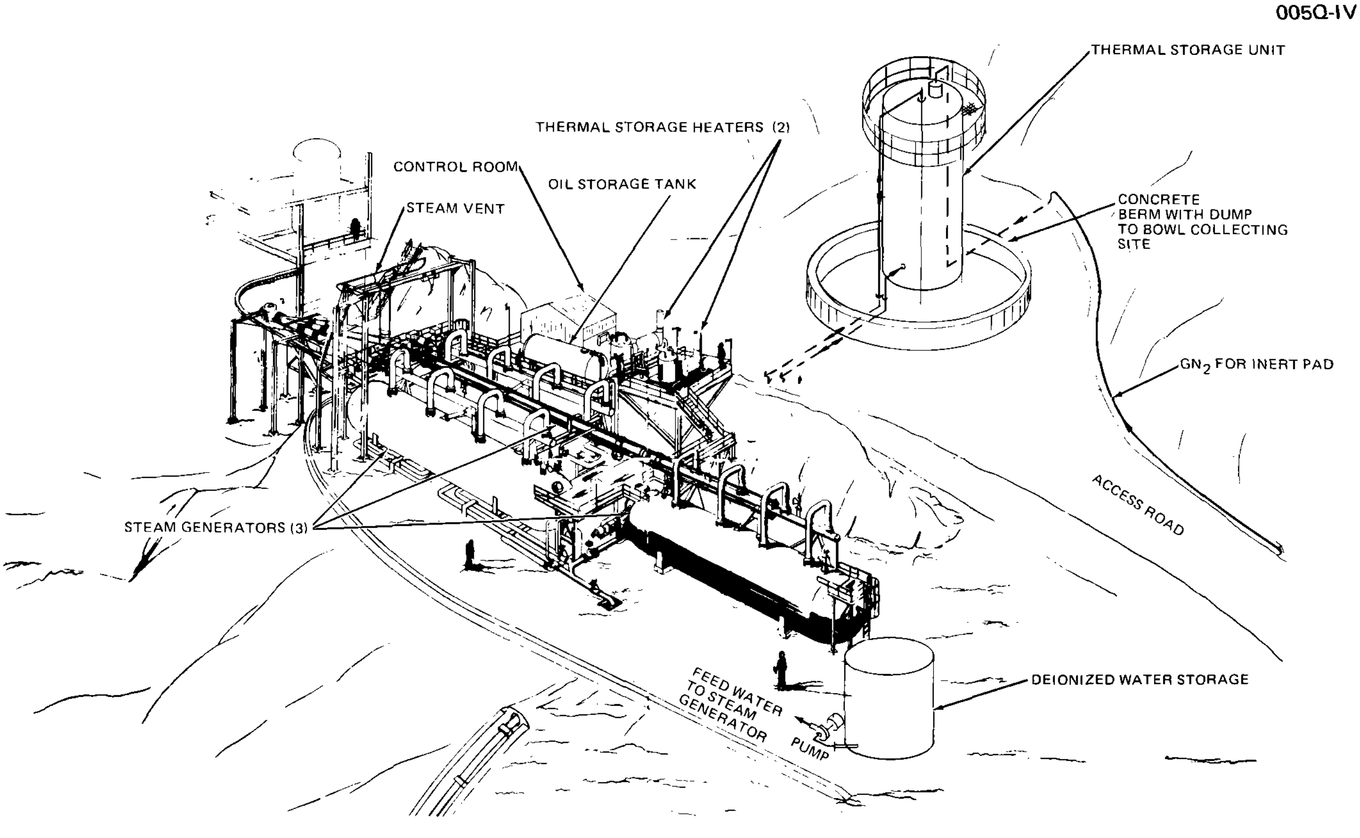

Figure 1-12. Recommended Thermal Storage SRE Test Site

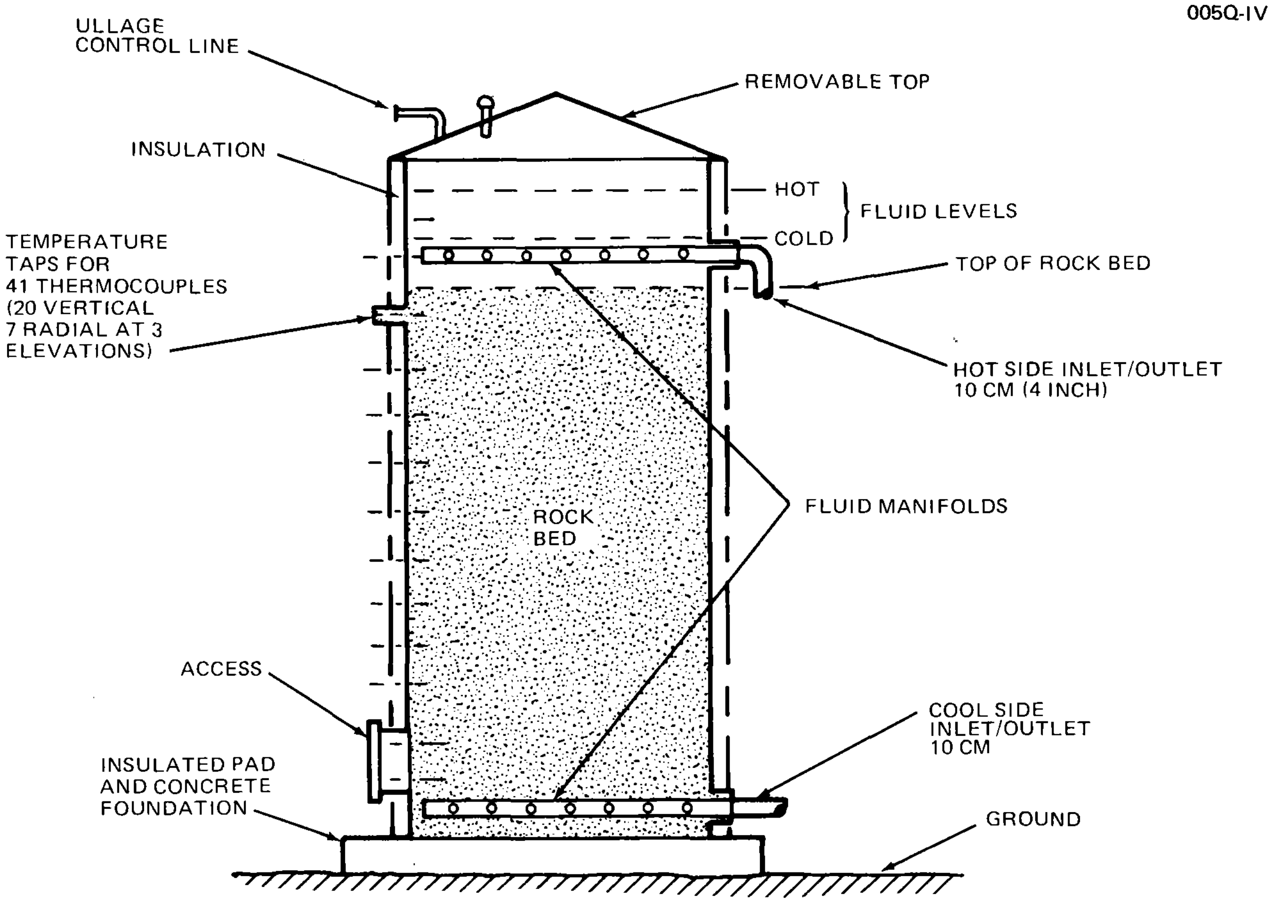

Figure 1-13. Thermal Storage Unit

Tests will commence with an initial warmup of the thermal storage unit through operation of the thermal charging loop. Following this, the system will be operated to establish the charge/discharge capabilities of the subsystem. The full scope of tests will then be conducted. These will include, but not be limited to:

- The thermal energy recovery conditions (efficiency, temperature) as a function of all variables representative of POCE operation
- The subsystem response to duty cycles simulating all normal and emergency operating modes as well as transitions between modes
- The suitability of the heat transfer fluid, its design temperature, and appropriate fluid maintenance methods for the POCE.

These tests will be conducted at the Rocketdyne Santa Susana facility.

SC424D Test Data Evaluation and Documentation – Test data collected from each test, including the two preliminary qualification tests, will be evaluated and documented to support the project reviews (CDRL item 10) and the POCE preliminary design activity (CDRL item 2). These data will also be presented to ERDA and program management at periodic intervals for assessment of overall thermal storage SRE status and progress. At the conclusion of the test program, the thermal storage unit and other SRE test hardware and software will be disassembled and packaged for shipment as directed by ERDA.

SC040* SUPPORT EQUIPMENT

The objectives of this task are to identify and provide maintenance and simulation support equipment required for the conduct of the SRE's. Based on this SRE experience and after analyzing POCE design, performance and operational requirements, support equipment requirements for the POCE subsystems and pilot plant will be identified. The schedule for these activities is presented in Figure 2-1, Section 2.

SC041* Maintenance Equipment

This task first identifies the need for maintenance equipment and then establishes the most efficient means of satisfying the need. For SRE operations, equipment will be purchased when it is available and more economical to do so. From SRE operations experience, the identification of maintenance equipment required to maintain and support the POCE subsystems and pilot plant during POCE operations will be established.

SC041A SRE Maintenance Equipment – The equipment and tools required to maintain and support the SRE hardware will be identified by analyzing the SRE hardware designs, test plans, test descriptions, and operational requirements including the consideration of any peculiar test location requirements. These analyses will include coverage of the collector, receiver, and thermal storage subsystems. With the requirements established, the availability of off-the-shelf equipment that meet the requirements will be investigated. When the need for a new design is defined, conceptual and detailed designs will be accomplished for reviews at the SRE CDR's and DDR's, respectively. Subsequent to these reviews and ERDA approval, the maintenance equipment will be fabricated.

Present planning indicates that the collector subsystem maintenance equipment requirements will be limited to:

- Sensor boresight adjustment telescope
- Reflector assembly handling sling
- Segment lifting device.

The boresight telescope will be used to provide initial heliostat-sensor-target alignments. The handling sling and lifting device will be used during assembly or transportation operations.

The receiver SRE operations analysis has presently identified only one piece of equipment – the receiver unit combined assembly/transportation fixture. This fixture will be used initially to stack the absorber tubes and hold them in place while brazing the absorber structure. This fixture also will be used in the welding of water inlet and steam discharge manifolds. During transportation by truck to the test site, the fixture will support the assembly. Finally it will provide the means of mounting the panel to the simulated receiver structure at the Rockwell International El Segundo test site.

No special maintenance equipment requirements have been identified for the thermal storage SRE at this time.

At the conclusion of the SRE test activity, all maintenance equipment will be packaged for shipment as directed by ERDA.

SC041B POCE Maintenance Equipment – Requirements for equipment and tools required to maintain and support the POCE subsystems and pilot plant will be identified by analyzing the operational results of the SRE maintenance equipment and the POCE hardware designs, test plans, test descriptions, and operational plans for additional requirements. The results of these analyses will establish definition of the POCE maintenance equipment and will be presented at the PDR (CDRL item 2).

SC042* Simulators

This task will identify the need for and provide the simulators (subsystems and interface) required for SRE hardware checkout and test operations. Simulation equipment will also be identified for the POCE subsystems and pilot plant.

SC042A SRE Simulators – Simulators required to check out or test the SRE hardware will be identified by analyzing the SRE hardware design, interface, test plan, test description, and operational requirements. Based on these requirements, new simulator equipment conceptual and detailed designs (CDRL items 3 through 8) will be accomplished wherever existing equipment will not suffice. Subsequent to these reviews and ERDA approval, the simulators required for SRE checkouts and tests will be procured or fabricated.

Collector SRE studies have identified the need for a:

- Master control software simulator for use in conducting the collector SRE testing.

The receiver SRE will require support equipment for a:

- POCE plant steam downcomer and turbine simulator composed of a back pressure regulator and downstream plumbing which automatically provides a constant and controlled exit pressure for the absorber panel steam effluent as it will exist in the POCE plant.

No simulators for the thermal storage SRE have been identified at this time.

At the conclusion of the SRE test activity, all simulators will be packaged for shipment in accordance with ERDA direction.

SC042B POCE Simulators – Simulators required for the POCE subsystem and pilot plant support will be identified by analyzing SRE simulator performance and the POCE hardware designs, interface requirements, test plans, test descriptions, and operational plans for additional requirements. The results of these analyses will establish the requirements for and the definition of any POCE simulators. The results will be documented and reported at the PDR (CDRL item 2).

SC050* SYSTEM TEST AND EVALUATION

The objectives of this task are:

- Prepare POCE system test plans based on the test requirements contained within the POCE specifications and on the experience and results of the SRE verifications.

- Identify SRE test support equipment and facilities required to support the SRE test plans.
- Identify the POCE test support equipment and facilities required to support the system test plan. (Maximum use will be made of the equipment and facilities provided during the SRE's.)

The schedule for these activities is presented in Figure 2-4, Section 2, Program Schedules.

SC051* Development Test and Evaluation

Development test plans for the POCE subsystems and pilot plant will be established to obtain necessary design and performance data and satisfy the requirements of the POCE specifications. These plans will incorporate the results of and experience gained through performance and analysis of the SRE tests. All plans will be generated in a similar fashion and include the following test category breakdown:

SC051A	Engineering (Development) Test
SC051B	Qualification (Qualification and Acceptance) Test
SC051C	Integrated System (Compatibility and Operation) Test

Design, logistic and test engineers will review all POCE design and performance requirements against verification requirements. During these reviews, the SRE hardware configurations and test results will be analyzed to ensure that the POCE development program takes full advantage of this experience and in no way duplicates any of that effort. The test plans will be prepared in accordance with the contractor's established formats which include detailed test objectives, test specimen descriptions, test equipment and facility requirements, test sequence, and data and evaluation requirements. The integrated system test planning will be supported by West Associates. The plans will be submitted to ERDA for approval in accordance with CDRL item 2 requirements.

SC052* Subsystem Research Experiment Tests

No effort has been identified for this task. All SRE test planning, testing, and evaluation of test results is being performed under Tasks SC224*, SC324*, or SC424*. No system-level tests are being proposed for Phase 1 and all POCE test planning is being done in Task SC051*.

SC053* Test Support Equipment

Test support equipment required to support the SRE's and the POCE system test plan will be identified in this task. The results of these subtasks will be documented in the SRE test plans in accordance with CDRL items 3 through 8 and in the POCE system test plans in accordance with CDRL item 2.

SC053A SRE Test Support Equipment – SRE test support equipment requirements will be compiled from an analysis of SRE test objectives, test configurations, and plans. These requirements will be evaluated to determine whether or not existing equipment can be utilized or if new equipment has to be designed. The results of these evaluations will establish the test support equipment requirements for the SRE's. New equipment requirements will be procured or built as part of Tasks SC224*, SC324*, and SC424*. Existing equipment in MDAC and Rocketdyne inventory will be used wherever feasible in order to reduce cost. Test support equipment that has already been identified through preliminary requirement analyses is described in the SRE Test Plan, Volume 3.

SC053B POCE Test Support Equipment – POCE test support equipment requirements will be established through analysis of POCE test objectives, test configurations, and plans as well as from the results of the SRE tests. These requirements will be evaluated to determine if existing equipment can be used or if new equipment has to be designed and fabricated. The results of these evaluations will document the test support equipment requirements (CDRL item 2) for support of the POCE system test plan and will be reported at the PDR.

SC054* Test Facilities

Test facilities required to support the SRE test plans and the POCE system test plan will be identified. The results of this effort will be documented in the SRE test plans in accordance with CDRL items 2 through 8 and in the POCE system test plan in accordance with CDRL item 2.

SC054A SRE Test Facilities – SRE test facilities needs have been determined from the analyses of preliminary SRE test objectives, descriptions, and plans. Final tradeoffs of objectives versus various facilities, costs, and other influencing factors will be conducted to assure advantageous final selection. Facilities presently identified for the collector subsystem tests include MDAC's circuit, structures, and environmental test laboratories. The Naval Weapons Center, China Lake, has been selected as the site for the collector heliostat array test, with MDAC's Grey Butte facility on the Mojave Desert as an alternate. The majority of the receiver assembly tests will be conducted at the Rockwell Thermal Laboratory. The environmental tests of the receiver components will be conducted with the solar furnace at the White Sands Missile Range and the Approved Engineering Test Laboratory in Los Angeles. The thermal storage subsystem model tests will be conducted at Rocketdyne's Santa Susana Field Laboratory Energy Development Area, utilizing the J2 Altitude Steam Generator facility.

SC054B POCE Test Facilities – POCE test facility requirements for support of the subsystem development and POCE integrated system tests will be derived from an analysis of POCE test objectives, test descriptions, and plans, utilizing MDAC test facilities where feasible. This study will be completed after the POCE test site has been selected by ERDA and will consequently be influenced by that decision. The output of this task will be a complete description of POCE test facility requirements; these will be documented and presented at the PDR (CDRL item 2).

SC060* SYSTEM/PROJECT MANAGEMENT

Work conducted under this element of the program task plan will provide system engineering management, certain system-level supporting analysis tasks, and program management support. These management and analysis tasks will support both POCE preliminary design and SRE design and test activities. The management planning and program cost, schedule, and technical performance results will be reported in revisions to the program plan (CDRL item 9) prepared under Subtask SC062C. A schedule for all SC060* tasks is presented in Figure 2-5, Section 2.

SC061* System Engineering Management

The system engineering management functions to be performed under this task element will provide supporting analyses, simulations, and technical liaison with vendors necessary for overall central receiver system evaluation and integration. These tasks, grouped under the categories of system definition, system effectiveness, and technical liaison with vendors, are described below.

SC061A System Definition – Certain specific efforts in support of the POCE preliminary design activities of Task SC010* will be performed under this task. These will include tradeoff analyses using existing computer programs, interface definitions and requirements identification, and examination of transportation problems as they effect the design. The conduct of design reviews for both POCE and SRE activities is included.

SC061A.01 POCE Computer Simulation – A POCE computer simulation will be used as a primary design verification tool during the course of the study. This tool will be useful in simulating the operation of the master control unit and in verifying subsystem operational interface compatibility. In addition, the simulation will be capable of predicting overall system operational characteristics during all anticipated normal and failure modes of operation. This effort will be accomplished by MDAC, with support from Rocketdyne, Stearns-Roger, and West Associates, to provide information on receiver, thermal storage, electrical power generation subsystems, and utility interfaces, as appropriate.

Computer Model Development – The purpose of this subtask is to ensure that an accurate and up-to-date computer simulation of the POCE system, reflecting the latest design and test data available, is developed and maintained. The task will be accomplished by the timely expansion and refinement of an existing MDAC dynamic computer simulation (G-189) of the POCE. Initial activities will include conceptual design refinements developed during the initial two months of the study. During the SRE activities, simulation updates will be carried out to reflect preliminary test data and design information developed in parallel on non-SRE items. When the SRE activity is complete, the simulation will be correlated to the resulting test data. Typically, such activities will include dynamic correlation of heat exchangers, pumps, control valves, receiver panels, heliostat operation, and thermal storage energy losses. This simulation will serve as the primary system evaluation tool to be utilized in the following subtask.

POCE Computer Verification Analysis – POCE system simulation analyses will be conducted to determine the operational characteristics of the system and to ensure its stability for all operational modes. All system control functions will be modeled to ensure compatible operation between the control system and the other system hardware. Particular attention will be paid to transient modes such as system startup, shutdown, and controlled system transitions between operational modes. The impact of solar-induced transients will also be investigated to ensure system compatibility at all points, including subsystem interfaces. Complex subsystem interfaces such as those between the thermal storage subsystem and the receiver and power generation subsystems will be given particular attention. Trade studies related to the functioning of various candidate components (pumps, heat exchangers, control valves, etc.) to be integrated into the system will also be evaluated to aid the design activity. The impact of system anomalies and component failures on system operation will be investigated; this investigation also serves as a means of predicting the nature of the design protection required.

The POCE computer simulation developed in the previous subtask will be used to carry out this analysis. The results of such an analysis will be a collection of system performance and fluid state data (pressure, temperature, flowrate, heat loss or gain, time lag, valve positions, etc.) which completely predict system operation under the various operational and failure modes under investigation. This subtask will provide timely analytical support to the POCE system design activity being carried out as part of Task SC010.*

SC061A.02 Collector Optical Model – Two optical models are available for use for the central receiver collector subsystem analysis. One model, developed at the University of Houston under an NSF/RANN grant, simulates the optical performance of the collector subsystem under a wide variety of conditions. This model will be used by the University of Houston during the program. The other model was developed at MDAC with Company-sponsored support, initially for the purpose of analyzing the collector performance with mirror surfaces which are not flat. The latter model (Program CONCEN 1) has since been expanded to include determination of flux density distribution and total received power for several receiver configurations, mirror shapes and conditions, and aiming strategies. MDAC will use this program during the proposed effort.

The two models are complementary in that different approaches are used to arrive at similar determinations. As a result, each model has particular areas of usefulness in the collector subsystem analysis. Effects on the total power collected and flux density distribution of random pointing errors, shading, and blocking by neighboring mirrors, sensor misalignment, focusing by canting of mirror segments, mirror effective reflectance, and variation of the collector and receiver dimensions may be computed by both programs. Computation may be carried out on CONCEN 1 by either systematic ray tracing or random Monte Carlo ray selection.

Tradeoffs and optimization of parameters for the collector andreceiver subsystem configurations and dimensions will be done using these programs. The University of Houston program is particularly useful for optimizing the heliostat array configurations for maximum efficiency of heliostat use in the array. CONCEN 1 will be employed to determine the effects of mirror surface irregularities and aiming errors on collection performance. Both programs will be used to obtain flux density profiles on the receiver surface for the purpose of relating the collector array parameters to the receiver heat flux input requirements and limitations. Specifications for the heliostat mirror surface flatness and canting angle of the mirror segments will be established using the CONCEN 1 program. The final analytical model will be documented and submitted to ERDA.

SC061A.03 Interface Engineering — This task provides a key element in the definition and control of the POCE preliminary design configuration. The overall interface engineering responsibility is assigned to the program System Definition Manager at MDAC. This effort will be supported by Rocketdyne and Stearns-Roger personnel for the receiver and electrical power generation subsystems, respectively, Collector interface data will be prepared by MDAC.

Interface Control — The objective of this subtask is to assure the sufficiency and compatibility of all interfaces within the POCE system itself and between the system and associated equipment in the anticipated operational environment. System interface compatibility of the POCE system with the installation requirements and constraints will also be maintained. Subsystem specifications and interface drawings will be prepared as the principal outputs of this task; they will include appropriate functional and physical definition of all interfaces. Informal working interface control documents will be maintained by MDAC during the contract period, with updated versions presented as part of the POCE PDR reports at the end of month 22. They will be kept current by active review of the subsystem designs, and approved changes will be disseminated in a timely manner to facilitate an effective POCE preliminary design effort.

Master Control Interface Definition — Interface definition of the master control will be performed in this subtask. A preliminary design of the physical and functional interfaces of the master control with the receiver, collector, thermal storage, and power generation subsystems will be established in response to the system requirements developed in Task SC110*. The POCE and subsystem baselines will be reviewed and the master control subsystem control functions will be identified. These data will be presented at the PDBR at the end of the month 2. For each of these identified functions, the portions allocated to the subsystem and to the master control will be defined. Physical interface implementations will be defined following completion of the functional interface definitions.

SC061A.04 Transportability — The transportability of subassemblies and components will be analyzed during the preliminary design activities of the POCE. An example is the heliostat reflector which is 6 m (20 ft) in diameter but will be transported as petal subassemblies approximately 2.4 by 2.4 m (8 by 8 ft) for more economical packing and handling. Other hardware that will receive special transport considerations include the receiver panel modules which are approximately 1 x 17 m (3 by 55 ft) and the material for the thermal storage tank. Special attention will be given to large-quantity items such as heliostat components and to fragile hardware requiring special packaging or handling such as the heliostat mirrors.

Transportation planning will include comparison of truck and rail transport options with the objective of selecting the minimum-cost approach that will meet the specific transportation requirements.

SC061A.05 Design Reviews – Design reviews will be conducted at the MDAC Huntington Beach facility (or at Rocketdyne for the receiver and thermal storage SRE's). MDAC will prepare an agenda and detailed schedule for coordination with ERDA in advance of each review meeting. The applicable design reports (CDRL items 1 through 8) will serve as the basis for the reviews. Design report material will be prepared and copies reproduced for use by all who attend the meeting. Oral presentations will be made and their content discussed by the MDAC and subcontractor personnel who have developed the design definition. Upon completion of the design reviews, CDRL documentation will be delivered to ERDA for approval or comment. All comments will be reconciled and incorporated in final issues of the design reports.

Minutes of the meetings will be kept in the form of action items, agreements, or comments. It is anticipated that these subjects will be discussed and mutually agreed to between the contractor and ERDA following conclusion of the reviews.

Effort to be performed under this design review task includes only that required for preparation for the review, participation in the review, and resolution of resulting action items. All basic material to be presented is generated in other tasks.

The Program Manager is responsible for and will participate in all design reviews. Responsibility for detail preparation and coordination of their respective reviews will be delegated to the System Definition Manager and Subsystem managers. The SRE CDR's and DDR's will be scheduled sequentially so that responsible program personnel may participate in all of them. Design reviews to be performed, responsibility, and their nominal schedules are shown in Table 1-2.

SC061B System Effectiveness – This task will be directed at achieving availability and safety objectives in the POCE preliminary design by establishing a controlled system-effectiveness program for design and SRE test support. MDAC will have principal responsibility for performing this task. The four major subtasks and approaches for accomplishment are described here.

Reliability Allocation/Prediction – Reliability allocations will be refined for POCE subsystems and critical components during the first two months of the contract. The allocations will be reported at the PDBR and included in the POCE preliminary design baseline report (CDRL item 1). The approach will be to make early subsystem predictions of failure risk for the baseline system at the component level of definition, treat these along with maintainability to verify achievement of 90-percent availability, and then proportionately allocate reliability in accord with the prediction. POCE availability will be predicted as a design audit parameter utilizing reliability and maintainability models.

Table 1-2. DESIGN REVIEW RESPONSIBILITIES

Design Review	Schedule	Preparation Responsibility	Related CDRL Item
POCE (Pilot Plant) Preliminary Design Baseline Review (PDBR)	ATP + 2 months	System Definition Manager	1
Conceptual Design Reviews (CDR's)			
Collector Subsystem	ATP + 3 months	Collector Subsystem Manager	3
Receiver Subsystem	ATP + 3 months	Receiver Assembly Manager (Rocketdyne)	4
Thermal Storage Subsystem	ATP + 3 months	Thermal Storage Subsystem Manager	5
Detailed Design Reviews (DDR)			
Collector Subsystem	ATP + 8 months	Collector Subsystem Manager	6
Receiver Subsystem	ATP + 8 months	Receiver Assembly Manager (Rocketdyne)	7
Thermal Storage Subsystem	ATP + 8 months	Thermal Storage Subsystem Manager	8
Environmental Impact Data Review	ATP + 15 months	Stearns-Roger	12
POCE (Pilot Plant) Preliminary Design Review (PDR)	ATP + 22 months	System Definition Manager	2

Worst-Case Design Analysis – POCE subsystems and major components will be analyzed for worst-case effects. The approach will be to list all components and perform a qualitative evaluation with respect to operating extremes, function response time, interfaces, and environments. The worst-case design requirements will also be specified for the POCE at the PDBR and will be included in the SRE test planning.

Failure Modes and Consequences Analyses – A failure modes, effects, and consequences analysis (FMECA) will be conducted at the component level for each of the POCE subsystems. The FMECA's will be integrated with the prediction analyses and presented at the PDBR. They will be updated for the preliminary design on the basis of SRE test findings. These final data will be reported at the PDR at the end of month 22.

System Effectiveness Test Support – Recommendations for the SRE test plans will be developed on the basis of the system effectiveness analyses described above. Each of the parameters of environment, equipment variations, and availability will be evaluated with regard to performance, technical risk, configuration, and scalability for each subsystem, then for critical components. The test priorities, parameters to be measured, and data required will then be included in CDRL items 6, 7, and 8.

Evaluation parameters will include maximum solar flux variations, maximum and minimum environmental conditions, mechanical variations, thermal power and tube transients, part tolerance, and startup/shutdown extremes; also availability, potential failure modes and probable consequences, fail-safe and redundancy provisions, failure-warning devices, and return-to-service time.

Technical design reviews will be conducted with regard to the consideration of environmental factors, reliability/parts control, maintainability/human factors and system safety design methods, and quality assurance concerns based on SRE test findings.

SC061C Technical Liaison with Vendors – This task provides the MDAC effort to establish and conduct a technical review program with our subcontractor team members. Liaison with suppliers of critical technical items is included. The objective of this effort is to assure ERDA that technical performance and program aspects of supplier effort will be monitored and needed management action will be initiated. ERDA will be notified of review meetings in advance to permit attendance if desired.

Periodic subcontractor reviews have been scheduled as shown in Figure 1-14. These reviews will be performed at the supplier's facility. A single-point technical contact will be assigned for each subcontract and this individual will be responsible for planning and conducting the reviews as well as day-to-day technical liaison. All review results and other technical interchanges will be reported to program management. The Deputy Program Manager will be particularly active in the direction of the subcontractors and consequently will attend or assign a representative to attend each of the reviews. All matters that affect subcontract scope, cost, or schedule will be referred to the subcontract administrator for action. Subcontractor management is discussed further in Section 4.3 of this volume. Technical liaison contacts will be responsible for obtaining and approving subcontractor and vendor inputs to the technical performance measurement system (described in Section 3.2). In the performance of liaison tasks, they will use rapid communications systems such as facsimile transmission and telephone, and will visit the subcontractor facility when necessary.

SC062* Project Management

Effective management of the total Phase 1 contractor effort is the overall objective of tasks in this WBS matrix. The MDAC team will organize all management functions to properly plan program effort; assign task responsibilities; maintain cost, schedule and technical performance controls; and document and report results. Under our multi-company team concept, MDAC program management will work closely with all subcontractors and major suppliers to integrate their effort and ensure consistency in program direction and documentation. Our experience in directing similar programs with major subcontracted

005Q-IV

Program Milestones		PDBR POCE △	△ CDR SRE					DDR SRE △							EID POCE △							PDR POCE △		
Subcontractor	Months from ATP																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Rocketdyne		△	△			△		△				△			△			△			△	△		
Stearns-Roger		△				△									△			△			△	△		
Sheldahl		△	△			△		△				△			△			△			△	△		
University of Houston		△				△									△			△			△			

Figure 1-14. Subcontractor Technical Reviews

effort will be applied to produce an integrated control and reporting system that will be capable of effectively responding to changing program conditions and to ERDA direction. The goal of this program approach will be to maintain open communication covering complete program status with the ERDA Program Office at all times.

SC062A Project Reviews – This task provides for the periodic review of current program status and discussion of problem areas with ERDA per CDRL item 10. Additional frequent meetings will be supported for management and technical information exchange. Prior to each meeting, MDAC will prepare and submit a recommended agenda to ERDA for review and approval. Viewgraph-type visual material will be prepared for the oral presentations and copies of all material will be provided at the beginning of each meeting. For planning purposes, to minimize travel costs, MDAC has scheduled all design reviews at Huntington Beach. ERDA concurrence on this plan will be requested during contract negotiations.

Project reviews will be scheduled, planned, and directed by the Program Manager. Technical status and plans will be presented by responsible system and subsystem engineering personnel. Subcontractor members of the MDAC team will participate in these meetings in their areas of responsibility. Management cost, schedule, and manpower use data will be presented at the reviews and included in program plan updates under CDRL item 9.

At the conclusion of each review meeting, MDAC will support ERDA in executive sessions to resolve any problems, make program decisions, and consider other management matters. Accurate minutes of the review meetings will be prepared promptly and submitted to ERDA for approval.

SC062B Configuration Management – No separately identifiable configuration management effort is required for the Phase 1 program. Normal MDAC and subcontractor release practices will maintain change control and test configuration identification for the SRE hardware. System and subsystem specifications will be updated as required by inclusion in program design reports.

SC062C Support Management – This WBS task provides management support functions for planning, implementation, and control of all program effort. These functions include cost/schedule management, technical performance management, data management, and other general support requirements such as subcontract administration, procurement support, and transportation management.

This task includes revision of the program plan 10 days after ATP, quarterly updating for program reviews, and revision at program completion, as required by CDRL item 9. These revisions will utilize the data developed in this management task.

The MDAC management approaches and systems are discussed in detail in Sections 3, 4, and 5 of this plan. Since many of these functions are provided as indirect support, manloading reflects only the limited amount of direct-charge effort. In addition to the MDAC role of program integrator and the associated management tasks, Rocketdyne and Stearns-Roger will participate in this task to the extent of their in-house support management.

SC062C.01 Photographic Program – Photographic coverage will be provided to document all appropriate fabrication, assembly, site installation, and test operations during the program. This effort is included in the CDRL data requirements of Task SC070*.

SC063* Operations Analysis – No formal operations analyses are required in the Phase 1 program. However, operational considerations will be an integral part of the POCE preliminary design effort to be performed in Task SC010*.

SC064* Special Analyses, Environmental Impact Data

Environmental impact data relative to the installation of the POCE and pursuant to the National Environmental Policy Act (NEPA) will be furnished in draft form 15 months after ATP. This is based on the assumption that the POCE will be announced 12 months after ATP. The final report, revised as necessary, will be furnished 24 months after ATP. This effort will be performed by Stearns-Roger with MDAC and Rocketdyne subsystem definitions inputs. Should the selected site be in California, additional applicable information required under the California Environmental Quality Act (CEQA) will also be furnished. The data submittal is outlined below.

- Description of Project – Location and specific description of project's technical, economic, site alteration and environmental characteristics.
- Environmental Setting – General environment in vicinity and region of proposed site (topographic, geologic, demographic, historic), other developments planned nearby (if any), identification of resources rare and unique to region.
- Environmental Impact (short and long term) – Outline of an environmental impact report describing the various conditions that must be assessed (e.g., site alteration, endangered species and natural habitats, soil and erosion, hydrology, air pollution, water pollution, waste disposal, traffic and transportation, air corridors, noise pollution, schools, housing, positive and negative impacts in general on nearby communities, aesthetics, safety, seismic risk, archaeological sites, and public utilities). The time frame, effort required and methodology of accomplishment to provide a complete report will be determined.

SC070* DATA

The compilation, publication and photographic support of CDRL data items will be accomplished in this task. Documentation is an important part of the Central Receiver Program since this documentation is not only the major product of the Phase I study but also serves as a management tool for ERDA review, appraisal, and direction. The data items will be scheduled for delivery in accordance with the CDRL requirements (see Figure 2-6, Section 2).

Responsibilities – All data items have been scheduled and origination of the data is included in applicable program plan task requirements. Since the majority of the reports require collection and assembly of data from a number of tasks, our approach is to have the Program Manager assign a single individual overall responsibility for each document. This individual is then responsible for scheduling document preparation time, defining required inputs from others, and collecting and integrating the documents. Data preparation support requirements are disseminated by directives from the Program Manager.

Data which are the primary responsibility of suppliers are included in the work statement requirements of the applicable subcontract. MDAC will review and approve each supplier report after which it will be either integrated into an overall report by MDAC or delivered to ERDA if it is a complete data item.

Upon completion of each CDRL item document, copies will be delivered to ERDA by contract letter of transmittal. The contract administrator will track all CDRL due dates to ensure on-schedule delivery and will maintain status of all submittals and ERDA approvals or comments.

Photographic Data – Suitable photographic coverage will be provided to document all appropriate fabrication, assembly, site installation, and test operations during the program. This coverage will provide both technical and management historical data in support of program reviews and for subsequent ERDA use. Photographic products will include color and black-and-white still photographs and motion pictures. Motion picture coverage will be edited and assembled into usable sequences. No narrated coverage is planned.

MDAC is capable of providing all types of photographic coverage. This will be supplemented with photo coverage of their operations provided by Rocketdyne and Sheldahl. NWC, China Lake, will provide photo coverage of operations there.

Data Preparation – All documentation will conform to the CDRL data item descriptions. They will be published in format specified by ERDA with use of engineering charts and illustrations where feasible to minimize documentation cost.

MDAC has available complete in-house capability for rapid and quality reproduction of the required reports and drawings. Use of these facilities ensures documentation will be published when required at reasonable cost.

The specific technical, engineering, and management data items, WBS tasks, and organizational responsibilities are shown in Table 1-3. Only costs associated with editing, illustrating, assembling, and reproducing the documents for ERDA use are included in these tasks since generation of all basic data is required elsewhere.

SC093* Support

The logistics support included in this task is limited to the collector SRE activities conducted at NWC, China Lake, California.

SC093A Logistics Planning – The planning and coordination required in the selection and scheduling of transportation to support SRE testing activities will be accomplished in this task. Transportation modes will be selected to minimize packaging or crating needs for reduced costs.

Table 1-3. DATA PREPARATION RESPONSIBILITIES

WBS Task	CDRL Item No.	Item Description	Responsibility
SC071* Technical Publications	13	Test Hardware Operating Instructions	
		Collector subsystem	Collector Subsystem Manager
		Receiver subsystem	Receiver Assembly Manager (Rocketdyne)
		Thermal storage subsystem	Thermal Storage Subsystem Manager
SC072* Engineering Data	1	POCE Preliminary Design Baseline Report	System Definition Manager
	2	POCE Preliminary Design Report	System Definition Manager
		Conceptual Design Reports	
	3	Collector subsystem	Collector Subsystem Manager
	4	Receiver subsystem	Receiver Assembly Manager (Rocketdyne)
	5	Thermal storage subsystem	Thermal Storage Subsystem Manager
		Detailed Design Reports	
	6	Collector subsystem	Collector Subsystem Manager
	7	Receiver subsystem	Receiver Assembly Manager (Rocketdyne)
	8	Thermal storage subsystem	Thermal Storage Subsystem Manager
	11	Program Analyses and Data	Program Manager
SC073* Management Data	9	Program Plan	Program Manager
	10	Project Reviews	Program Manager
	12	Environmental Impact Data	Stearns-Roger

SC093B Transportation – This task consists of providing the actual transportation for SRE testing activities as described in Subtask SC093A. Contractor-owned and operated trucks will be used. Four round trips between Huntington Beach and China Lake are planned.

Other support operations that are usually part of a complete logistics plan are included in SRE Tasks SC020*, SC040*, or SC050*. Examples of these are:

- Spares, repair parts, and consumables are procured or fabricated concurrent with production of test hardware.
- Support equipment is fabricated under Task SC040*; there are therefore no charges against this WBS item.

Facilities needed to support the field site operation are identified in Volume 3, Test Plan and Volume 5, Cost Proposal.

PROGRAM SCHEDULES 2

Section 2

PROGRAM SCHEDULES

The MDAC team has prepared what it considers to be the optimum number and type of schedules required to successfully and economically plan, track, control, and report Central Receiver Program Phase 1 tasks. Preliminary issues of each of these necessary schedules are presented in this section as well as Section 1 of this Program Plan volume. Updated versions of these schedules, reflecting task changes agreed to by ERDA and the MDAC team, will be maintained for program management use throughout Phase 1. These schedules present the combined activity of all elements of the MDAC team.

Schedule selection was based on a thorough evaluation of the use to which they will be applied. The prime objectives are to illustrate the planned sequence of activities, to synchronize the tasks of the program, and to keep ERDA and MDAC team management fully informed of program progress.

2.1 SCHEDULES

The Master Program Phasing Schedule (MPPS) is shown in Figure 2-1. The MPPS is the baseline program schedule to be followed in support of customer requirements. It shows the time-phased relationships of all major tasks and will be used for displaying and monitoring program progress.

The Master Program Chart shown in Figure 2-2 is primarily a manager's tool for tracking major events and data submittals. To provide expanded task scheduling detail, schedules have also been prepared for:

SC010*	Central Receiver POCE (Pilot Plant) Preliminary Design Schedule (Figure 2-3)
SC220*	Collector Subsystem Research Experiments (Figure 1-3, Section 1)
SC320*	Receiver Subsystem Research Experiments (Figure 1-5, Section 1)
SC420*	Thermal Storage Subsystem Research Experiments (Figure 1-7, Section 1)
SC050*	System Test and Evaluation (Figure 2-4)
SC060*	System/Project Management (Figure 2-5)
SC070*	Contract Data (Figure 2-6)

All schedules are contained in this volume but all are not in this section. We have elected to locate the three SRE schedules with their respective task descriptions in Section 1. An executive summary (Figure 1-2) of the MPPS is located with the introductory material of Section 1.

This set of schedules is intended to satisfy all ERDA schedule needs in the most cost-effective and logical manner. They represent realistic and coordinated schedule application and are the product of total program analysis.

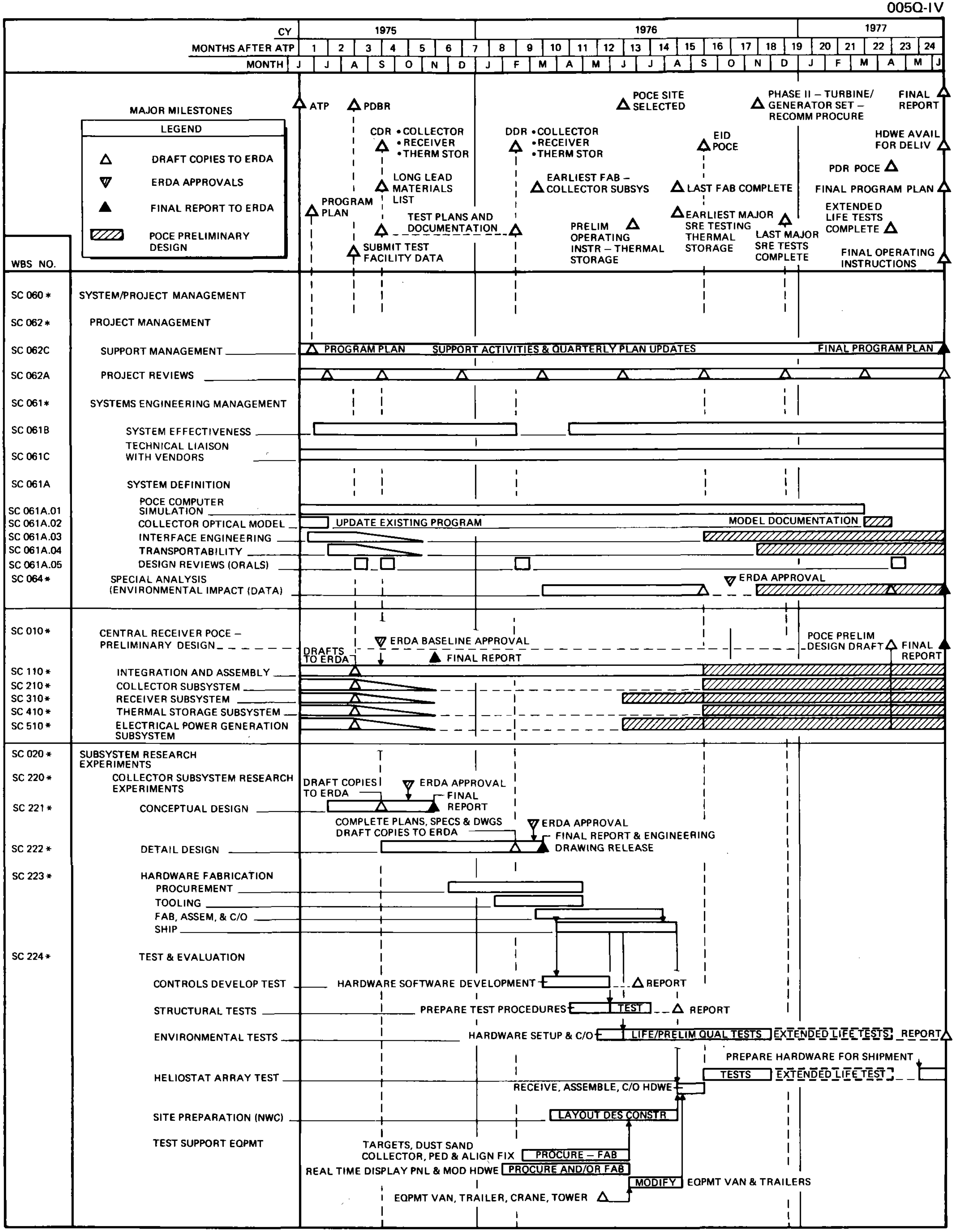

Figure 2-1. Master Program Phasing Schedule (MPPS) (Sheet 1 of 3)

005Q-IV

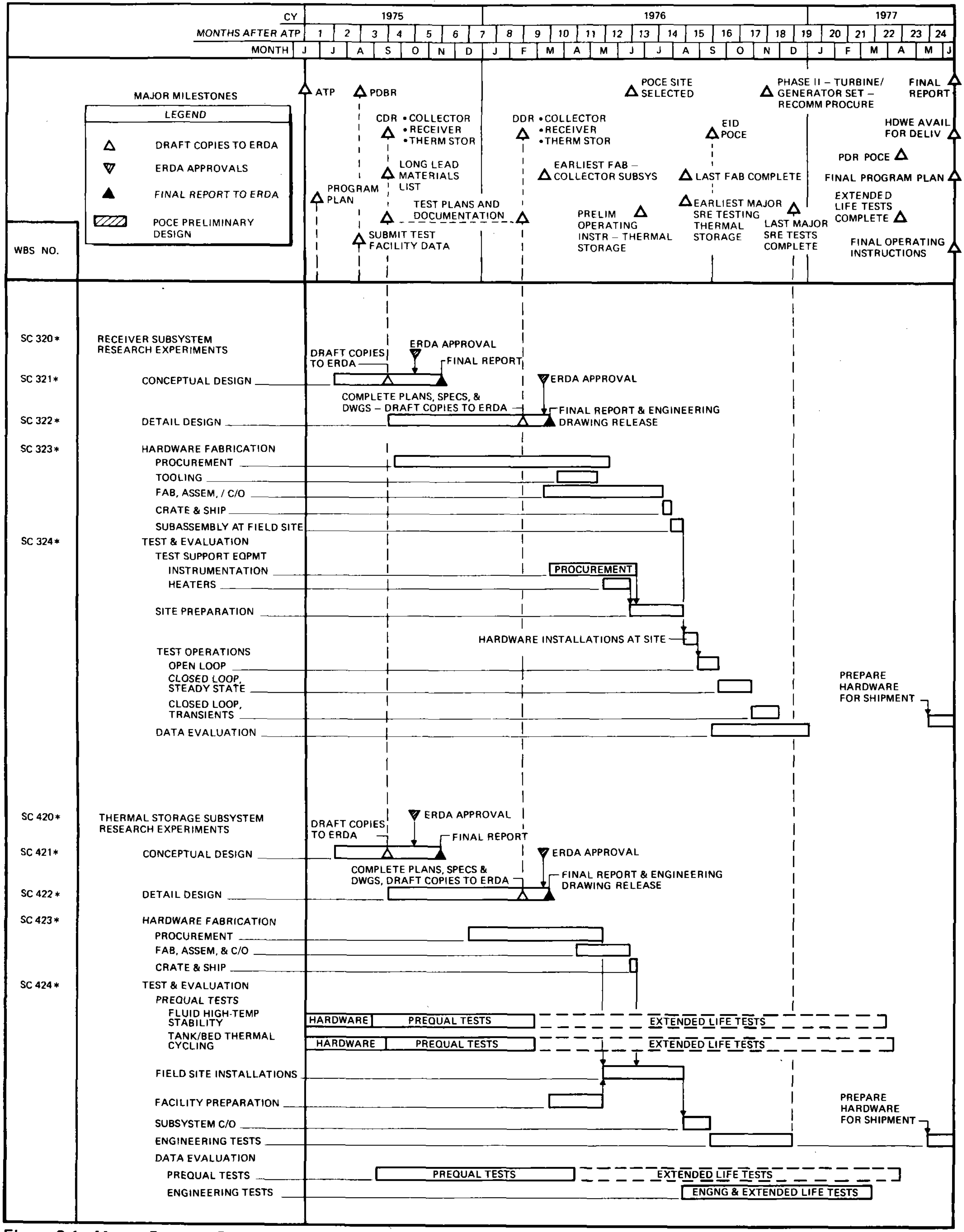

Figure 2-1. Master Program Phasing Schedule (MPPS) (Sheet 2 of 3)

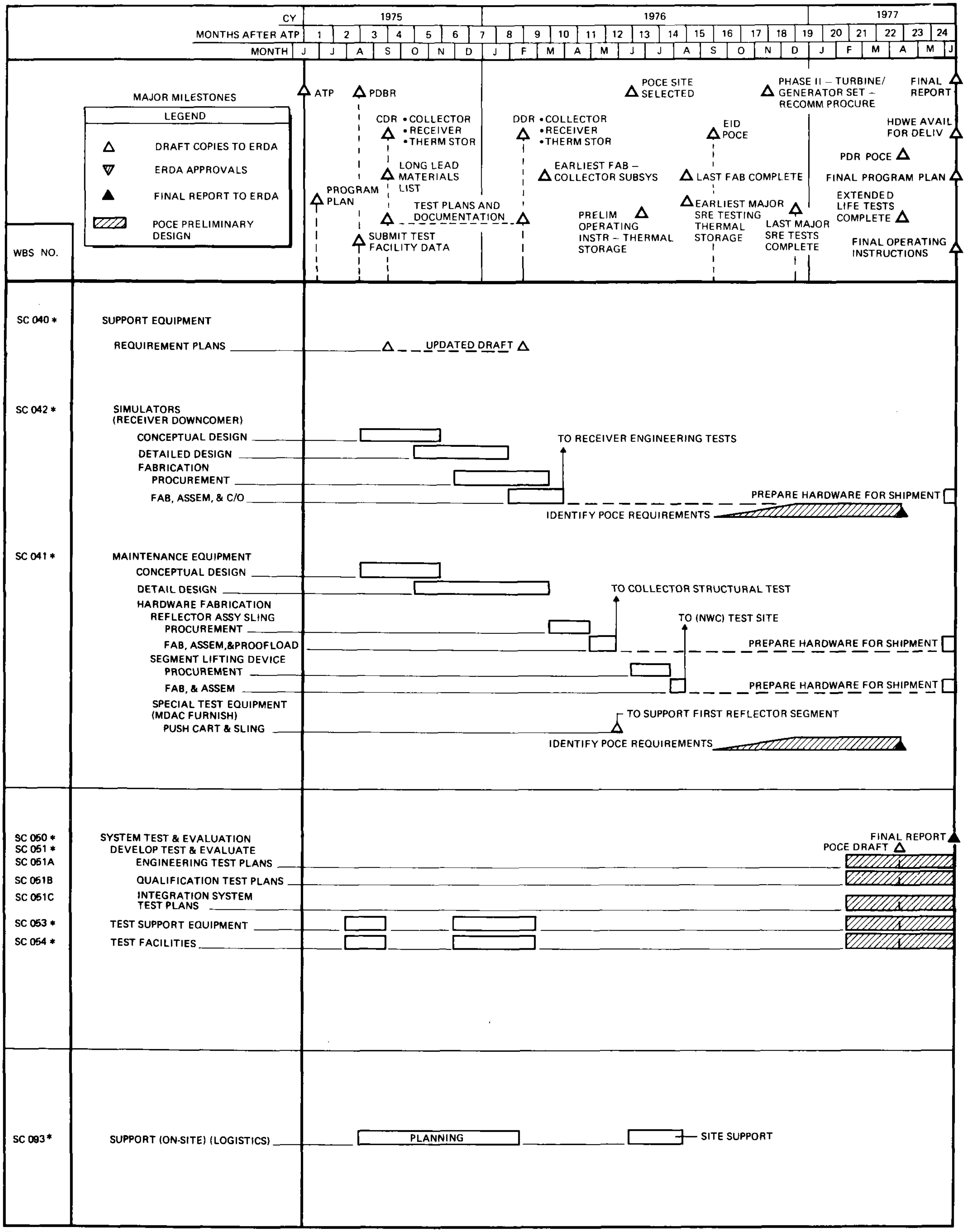

Figure 2-1. Master Program Phasing Schedule (MPPS) (Sheet 3 of 3)

2.2 SCHEDULE MAINTENANCE PLAN

After contract award, the proposal schedules will be updated to reflect negotiated changes and included with the revised Program Plan to be resubmitted 10 days after ATP (CDRL No. 9). This will establish the program schedule baseline from which the task of schedule management and maintenance will begin.

Schedule maintenance involves controlling the baseline and supporting documents, incorporating approved changes, and maintaining schedule traceability. Schedule status will be reviewed weekly for all in-house and subcontracted work. Each in-house task will be monitored against its individual WBS schedule. Status is obtained routinely from each functional organization on a daily basis for all MDAC

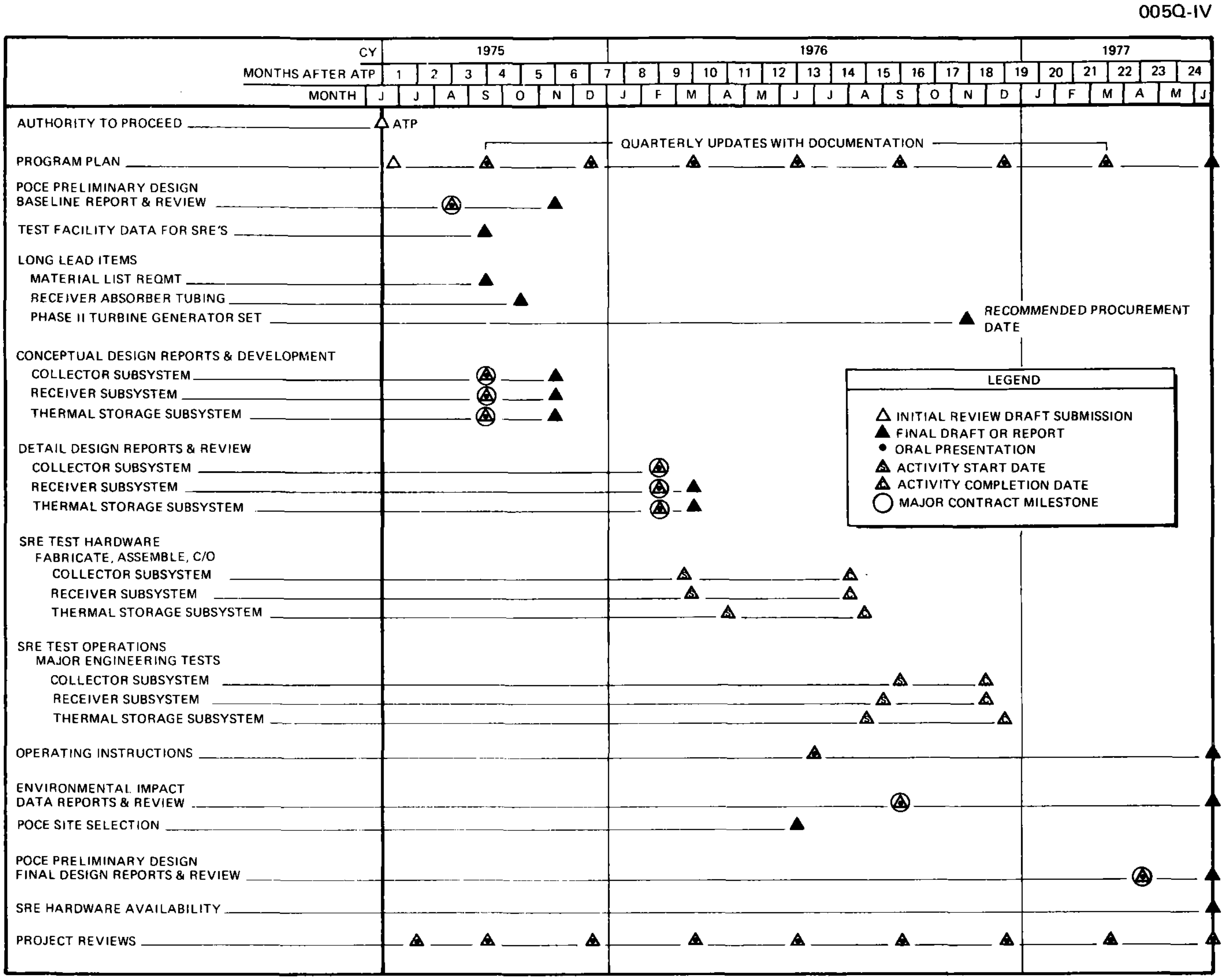

Figure 2-2. Master Program Chart

programs. Responsible control personnel measure progress against time-now on a weekly basis. Similar data will be obtained from each major subcontractor through weekly telephone conversations using his approved schedule baseline as a common script.

The MPPS is updated from this information and the following analysis performed:

- Comparison of MDAC and subcontractor progress with schedule
- Analysis of schedule variances for nature and degree of severity
- Identification of problem areas and preparation of reports.

Schedule analysis also includes identifying the exact schedule position of late items, the underlying causes and forecasted impact, and available options for corrective management action with recommendations and planned solutions.

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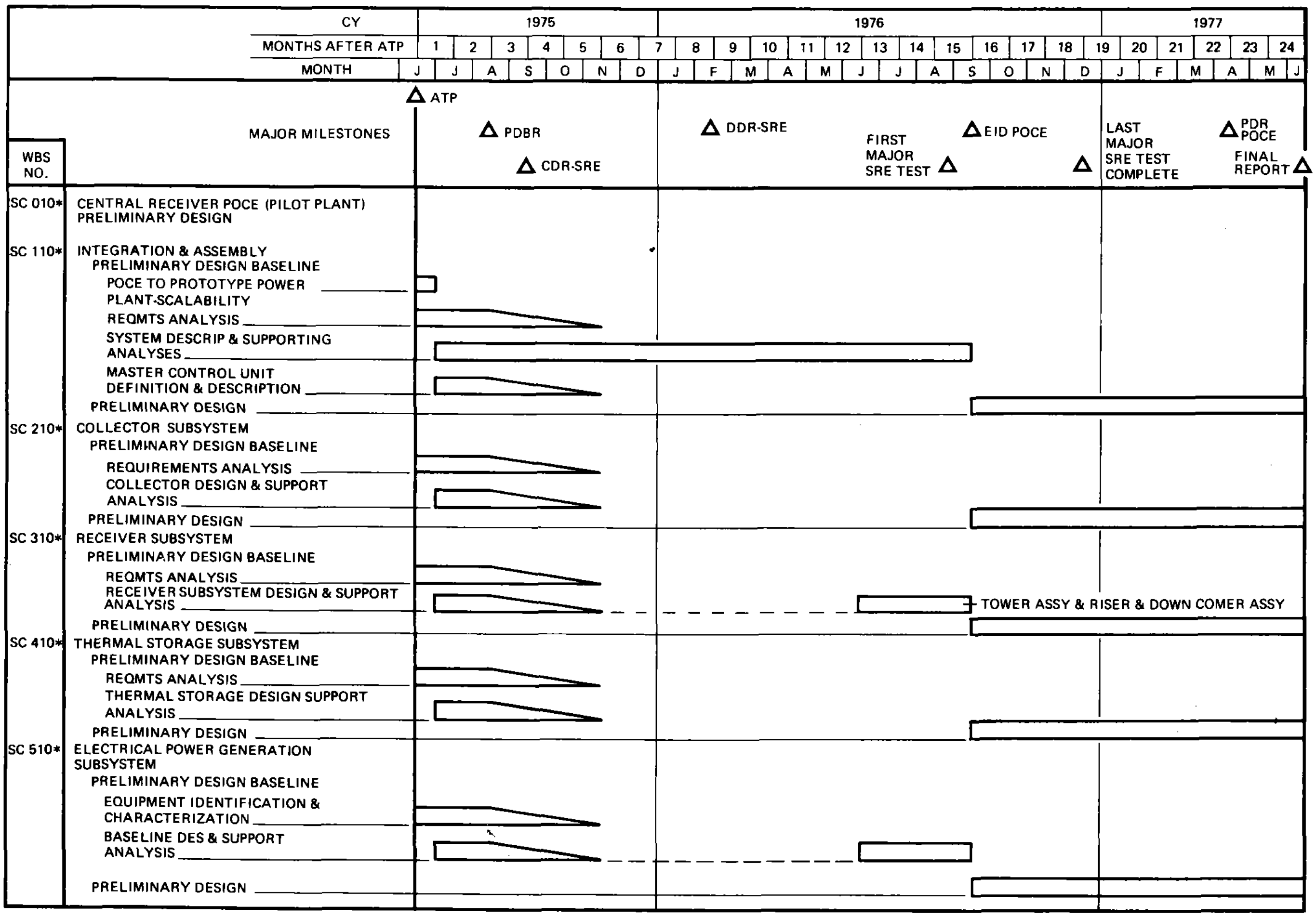


Figure 2-3. Central Receiver POCE (Pilot Plant) Preliminary Design

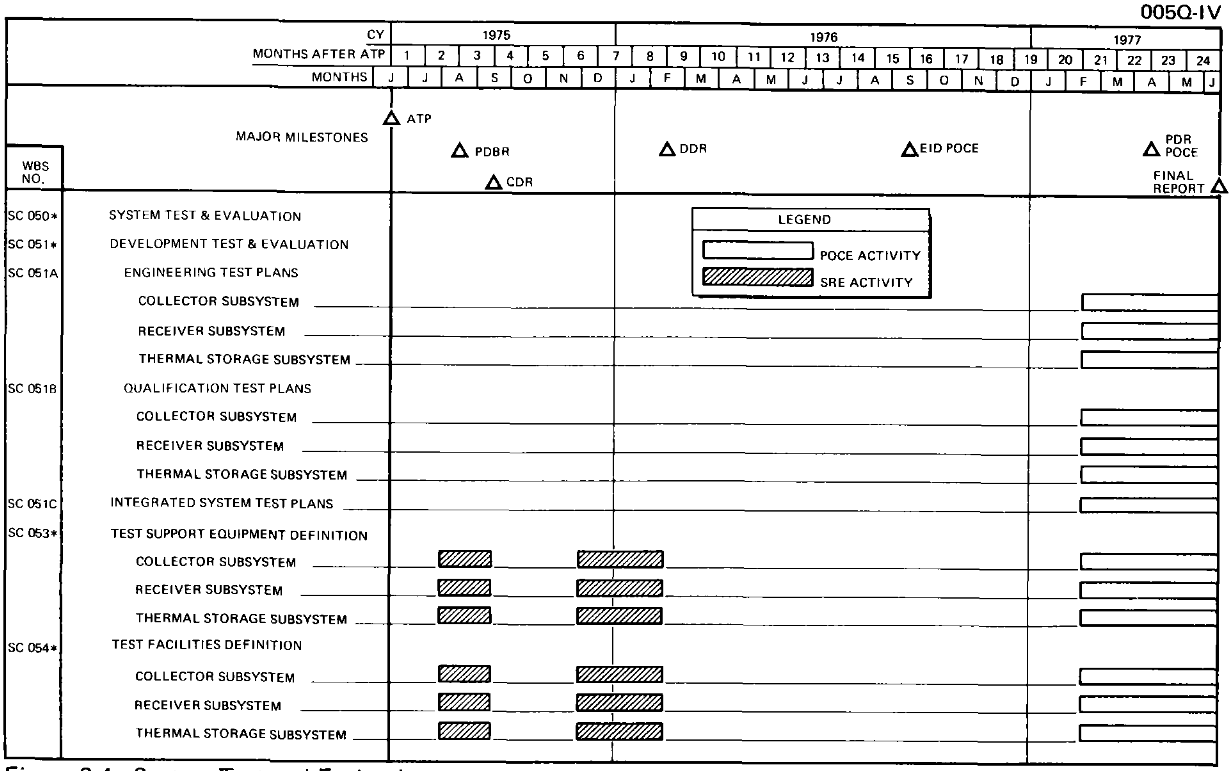


Figure 2-4. System Test and Evaluation

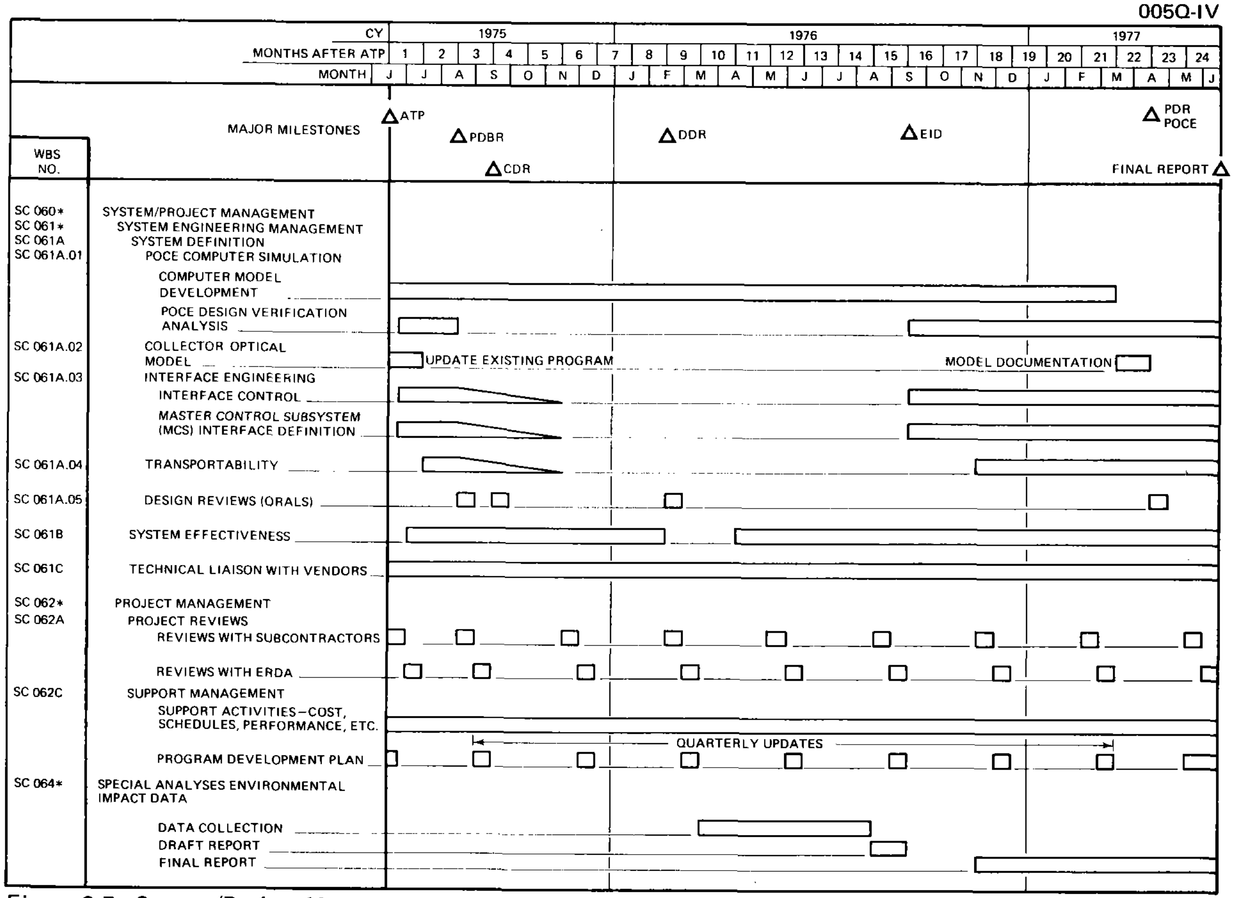
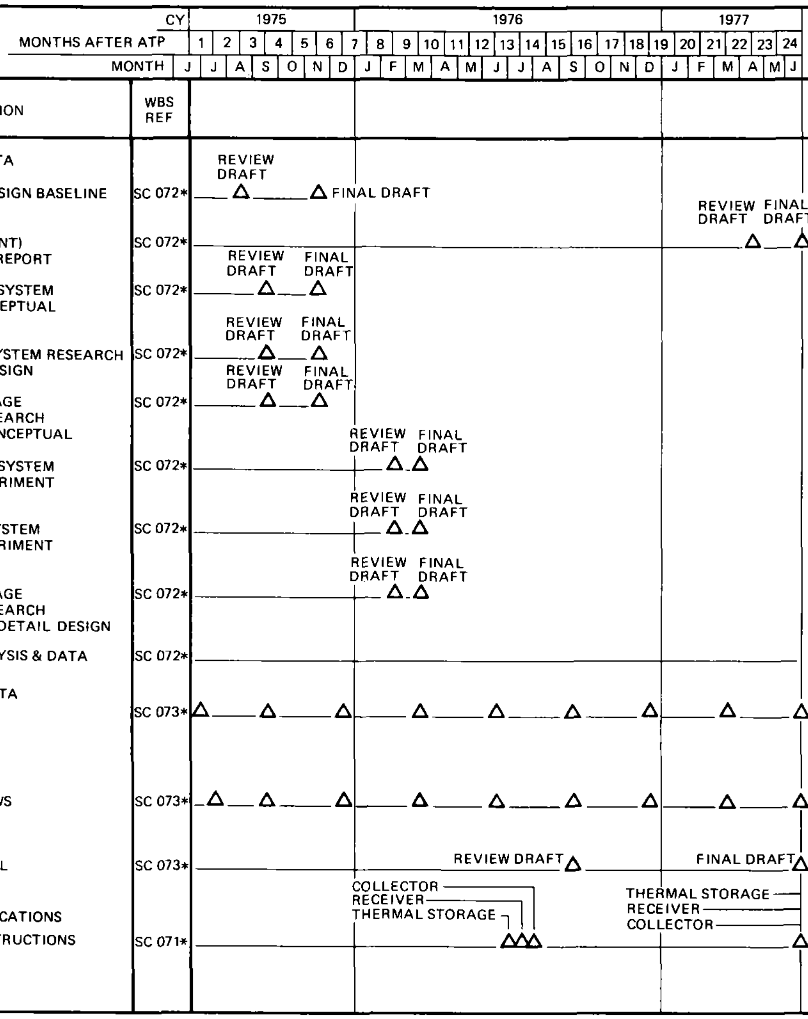


Figure 2-5. System/Project Management

CONTRACT DATA REQUIREMENTS LIST



CDRL NO.	TITLE/DESCRIPTION	WBS REF	SUBMITTAL	DRAFT COPIES	FINAL COPIES	FREQ-UENCY
	ENGINEERING DATA					
1	POCE PRELIM DESIGN BASELINE REPORT	SC 072*	2 AND 5 MONTHS AFTER ATP	1/20	1/50	ONCE
2	POCE (PILOT PLANT) PRELIM DESIGN REPORT	SC 072*	22 AND 24 MONTHS AFTER ATP	1/20	1/200	ONCE
3	COLLECTOR SUBSYSTEM RESEARCH CONCEPTUAL DESIGN	SC 072*	3 AND 5 MONTHS AFTER ATP	1/20	1/50	ONCE
4	RECEIVER SUBSYSTEM RESEARCH CONCEPTUAL DESIGN	SC 072*	3 AND 5 MONTHS AFTER ATP	1/20	1/50	ONCE
5	THERMAL STORAGE SUBSYSTEM RESEARCH EXPERIMENT CONCEPTUAL DESIGN	SC 072*	3 AND 5 MONTHS AFTER ATP	1/20	1/50	ONCE
6	COLLECTOR SUBSYSTEM RESEARCH EXPERIMENT DETAIL DESIGN	SC 072*	8 AND 9 MONTHS AFTER ATP	1/20	1/200	ONCE
7	RECEIVER SUBSYSTEM RESEARCH EXPERIMENT DETAIL DESIGN	SC 072*	8 AND 9 MONTHS AFTER ATP	1/20	1/200	ONCE
8	THERMAL STORAGE SUBSYSTEM RESEARCH EXPERIMENTAL DETAIL DESIGN	SC 072*	8 AND 9 MONTHS AFTER ATP	1/20	1/200	ONCE
11	PROGRAM ANALYSIS & DATA	SC 072*	AS REQUIRED	AS REQ	AS REQ	AS REQ
	MANAGEMENT DATA					
9	PROGRAM PLAN	SC 073*	FIRST SUBMIT 10 DAYS AFTER ATP - UPDATED QUARTERLY – LAST SUBMIT 24 MONTHS AFTER ATP	1/20	1/200	QRTLY
10	PROJECT REVIEWS	SC 073*	30 DAYS AFTER ATP, 90 DAYS AFTER ATP, QUARTERLY THERE AFTER	–	1/20	QRTLY
12	ENVIRONMENTAL IMPACT DATA	SC 073*	15 AND 24 MONTHS AFTER START OF CONTRACT	1/20	1/200	TWICE
	TECHNICAL PUBLICATIONS					
13	OPERATION INSTRUCTIONS	SC 071*	6 WEEKS BEFORE START OF TEST AND WITH DELIVERY OF HARDWARE	1/20	1/200	TWICE

Figure 2-6. Contract Data Requirements List.

PERFORMANCE MANAGEMENT PLAN 3

Section 3

PERFORMANCE MANAGEMENT PLAN

MDAC has proven management control systems of varying complexity which are suitable for programs ranging in size from small studies to such major system contracts as Orbital Workshop, Site Defense, and Delta. These management systems include a fully validated performance measurement system (PMS) meeting all requirements of DoD Instruction 7000.2, Cost/Schedule Control System Criteria (C/SCSC). For Phase 1 of the Central Receiver Program, we have selected an intermediate level of management and technical performance systems which will ensure adequate visibility and control without imposing excessive system support requirements. The use of these systems enables continuous management integration of the interrelated technical, cost, and schedule performance.

3.1 MANAGEMENT APPROACH

The MDAC plan for Phase 1 technical performance, cost, and schedule management control is described in the following sections. Basically, this plan is to use existing work authorization and cost/schedule control systems and to combine these with a technical performance measurement (TPM) plan tailored to the specific system requirements of this program. The TPM system provides recording and tracking of selected performance parameters for monitoring achieved performance during the analysis, design, and test activities. MDAC will integrate all subcontractor performance results into the system, thereby providing single-point TPM data to ERDA. The cost/schedule systems will concurrently provide both contractor management and ERDA with the program visibility and control needed to meet program objectives on schedule and at minimum cost. The integration of these systems and frequent management review of system progress will enable replanning or redeployment of program resources as necessary to achieve the desired total program performance.

A summary of the elements of these systems is shown in Table 3-1. During the phases of planning, implementation, and control the total data are integrated by management. Considered in this activity are technical achievements and risks, task scopes, schedule plans and uncertainties, and related labor, subcontract, and material costs. This integration achieves a balanced and consistent program plan with the ability to control and revise it as the need arises.

3.2 TECHNICAL PERFORMANCE MEASUREMENT

The application of TPM methodology is a particularly appropriate management tool for the Central Receiver Program. Each subsystem represented in the POCE system design and the system research experiments has characteristic, well-defined parameters which enable the establishment of values for required (specification value) and planned (design goal) figures. Tracking the predicted values of these parameters through analysis, simulation, SRE design, test, and POCE preliminary design will provide both MDAC management and ERDA with visibility of technical performance and predictions of achievable

Table 3-1. SUMMARY OF INTEGRATED PERFORMANCE MANAGEMENT PHASES

	Planning	Implementation	Control
Technical Performance Management	• Prepare TPM plan • Select initial TPM parameter, establish values	• Impose TPM updating requirements in accordance with plan • Maintain TPM data current as analysis, design and test data are obtained	• Review TPM data monthly; more frequently if changes occur • Evaluate variances for impact on total system performance • Analyze variances with respect to cost/schedule status • Initiate corrective action as required • Report changes to ERDA as they occur and in quarterly project reviews
Work Definition & Authorization	• Review/expand WBS as necessary • Prepare WBS dictionary and pricing work statement • Prepare subcontract work statements	• Convert pricing work statement to program operating work statement • Prepare and issue work authorization documents • Authorize subcontract effort	• Maintain program plan and work statements up to date • Authorize changes to in-house and subcontract effort when approved by Program Manager/ERDA
Cost Management	• Establish WBS level for budget control • Establish functional budgets • Establish time-phasing of budgets	• Review and approve budgets-program and functional management • Release time phased budgets • Functional managers perform to budgets	• Retrieve costs for direct labor, material, subcontracts, other charges, burden, and G&A • Prepare weekly summary reports by budget function • Prepare monthly and quarterly reports by WBS/budget function • Review status in weekly program review meetings • Submit reports to ERDA
Schedule Management	• Determine program requirements • Define sequence and flow of activities • Develop realistic time spans • Prepare individual WBS schedules	• Prepare and release detail WBS/work package schedules • Prepare detail subcontractor requirements schedules	• Monitor status on daily basis • Review status weekly in program review meetings • Perform problem analysis and prepare recovery plans as required • Prepare schedule updates for quarterly ERDA reviews

POCE performance. In keeping with the nature of the Phase 1 program, a relatively simple TPM approach is planned which will provide the desired visibility and early warning of problems without incurring excess program cost for maintenance of an extensive system effort.

In maintaining control of the performance baseline, MDAC will also make sure that the SRE configurations from which test and analysis data are derived are documented and conform to the configurations used in POCE preliminary design.

3.2.1 TPM Parameter Selection

The selection of parameters to be tracked is derived from the system and subsystem specifications. In order for them to be useful management tools, the parameters chosen should be sufficiently detailed to ensure visibility of predicted performance down to a subsystem level where specific problem areas may be readily identified, yet at a high enough level that detail design of components or subsystem elements are not unduly constrained.

TPM parameters to be monitored during the Phase 1 program are limited to the three subsystems for which SRE design and testing will be performed. POCE system level parameters do not require this type of tracking during preliminary design as the system design will be based on specification values with sizing of subsystem elements based on achieved subsystem performance. Design margins will be used as appropriate to ensure the required capability.

An initial selection of parameters has been established and is presented in Tables 3-2, 3-3, and 3-4. Planned (design goal) values are shown in these tables for parameters that we consider critical to system performance. Other parameters will have design goals established during the Phase 1 program. These will include a number of cases, such as heliostat tracking accuracy, where the value selected will depend upon cost-versus-performance tradeoffs. This selection and the design goals are subject to ERDA's concurrence and it is expected that revisions of the plan may be made by mutual agreement during the course of the program. Revisions and updates of these tables will be part of the data included in project reviews and in quarterly program plan updates under CDRL Items 9 and 10.

3.2.2 TPM Control

The subsystem technical managers for the collector, receiver, and thermal storage subsystems will be responsible for updating the TPM data for their subsystems. The System Definition Manager will then

Table 3-2. TECHNICAL PERFORMANCE MEASUREMENT PARAMETERS, CENTRAL RECEIVER – COLLECTOR SUBSYSTEM

Performance Parameter		**Performance Standards**					
Name	**Units**	**Reqd (Spec)**	**Planned (Des Goal)**	**Predicted Value**	**Analysis or Test**	**Latest Rev Date**	**Impact on System Performance**
Heliostat Surface Reflectivity	%	80	90-95				
Sun Acquisition Angle	deg	20	10				
Lifetime	years	30	30				
Randon Beam Error	mrad	3	*				
Emergency Defocus Time	sec	10	*				
Reflector Stowage Time	min	15	*				
Peak Heat Flux Imposed on Receiver	MW/m^2	0.3	0.3				
Image Acquisition After Synthetic Tracking	min	2	*				
Individual Heliostat Reliability (Daily)	–	.9994	*				

*POCE design goal values for these parameters to be developed during the Phase 1 study.

Table 3-3. TECHNICAL PERFORMANCE MEASUREMENT PARAMETERS, CENTRAL RECEIVER – RECEIVER SUBSYSTEM

Performance Parameter		Performance Standards					
Name	Units	Reqd (Spec)	Planned (Des Goal)	Predicted Value	Analysis or Test	Latest Rev Date	Impact on System Performance
Rated Receiver Capacity	MWth	42.3	*				
Outlet Steam Pressure	MN/m^2	10.3	12.4				
Outlet Steam Temperature	^{o}C	475	510				
Peak Water Flowrate per Panel	kg/sec	TBD	*				
Absorptivity	%	90	*				
Threshold Power for Panel Operation at Rated Conditions	MWth	TBD	*				
Maximum Heat Loss	MWth	TBD	*				
Heat Flux Variation Across Width of Panel	%	TBD	*				
Reliability (Daily)	–	.971	*				

*POCE design goal values for these parameters to be developed during the Phase I study.

Table 3-4. TECHNICAL PERFORMANCE MEASUREMENT PARAMETERS, CENTRAL RECEIVER – THERMAL STORAGE SUBSYSTEM

Performance Parameter		Performance Standards					
Name	Units	Reqd (Spec)	Planned (Des Goal)	Predicted Value	Analysis or Test	Latest Rev Date	Impact on System Performance
Capacity	MWHth	195	*				
Storage Fluid Temperature Range	^{o}C	220-300	220-315				
Thermal Loss in 24 Hours	%	1	*				
Duration of Operation at Design Extraction Rate	hrs	6	*				
Nonrecoverable Capacity	%	10	*				
Maximum Charging Rate	MWth	42.3	*				
Steam Generation Rate	kg/sec	12.9	*				
Reliability (Daily)	–	.986	*				

*POCE design goal values for these parameters to be developed during the Phase I study.

evaluate the impact of subsystem changes on POCE system performance and will maintain overall TPM documentation.

During the course of the program, the TPM tables will be updated by establishing the remaining design goal values and maintaining the latest prediction column to reflect data that have been generated by analysis, simulation, or test. The date of latest update will be entered for each individual parameter. Whenever an event occurs that significantly changes any prediction, it will be updated at that time. The total TPM listing will be reviewed monthly to ensure that all entries are up-to-date. The plan for reviewing at specific milestones and the technical activities which will generate inputs are illustrated in the flow chart of Figure 3-1.

A complete history of the TPM changes will be maintained. In the event that any parameter exhibits frequent or consistent changes, a time-phased trend analysis may then be performed as an aid in forecasting ultimate performance and determining corrective action requirements.

3.3 WORK DEFINITION AND AUTHORIZATION

The work breakdown structure is the framework for the preparation of both MDAC and subcontractor program plans and schedules, cost estimates, budgets, work authorization, collection of costs, and reporting of program performance. The WBS and WBS numbering system presented in the ERDA RFP are entirely compatible with the MDAC work authorization and cost collection system and will provide adequate definition and visibility of program work.

Work definition is keyed to the WBS and is reflected in the program plan, MDAC internal operating work statements, and subcontract work statements. The program plan and subsidiary work statements will be maintained throughout the life of the program and will be updated to reflect any contract changes.

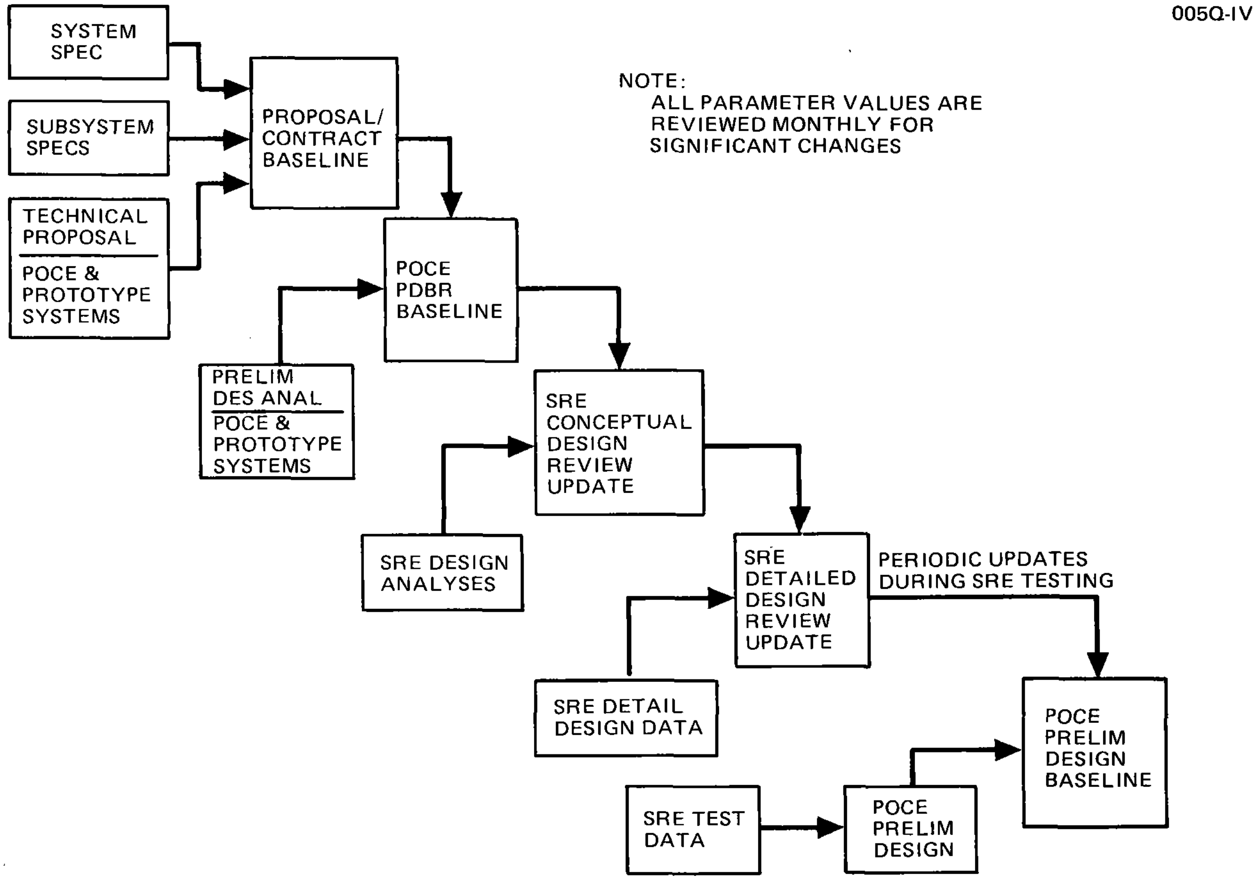


Figure 3-1. Technical Performance Measurement Data Flow and Updating

Based upon this definition, the work authorization system directs functional departments in accomplishment of their tasks and authorizes procurement actions. Three types of documents are used to implement work direction. All provide traceability to the WBS.

- Contracted effort is authorized by means of the work release order (WRO). The WRO is the MDAC program-level work authorization document used for disseminating overall program requirements and guidelines as well as detailed work authority for accomplishment of budget function tasks.
- Departmental work orders are used by the major budget functions to further segment the WRO for control at the detailed work package level.
- WRO's are issued to authorize subcontracting effort as defined in subcontract work statements and specifications.

Throughout the work definition and authorization cycle, the Program Manager reviews and approves each important component. He approves changes to the program plan, to in-house and subcontractor work statements, and to each WRO before it can be released for implementation.

3.4 COST/SCHEDULE MANAGEMENT

The objective of program cost/schedule management is to accomplish contract objectives within, or below, negotiated contract cost and current funding limitations, and within the negotiated timeframe.

Successful program cost/schedule management requires constant assessment of current costs versus accomplishments, accurate determination of current status, and visibility concerning final contract costs. The financial elements of budgeting, retrieval of actual cost, comparison of planned and actual costs, and estimates-to-completion are the basis for performing effective cost analysis. The management system for Phase 1 of the Central Receiver Program includes all of these elements.

Our program schedules approach is directed toward the effective integration of all elements of the program. The essential objectives of the schedule control system are:

- Ensure realistic and coordinated schedule planning
- Maintenance of a clearly defined schedule baseline
- Full traceability of all schedule levels
- Timely identification of variances for management attention and action.

Our system is comprised of two basic levels of schedules – program and implementing. This system is structured so that each schedule will provide continuity of flow from the Master Program Phasing Schedule down through the detail implementing schedules. The program schedules display top-level schedule requirements, define the time-phasing required for implementation, and serve as the basis for schedule interface with ERDA. The implementing schedules cover the detailed phasing of functional tasks and establish due dates entered on manufacturing shop paper, purchase orders, and other working-level documentation.

The schedules and budgets form a baseline which is fully coordinated with and committed to by the organizations performing the work. This commitment (by signature of responsible personnel) entails full obligation to perform within the baseline. This practice has made cost and schedule adherence an important criteria for measuring the success of MDAC program and functional management.

3.4.1 Planning

Cost Planning and Budgeting – Budget planning is accomplished prior to development and release of budgets to assure that both internal and external control requirements will be met. Determination of the WBS level for budget control is based on the importance and value associated with each WBS element. Budgets are established at selected levels of the WBS and are further subdivided by functional organization. Detail schedules provide the necessary parameters to time-phase budgets for each budgeted WBS level. The proper distribution of funds over the scheduled period of performance is an integral part of the resource-allocation process.

Schedule Planning – Detail schedule planning has determined what has to be done, who does it, and what resources are required. Many schedule tradeoff evaluations were made to provide a technically sound approach with low cost and schedule risk. The results of this planning are reflected in the schedules in Sections 1 and 2.

First, all ERDA schedule requirements were identified and, with the help of our engineering and manufacturing departments and our major subcontractors, the detail sequence and flow of activities were defined. Then the Master Program Phasing Schedule (MPPS) which provides the top-level schedule requirements was defined. After this planning was completed, we developed individual WBS schedules and correlated them with the MPPS to establish the baseline. This baseline will be updated at the start of contract effort and included in the revised program plan under CDRL Item 9.

3.4.2 Implementation

Budget Implementation – Budgets are issued as developed from estimates made or approved by the organizations responsible for performing the effort. Prior to release, the time-phased budgets are presented to the Program Manager and functional managers for review and approval. These time-phased budgets provide the using organizations with a plan against which they allocate manpower and other direct resources to accomplish tasks.

Schedule Implementation – In order to provide schedule direction for both in-house and subcontractor effort, detailed WBS/work package schedules are prepared and released to the program organizations. These schedules serve as the basis for work planning and schedule performance analysis.

3.4.3 Cost/Schedule Control

The existing MDAC data collection and reporting system will be used for Phase 1 cost/schedule control. The major elements and data flow of this system are illustrated in Figure 3-2 and described in the following paragraphs.

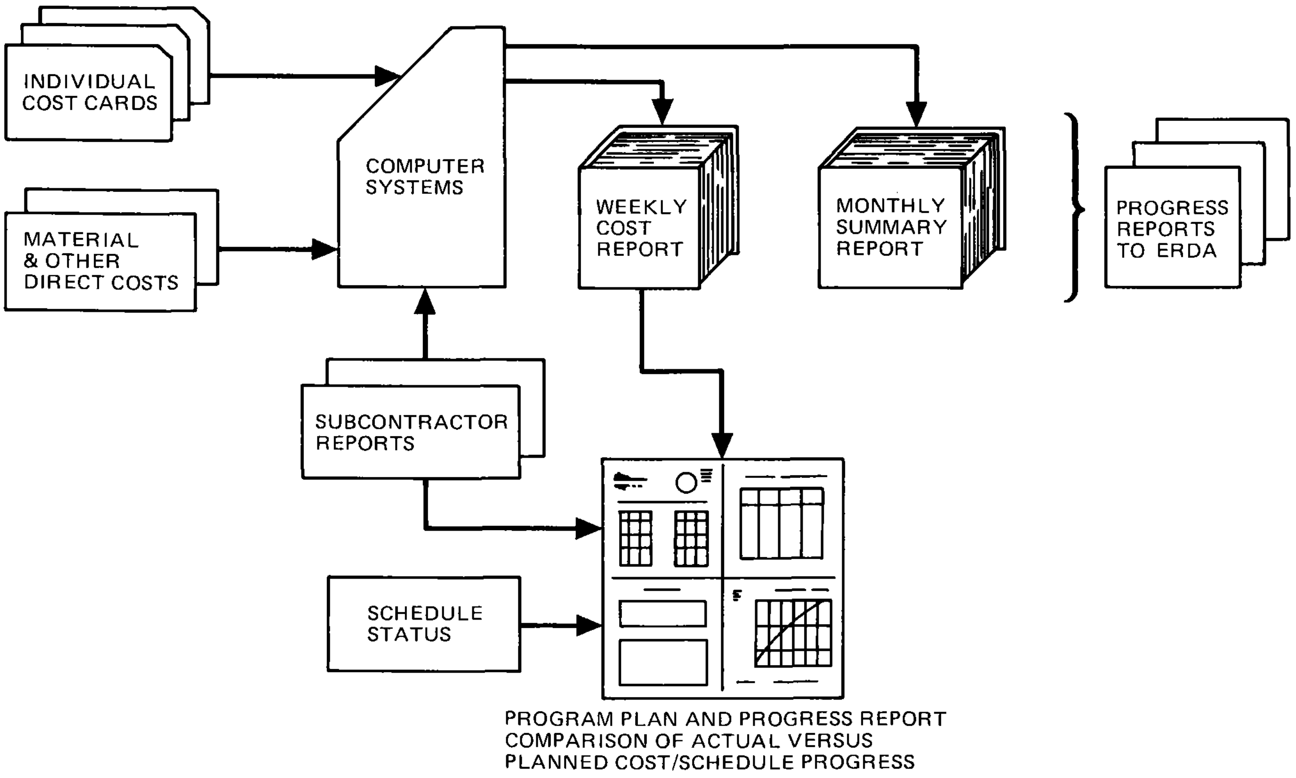


Figure 3-2. Cost/Schedule Control and Reporting

Cost Control – Actual costs for direct labor, major subcontracts, material, other direct charges, and indirect costs are retrieved using a cost charge number (CCN)/accounting element system. These costs are identifiable to the budgeted tasks and responsible organizations through establishment of CCN's on a WBS element basis.

Tabular and graphic reports which measure cost performance are provided on a weekly basis using MDAC's automated management visibility system (MVS). These reports are used in making detailed analyses of budgets and actual costs. The tabular reports reflect both weekly and cumulative hours and dollars in terms of budgets, actuals, variances, and estimates at completion (EAC's) by functional responsibility. Graphs are prepared for selected organizations which portray time-phased budgets, actuals, and EAC information. These management reports can be prepared at any level of the WBS as dictated by program needs.

Subcontractor financial performance, delivery, and schedule status reports are submitted by each subcontractor on a monthly basis. These reports reflect expenditures (manpower and dollars), commitments, authorized changes, EAC's, and billing and funding plans. These data are analyzed upon receipt and incorporated into the MDAC financial control system.

As work progresses and trends develop, cost performance is continuously reviewed. Analytical attention will be focused on emerging trends that could, if allowed to continue, produce a variance. An

EAC will be prepared periodically which will constitute a total reevaluation of all remaining program work. Analysis of cost trends may necessitate budget revisions. If so, the Program Manager may approve budget reallocations, if required, to remain within the contract value.

MDAC will provide actual manhour and expenditure information to ERDA on a monthly basis. On a quarterly basis, a projection through program completion will be provided. This submittal (CDRL Item 10) will coincide with the quarterly program review meetings.

Schedule Control – For this program, schedule control has been structured to provide MDAC team management and ERDA with an effective tool for monitoring, analyzing, resolving problems, and reporting schedule progress. Our overall concept of schedule analysis is to communicate fully with ERDA the current and future outlook on schedule performance. The objective is to combine the detailed near-term focus on accomplishments and recovery actions with long-term focus on key events.

Schedule status is updated weekly and analysis is performed as described in Section 2, Program Schedules.

If problems are uncovered which involve subcontractors or more than one discipline, or which may necessitate potential change to customer commitments, immediate action will be taken to fully understand the problem, its ramifications, contributing factors, and possible solutions. While these activities are being performed, the task leader and Program Manager will be informed and action items assigned for further investigation and/or solution. If any of these action items do result in potential changes to customer requirements and/or commitments, notification will be provided ERDA.

By adhering to the basic cost/scheduling system, maintaining a coordinated program, and reporting progress to ERDA, the Central Receiver Program objectives are realistically obtainable. Satisfactory performance on similar programs in the past indicates that the system works well. It provides the proper mechanics and degree of sophistication necessary to engender a high level of confidence that Phase 1 tasks will be accomplished with minimum cost and schedule risk.

MATERIAL AND SUBCONTRACT PLAN 4

Section 4

MATERIAL AND SUBCONTRACT PLAN

The material and subcontracting plan described in this section will utilize MDAC's established procurement system. This system is under the specific surveillance of the Air Force Plant Representative – Air Force Contract Management Division (AFSC), in accordance with Government directives. It currently is unconditionally approved (as of October 25, 1974). This section does not therefore dwell on the specifics of the system, but addresses those elements we feel are particularly supportive of the Central Receiver Program activities.

4.1 MATERIAL SUPPORT

Material support covers procurement activity for all SRE hardware items not included in the subcontracts discussed in Section 4.3, Subcontract Management. MDAC's procurement and material systems integrate the functions of material planning, handling, control and inventory management, receiving, GFE administration, and source development and selection. Also administration of small business and minority-owned enterprises, purchasing, cost and price analysis, supplier followup, and traffic management.

4.1.1 Source Surveys

Long-lead and other critical procurement items are identified to properly assess cost, availability, and degree of development of all items making up the SRE hardware. These data are developed through the preparations of requests for information (RFI) which contain short, concise technical and program requirements for the selected components. The RFI's are issued to representative, competent industry sources for the specific items. (This step has already been taken for many Phase 1 items during proposal preparation.)

The data will be updated and expanded during SRE design. The use of RFI data has proven to be particularly useful in getting a clearer understanding of the availability of lead time items and cost of the hardware. This information is then used to realistically substantiate Conceptual Design Review conclusions.

4.1.2 Source Selection

Source selection for key technical items has already been performed (see Section 4.3). An analysis based on our make or buy plan (Section 4.4) shows that remaining buy items will not require formal Source Selection Board activity. We anticipate that this activity will be accomplished through the preparation of RFQ's by the appropriate buyer and an analysis of the responses by the buyer and cognizant engineers assigned to those components.

Our policy will be "competitive procurement" of as much SRE hardware as possible to obtain the most competent supplier at the most reasonable price.

4.1.3 Material Control

Material requirements will be released for buying action through the use of a direct procurement action work release order (WRO). This action affords a minimum-time response and maximizes combining like items for efficient procurement.

When material is received and inspected in accordance with the appropriate quality requirements, it will be routed into inventory and held under controlled conditions to prevent loss or damage. Issuance from inventory will be made in accordance with the appropriate using organization's requirements.

4.1.4 Purchasing

MDAC's Purchasing Department is segregated into commodity buying groups. This segregation provides efficient and knowledgeable buyers who know the best suppliers for a given item and what price should be paid under current market conditions. This will provide ERDA with quality hardware at a reasonable price.

As part of the purchase order requirement for the Central Receiver Program, the right to conduct vendor meetings (SCO61C) with ERDA attendance will be stipulated in the terms of the contract for selected key items. Vendor contract requirements will include a milestone chart depicting significant events to allow tracking of vendor progress. As part of our standard purchase order terms and conditions activity, an equal opportunity clause for Government prime contracts is called out.

4.1.5 Status and Followup

All critical items will be tracked by procurement status group personnel. This tracking will take the form of weekly telephone conversations assessing progress against previously determined milestones. Periodic on-site reviews will also be conducted.

If a supplier appears to be getting into trouble, Procurement immediately notifies the Program Manager to begin developing a work-around plan. Our policy is also that if a supplier needs technical or management help we will place a man in residence with that supplier as long as necessary.

4.1.6 Spares Policy

The selection and procurement of spares will be based on ensuring timely support of SRE test operations while minimizing cost of spare components. Since most components subject to failure will be repairable, spares of the complete units will not be required. In procurement of such items, MDAC will establish supplier repair capability and the necessary turnaround time in advance. In-house fabricated items will be repaired in the same departments doing the original fabrication.

A limited number of spares will be procured of those items which are nonrepairable and may be subject to failure or damage. These items will be selected based on engineering design considerations and failure-rate expectations. A preliminary analysis has already been performed and the list of these items is included in Volume III, Test Plan and Volume V, Cost Proposal. This list includes such items as reflector segments, consumable fasteners, and electronic components. As the detail design is released for fabrication or procurement, specific spare items will be authorized based on the above policy.

Spares components will be shipped to the test site with other hardware and will be subject to controlled use as authorized by the SRE test manager. Repairable items removed because of malfunction or damage will be given expedited handling for transfer to the factory or supplier for repair.

Receiver and thermal storage SRE tests performed by Rocketdyne will be subject to the same spares policy. After program management approval of requirements, the necessary spare items will be procured, stocked, and controlled by the subcontractor.

4.2 SUBCONTRACT MANAGEMENT

MDAC has selected a number of subcontractor team members, subject to ERDA approval, whose program-applicable skills and technology developments form an integral part of the program approach. These subcontractors are identified in Table 4-1, along with the tasks they will be responsible for and the rationale for their choice. The work listed covers all areas of subcontracted work anticipated for Phase 1.

Management of subcontractor activities will be a team effort with close contact and coordination planned at program management, contractual, and technical levels. The Program Manager, working

Table 4-1. RATIONALE FOR SUBCONTRACTOR SELECTION

Subcontractor	Task	Rationale
Rocketdyne Division Rockwell International 6633 Canoga Avenue Canoga Park, Calif. 91304	Receiver, Subsystem Research Experiment (WBS SC310* & SC320*)	Rocketdyne has high heat flux and boiling heat exchanger design experience. Outstanding performance as subcontractor to MDAC on University of Houston Solar Receiver Study. Six firms were surveyed prior to selection of Rocketdyne.
	Thermal Storage, Subsystem Research Experiment (WBS SC410* & SC420*)	Rocketdyne has extensive experience in this field. MDAC and Rocketdyne have joint patent on innovative approach to thermal storage.
Stearns-Roger 700 South Ash Street P.O. Box 5888 Denver, Colo 80217	Electrical Power Generation Subsystem: A&E Support for Tower and Energy Transport (WBS SC310* & SC510*)	Requires experience in commercial power plant design, applicable codes and familiarity with available equipment. Seven firms were surveyed for understanding of problem and experience.
	Environmental Impact Analysis (WBS SC064*)	Stearns-Roger has established environmental capability and knowledge of system.
University of Houston 3801 Cullen Boulevard Houston, Tex. 77004	System Analysis and Test Support (WBS SC210* & SC224*)	University of Houston has developed a computer program on previous NSF contracts which can be utilized for field layout optimization. University also familiar with MDAC design and test concepts through previous teaming arrangements.
Sheldahl, Inc. North-Highway 3 Northfield, Minn. 55057	Mirror Reflective Surface and Protective Coating (WBS SC210* & S220*)	Sheldahl has extensive experience in this field, has developed a proprietary process, and has conducted extensive specular reflectivity and environmental tests.

through the Deputy Program Manager, will control and coordinate all subcontract effort. A negotiator/administrator will be responsible for subcontract preparation, negotiation, and administration. Technical managers will be assigned as single points of contact for each subcontractor to ensure continuous technical coordination and communication. The negotiator/administrator maintains close liaison with these managers to ensure consistency with contract requirements.

The negotiator/administrator uses a number of management tools to maintain subcontract control:

- Technical requirements are controlled using an engineering requirements specification that describes the item or service being supplied. Change control is accomplished through formal release procedures for this specification which will prevent unapproved deviations from the technical baseline. This ensures that SRE test configurations are maintained consistent with the technical performance measurement data described in Section 3.2.
- The scope of work to be accomplished by the subcontractor is controlled through a statement of work approved and issued by the Program Manager and incorporated in the subcontract.
- Monthly financial and progress reports are required and these inputs are monitored against previously determined milestone schedules and budgets.
- Any significant deviation from the plan is immediately reported to the Program Manager so he may initiate action to establish a work-around plan.

To ensure good communication from both a technical and contractual point of view, periodic review meetings are held as required by and defined in WBS Task SC061C*. To fulfill ERDA requirements for participation in subcontractor reviews, this activity will be included as part of the subcontract work statements.

4.3 MAKE-OR-BUY PLAN

Standard MDAC make-or-buy (M/B) practices have been utilized to develop the M/B plan for system design and production and test of the subsystem research experiment hardware. These practices are also applicable to the more extensive hardware production requirements for subsequent phases of the Central Receiver Program.

Our M/B analysis for any program is performed in accordance with good business practices and Government regulations, with the following objectives:

- Produce products and services of high quality and technical excellence at the lowest possible overall costs consistent with performance, reliability, and delivery commitments.
- Give full consideration to the technical capability of MDAC and other MDC components for work related to their fields of specialization and requiring close integration with other products.

- Assign to outside suppliers that work requiring specialized capability or work which they can provide to meet performance, quality, and delivery requirements at a lower total cost than MDAC can make the items.
- Give fair opportunity to small business firms and minority-owned business enterprises and place work where possible in areas of concentrated unemployment or underemployment.

The detailed analysis and preparation of the recommended M/B plan is performed by a M/B subcommittee headed by the Program Manager and composed of representatives of each functional organization (engineering, manufacturing, quality assurance, procurement, etc.). The M/B plan covers both design and fabrication decisions for each significant hardware element. The overall plan and all major decision items are then reviewed by a formal M/B committee appointed by the MDAC President. This committee is chaired by the Vice President-Fiscal Management and is composed of directors of the MDAC functional organizations. All M/B decisions, therefore, are assured of management review reflecting total MDAC design, fabrication, and procurement experience.

Table 4-2 identifies the Phase 1 subsystems, components, software, and services already reviewed by the M/B committee and the M/B decisions reached. For major procurement items included in this proposal, the planned subcontractors are identified by footnote.

Table 4-2. MAKE-OR-BUY SUMMARY

WBS Element	Subject	Decision	
		Design	Mfg
SC110*	POCE (Pilot Plant) Integration and Assembly	Make (1)	–
SC210*	POCE (Pilot Plant) Collector Subsystem	Make (3,4,5)	–
SC310*	POCE (Pilot Plant) Receiver Subsystem	Buy (2, 3)	–
SC410*	POCE (Pilot Plant) Thermal Storage Subsystem	Make (2)	–
SC510*	POCE (Pilot Plant) Electrical Power Generation Subsystem	Buy (3)	–
SC220*	Collector Subsystem SRE	Make (4, 5)	–
SC223*	Hardware Fabrication	–	–
	Heliostat	–	Make
	Reflector	–	Make (5)
	Hub	–	Make
	Mount	–	Make
	Pedestal	–	Make
	Guidance, tracking, and control	–	Make
	Field controller	–	Make
	Power grid	–	Make
	Commander	–	Make
SC224*	Test and Evaluation	–	–
	Support services	Make	Buy
	Test support equipment	–	–
	Trailer	–	– (6)
	Digital image radiometer	Buy	Buy
	Target (soft)	Make	Buy
	Target (hard)	Make	Buy
	Weather van	–	CFE
	Equipment van	–	– (6)
	Mobile crane	–	– (6)
	Tower	–	– (6)
	Power generator	–	CFE
SC320*	Receiver Subsystem SRE	Buy (2)	Buy (2)
SC420*	Thermal Storage Subsystem SRE	Buy–(2)	Buy–(2)
SC0041*	Maintenance Equipment	–	–
	Collector	Make	Make
	Lifting device	Make	Make
	Sling, reflector	Make	Make
	Sensor Alignment Fixture	Make	Make
	Sling, miscellaneous	Make	Make
	Receiver	Buy (2)	Buy (2)
	Thermal Storage	Buy (2)	Buy (2)
SC042*	Simulators	–	–
	Collector	Make	Make
	Receiver	Buy (2)	Buy (2)
	Thermal Storage	Buy (2)	Buy (2)
SC050*	System Test and Evaluation	Make (1)	–
SC061*	System Engineering Management	Make (1)	–
SC062*	Project Management	Make	–
SC064*	Special Analysis	Buy (3)	–
SC070*	Data	Make (1)	–
SC093*	Support	Make	–

Footnotes: A Make ( ) indicates MDAC has prime responsibility with assistance as noted below.
A Buy ( ) indicates subcontractor has prime responsibility.

(1) With support from Rocketdyne, Stearns-Roger, University of Houston
(2) Rocketdyne
(3) Stearns-Roger
(4) University of Houston
(5) Sheldahl
(6) To be supplied by test site support contractor
CFE = Contractor-furnished equipment – no cost to contract and nondeliverable

ORGANIZATION AND KEY PERSONNEL 5

Section 5

ORGANIZATION AND KEY PERSONNEL

Our Central Receiver Program organization is a completely integrated and projectized team of MDAC and subcontractor technical specialists supported by architectural-engineering personnel. Each team member has been selected for his particular experience and ability pertinent to applicable Phase 1 tasks. All are presently organized and working effectively as a team. The key personnel were major contributors to this proposal.

MDAC's team originates from the Company's Energy Systems organization at Huntington Beach, California. It is augmented by personnel of the Rocketdyne Division of Rockwell International Corporation, Stearns, Roger, Inc., Sheldahl Corporation, and the University of Houston. These subcontractor personnel were chosen for their particular technology skills which are specifically applicable to the solar thermal power system and its subsystems and which complement those available within MDAC. Selection of the subcontractors was based not only on their ability to contribute constructively to the Phase 1 effort but also on their capability to successfully conduct the total program – from 10-MWe on-site POCE (pilot plant) to commercially competitive 100-300-MWe power plant. (See Section 4.2 for the rationale for selection of our subcontractors.)

MDAC has teamed successfully with all the program subcontractors before. Rocketdyne, who will manage the receiver assembly tasks and conduct the thermal storage test, has been a teammate for more than 20 years on Thor-Delta and Saturn-Apollo programs. Stearns-Roger has the technical production experience to design and construct the electrical power generation subsystem and assemble the other subsystems in the total plant. MDAC and Stearns-Roger have worked cooperatively together on the SAFEGUARD/Spartan and Site Defense programs, and the Delta launch facilities at Kennedy Space Center (1973-74). Sheldahl, with their extensive experience in developing and producing reflective materials, will provide support in evaluation and fabrication of efficient reflectors. Sheldahl teamed with MDAC on the 1971 HAVE IVORY (classified) program, on the sunshade design devised for the urgent repair of Skylab in 1973, and on the ABMDA Optical Model (1974). For more than two years, MDAC has been a subcontractor to the University of Houston on three of their solar energy research programs – Large Scale Solar Energy, Heliostat Model Test, and Solar Thermal Power System.

5.1 PROGRAM RELATIONSHIP WITHIN MDAC

MDAC will manage the Central Receiver Program at its Huntington Beach, California facility. R. L. Johnson, MDAC's President, has assigned Company-wide responsibility for energy programs to Dr. A. J. Vander Weyden. Mr. Johnson has further appointed R. W. Hallet, Jr. as Program Manager for the Central Receiver Program. Both of these assignments reflect MDAC's recognition of the increasing scope of energy development nationally and within the Company.

Dr. Vander Weyden has been responsible for the overall management planning and technology definition of all of MDAC's new business activities, including solar energy. He recently directed and was personally involved in a comprehensive corporate-wide energy technology study that defined available energy systems and investigated alternative energy sources, including solar-thermal electric power. This survey additionally identified potential marketable services and equipment for application to the solar power plant. Earlier, as Chairman of the Douglas United Nuclear Safety Advisory Committee, he established safety policies and provided guidance contributing to improved safety procedures associated with the Company's operation of the production and electrical power reactors at the AEC's Hanford facility at Richland, Washington.

Before joining MDAC in 1965, Dr. Vander Weyden held the position of AEC Deputy Assistant General Manager for Reactors. In this position he managed three of the Commission's major Divisions: Naval Reactors, Space Reactors, and Reactor Development and Technology. He held technical management positions with the AEC from 1950 until 1965, and holds the Distinguished Service Award, the highest honor that the Commission can bestow upon its employes. Today, Dr. Vander Weyden is considered one of the Country's foremost authorities on energy technology. He was recently a member of the National Technical Committee on Management of the AIAA. His BS degree in chemistry was awarded by Colorado College in 1940, and his PhD in chemistry by the Massachusetts Institute of Technology in 1943.

The relationship of the program to the overall MDAC organizational structure is shown in Figure 5-1, and of the subcontractor program groups to their Company structures in Figure 5-2.

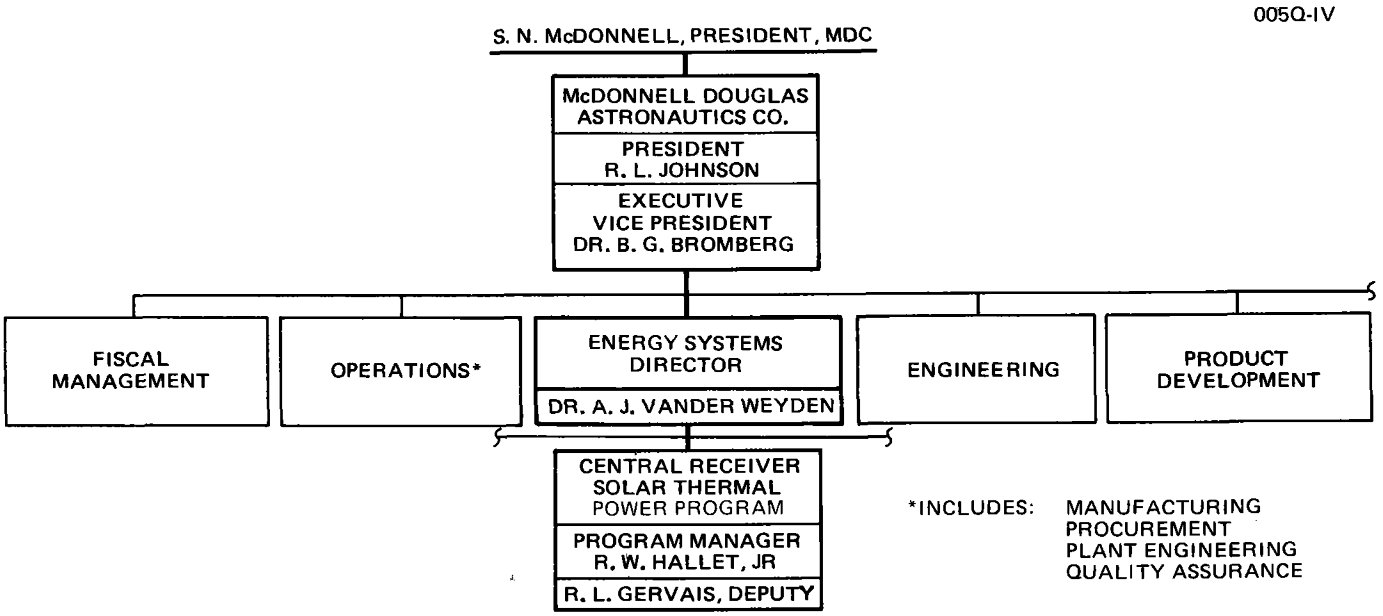


Figure 5-1. Relationship of Program to Company Organization

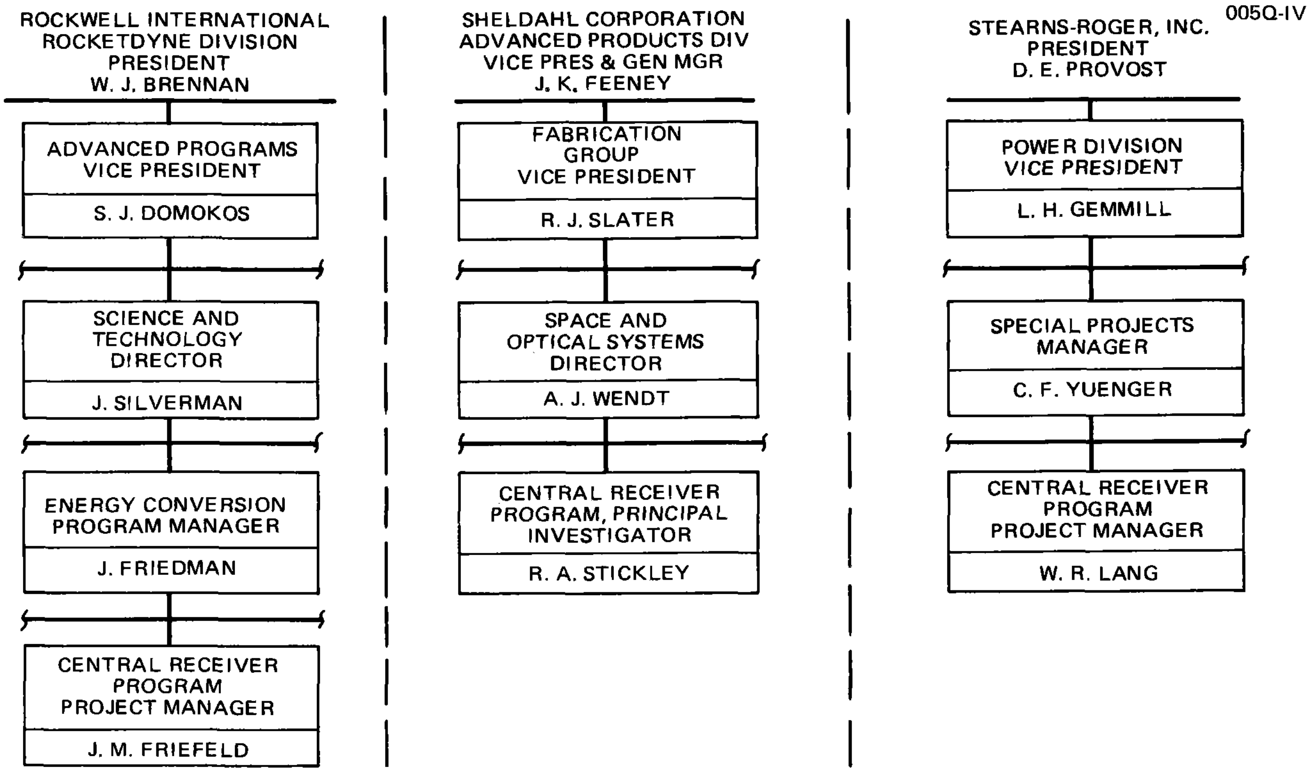


Figure 5-2. Relationship of Program Activity to Subcontractor Organizations

5.2 PROGRAM ORGANIZATION

The organization of MDAC, subcontractor, support, and advisory program personnel is presented in Figure 5-3. The structure is simple with the subcontractor roles completely integrated. Management levels are minimized to reduce communication links and cost. Organizational lines are consistent with maximum program direction and efficiency of operation so that problems can be rapidly identified, action items can be clearly assigned, and current program status can be promptly obtained and communicated to ERDA. West Associates, comprising representatives from more than 20 western utility companies, has provided an advisory committee to review our work and provide consultation.

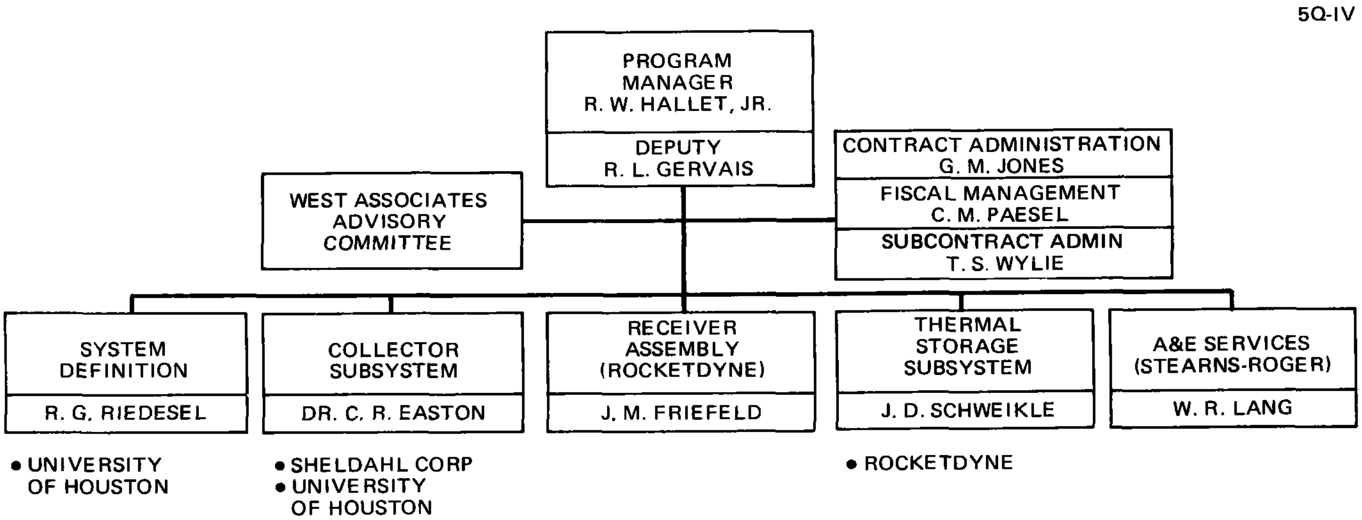


Figure 5-3. Program Organization for the Central Receiver Solar Thermal Power System

5.2.1 Program Management

Mr. Hallet's 20 years of increasingly responsible technical management experience includes responsibility for initiating and directing MDAC's contracted and Company-sponsored work in solar thermal power for the past four years. He has used the experience and data gained from his work in solar energy systems and subsystems as the basis for our proposed Central Receiver Program. He was influential in the development of the central receiver concept during the Large Scale Solar Energy studies conducted by MDAC for the University of Houston and the current follow-on contract, the Solar Thermal Power System study. Since the inception of MDAC's solar energy efforts, Mr. Hallet has been instrumental in initiating Company-sponsored studies to identify thermal processes best suited to solar energy utilization, defining an optimum solar-thermal-electric system concept, and establishing design principles and fabrication methods for collectors.

Previously, he served for four years as Vice President and Deputy General Manager of Douglas United Nuclear, Inc., the Company's subsidiary that operated the fuel production facilities and production reactors (including the "N" reactor which generated 800 megawatts of electrical power) for the AEC at its Hanford facility in Richland, Washington. This provided Mr. Hallet direct experience in working with electrical power generation systems, utility companies and the many associated Government agencies. From 1964 to 1967, he directed all Research and Development activities of the Douglas Missile and Space Systems Division, following nine years of managing aerothermodynamic, nuclear, and power plant technologies. Mr. Hallet has an MS degree in engineering from the University of California, Los Angeles (1958). His biography appears in Leaders in American Science, American Men of Science, and Who's Who in the West.

The MDAC managers identified in Figure 5-3 have program-wide responsibilities for their specialties, report directly to the Program Manager and are assigned full-time to the program for the duration of the contract. Other team members are assigned to the program from the Company's functional divisions when needed. They are dedicated to the program for the duration of their assignments and take work assignments from these managers. Mr. Hallet selected and organized the team members and participates in evaluating them for periodic salary or promotional reviews.

R.L. Gervais has been selected as Deputy Program Manager. He is authorized to take action on behalf of Mr. Hallet on all program matters in Mr. Hallet's absence and is responsible for those portions of the Program Manager's tasks delegated by Mr. Hallet. In particular, Mr. Gervais will continually review and provide direction for subcontractor project activities external to MDAC. The **MDAC** teaming arrangement provides for the subcontracting of approximately **60% of the total contract dollar value**. Mr. Gervais is supported in this role by the Subcontract Administrator, T.S. Wylie, and the assigned technical engineers.

Mr. Gervais has over 18 years of technical management experience. He has been managing all technical aspects of MDAC's contracted and Company-sponsored solar energy studies for the past four years; has been

MDAC's primary point of contact with the University of Houston and the NSF throughout the development of central receiver concepts; and was responsible for MDAC's performance on the subcontracted Solar Thermal Power System, Large Scale Solar Energy studies, Heliostat Model Test program, Elimination or Control of Material Problems in Water Heat Pipes Study (conducted directly for the NSF), and the MDAC-sponsored Solar Energy Conversion and Solar Power Concentrator/Receiver Development studies. As Project Manager, Space Stations, Mr. Gervais directed power system design and analysis activities and subcontractor interfaces for MDAC's manned spacecraft programs for seven years. Prior to this, he devoted five years to the supervision of manned interplanetary system analysis, nuclear interplanetary and nuclear launch vehicle projects, and aero/astrodynamics aspects of reentry vehicle programs.

Mr. Gervais is First Vice President of the American Astronautical Society and a member of its Executive Committee. He is also the AIAA Technical Specialty Group Coordinator-Energy Systems and has recently been appointed Chairman of the AIAA Energy Activities Task Force. He has published more than 40 papers on solar energy power systems and manned spaceflight. His MS degree in aeronautical engineering was awarded by the University of Notre Dame in 1957.

5.2.2 Program Team

Within the groups shown in Figure 5-3, all tasks described in the statement of work have been assigned for implementation. The organization and functions of each group, its responsibilities, and the qualifications of its personnel follow.

The System Definition Group (Figure 5-4), managed by R.G. Riedesel, is responsible for all system-related aspects of the program, including requirements analysis, specifications, iteration of experimental results, and POCE plans and preliminary design. Also included is the preliminary design consideration of a master control for POCE. Mr. Riedesel will be responsible for the development and test plans work. In addition, he will control all subsystem interfaces, as defined in Task SC061A.03, to maintain compatibility. He will review all proposed MDAC and subcontractor changes to the POCE system and subsystem definition and to SRE test requirements, and submit all significant changes to the Program Manager for approval.

Mr. Riedesel has recently been involved in a corporate activity to define available energy systems and investigate alternative energy sources, including solar-thermal electric power. He performed an overview analysis of the various types of energy systems, assessed the availability of resources for each type, analyzed economic and environmental considerations, and identified potential marketable services and equipment for application to the solar power plant. He has also been continuously involved in Company-sponsored solar energy studies, particularly the Solar Heating and Cooling of Buildings Study for which he defined system requirements, planned development test activities, and identified thermal processes best suited to utilization of solar energy. His 13 years' experience include the past 2 years on solar energy projects, 6 years formulating program plans and schedules and directing space system analysis/definition studies,

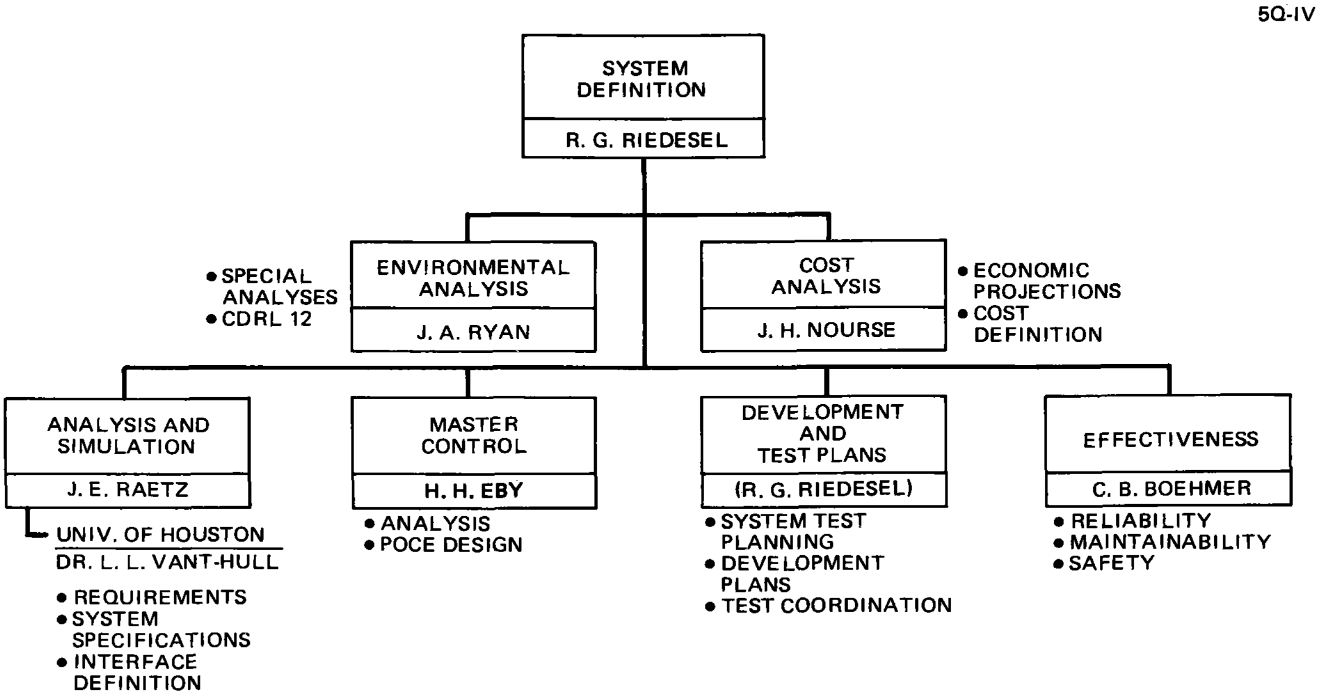


Figure 5-4. System Definition Organization

4 years analyzing and testing propulsion hardware, and 1 year analyzing commercial power plant operations. Mr. Riedesel's BS degree in mechanical engineering was awarded by Iowa State University in 1957.

The Collector Subsystem Group (Figure 5-5) will cover all technical effort associated with the collector both for the subsystem research experiment hardware and test and POCE analysis and design. Dr. C. R. Easton will direct the Sheldahl and University of Houston subcontract support efforts in addition to heading the analysis and design task work and managing the remaining three subgroups identified on the chart.

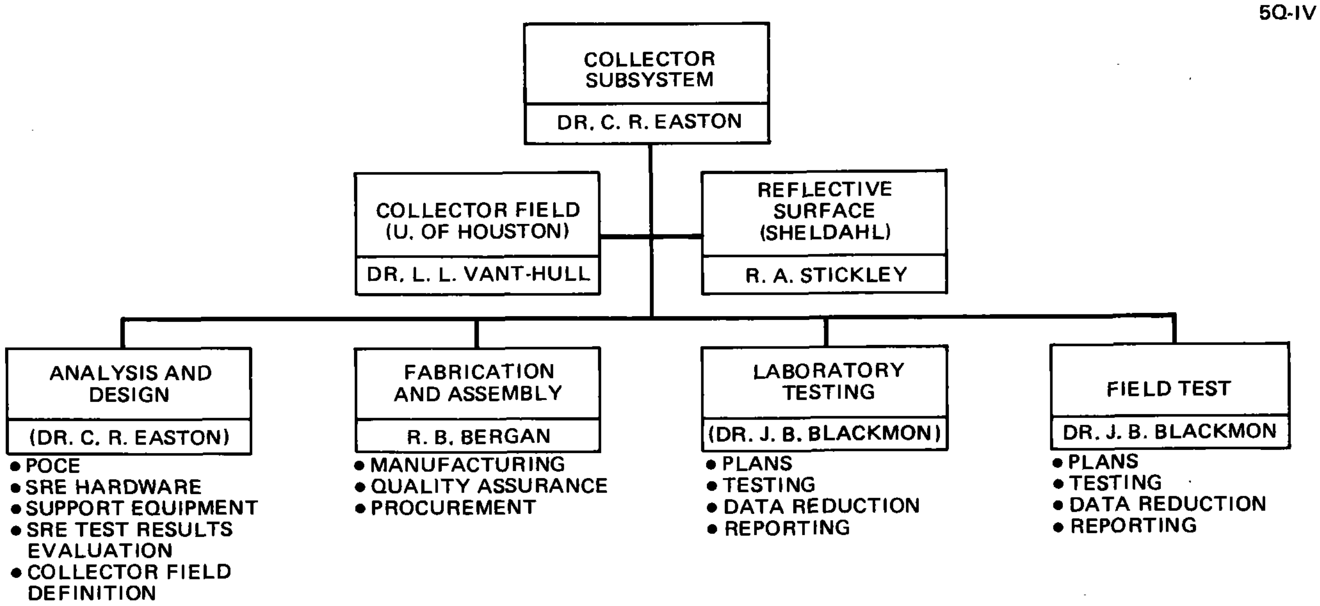


Figure 5-5. Collector Subsystem Organization

As Principal Investigator for the Large Scale Solar Energy program and the current Solar Thermal Power System program, Dr. Easton worked with the University of Houston to establish collector field optimization and supervised the resultant basic heliostat design activity at MDAC. Additionally, he performed the interface analysis between the collector and the receiver and developed the conceptual designs for the receiver and energy transfer system. As Principal Investigator for the Dynamic Conversion of Solar-Generated Heat to Electricity studies, he supervised and conducted analyses related to collector field optimization. Since joining the Company in 1957, Dr. Easton has made significant contributions in fluid mechanics and heat transfer technology to the research and advanced design of missiles, space systems, aircraft, propulsion systems, and high-energy-laser systems. Dr. Easton has a BS degree in mechanical engineering from Oklahoma State University (1956) and MS and PhD degrees in engineering (specializing in heat and mass transfer) from the University of California, Los Angeles (1964 and 1970). He has written 4 publications on solar energy and 19 on heat transfer and fluid mechanics.

The receiver assembly is the responsibility of Rocketdyne. J. Friedman, Rocketdyne Program Manager, Energy Conversion, is responsible for all work under the subcontract. The Central Receiver Program group, under the management of J. M. Friefeld, Project Manager (Figure 5-6), will be responsible for SRE hardware, design, fabrication, and test. They will support the Systems Definition Group for POCE analysis and design. (The design, integration, and assembly of the tower assembly and energy transport for the receiver subsystem are the responsibility of Stearns-Roger.)

Mr. Friefeld is a technical specialist in thermodynamics and heat transfer, and has been responsible for company-funded solar energy activities for the past 2 years. As Project Engineer for the Heat Flux Demonstration Test studies, he supervised coolant heat transfer tests, generation of heat fluxes for these tests, and development of wall and coolant temperature profiles for various heat flux levels. He was also Project Engineer for the Solar Absorptance Test studies, which involved supervision of experiments to determine ways of obtaining high solar absorptivity of candidate surface treatments for the receiver subsystem. Under subcontract to MDAC, he supervised all technical aspects of the Receiver Subsystem Study, including

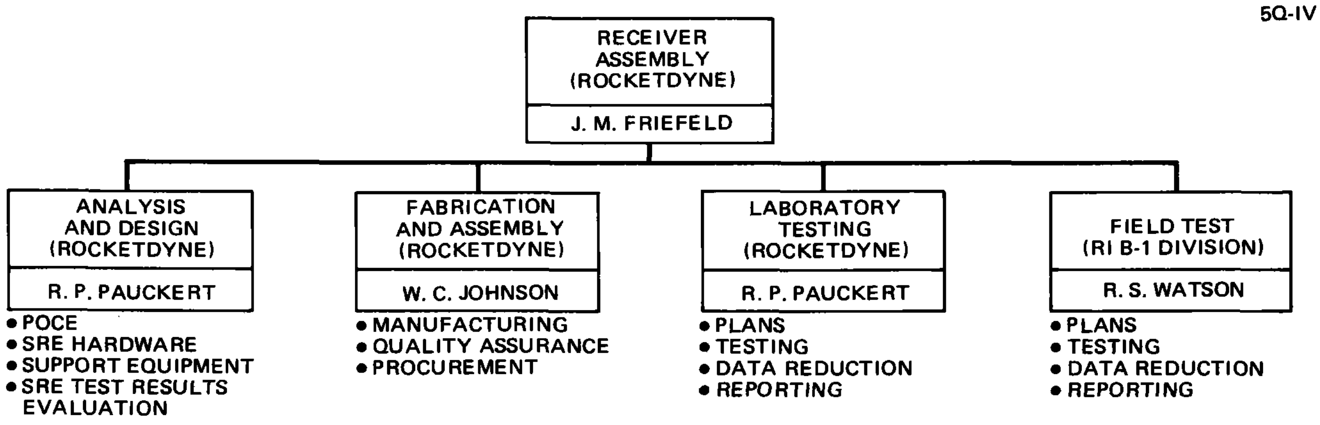


Figure 5-6. Receiver Assembly Organization

evaluation of candidate receiver shapes for fluid accommodation, preliminary design of candidate receiver shapes, and identification of test requirements for the receiver subsystem. From 1965 to 1973, he managed all heat transfer and aerodynamics activities including cooling system design for both rocket engine components and commercial stationary power systems. Mr. Friefeld's MS degree in mechanical engineering was awarded by the University of Southern California in 1965.

MDAC's J. D. Schweikle has been selected to manage the Thermal Storage Subsystem Group (Figure 5-7), and to be personally responsible for the subsystem integration task. The design, fabrication, and thermal storage test has been subcontracted to Rocketdyne. Their personnel respond to Mr. Schweikle's technical direction, but report internally to Mr. Friefeld, who as Project Manager is responsible to Rocketdyne management for the performance of all Rocketdyne personnel assigned to the program. Mr. Schweikle has directed a number of company-sponsored R&D activities involving the solar energy technology. He has supported many of the studies that led to the development of the central receiver including those that identified processes suitable for application to the thermal storage subsystem. As Supervisor of the technical personnel who conducted the Solar Power-Concentrator Development Study, he was responsible for test planning, field test performance, test article production, and evaluation of test results. His more than 15 years of experience includes 9 years in the design and analysis of propulsion systems, 4 years in the research and development of advance mechanical systems and liquid/solid propellant control systems, and 2 years in the advancement of solar energy technology. Mr. Schweikle has an MS degree in engineering from UCLA (1965).

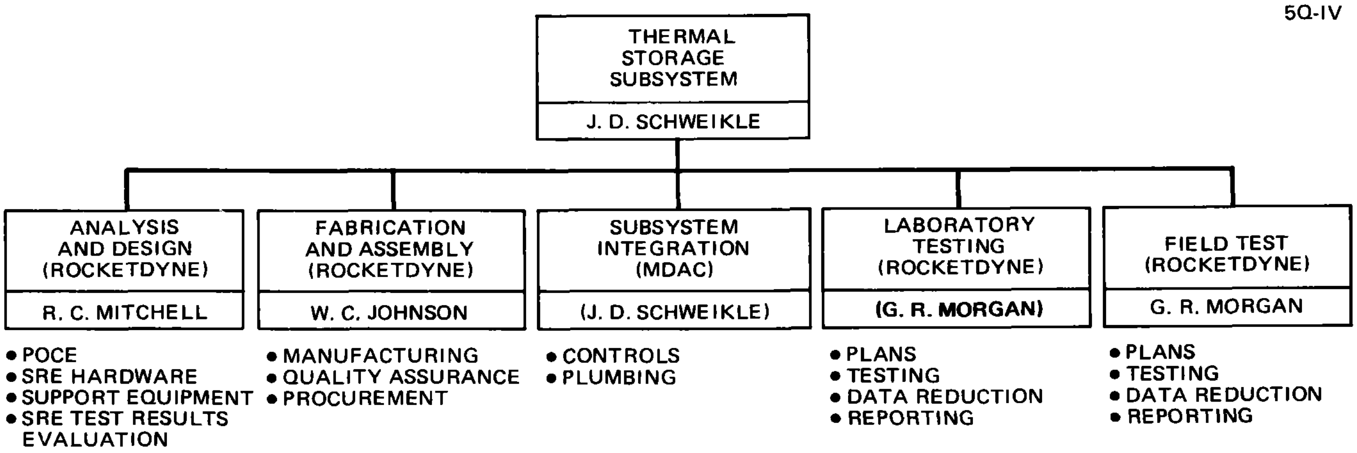


Figure 5-7. Thermal Storage Subsystem Organization

The Architectural and Engineering Services Group is staffed entirely by Stearns-Roger personnel. It is headed by W. R. Lang, Project Manager, who will direct the electrical power generation subsystem POCE design, test plans, and integration and assembly; design the tower assembly and energy transport for the receiver subsystem; and provide general A&E support to other program groups. Figure 5-8 identifies the principal Stearns-Roger assignments and tasks.

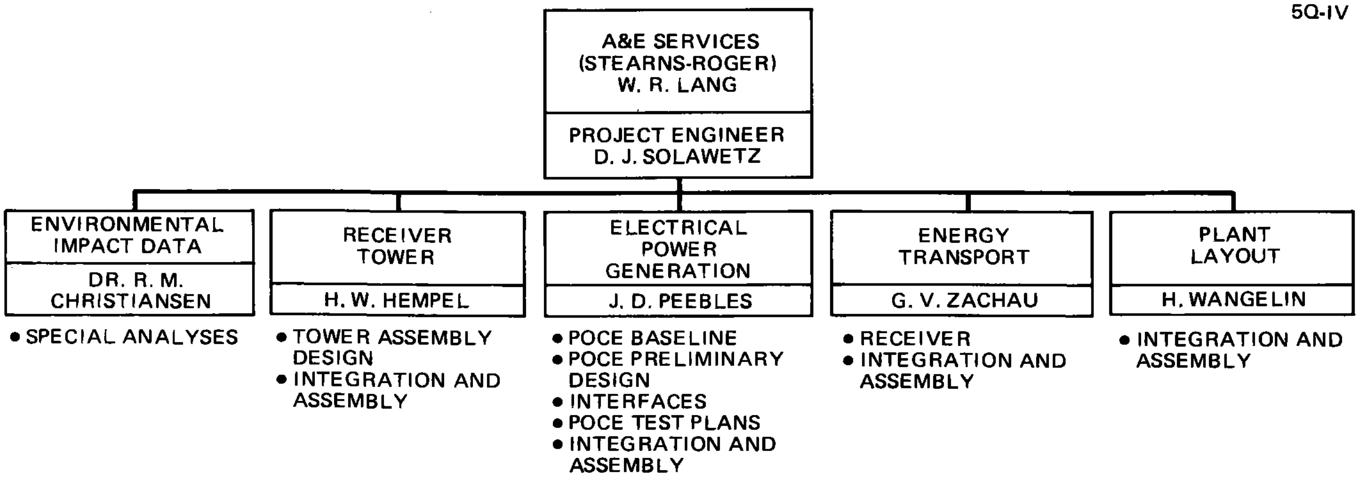


Figure 5-8. A&E Services Organization

Mr. Lang brings to the Central Receiver Program more than 15 years' experience in engineering design and construction management of large-scale field test and launch facilities for Government and aerospace contractors, including subcontracted support of major MDAC programs for the past 5 years. Since joining Stearns-Roger in 1956, he has managed fabrication and testing of the platforms required for mounting the major elements of the Site Defense data processing and radar subsystems, mechanical installation of Spartan launch hardware, and design and construction work on the launch tower for MDAC's Delta space vehicle. He has also managed a number of other architectural and engineering projects, including a recent program to construct a complete water filtration, transmission, distribution, and storage facility for the city of Lafayette, Colorado.

Mr. Lang's BS degree in chemical engineering was awarded by the University of Colorado in 1953.

5.2.3 Personnel Availability and Qualifications

Personnel in the required disciplines are available and are committed to the program to provide the specific required skills. Projected total employment at McDonnell Douglas Astronautics Company-West for the June 1976 program midpoint is approximately 5,300 of which 3,800 are scientists, engineers, and technical personnel. This illustrates the depth of technical backup capability available to this program. The qualifications of additional key personnel who will participate in the program are presented in Table 5-1.

5.3 PROGRAM DIRECTION AND COMMUNICATIONS

We have organized the program team with the objectives of first achieving Phase 1 goals and then providing for ready transition to subsequent phases. As discussed in the preceding section, we have experienced personnel with which to staff the total program organization. Section 3, Performance Management Plan, discussed the use of existing MDAC management and financial control systems for performance, cost, and schedule management. Effective use of these tools ensures that key issues are tracked and schedule impacts are flagged. Continuous program visibility through use of these systems is provided to ERDA for the early identification of potential problems. The Program Manager has the factual information upon

Table 5-1. APPLICABLE EXPERIENCE OF ADDITIONAL PROGRAM TEAM MEMBERS (Page 1 of 4)

MC DONNELL DOUGLAS ASTRONAUTICS COMPANY

C. R. Applebaugh – Structural Analysis and Design • Established structural design requirements and contributed to heliostat design concept for Solar Thermal Power System, Large-Scale Solar Energy, Dynamic Conversion of Solar-Generated Heat to Electricity studies • Designed and developed test model of heliostat for Heliostat Model Test Program • 31 years in structural and mechanical design and analysis.

R. B. Bergan – BSAE • Fabrication and Assembly • Directs and participates in fabrication, assembly, and test of experimental systems and equipment • Supervised fabrication, assembly, and checkout of test and flight hardware for UpSTAGE advanced interceptor development program • Supervised definition of subcontractor performance for Delta second-stage system • 33 years in engineering, maintenance, fabrication, and test of aircraft and space systems.

J. B. Blackmon – PhD engineering • Field and Laboratory Test • As Principal Investigator for Heliostat Model Test Program, planned and implemented tests, coordinated design and production of test article, supervised test data reduction, and prepared reports • As Principal Investigator for Solar Power Concentrator Development Study, supervised definition of design principles, development of low-cost fabrication methods for collectors, and laboratory testing related to adhesives, reflective surfaces degradation, control sensors, drive unit performance, and structural loads • Performed design and analysis for Solar Thermal Power System, Large-Scale Solar Energy, and Dynamic Conversion of Solar-Generated Heat to Electricity studies • Principal Investigator for Company-sponsored Propellant Orientation and Control program, involving applied research on surface-tension propellant control and low-g fluid dynamics • 14 years in propulsion and mechanical systems design and development.

C. B. Boehmer – MS physics • Effectiveness Engineering • Supervises reliability, maintainability, and safety analysis for urban mass transportation systems • Performs energy consumption studies for specific transportation concepts. • Responsible for reliability, safety, and test program definition for NASA Nuclear Stage program • At Westinghouse, responsible for NERVA nuclear rocket engine control system design • 13 years in control and safety system design, system, and reliability analysis.

H. H. Eby – BSEE • Master Control • Defined master control system requirements for POCE operations for Solar Energy Conversion Studies • Responsible for system design of a control and instrumentation system to tie all MDAC-W engineering laboratories to a control data facility • Supervised hardware design of Saturn S-IVB automatic checkout system • Directed system, hardware, and software design of Manned Orbiting Laboratory automatic test and launch system • 17 years in test and electronics design.

S. J. Kong – MS applied mechanics • Collector Structural Analysis • Participated in structural analysis of tower design for Solar Thermal Power System study • Analyzed structural aspects of heliostat reflective surface, support, and pedestal for Solar Power-Concentrator Development Study • Developed techniques to strengthen receiver assembly structure for Solar Power-Receiver Development study • Conducted investigations of the application of advanced composites to structures of missiles and space vehicles • Involved in reentry vehicle structures design and test • 25 years in mechanical and structural design and analysis.

R. E. McCormick – MSME • Heliostat Control Electronics • Designed and tested control electronics for Heliostat Model Test Program • Supervised design, analysis, fabrication, and testing of heliostat control system for Solar Power-Concentrator Development study • 10 years in design, analysis, and testing of electronic circuits and components, including nuclear-hardened circuits for Spartan, an arithmetic unit for a semiactive laser system, and the UpSTAGE interceptor attitude-reference computer.

R. H. McFee – PhD physics • Collector Optics Design • Developed optics elements of collector subsystem for Solar Thermal Power System, Large-Scale Solar Energy, and Dynamic Conversion of Solar-Generated Heat to Electricity studies • Designed and developed photovoltaic sensor for Solar Power-Concentrator Development Study • Developed CONCEN collector optical computer program • Developed pointing and tracking techniques for high-energy-laser systems • Directed Advance Research Laboratory in solid state physics, gas-phase physics, and fluoropolymer chemistry • 29 years in optical and electronics design and development.

Table 5-1. APPLICABLE EXPERIENCE OF ADDITIONAL PROGRAM TEAM MEMBERS (Page 2 of 4)

J. H. Nourse – MS business administration • Cost Analysis • Developed computerized cost models, including LEADER cost modeling system, for cost optimization of Industrial Application of Solar Energy, Solar Thermal Power System, Large-Scale Solar Energy, and Dynamic Conversion of Solar-Generated Heat to Electricity studies • Conducted Cost and Economic Methodology Studies related to solar energy • 15 years in automotive and aerospace systems cost analysis.

J. E. Raetz – MSME • Analysis and Simulation • Supervised system analysis and developed computer programs to simulate POCE system operation and to verify collector and receiver subsystem design for Solar Thermal Power System, Large-Scale Solar Energy, Industrial Application of Solar Energy, Dynamic Conversion of Solar-Generated Heat to Electricity, Solar Power-Receiver Development, and Elimination or Control of Material Problems in Water Heat Pipes studies • Developed transient fluid dynamic and heat transfer computer simulation for Skylab thermal control system • Test director for Skylab Thermal Storage development program • 6 years in system analysis, and aerothermodynamic test and simulation.

J. A. Ryan – PhD geophysics • Environmental System Definition • Defined environmental factors influencing collector subsystem operation and analyzed seismic impact on total system design for Solar Thermal Power System Study • Participated in site selection for reflective surface environmental test and analyzed meteorological factors from computer data for Solar Power-Concentrator Development Study • Directed research in remote sensing of earth environment, atmospheric transmission, meteorology, atmospheric chemistry and physics, geophysics, and planetary atmospheres for the past 16 years.

H. Taketani – BS metallurgy • Collector Material Testing • Analyzed effects of testing on heliostat test article materials for Heliostat Model Test • Prepared transmission measurements and performed solar simulation test on candidate reflector materials at Boron AFB desert test site for Solar Power-Concentrator Development Study • Performed material screening tests for Solar Power-Receiver Development Study • Developed methods of forming, heat-treating, and assembling aerospace structures • Performed tests in support of engineering on a variety of materials and components • 22 years in materials development and test.

C. A. Van Ornum – PhD mechanical engineering • Collector Control • Defined heliostat control system requirements for Solar Thermal Power System, Large-Scale Solar Energy, and Dynamic Conversion of Solar-Generated Heat to Electricity studies • Developed heliostat control and drive mechanism for Heliostat Model Test Program • Developed concept for open-loop command tracking of an array of heliostats for Solar Power-Concentrator Development Study • Analyzed hydraulic, pneumatic, and electromechanical servo systems for tactical missiles and precision pointing and tracking systems • Determined thrust vector control servo system requirements for AGILE missile and Saturn S-IVB space vehicle • 21 years in mechanical systems analysis and requirements definition.

ROCKETDYNE, DIVISION OF ROCKWELL INTERNATIONAL

R. G. Barnsdale – BSME • Receiver Assembly Design Engineering • As Lead Design Engineer on Compact Steam Generator program, supervised detailed design, layout, and fabrication of concentric heat exchanger for generation of steam using natural gas and gaseous oxygen as fuel • 17 years in mechanical and thermodynamic design and analysis of power plants and rocket engines.

W. C. Johnson – BSME • Thermal Storage and Receiver Subsystems Fabrication and Assembly • As Manufacturing Program Representative on Compact Steam Generator Program, was responsible for fabrication from process flow planning through final assembly and system checkout • 22 years in manufacturing, including manufacturing development and special machine design for experimental projects.

R. C. Mitchell – PhD chemical engineering • Thermal Storage Subsystem Analysis and Design • Supervised scaled heat storage testing, development of analytical model of thermal storage tank, and cost studies of thermal storage methods for Thermal Storage System Test Study, which demonstrated thermal storage system at subscale level • As Chemical Technology and Applied Mathematics supervisor, directs chemical engineering activities as applied to environmental problems • 12 years in chemical, environmental, and safety engineering.

G. R. Morgan – BSME • Thermal Storage Subsystem Laboratory Testing • Responsible for all overall system analysis, including component evaluation and selection, as well as control system syntheses in connection with Company-sponsored Thermal Storage System Test Study • Experience includes component selection and design of valves, heat exchangers, fluid lines, pumps, and actuators • 26 years in design, analysis, and test of gas and fluid flow systems.

Table 5-1. APPLICABLE EXPERIENCE OF ADDITIONAL PROGRAM TEAM MEMBERS (Page 3 of 4)

R. B. Pauckert – MSME • Receiver Assembly Analysis, Design, and Laboratory Testing • Responsible on Solar Tower Receiver Study for identification of laboratory testing requirements for a complete receiver subsystem • Performed system analysis and design investigation of advanced versions of Compact Steam Generator • Principal Investigator for rocket engine development programs such as Space Shuttle Orbital Maneuvering Engine project • 20 years in propulsion system design and analysis.

R. S. Watson – BSME • Receiver Subsystem Field Test • Supervised Compact Steam Generator single-tube and complete-system tests • Coordinated experiments to demonstrate successful cooling of tube walls subjected to extreme heat flux intensities for Heat Flux Demonstration Tests • Developed a combustion burner facility used to simulate thermodynamics and aerodynamic loads on aircraft and rocket engine structures • 19 years in thermodynamic and propulsion system simulation and test.

SHELDAHL, INC.

D. E. Anderson – PhD electrical engineering • Collector Reflector Assembly • Developed concept, determined optical evaluation techniques, and supervised materials selection methods for Solar Power Array for the Concentration of Energy (SPACE) project • Developed concept for Solar Linear Array Thermal System (SLATS), initiated and supervised development program, and directed optical steering analysis and system performance predictions • Initiated and supervised development of Polymer Coating Development Program • For 8 years, managed industrial research on coatings and surface physics • 17 years of academic research in physical electronics.

R. A. Stickley – BSME • Collector Reflector Assembly • Evaluated metallized thin-film membranes for potential use as heliostat reflective surfaces, established system requirements, supervised development of system performance models, and evaluated cost factors for Solar Power Array for the Concentration of Energy (SPACE) Program • 17 years in electromechanical design and technical direction of system and subsystem laboratory and field tests of high-performance aerospace vehicles.

STEARNS-ROGER, INC.

R. Christiansen – PhD chemical engineering • Environmental Impact Data • Environmental Sciences Manager for past 5 years, supervising environmental factors analysis for projects such as Kauai Station, Colorado-UTE Electric Association, and Public Service Company of Colorado steam/electric generation plants • Supervised process design work for various chemical plants for 11 years.

H. W. Hempel – BSCE • Receiver Tower • Responsible for site development, water resources, and architectural design for projects such as Kauai Station, Colorado-UTE Electric Association, and Public Service Company of Colorado steam/electric generation plants for past 2 years • Responsible for design specifications and drawings for steam-electric power generation projects varying from 15 to 450 MW for 18 years.

J. D. Peebles – BSEE • Electrical Power Generation • Supervised generation of electrical power for projects such as Kauai Station, Colorado-UTE Electric Association, and Public Service Company of Colorado steam/electric generation plants for past 11 years • Performed electrical design and test of power-generating stations for 13 years.

D. J. Solawetz – BSME • Project Engineer • Performed mechanical equipment sizing and specifications for PSCC Comanche Power Plant Units 1, 2 (350 MW each) for past 5 years • In charge of design, engineering, and mechanical equipment sizing for power plants for 15 years.

H. Wangelin – BSME • Plant Layout • As Chief Mechanical Engineer of Power Division for past 3 years, responsible for plant layout of projects such as Kauai Station, Colorado-UTE Electric Association, and Public Service Company of Colorado steam/electric generation plants • Conducted and managed design and engineering of power plant facilities for 23 years.

G. V. Zachau – BSME • Energy Transport • As Piping Engineering Group Supervisor for past 4 years, directed energy transport aspects of projects such as Kauai Station, Colorado-UTE Electric Association, and Public Service Company of Colorado steam/electric generation plants • Supervised energy transport consulting services, design of pipe support systems, and analysis of critical piping systems for fossil-fueled and nuclear power plants for 7 years • Performed mechanical engineering assignments for power generation stations for 9 years.

Table 5-1. APPLICABLE EXPERIENCE OF ADDITIONAL PROGRAM TEAM MEMBERS (Page 4 of 4)

UNIVERSITY OF HOUSTON

A. F. Hildebrandt – PhD physics • **Collector Field Analysis** • Originated central receiver design concept, calculated quantity of solar energy available, and estimated system costs for Company-sponsored Conceptual Studies on Solar Tower project and NSF Solar Thermal Power System Based on Optical Transmission contract • Conducted collector field analysis and supported MDAC performance of Solar Thermal Power System, Large-Scale Solar Energy, and Heliostat Model Test subcontracts • 21 years in supervision of chemistry and physics research at University of Houston, Jet Propulsion Laboratory, and California Institute of Technology • Surveyed 1-megawatt solar energy facility in France and 50-kilowatt facility in Italy.

L. L. Vant-Hull – PhD physics • **Collector Field Optimization and Test Data Evaluation** • Developed central receiver design concept, estimated properties of candidate mirror surfaces, developed preliminary computer model for optimizing geometry of heliostat collector field, and estimated properties of candidate mirror surfaces for Company-sponsored Conceptual Studies on Solar Tower project and NSF Solar Thermal Power System Based on Optical Transmission contract • Conducted collector field optimization, monitored MDAC performance, and provided technical consultation for Solar Thermal Power System, Large-Scale Solar Energy, and Heliostat Model Test subcontracts • 19 years in supervision and chemistry, physics, and electronics research at Jet Propulsion Laboratory, California Institute of Technology, University of Minnesota, and Hughes Research Laboratory • Participated in 1974 as member of Solar Thermal Conversion Group of US/USSR Visiting Scientists Program.

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which to base timely decisions for the correction of deficiencies which may arise. Corrective management actions are implemented through the program interface channels discussed below.

5.3.1 Internal Interfaces

Our approach to program management emphasizes close, personal, positive direction by Mr. Hallet, the Program Manager. In evaluating progress and providing direction, Mr. Hallet plans daily progress reviews of all problem areas with cognizant program personnel. All task schedules and cost status as well as technical progress will be reviewed at weekly sessions. The Program Manager also reviews program status weekly with the Director – Energy Systems and other top management. These review meetings provide a forum for open discussion of potential problems so that a policy of problem prevention may carried out by timely decision and project redirection. The benefits of these personal, direct communications are early detection of variances from plan and reduced internal paperwork, therefore achieving associated time and cost savings.

The System Definition Group, under Mr. Riedesel, is charged with an important technical interface with the subsystems groups for the control of system design and test baselines. The managers of the subsystems groups are responsible for the control of test configurations, operating instructions, procedures, and instrumentation requirements. They will review and approve all drawings, specifications, and procedures prior to release for fabrication, and review for approval all changes to these documents. Changes to the POCE system and subsystems definition and to SRE test requirements will be submitted by Mr. Riedesel to the Program Manager for approval. Technical control is facilitated by this interface, which is independent of geographical separation of subcontractor personnel.

5.3.2 External Interfaces

External MDAC/ERDA interfaces assure a common level of program visibility. Mr. Hallet has stressed to the program team the necessity of keeping cognizant ERDA personnel informed of potential problems as well as program status. As Program Manager, Mr. Hallet is the primary program interface between ERDA and the MDAC team for program direction and response and formal design reviews. However, he encourages open, informal counterpart communications among MDAC and subcontractor technical personnel and their ERDA counterparts. These day-to-day discussions provide the foundation for subsequent formal communication through management channels which document contractual changes, technical direction decisions, problem solutions, and accomplishments. G. M. Jones, the MDAC Contract Administrator who reports to Mr. Hallet, will handle all contractual matters. He interfaces with ERDA for negotiations, scope and schedule changes, and terms and conditions of the contract, and assures conformance with the contract data management requirements.

Mr. Hallet anticipates that he will make a telephone report at least once a week, if no other contact is scheduled, to review status with the ERDA Program Office. ERDA will be notified immediately of significant problems or key program matters as they are identified. The MDAC Program Manager and ERDA will have common program visibility for control of performance in time to replan tasks when necessary to avoid wasted effort.

MDAC will support ERDA presentation and data requirements for design reviews (CDRL items 1 through 8) and the project reviews stipulated in CDRL item 10 as discussed in Section 1, WBS Tasks SC061A.05 and SC062A.

The Program Manager, through his staff subcontract administrator, will direct supporting procurement activities. The subcontract administrator will be the direct contact for contractual direction to subcontractors. He will work closely with the technical managers who have been designated to provide a technical interface for each subcontractor. A detailed scope of work covering both the technical and general contractual support required has been prepared, and is ready to be negotiated. The tools and techniques to be used in technical and business management of the subcontractors are discussed in Section 3.4. The Program Manager exercises direct management control of subcontractor efforts.

5.4 TRANSITION TO PHASE 2

A criterion for selection of Phase 1 subcontractors is their capability to meet the requirements of the program through the subsequent phases, culminating in the construction and operation of a commercial central receiver power system. Accordingly, a major team realignment will not be required in order to proceed into Phase 2. Our program team has the reserve technology, resources, and production capacity to work with ERDA in all successive program phases, and the Phase 1 personnel have the capability to manage them. Our integrated team organization for the Phase 1 POCE preliminary design provides the framework and nucleus of key program personnel to provide continuity for expansion and growth into the Phase 2 demonstration of technical feasibility. This Phase 2 organization would follow through with the concept of subsystem management, POCE system integration, and balance-of-plant field construction and operation.

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

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