KILOWATT ISOTOPE

POWER SYSTEM

PHASE II PLAN

VOLUME I

PHASE II PROGRAM PLAN

MASTER

Sundstrand Energy Systems

ROCKFORD, ILLINOIS 61101
unit of Sundstrand Corporation

C00-4299-025

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KILOWATT ISOTOPE POWER SYSTEM

PHASE II PLAN

**VOLUME I
PHASE II PROGRAM PLAN**

To

DEPARTMENT OF ENERGY

From

**SUNDSTRAND ENERGY SYSTEMS
4747 HARRISON AVENUE
ROCKFORD, ILLINOIS 61101**

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**C00-4299-025
15 MARCH 1978**

FOREWORD

This report was written to satisfy the requirement of Task 10.0 of the Statement of Work to Sundstrand Energy Systems under the Department of Energy Contract Number EN-77-C-02-4299. The report is contained in five volumes:

Volume I	—	Phase II Program Plan
Volume II	—	Flight System Conceptual Design (FSCD)
Volume III	—	Ground Demonstration System (GDS) FSCD vs. GDS Comparison Evaluation Criteria Comments
Volume IV	—	Teledyne FSCD and GDS
Volume V	—	Safety Quality Assurance Reliability

SECTION 1.0

PHASE II — PROGRAM PLAN

1.1 INTRODUCTION

This section defines the work to be performed by Sundstrand Energy Systems, a unit of Sundstrand Corporation, acting as the contractor for the United States Department of Energy (DOE) under the Phase II follow-on to contract EN-77-C-02-4299. This program plan covers Phase II of an overall three phase program for the development of a 500 to 2000 watt dynamic power system to be used on satellites in the 1980s. The power system uses a closed Rankine power conversion cycle to convert energy from the Multi-Hundred Watt (MHW) heat source. Teledyne Energy Systems is the major subcontractor for the heat source assembly and the radiator.

Phase II, a 30 month program, encompasses the flight design and fabrication of a system for ground qualification. Qualification will include testing with the MHW heat source. The flight design will be based upon the technology obtained during the Ground Demonstration System design, fabrication, and testing in Phase I.

Phase III will be the follow-on production phase for fabrication, acceptance test, and delivery of units in December of 1981.

Program Objective

The primary objective of the Phase II KIPS program is to qualify an organic Rankine power system in the 500 to 2000 watt(e) output range for flight test in 1982.

1.2 PROGRAM APPROACH AND SCHEDULE (SUMMARY)

The program approach to meet the Phase II objective is to:

- Design and fabricate the proposed flight power system
- Conduct a development and a qualification program including both environmental and endurance testing, using an electrical and a radioisotope heat source
- Planning for flight test and spacecraft integration
- Continue Ground Demonstration System testing to act as a flight system breadboard and accumulate life data

Phase II consists of the ten tasks which are described in Table 1-A.

The time phasing of these tasks is shown on the Phase II schedule, Figure 1-1. The preliminary Phase III schedule is also included as part of this program plan as Figure 1-2.

Table 1-A Phase II Task Summary

Task 1 — Program Management

- Program Direction
- Contract Administration
- Planning and Scheduling
- Evaluation of Progress and Performance
- Cost Planning and Control
- Document Control and Distribution
- Procurements
- Liaison with Other Program Participants and Potential User Organizations

Task 2 — Design and Analysis

- Heat Source Assembly
- Radiator
- Power Conversion System
- Ground Support Equipment
- Spacecraft Integration
- Component Specifications
- Design Reviews

Task 3 — Safety

- Launch and Flight Safety Analysis
- Ground Safety Analysis

Task 4 — Quality Plan

- Quality Assurance Plan
- Product Assurance Implementation
- Testing and Inspection Requirements
- Receiving, Source, and In-Process Inspection
- Non-Conforming Articles and Materials
- Material Review Board
- Ground Support Equipment
- Test Equipment

Task 5 — Reliability Plan

- Management
- Design Analysis
- Testing Evaluation

Task 6 — Fabrication and Assembly

- Assembly of Flight Qualification System (FQS)
- FQS Spares
- FQS Engineering Test Hardware
- GDS Upgrade
- System Mass Model
- Ground Support Equipment
- Component Sub-Assembly Tests
- Processes, Procedures, and Specifications

Table 1-A Phase II Task Summary (cont'd)

Task 7 — Test Equipment

- FQS Testing
- GDS Testing
- Breadboard Stand Component Testing
- New Component Facilities

Task 8 — Qualification Testing

- Test Plan
- Test Procedure
- GDS Testing
- Qualification Program Plan

Task 9 — Component Development Tests

- Test Plans
- Heat Source Assembly
- Radiator
- Combined Rotating Unit
- Jet Condenser
- Other Components

Task 10 — Reports & Data

- Monthly Top Summary, Financial, Technical
- Topical and Special
- Final
- Phase III Program Plan

Figure 1-2 KIPS Program Plan Schedule -- Phase III

1.3 PROGRAM TECHNICAL APPROACH — STATEMENT OF WORK

The KIPS Phase II technical approach to meet the previously stated objectives is as follows:

- Design and fabricate the proposed flight power system. This includes accounting for any operational and/or performance differences compared to the GDS of Phase I, as reflected by spacecraft physical and environmental inputs
- Conduct a development and a qualification program including both environmental and endurance testing using an electrical and a radioisotope heat source. A prime input in the design and analysis phase is the development testing of the Phase I GDS.
- Plan for flight test and spacecraft integration
- Continue GDS testing to act as a flight systems breadboard and accumulate life data. A prime input to the flight system data base will be the continued GDS running and testing.

The KIPS Phase II program approach as it relates to the Teledyne Energy Systems subcontract activity is as follows:

- Provide radioisotope heat source design and fabrication consistent with performance and safety requirements
- Provide a radiator which can be integrated with the Power Conversion System to yield assembly and flight qualification test of the KIPS
- Provide ground and space support equipment to enable heat source handling, loading, and transportation
- Conduct safety analysis, issue a Preliminary Safety Analysis Report (PSAR) and an update report during Phase II, and a Final Safety Analysis Report during Phase III

The following Statement of Work defines the program and its objectives.

PHASE II – STATEMENT OF WORK

Task 1.0 Program Management

1.1 Program Direction: The Program Manager will have the authority and responsibility to direct the integration, technical program, financial expenditures and scheduling. It will be his responsibility to assure that all contractual obligations are met and, further, to maintain proper balance of all factors.

To facilitate this authority in technical management decision making, the Program Engineering Manager will report directly to the Program Manager.

The Teledyne Program Manager and Power Conversion System (PCS) Engineering Manager will be fully responsive to direction from the Sundstrand Program Manager. Work direction will be primarily developed through close coordination with the Sundstrand Program Manager in the formulation of technical, cost, and schedule matters in conduct of program operations.

Both the Sundstrand and Teledyne Program Engineering Managers will maintain close coordination of all activities through frequent meetings with each other and DOE personnel.

1.2 Contract Administration: The Program Control Manager will support the Program Manager in all matters pertaining to contract requirements, planning and scheduling, contract documentation and cost control. Contract requirements include all contractual matters pertaining to the KIPS program, including interpretation of contractual commitments, monitoring of contract technical compliance, maintenance of adequate documentation of program efforts, and submission of contractual correspondence and reports. The Program Control Manager will coordinate final preparation of all program documentation identified under this task, and through Configuration/Change Control Board (CCB) activity he will effect changes in contractual and product control specifications as required by the contract.

1.3 Planning and Scheduling: The planning and scheduling effort will be maintained by the Program Control Manager. Teledyne will assign a program planner to oversee their task responsibilities. All major inputs will be made through the engineering, manufacturing, and quality assurance managers. This effort is defined by the major categories of planning, scheduling and control. Close work with engineering and manufacturing to develop overall summary and detail plans will be required.

In accord with contract milestones, schedules will be generated to match resource capability and end item delivery requirements. Page and line control schedules will be established and schedule reviews held at the functional and program level to assure schedule compliance.

1.4 Evaluation of Progress and Performance: The Program Manager will be fully responsive to DOE personnel and the Teledyne Program Manager will be fully responsive to direction from the Sundstrand Program Manager. Planning of work direction will be primarily through the Sundstrand Program Manager in the formulation of technical, cost, and schedule matters in conduct of program operations.

1.5 Cost Planning and Control: This effort will be the responsibility of the Program Control Manager. He will prepare and update, as required, program cost plans representing applied resources but within limitations imposed by the contract. He will obtain and analyze manpower and material requirements from all program functions in the preparation of these plans. For effective cost control, the costs will be identified by task and by month. Firm cost plans will be established by fiscal year through program completion. Detailed program cost data will be provided and updated when required. Actual costs by task and subtask will be obtained and analyzed to evaluate program input/output performance.

1.6 Document Control and Distribution: In compliance with the requirement for definition of the power system, documentation identified in this or other tasks in the program will be completed and controls established. Coordination, compilation, publishing, and distribution of program documentation will be performed under Task 1 and 10.

1.7 Procurements: Timely procurement of the materials, fabricated parts and assemblies is critical to the project and requires vendor evaluation, expediting, and technical liaison. The Manufacturing Manager will ensure the availability of procured, fabricated and assembly hardware and associated functions to provide timely and as-budgeted parts availability. He will manage production planning, parts flow including machining, fabrication, inspection, stocking and assembly, tool design and fabrication, procurement including subcontract, producibility analysis, and performance measurement.

1.8 Liaison with Other Program Participants and Potential User Organizations: Meetings and presentations will be held with participating government agencies or contractors to assure coordination of all interfacing activities. These interfacing activities will be conducted with prior knowledge and through cooperation of Sundstrand, Teledyne, and DOE as required. A specific area of close liaison concerns the isotopic heat source which is government furnished (GFE).

The Program Manager has the overall responsibility for the KIPS contract and is responsible to the DOE Contracting Officer for its fulfillment. He has the authority and responsibility to commit Sundstrand on matters relating to the contract.

The Program Control Manager is the interface with the DOE Contracting Officer relating to all contractual matters and official correspondence.

The Engineering Manager will interface with the DOE Technical Manager for those items of an engineering nature. Likewise, Quality Assurance, Data Management, and other functional personnel will have a specific interfacing relationship in the DOE organization.

Task 2.0 Design and Analysis

A finalized Flight Qualification System (FQS) design along with the required Ground Support Equipment (GSE) design will be completed in this task. The effort will consist of modifying the Phase I Flight System Conceptual Design (FSCD) as presented elsewhere in this report to incorporate any re-definitions resulting from the design reviews. In addition, redesign may result from the need to adapt the KIPS system to a specific launch vehicle or mission requirement. The design shall consider power, weight, envelope, cost, efficiency, operation in zero "g", safety, reliability and quality of the system to support a 1981 flight hardware delivery schedule. The results shall be documented in design layouts and reported in a Flight System Design Report. Upon approval of the FQS design, detailed and assembly drawings will be prepared.

Specific items which will be considered are presented below.

2.1 Heat Source: Teledyne Energy Systems (TES) will perform a detailed design and analysis of a prototype plutonium isotope (Pu-238) fueled, heat source containment assembly. The heat source containment assembly will be designed to meet all performance, interface, structural, and safety objectives to be compatible with the MHW isotope heat source design. The design will consider the tradeoff between weight and parasitic heat losses, ease of assembly and fueling, compatibility with the use of both electrical and isotope heat sources, compatibility with testing, on pad and launch environments and consideration of potential spacecraft integration problems.

2.2 Radiator: A detailed design and analysis of a waste heat radiator for operation in a spatial environment will be performed by TES. The lowest weight radiator, consistent with other KIPS system design and performance constraints, as well as spacecraft integration constraints, will be designed.

Existing computer software at TES will be applied during radiator design to select the best values of design variables and parameters. No computer programming is planned but appropriate radiator design equations and data will be supplied for use with the existing software.

2.3 Power Conversion System: A complete update of the thermal, stress, dynamic, hydraulic and performance analyses will be prepared on the Power Conversion System (PCS) to allow a minimum weight, maximum energy conversion efficiency unit to be designed. All environmental operating conditions will be considered, including ground, launch and space operation. Detailed analysis and design will also be performed for the integration of the PCS with heat sources and radiator, and will be controlled through an interface control document.

2.4 Ground Support Equipment: Detailed design and analysis of the Flight System support equipment will be performed. This will consider isotope fueling, starting modes, and operational environment. Particular attention will be paid to safety and reliability, in particular for the isotope handling and cooling.

2.5 Spacecraft Integration: Investigation of the required spacecraft and launch vehicle interfaces will be performed. Interface with the spacecraft will include structural mount design and electrical power connections. KIPS launch vehicle interfaces will include GSE coolant connections. These interfaces will be mission dependent.

A non-functional flight system mass model will be designed for use with the spacecraft in vibration testing. The mass model will simulate the flight system c.g., mass, and spring constant.

2.6 Component Specifications: Component specifications will be generated for all major components to define basic function and performance requirements.

2.7 Design Reviews: Detailed analysis, design and test result summaries will be prepared for both system and support equipment design reviews. These reviews will define further direction or action deemed necessary by the DOE. The preliminary design review will take place upon completion of the design layouts and will result in release of long-lead hardware for manufacture. A final design review will be held on completion of all detail drawings and associated analyses, initiating approval to release all remaining hardware for fabrication.

Task 3.0 Safety

Safety assessment for Phase II effort includes two major subtasks: Launch and Flight Safety Analysis and Ground Safety Analysis.

Launch and flight safety analysis will be performed for a specified typical reference mission. A formal PSAR (Preliminary Safety Analysis Report) will be issued twelve months after contract initiation. The safety effort will continue throughout the 30 month period; the latter phases being analyses performed in support of a FSAR (Final Safety Analysis Report) to be issued during the Phase III effort.

Ground safety analysis is provided in support of isotopic fuel handling activities during the testing portion of the program.

3.1 Launch and Flight Safety Analysis: Included in this subtask is an assessment of the consequences of potential accidents associated with the launch of a system employing the KIPS. The assessment covers all phases of the launch from loading of the KIPS aboard the launch vehicle through attainment of the nominal mission orbit (for earth orbiting missions) or through attainment of earth escape conditions (for a planetary mission). A probabilistic assessment will be performed for the nuclear fuel to include accident probabilities, resultant source term (released fuel) distributions, and the biological consequences of fuel release.

No specific mission is assigned for the Phase II effort. Safety assessment will be performed for a selected typical reference mission. The reference mission will assume employment of the STS (Space Transportation System) and IUS (Interim Upper Stage) vehicles. The STS is used to transport the IUS to a relatively low, nearly circular earth orbit (approximately 150 mile altitude). The IUS/Spacecraft/KIPS is then off loaded and the IUS vehicle is used to achieve the mission. Launch of one KIPS unit fueled with three MHW IHS's (Multihundred Watt Isotope Heat Source) is assumed. The IHS is the MJS type as modified according to the result of the current DOE Improved MHW Heat Source Effort. Current plans call for revised heat source specifications prior to November 1978.

Throughout the analysis, computerized Monte Carlo techniques are used. Computer programs are available at TES for initial assessments of launch pad accidents (STS vehicle), flight abort condition involving atmospheric re-entry and land impact, and assessment of the biological consequences of released (wind born) fuel. Many aspects of the current modeling must, however, be considered preliminary because of uncertainties in the STS accident environments and the nuclear system response modeling. A major effort of this subtask is model improvement and extension to achieve an accurate safety assessment for realistic launch conditions. The assessment will provide the basis for system or heat source modifications to achieve a greater degree of safety.

Specific items of work (lettered A through G) included in this subtask are described below:

A. Preliminary Safety Assessment

A preliminary safety assessment has been performed for a potential mission employing the STS and IUS vehicles, the KIPS and other prototype power systems fueled with the MHW IHS. This task will provide a summary report of the results of the study as modified for the KIPS system only. A

description of accidents, accident probabilities, sequential environments resulting from the accidents and their effect on the nuclear systems including source terms will be provided. A summary description of response models will be provided in the final report.

The data generated will be used to perform an initial classification of the accidents and accident environments. Severity of the accident will be assessed according to the product of accident probability, conditional probability for fuel release and the expectation value of the source term. The derived "safety indices" provide a basis for concentration of effort in subsequent phases of the program.

Model information could be disseminated by DOE to members of the INSRP (Interagency Nuclear Safety Review Panel) and other relevant agencies for critical review.

The report will be issued three months after initiation of the contract.

B. Safety Test Plan

A safety test plan will be prepared and submitted to DOE. The test plan report (informal) will be issued 6 months after initiation of the contract. The objective of this plan is to define those accident environments for which existing test data base is inadequate or non-existent, and in general terms, propose testing which would provide a suitable data base for response modeling. Statistical limitations of the proposed testing will be provided and implication of reduced or lack of testing will be discussed in the report. Tests will be prescribed in terms of types and numbers. Detailed specific test plans, test execution (including required materials) and test reporting are assumed to be Government furnished and are not included as part of this item.

C. Safety Test Liaison

This item includes liaison with external agencies actively or previously involved in testing or test related analyses which is pertinent to the safety assessment. It includes liaison, witnessing of tests (when desirable), review of test reports and follow-up. It is in direct support of the Modeling response and integration studies (described below). A limited amount of preliminary type analyses is included to provide an initial assessment of the significance of the test results:

D. Model Development

Existing models which describe the response of the system to the sequence of environments created by the potential launch accidents will be updated and improved. New models will be developed in areas not previously considered in SAR's (Safety Analysis Reports) but which are required to provide the more complete safety assessment. The information obtained from test review (Tasks B and C above) provide the basis for much of the model development.

Model development will be a continuing effort throughout the contract period. Individual studies will be performed on a priority basis (as defined in A, above). The following list of subjects which may be included is a result of the review of the preliminary assessment (see A, above).

- (1) Fragmentation — Fragment environment (particle velocity and size distributions as a function of liquid fuel explosive yield) — response: penetrations models, resultant source term.

- (2) Fireball — Formation, persistence, displacement ground touchdown duration, possible vaporization of fuel released by impact event.
- (3) Solid Propellant Dispersion — Propellant explosive threshold on impact, explosive yield, chunk size and dispersion characteristics.
- (4) Solid Propellant Flame — Flame temperature as function of chunk size, distance from surface, fuel "blow off," chemical and insulating effects of combustion products.
- (5) Orbital Lifetime — Examine solar and lunar effects on lifetime.
- (6) Post Impact Integrity — Fuel containment - effects of burial and natural, man-made environments (earthquakes, excavations, flood).
- (7) Post Impact Dispersion — Resuspension and deposition of released fuel, conditions meteorological distribution, feedwater contamination.
- (8) Impact Modeling — Failure probabilities for doped iridium PICS system, effects of impact velocity, target.
- (9) Launch Pad Abnormal Flight — Launch vehicle abnormal flight simulation, failure (breakup) to critical loads imposed by flight-destruct system activation.
- (10) Graphite Failure Mechanics — Three-dimensional carbon-carbon graphite, micro failure mechanism from thread properties, connected region failure approach.
- (11) Explosive Impulse — Velocity imparted to structure containing fuel, dependence in yield, configuration, reflected blast overpressure.
- (12) Recovery Model — Assess recovery probability after reentry, develop model for recovery probability, time.
- (13) Non-Inhalation Exposure Paths — Examine distribution of released activity vs time. Fresh water, salt water, vegetation, uptake models - dependence on particle size, meteorology.

E. Response Analysis

Parametric response data will be generated which describes the effect of the various accident environments on the residual configuration containing the nuclear fuel. The generated data is input to the final integration studies (F, below). The following list is typical of the items of work which may be performed:

- (1) Blast over-pressure response analysis — define the residual status of the system as function of yield, other blast parameters.
- (2) Fragmentation response analysis — evaluate penetration threshold velocities for materials in path of fragments.

- (3) Liquid and solid fire response — evaluate nuclear fuel clad damage, fuel vaporization as function of fire parameters.
- (4) Configuration breakup studies — examine breakup of residual systems re-entering the atmosphere, define heat source release altitude ranges - consider impact of residual systems (where no heat source release is probable).
- (5) Reentry response of the heat source — consider the consequences of heat source release at varying altitudes, flight path angles, velocities, reentry motions and attitudes - evaluate physical parameters critical to failure such as graphite thermal and mechanical stress, PICS temperature profiles through impact.
- (6) Reentry conditions — evaluate initial atmospheric reentry condition for the various accidents, velocity, flight path cycles, initial temperatures.
- (7) Orbital lifetimes — evaluate or estimate orbital lifetime for residual systems left in earth orbit following abort.

F. Integration Studies, PSAR (Preliminary Safety Analysis Report)

The integrating study produces the final safety assessment. Computer programs and input data will be updated according to the results of items D and E. The updated programs will be used to produce results for the PSAR.

The PSAR will be in the standard three volume format. Safety assessment will be for the aforementioned reference mission. Mission definition is included as part of this work item.

Subsequent to issuance of the PSAR, computer program update will continue in preparation for the FSAR (Final Safety Analysis Report) which will be issued in Phase III of the contract.

G. Interagency Nuclear Safety Review Panel (INSRP) Activities

It is assumed that the PSAR will be distributed to members of the INSRP for review and comment. This work item includes liaison with the INSRP and response to comments. Timely review and constructive criticism of the safety effort as reported in the PSAR would enhance the subsequent safety analysis effort.

3.2 Ground Safety Analysis: The ground safety analysis subtask provides support for receipt and handling of the IHS at the testing facility. During the Phase II effort, one IHS will be received and utilized in a KIPS system. Activities related to actual shipment of the heat source to and from the testing facility are assumed Government Furnished (MRC).

Specific items of work for this subtask are as follows:

A. IHS, MRB Technical Support

Specification deficiencies noted for the specific IHS to be utilized for KIPS will be reviewed and analyzed with respect to their nuclear safety implications. Recommendations for corrective action will be submitted if deemed appropriate after the review.

B. GSAR (Ground Safety Analysis Report)

The updated GSAR will be prepared and submitted to DOE and ALO at least two months prior to receipt of the IHS at the testing facility.

The GSAR will define heat source operations at the testing facility. This includes all handling, storage, and intra-site transport. An evaluation of the consequences of potential accidents at the facility which could involve the IHS will be prepared. The GSAR will include a thorough discussion of the following:

- (1) Organization
- (2) Facilities and Equipment
- (3) Postulated IHS and/or KIPS Accidents
- (4) Consequences of the Above
- (5) Steps Taken to Mitigate the Above
- (6) Off-site Releases, If Any are Postulated
- (7) Personnel dose estimates for all IHS and KPS operations
- (8) Steps taken to ensure that radiation doses are as low as practicable for compliance with applicable requirements

To provide support material for the GSAR the following tasks will be performed.

- (1) Review fuel handling and fueling procedures. Evaluate radiation doses to specific personnel (by job titles) for all phases of fuel handling. Identify procedural changes which would be effective in reducing dose. Provide final dose assessment information for the GSAR.
- (2) Evaluate worth of radiation shielding for fueling and other fueled system operations. Specify shielding (materials, thickness, extent where it will be effective).
- (3) Identify plausible potential accident situations which could result in fuel release. Perform assessment to categorize accidents according to severity.
- (4) From the accident list (3, above), select one or a few for more extensive analysis.

Task 4.0 Quality Plan

4.1 Quality Assurance Plan: A Quality Assurance Plan, consistent with the objectives of the latest NRA-1 in effect at the time of the contracts' issuance, will be prepared and submitted to the DOE for approval. This Phase II Quality Plan will use the KIPS Phase I Quality Plan as a baseline, adding certain requirements commensurate with the Phase II flight qualification effort. It will include the controls placed on all Sundstrand and subcontractor manufacturing and inspection efforts, and define the tasks of the Quality Assurance Engineering and the Quality Special Process Engineering organizations.

Periodic review of the Quality Assurance Procedures which are contained within the Quality Plan shall be made as required and revisions incorporated as necessary to apply the most effective quality assurance practices to hardware design, development, fabrications and test.

4.2 Quality Assurance Implementation: Quality Status Reports reflecting Quality Program activities, summaries of current problems, nonconformances and trends will be included as part of regular Management reports to assure adequate Quality cognizance and participation during the course of the program.

Records of activities affecting the Quality Program shall be maintained and made available to the Government Inspector as required. Quality Assurance Engineering will support the functioning of the Contract Change Board through its representative as required.

4.3 Testing and Inspection Requirements: Inspection and testing of the components, subsystems and systems, in accordance with established plans, instructions, and procedures shall be performed. Inspection and test results shall be furnished for review and evaluation by the Government on request.

Non-destructive inspection of critical components as determined by Quality Assurance Engineering working in conjunction with Design, Material and Reliability Engineering will be provided. The specific requirements for the test will be incorporated within drawings, specifications or procedures as necessary. Quality Assurance Engineering will review all Non-Destructive Inspection Requirements prior to testing for verification and proper application. Activities will include periodic review of test requirements and preparation of new or revised procedures as necessary.

4.4 Receiving, Source and In-Process Inspection: Receiving inspection will verify that suppliers comply with all applicable requirements. Inspection during the fabrication and assembly of details, sub-assemblies and assemblies will assure that the required quality levels are maintained. Authorized or assigned quality assurance personnel may be employed at supplier's facilities to verify that the supplier complies with all applicable component and/or process requirements.

4.5 Non-Conforming Articles and Materials: Using established procedures, reporting, verification and correction of non-conformances will be performed. As part of this plan, identification and segregation of all non-conforming items will prevent unauthorized use or shipment.

4.6 Material and Failure Review Boards: A Quality Assurance Engineering representative will serve as chairman of the review boards. The Material Review Board (MRB) will review instances of nonconformances, determine their causes, propose corrective action, and disposition of nonconforming items. The Failure Review Board (FRB) will review hardware malfunction or failure, determine cause and propose corrective action.

4.7 Ground Support Equipment: Inspection and testing of ground support equipment and associated cabling will be provided. Included within this control system will be Quality Certification Logs for individual assemblies which will incorporate all test and inspection data.

4.8 Test Equipment: Documentation and control of test equipment will be provided to ensure the design and integrity of this equipment is consistent with the KIPS hardware under test.

Task 5.0 Reliability Plan

The KIPS program reliability effort will be delineated in a Reliability Program Plan formulated in general accordance with procedures specified in DOE Reliability Engineering Program Requirements Publication NRA-2. The reliability plan defines the organization and documentation associated with the reliability analysis, assessment and allocation for the design and testing phases of the program. The preliminary plan is presented elsewhere in this report. Specific work to be performed is identified in the following subtasks.

5.1 Management Reliability management, audit and support functions will be provided to consist of the following:

- a) Prepare Reliability Program Plan
- b) Provide input to Program Monthly Progress Reports and Final Report
- c) Provide input to the Design Reviews
- d) Participate as a member of the Failure Review Board

5.2 Design Analysis: Reliability design analysis will include:

- a) Prepare failure modes, effects and criticality analyses
- b) Define performance and environmental requirements for the KIPS system
- c) Reliability design, incorporating use of stress derating, materials analysis, etc
- d) Approval of design specifications, drawings, procedures and processes
- e) Prepare a System Logic Synthesis to indicate the logical combination of failure modes leading to a critical system failure.
- f) Preparation of a Manufacturing to Use Sequence (MUS)

5.3 Testing Evaluation: Evaluation of test data to support the reliability assessment will consist of the following:

- a) Define test matrix and sample plan for component and end item acceptance in process and engineering testing

- b) Approve test specifications and test procedures to increase usability of resulting data for reliability purposes
- c) Support and participate as a member of the Failure Review Board
- d) Perform failure/anomaly or disassembly evaluation investigations

Task 6.0 Fabrication and Assembly

The effort under this task will be to use the DOE approved detailed drawings to procure and fabricate the detail parts that make up the individual system components. These components will then be cleaned, leak checked and assembled into the KIPS system under controlled environmental conditions. Also included in this task will be the fabrication of special tools and fixtures which may be required during component and system assembly operations.

Fabrication and assembly of simulated components to enable construction of a mass model will be included in this effort. The mass model will be constructed to simulate the flight system c.g., mass, and spring constant for use with the spacecraft in vibration tests.

Sufficient hardware will be procured to build one complete system, one system built to major component level, and spares to support these systems and an updated Ground Demonstration System (GDS). These are summarized below.

- a) Assemble one complete system for qualification testing with three electric heat source assemblies (EHSA)
- b) Complete and stock, as piece parts, all hardware necessary for another complete system with three EHSAs
- c) Fabricate, but do not assemble, three spare EHSAs
- d) Assemble one EHSA and one Radiator for engineering test and evaluation
- e) Assemble one Isotope Heat Source Assembly, using the multihundred watt (MHW) heat source
- f) Upgrade the Phase I GDS unit to complement qualification and endurance testing. The upgraded system will be functionally similar to, but not identical, to the FQS.
- g) Assemble a mass model to be used for spacecraft vibration tests. This unit will be non-functional, but will have the appropriate mass, centre-of-gravity and mounting dynamics to permit it to simulate the FQS in the spacecraft dynamics tests.
- h) Fabricate and assemble all ground support equipment necessary for system operation, including electric heat source power supplies, start module, heat rejection modules, and isotope loading chamber
- i) Assemble the major components to be subjected to subassembly tests. Complete all in-process tests and inspections.

- j) Fabricate all hardware necessary for spares to support the manufacture, assembly, test and evaluation effort. Assemble, test and inspect the major components and subassemblies as necessary to most expeditiously support the test program.

Processes, procedures and specifications developed during the Phase I effort will be followed where possible during the fabrication and assembly phase.

Test procedures will be written for the in-process testing of major subassemblies, where the information is too complex to be placed on the drawing. These will include the procedures for leak testing, calibration, proof pressure tests, insulation resistance and acceptance tests, as appropriate for the individual subassemblies. All test procedures will be submitted to the DOE for approval prior to initiating the test.

Task 7.0 Test Equipment

This effort will consist of the design and analysis of proposed test facilities, and the modification and updating of existing GDS and component test facilities to accomplish the required system and component tests. Design reviews of the proposed test rigs, facility modifications and set-ups will be held with the DOE as required to evaluate the appropriateness of the proposed design, test equipment, and instrumentation. Control of the test equipment design and documentation will be included and defined in the quality assurance and reliability plans. This task will also include fabrication, assembly, and initial checkout of the test fixtures, control consoles, instrumentation, data acquisition, and reduction provisions.

Specific items covered under this task will include test fixtures and equipment for the following tests:

- a) The Flight Qualification System (FQS) will be tested in the existing GDS vacuum chamber facility, which will be updated to incorporate cold wall facilities to allow for integrated system radiator testing. Control consoles, instrumentation, signal conditioning, and data acquisition systems will be upgraded to support FQS testing.
- b) The GDS will be tested in the existing vacuum chamber until the GDS retrofit, after which all further testing will be done in a new smaller vacuum chamber. The new test facility will use much of the existing signal conditioning and data acquisition due to the reduced scope of instrumentation necessary for the FQS.
- c) The existing hot dowtherm loop breadboard stand with some modifications will be used to support the CRU and jet condenser component tests.
- d) New facilities to support:
 - (1) Jet condenser dynamic test
 - (2) CRU dynamic test
 - (3) Electronic controls and flow controls reliability tests
 - (4) Electric heat source dynamic test
 - (5) Radiator thermal and dynamic test
 - (6) Coating degradation tests

Task 8.0 Qualification Testing

A test program will be conducted to determine the actual performance capability of the components and the system. This will provide data to correlate with predictions and to identify potential problem areas. An iterative testing process will be conducted (as time permits) with design modification and retest.

This task is broken down into various subsections as follows:

8.1 Test Plan: A comprehensive test plan for the Flight Qualification System testing will be prepared early in Phase II for approval by the DOE. This test plan will ensure that the complete isotope power system is flight-qualified. The present plan is to conduct the required tests with two power conversion systems; one upgraded GDS for engineering tests and early endurance, and one flight qualification system for performance, dynamic and endurance tests.

8.2 Test Procedures: Test procedures will be prepared to cover all phases of testing anticipated. Specifically these will cover the following topics:

- a) Start-up methods
- b) Design and off-design performance
- c) Space simulation
- d) Launch environment testing
- e) Endurance operation
- f) Flight Qualification Testing

These procedures will be submitted to the DOE for approval.

8.3 GDS Testing: Ground Demonstration System (GDS) testing will continue throughout Phase II. The endurance testing of Phase I will be continued to accumulate life data. The GDS will also act as an engineering system to evaluate potential improvements for incorporation in the Flight Qualification System (FQS) Design, and to identify any advanced development involvement to be enumerated. Early in the program the GDS radiator will be incorporated on the system to allow performance mapping with the prototype radiator in a vacuum.

Mid-way through the Phase II program the GDS will be retrofitted with much of the newly designed FQS component hardware while retaining its full instrumentation capabilities. This will allow performance mapping in sufficient depth to permit comprehensive cycle evaluation and parasitic loss analysis on a component level not possible with the flight weight FQS. Measurements will be taken of all state points, and metal and insulation temperatures, in a vacuum but without the prototype radiator. This subsequent phase of GDS testing will be done in a smaller vacuum chamber with the facility heat exchanger simulating the radiator conditions. This is a minimum test cost approach. After completion of GDS performance testing the unit will be reverted to endurance testing through the remainder of Phase II.

8.4 Qualification Program Plan: This plan will be prepared to define the requirements of the Flight Qualification Testing. Performance, dynamic, and endurance testing as planned and approved by the DOE shall be conducted to verify the system capability to meet the mission requirements; one unit is planned with which to conduct the qualification test program.

After initial shakedown, the Flight Qualification System (FQS) will first undergo complete performance testing in a vacuum chamber with electric heat source assemblies including:

- a) Startup methods
- b) Design point performance
- c) Radiator cold sink testing
- d) Off-design point performance

These tests will be performed in sufficient depth to permit cycle evaluation and loss analysis.

The FQS will then be subjected to dynamic testing with electric heat source assemblies, to assure that the power system is capable of operating under launch environments. The dynamic testing will then be repeated with one Multi-Hundred Watt (MHW) heat source assembly and two EHSAs. Dynamic testing will be done at ambient pressure and room temperature.

Prior to the dynamic tests with the MHW heat source, the FQS will be mated to an isotope loading facility for fitup and checkout. The ground support equipment associated with the isotope handling will be demonstrated at this time. Proven and qualified handling techniques as demonstrated on other MHW programs can be fully utilized for the FQS loading; no unique problems are anticipated. All FQS testing with an isotope heat source will possibly be done at a outside licensed facility. A number of potential licensed facilities have been contacted for the isotope system testing.

The final phase of FQS testing will be a 5000 hour endurance test (may extend into Phase III) with one MHW heat source in a vacuum chamber. The data generated during qualification testing will be examined and compared to predicted behavior to determine compliance with design requirements.

The qualification plan will incorporate the most cost effective way in which to qualify the FQS with the isotope heat source.

Task 9.0 Component Development Tests

Component development tests will be conducted prior to and in parallel with the system tests. This will permit evaluation of the component design to maximize reliability and performance. It will also provide the capability of troubleshooting problems at the component level, permitting system testing to proceed at the qualification test level.

Test plans will be prepared for each component and will be submitted to the DOE for approval. Reliability engineering will be involved during all phases of the component tests.

The individual components for which component tests are currently planned are presented below.

- a) Heat Source Assembly: A vibration and shock test will be performed on an electric HSA.
- b) Radiator: Both dynamic (vibration, shock and acoustic) and thermal/vacuum tests will be performed on a flight system radiator.
- c) Combined Rotating Unit (CRU): Shock and vibration tests will be performed on the CRU to confirm dynamic response. CRU performance testing will be done to maximize information fallout relative to schedule. Alternator, pump, bearing and seal, and turbine performance will be measured and correlated to predicted calculations. In this manner CRU components can be matched and parameters varied to obtain the optimum "matched" performance. This includes testing from 500 to 2000 watt(e) output.
- d) Jet Condenser: Dynamic testing will be performed to prove immunity to hydraulic problems in the launch environment.
- e) Other component tests involving the packaged electrical controls, control valves, and flow loops will be performed to obtain the reliability assurance associated with the design, fabrication, and expected life.

NOTE: The above tasks will be defined and added to as further development and GDS testing is accomplished.

Task 10.0 Reports and Data

The reports and data submittals during the Phase II program will include:

- a) Program Plan
- b) Quality Assurance Program Plan
- c) Reliability Program Plan
- d) Safety Reports
- e) Qualification Test Plan
- f) Monthly Top Summary Reports
- g) Monthly Technical Summary Reports
- h) Design Review Data
- i) Topical and Special Reports, as required, associated with safety, design, testing, materials, specification and operating procedures

- j) Configuration Control Report, updated as necessary
- k) Final Technical Report summarizing all design analysis and test results at the end of Phase II
- l) Phase III Program Plan

1.4 PROGRAM ORGANIZATION

The KIPS program is conducted in the Energy Systems Unit of Sundstrand Corporation. The Program Manager reports directly to the Energy Systems General Manager and is responsible to him for the successful operation of all aspects of the program.

Figure 4-3 is presented to show the Sundstrand organization elements which are directly involved in the KIPS program.

The four product line units, Aviation Mechanical, Electric Power, Fluid Pumping and Energy Systems, in the Advanced Technology Group, are shown along with the Operations unit. The Operations unit supports the three product line units in the functional areas of Engineering (Research, Design, Test), Production (Material, Quality Assurance, Manufacturing) and Administration (Data Control and Management, Accounting, Pricing).

For specific programs such as KIPS, it is the responsibility of the Reliability and Quality Assurance Managers to assign individuals to support the program and functionally report to the Program Manager. For major subcontractors such as Teledyne, the Materials Department of the Operations unit is responsible for assigning an individual to the program to perform the contractual interface function with the subcontractor. The Materials Department of the Operations unit assigns a Program Hardware Manager to the Program Office.

In the Operations unit, the Vice President of Engineering is responsible for the research, test and design functions. Due to the nature of the KIPS program, a Research Engineering Manager has been assigned to functionally work within the program organization. The test and design functions are directed by task assignment originating from the KIPS Project or Research Engineering Managers.

Likewise, the Contracts Manager in the Energy Systems unit has assigned Program Control and Cost Control personnel to functionally report to the KIPS Program Manager.

Figure 1-3 Sundstrand/KIPS Program

1.5 COST REPORTING

In order to provide complete cost visibility in Phase II, it is planned that projected and actual costs will be reported in the following manner:

- A) Monthly Flash Reports will be telephoned to the Chicago Operations Office on the second working day of each month. The information reported would be:

Cost Current Month Estimated
Cost from Inception
Uninvoiced Commitments

- B) A Supplemental Flash Report will be telefaxed to the DOE program manager monthly by the fifth working day (see Figure 1-4). This report is identical to that which was initiated late in the KIPS Phase I program.
- C) The Monthly Top Summary Report includes schedules of costs and manpower projections by government fiscal year. Actual accumulations are reported against these projections. All effort is identified by work task and by the total program (see Figures 1-5 and 1-6). In addition the Top Summary Report includes the highlights of significant events by work task and presents the total program schedule with appropriate comments.

KIPS Monthly Costs

Supplemental information to Monthly Flash Report.

(\$000)

Operating Funds

Hardware Material	\$
Hardware Labor	\$
Software	\$
TES	\$ _____

TOTAL EXPENDED FOR MONTH: \$ _____

Uninvoiced Commitments: \$ _____

GFY

Total to Date	\$
Funds authorized to date:	\$
Estimated at completion:	\$

ENRC Funds

Labor	\$
Material	\$

TOTAL EXPENDED FOR MONTH: \$ _____

Uninvoiced Commitments: \$ _____

GFY

Total to date:	\$
Funds authorized to date:	\$
Estimated at completion:	\$

Figure 1-4 KIPS Monthly Costs

PROJECT _____

CONTRACTOR _____

CONTRACT NUMBER _____

Report Period	FISCAL YEAR												Actuals To Date Plus Latest Project	Latest Financial Plan	Supporting Cost Information
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP			
OCT															
NOV															
DEC															
JAN															
FEB															
MAR															
APR															
MAY															
JUN															
JUL															
AUG															
SEP															
													REMARKS		
ESTIMATE															
ACTUAL															

Form 100J81

Figure 1-5 Project Cost Summary

CONTRACT _____

Form 100380

PAGE ____ OF ____

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APPENDIX A AND B

NOTE:

Appendix A and B are included as a supplement to this report for the benefit of the people not familiar with Sundstrand's general program management and procurement procedures.

APPENDIX A — PROGRAM MANAGEMENT

Sundstrand's management approach to the KIPS Phase II Program is to provide a balanced combination of experienced management, proven in-place management systems, and a strong program organization. Sundstrand is a multiproduct, multimarket corporation whose product lines include power systems, nuclear accessories, aircraft and aerospace components, hydrostatic power transmission equipment, air comfort products, and fluid handling equipment.

To effectively manage each of these areas, Sundstrand Corporation is broken down into four groups. Each of these groups is headed by a Vice President reporting directly to Evans W. Erikson, President and Chief Operations Officer (see Figure A-1). The KIPS Phase II Program will be performed by Sundstrand Energy Systems under the direction of David MacMorris, General Manager. Mr. MacMorris reports to Bernard Kittle, Group Vice President of the Advanced Technology Group. The Advanced Technology Group has 1/3 of the total corporation's personnel, and conceptualizes, designs, and manufactures high technology products. Sundstrand Energy Systems is one of five product units of the Advanced Technology Group. In addition to the five product units, the Advanced Technology Group has an Operations unit which contains the manufacturing, quality control, central engineering, and other support areas.

The Advanced Technology Group is composed of over 5,000 employees and is made up of the following units:

- Sundstrand Energy Systems
- Sundstrand Aviation Electric Power
- Sundstrand Aviation Mechanical
- Sundstrand Data Control, Inc.
- Sundstrand Aviation Fluid Pumping
- Sundstrand Advanced Technology Operations

The five product units of the Advanced Technology Group operate as profit centers utilizing the common manufacturing, quality control, accounting, and central engineering staff of Sundstrand Operations. The central engineering staff contains the necessary engineering disciplines required to support the power systems product line. They conduct stress, thermal, and dynamic analyses and contribute mechanical, electrical, and analytical design support.

This centralized arrangement enhances product development and engineering support by concentrating resources, thus greatly increasing the depth of capability available to each unit. As a result, this structure lowers operating costs and financial burdens for each of the product units. Each unit has total responsibility for product marketing, development, manufacturing, and engineering of their respective product lines.

The systems of performance management, information management, configuration management, and quality assurance management are described in this section. Also discussed in this section are tasks, milestones, and schedules for the program and their relationship to the total management task.

1.0 OPERATIONAL APPROACH AND PHILOSOPHY

Successful completion of the KIPS FSCD program requires a management approach combining the efforts of planning, integration, and measurement evaluation accomplished in a cost effective manner. See Figure A-2 for Sundstrand's management approach.

Figure A-1 Sundstrand Corporation Organization

Figure A-2 KIPS Management Approach

1.1 Planning

The contract Statement of Work (SOW), and the program plan are the basic management plans for the Phase II program. The SOW is the basis for work definition, schedule definition, budget definition, and the baseline for performance measurements. The program plan defines organizational responsibilities, operating techniques, and the management systems to be utilized throughout the Phase II program.

1.2 Integration

Utilizing these basic planning documents, the work allocations will be accomplished. The KIPS program manager and his organization have total responsibility for the overall integration of the program. To insure maximum effectiveness, including minimum overlap of efforts, and timely and accurate decisions, maximum responsibility will be delegated to the Sundstrand functional organizations and managers doing the work as was done during Phase I. Sundstrand's tools in achieving the KIPS program integration function are:

- 1) Clear and comprehensive definition of the tasks to be performed. These tasks include performance, schedule and budget requirements.
- 2) Early commitment of resources to accomplish the tasks with sufficient flexibility to change or modify the effort when required.
- 3) Short communication links between the program manager and the contributing functional areas. This will assure quick analysis and follow-up or redirection of impending problems.
- 4) The existing KIPS Phase I engineering, manufacturing, management, contracts, quality assurance, and test team.
- 5) The continued utilization of the KIPS Program Office as an extension of the Sundstrand Energy Systems organization. This allows people and work relationships to be the same as currently organized.

1.3 Measurement

The measurement/evaluation effort provides the visibility and control of contract costs, schedule, performance and technical achievement. Sundstrand's present performance management system combining the efforts of accounting, data processing, contracts and the functional work centers (engineering, manufacturing, and quality assurance) will be the basis of the performance management system. This system will be complemented by those procedures and requirements necessitated by any special requirements of the KIPS Phase II program. It is anticipated that these additions will be minimal.

The effectiveness of the KIPS performance measurement system is dependent on a number of factors which are reflected in Sundstrand's present system. The philosophy which has guided the development of this system includes:

1) Performance data has to be available at all levels of involvement — from the lowest work function to the executive management level. The depth of detail will be commensurate with the level involved.

2) Realistic planning must be reflected through task assignments and accompanying budgets, milestones, and schedules.

3) Performance analysis is a major feature of a performance measurement system. Recognition and follow-up must be accomplished if the system is to be effective. Also, the action needs to be initiated at the lowest level of responsibility.

4) Performance data must be timely, accurate, and presented in a simple form. Summary information which is available immediately has more value than detailed information available later.

5) The detail of performance information is dependent on the value and program impact of the item measured. Emphasis will be on established sufficiency for day to day operation with the ability to retrieve greater detailed information when required.

2.0 MANAGEMENT SYSTEMS

The management systems to be employed in the KIPS FSCD program were developed for past Sundstrand programs including KIPS Phase I. They provide the information and procedures necessary to manage the business, products, and programs of the various units of the Advanced Technology Group. Most of Sundstrand's products and programs reflect the characteristics of the KIPS FSCD, especially that of being a highly engineered, sophisticated machine requiring high reliability and safety. The management systems have been developed over a period of time and are controlled manually with data provided by both computer data banks and individual record files. These systems, combined with the various program plans, procedures, and a reporting system tailored to DOE requirements, will provide the total integrated management system for the KIPS Phase II program.

Figure A-3 shows, in summary form, the various management systems now being utilized by Sundstrand. These systems provide the functions shown in Figure A-4. Successful management of the KIPS program is dependent on the integration of these functions into the program work flow process. This approach will result in effective program control and will provide visibility of costs, schedule, and technical performance throughout the program.

2.1 Performance Management System

Sundstrand will modify the existing KIPS Phase I performance management system for the Phase II program. This system complies with DOE requirements. The system will provide the planning, integration and measurement required to provide program control and visibility. This subsection describes how these activities will be accomplished.

2.1.1 PERFORMANCE MANAGEMENT SYSTEM DESCRIPTION

The Sundstrand KIPS performance management system is schematically shown in Figure A-5. This diagram depicts the basic work process.

Figure A-3 Sundstrand Existing Management Control Systems Relationship to the KIPS FSCD Program Total Management Systems

SUNDSTRAND MANAGEMENT SYSTEMS	SYSTEM DESCRIPTION	APPL. TO KIPS MGMT SYSTEM
PERFORMANCE MANAGEMENT <ul style="list-style-type: none"> Order Release Management Information Teledyne Subcontract 	<ul style="list-style-type: none"> Authorization & Instructions to performing organizations to initiate work. Requirements Cost & Schedules become part of release. Comprehensive reporting system for all functional management. System is based on "management by exception". Data includes: <ul style="list-style-type: none"> Profit/Loss by Product Centers Division Sales Division Profits/Losses Manufacturing Labor Manufacturing Material Distribution Functional Organization Burdens Indirect Exp. by resp. and Function Inventories Capital Expenditures Sales Forecasts Proposal Activity Contract Summaries Program Tech. & Contract Status Customer Service Personnel & Facilities Utilization 	<ul style="list-style-type: none"> Performance Management Performance Management
ENGINEERING <ul style="list-style-type: none"> Drawing/Specification/Procedures Control Technical Performance Drawing Release 	<ul style="list-style-type: none"> Define, control and distribute engineering drawings, documents, vendor specs., process specs., and procedures Quantitative and qualitative assessment of technical and schedule progress in comparison to baseline requirement Conduct and control for drawing releases to Manufacturing 	<ul style="list-style-type: none"> Performance Mgmt/Configuration Mgmt Performance Measurement Configuration Mgmt.
MANUFACTURING <ul style="list-style-type: none"> Base Data Maintenance Requirements Planning Order Release Work in Process Finished & Raw Material Inventory 	<ul style="list-style-type: none"> Data interrelating Bill of Material, Supporting Specifications, Procedures, Process Routings, Tools and Machine Tools Basis for Master Production Plan. Compares Parts/Assembly Requirements against Inventory Position. Provides for orders to be placed in sufficient time and quantity to meet Customer requirements Provides documents to proceed with manufacturing cycle. Audits order for sufficient information and accuracy. Control of work schedules, priorities, and costs of in process work Inventory control and maintenance. 	<ul style="list-style-type: none"> Performance Management Performance Management Performance Management Performance Management Performance Management
SUPPORTING <ul style="list-style-type: none"> Cost Accounting Pricing 	<ul style="list-style-type: none"> Integration of all cost recording. Charge numbers are assigned. Costs recorded for direct and indirect work by task, program function, and cost allocation Estimates, analysis, and supporting data for all proposals. 	<ul style="list-style-type: none"> Information Systems Performance Management
CONFIGURATION MANAGEMENT <ul style="list-style-type: none"> Configuration 	<ul style="list-style-type: none"> Procedures, surveillance and planning of the baseline design configuration and changes associated with it 	<ul style="list-style-type: none"> Configuration Management
QUALITY ASSURANCE <ul style="list-style-type: none"> Configuration Status Accounting Non conformance Reporting Material Review Board Reliability Safety 	<ul style="list-style-type: none"> Documented record of end items in terms of design criteria, manufacturing data, inspection and test records. Description, usage action, documentation of action taken. conformance of non conforming material Integration and action initiation of non conforming material 	<ul style="list-style-type: none"> Configuration Management Quality Assurance Management Quality Assurance Management Reliability & Safety Mgmt.
DATA <ul style="list-style-type: none"> Data Control 	<ul style="list-style-type: none"> Audit of data requirements to insure definition of requirements. schedule preparation. coordination of all functional inputs. review and integrate data preparations 	<ul style="list-style-type: none"> Information Systems Mgmt

Figure A-4 Sundstrand Management and Control System

Figure A-5 KIPS Program Performance Management System

Utilizing the Phase II program schedule, milestones are established which represent significant measurable happenings. These not only represent the basis for schedule performance, but also become the basis for the measurement of work progress. The program manager will select the task level to be used for measured purposes. Dollar value and potential program impact are the major criteria for this selection.

From the technical plans and contract technical requirements, critical technical parameters will be identified and criteria will be established for technical performance measurement as was done during Phase I.

Work authorization will be accomplished and defined by the program manager. The authorization will be through a Task Assignment (Figure A-6), which will define the Statement of Work, time phased cost, total cost, manhours, milestones, and schedule.

COST: Cost information is accumulated by work task and by work function for all software activities. Hardware costs are accumulated by work order which normally means by each detailed part.

Indirect costs that are pooled will be allocated to the work item based on the actual costs. The actual applicable indirect costs incurred in the program will be charged to the overhead pools as agreed to with DCASO. Monthly reports are prepared summarizing the actual pool costs in total and by line items making up the pools.

All costs recorded are controlled by a general ledger. The accounting system provides that these costs are recorded at the time they are incurred.

All costs are summarized at various task levels by functional area. This allows different levels of detail to be supplied to various levels of management – individual items to the performing function; summary items (representing larger functional work packages) and summary information for the program manager and/or Sundstrand upper management.

SCHEDULE: Schedule reports will be made for each task. Such reports will consist of milestone status including the percent of completion. When critical tasks are involved, analysis will be made to reflect the total program impact.

TECHNICAL PERFORMANCE: The selected technical performance milestones will be tracked. In addition, technical status reports will be utilized to supplement the performance milestone achievements. Potential problems will require more detailed reporting and follow-up with shorter reporting periods.

ANALYSIS AND FOLLOW-UP

Analysis: Cost reports are circulated to all necessary personnel. The level of the cost report is keyed to the management level. Each recipient reviews the report relative to his assigned budget and significant variances are identified. Schedule analysis will be based on milestones completed.

Technical achievement analysis will be based on variances from the selected milestones and from engineering progress reports. Each function involved has a responsibility to define any problem area and propose solutions (including technical action and cost and schedule effect).

Figure A-6 Work Authorization Flow

Reporting will be implemented by regularly scheduled review meetings within the Program Office and with the functional work organizations.

Follow-Up: Identified problems, whether they are cost, schedule, or performance, are the responsibility of the assigned function. Overall program impact will be assessed and, if serious, specific documented action will be undertaken such as back-up programs.

Changes: When a specific problem resolution requires a change to the baseline design, such changes will be made within the configuration management system. Where cost and schedule are involved, estimates of the changes will be made and evaluated by the Program Office. If approved, the master program schedule, budgets and milestones are modified to reflect the change. Any changes in the contract baseline would require approval by the DOE.

Reporting: Internal management reporting will be keyed to those items selected by DOE for their assessment. The depth of the reports will be determined by the work levels. This dual usage of the reporting system is desirable as it means lower program costs and a common basis for tracking program progress (see Figure A-7).

Accomplishment reports will also be made for problems identified with follow-up action and anticipated results identified.

2.1.2 STATEMENT OF WORK (SOW)

The SOW is the basic document in the performance management of the KIPS program. The SOW describes the various tasks and activities to be accomplished on the program. It becomes the planning document for the development of the master program schedule, supporting schedules, task descriptions, financial planning, budgets, and identification of organizational assignments.

The task assignments and the Sundstrand performance management system will be formally implemented coincident with commencement of Phase II. It will become a basis for planning of the tasks to be accomplished.

2.2 Information Management System

The preparation, retrieval, and use of information as a means of communication in the KIPS Phase II program is very important in meeting the overall program objectives. This subsection describes Sundstrand's approach to information management (data management) including the philosophy, planning, control, and application to subcontractors.

The Sundstrand information management system is a vital and effective management tool. This system is based on the premise that various levels within the company organization should be provided with appropriate information — at varying levels of detail. Some of the basic approaches to be utilized in the KIPS program are:

- 1) Short communication links between the program manager and the contributing functional areas to minimize the successive layers of documentation necessary to define instructions, requirements, decisions, and action.

REPORT RECIPIENT	PERFORMANCE MANAGEMENT REPORTS
Department of Energy Management Staff Field	<ul style="list-style-type: none"> ● Monthly Top Summary ● Monthly Financial ● Monthly Technical ● Special and Documentation <ul style="list-style-type: none"> Safety Design Testing Material Properties Specifications Operating Procedures ● Annual Technical Reports
KIPS Program Manager	<ul style="list-style-type: none"> ● DOE Reports or information ● Summary Cost Level vs. Budgets ● Cost Summary by Function ● Schedules & Milestone Completion by Work Task ● Manhour Expenditures Summary ● Technical Achievement Reports ● Subcontractor Reports
KIPS Functional Managers	<ul style="list-style-type: none"> ● Summary Cost Level vs. Budgets ● Cost Summary by Function vs. Budgets ● Overhead Costs by Pool vs. Budgets ● Manhour Expenditures Summary ● Technical Achievement Reports Subcontractor Reports (as applicable)
Functional Organization Manager	<ul style="list-style-type: none"> ● Summary Costs at Assigned Work Tasks vs. Level vs. Budget ● Work Task Costs by Function vs. Budget ● Schedules and Milestone Completion by Work Task ● Overhead Costs by Functional Responsibility Line Items ● Manhour Expenditures by Work Task ● Technical Achievement Reports
Special Reports to Designated Managers as applicable	<ul style="list-style-type: none"> ● Technical Problems ● Non-conforming Material ● Configuration Status ● Data Status ● Spare Parts Status ● Change Proposals

Figure A-7 Reports — Recipient Organization Matrix

2) Provide information to all levels of program contributors (program management, functional management, or functional work specialists) in the detail required for that specific job function.

3) Make maximum utilization of data required by DOE for internal purposes.

4) Utilization of Sundstrand's in-place, proven data management system.

5) The program manager will be wholly responsible for the KIPS information systems management. The configuration and data management section will perform the tasks.

6) Limit data required from subcontractors to that necessary to control their efforts, supply required contract data to DOE, and provide Sundstrand management visibility to their task.

DATA MANAGEMENT

The planning, implementation, and control of data in the KIPS program will be through Sundstrand's existing data management system. The work flow is described in Figure A-8. The KIPS Program Office will have the responsibility for all the identified steps except for the actual data preparation which will be accomplished by the various functional organizations. The Program Office will also assume the responsibility to control all data received from DOE as well as from Teledyne or any other subcontractors on the program.

Figure A-8 KIPS Data Management Work Flow

PLANNING AND CONTROL

The contract, through the Statement of Work (SOW), becomes the basic planning document for DOE data just as it is for other program work elements.

Specific data items will be assigned to specific functional areas as work packages. Each data work package will define the data required, schedule for completion (or other milestones if applicable), the charge number, and responsible organization. In those instances where similar data is being prepared by a function, the work packages may contain several data items, although each will be identified separately. Control of data in process will be through cost reporting against the charge allocation, schedules and status reports. When problems or potential problems are identified, action will be taken by the configuration and data management supervisor.

Procedures and policies which have been developed previously for the Sundstrand data management systems are controlled and administered by the data management group, which is a part of Sundstrand's Administration Department, one of Advanced Technology Operations support groups. Modifications and/or development of policies required by specific KIPS program requirements will be defined by the KIPS Program Office but implemented by the data management group.

Internally required data will normally be defined by the KIPS Program Office and/or the functional area. Policies and procedures already established will provide the basis for implementation.

SUBCONTRACTORS

At the time the data requirements are being defined, scheduled and allocated, data requirements for Teledyne and other subcontractors will also be defined. Such requirements will be processed to the Teledyne major systems buyer and to functional procurement organizations. The requirements will be limited to that required by contract, that required for the vendor's own control, or for Sundstrand's management visibility.

Data submitted by the subcontractor or vendor will be evaluated by the appropriate functional organization (engineering and quality assurance) in addition to its evaluation by procurement. This will insure its responsiveness to the specific need or equipment.

RELEASE, DISTRIBUTION AND RETENTION

After completion of the specific data items by the functional area, the results are verified against the requirements. Sign-offs are accomplished as specified and the data is distributed by the configuration and data management supervisor.

Comments and/or requested changes will be coordinated with the preparer of the data with disagreements mutually resolved by the KIPS Program Office.

Data generated by a functional area will generally be filed within the functional area files, with an overall location/availability list maintained by the Program Office.

Other data generated for internal use will be handled in a similar manner except that the recipient becomes a specific organization within Sundstrand rather than DOE.

Updating of data requirements will be made periodically throughout the KIPS program to insure that the data is current and, more importantly, that it is still required.

QUALITY ASSURANCE MANAGEMENT

Quality assurance management is a very important part of the total KIPS management system. Quality assurance management's objective is to insure that the product (hardware and software) meets the requirements as defined by the contract, drawings, procedures, data items, or other controlling documentation. It also provides a system to control applicable in-process activities and the means for making changes in a controlled and documented fashion.

The activities included as part of the quality assurance management system are: quality assurance, configuration management, reliability, maintainability, safety, human factors, cost effectiveness, and design audit (Figure A-9). The latter items are primarily engineering items ultimately reflected in the KIPS design. However, quality assurance management provides a check and balance function to insure their consideration in the design. The quality assurance manager in the KIPS Program Office will have responsibility for these items.

Quality, reliability, and safety will receive the utmost emphasis and will be managed, conducted, and monitored in accordance with the respective NRA documents. Sundstrand reliability and safety organizations have developed a strong capability in these areas by necessity -- Sundstrand products and systems have been applied to essentially every military and commercial jet aircraft flying today and, after many millions of flight hours, enjoy an unsurpassed reliability and safety record.

Although quality assurance management is discussed in greater detail in Volume V, the important functions of quality assurance and configuration management are discussed in the following subsections:

Figure A-9 Quality Assurance Management System Objectives

CONFIGURATION MANAGEMENT

Configuration management for the KIPS program provides for the management of the KIPS configuration through design reviews, hardware and software baselines, configuration change control, configuration status accounting and vendor configuration control.

How these various responsibilities will be implemented is delineated in the configuration management plan.

Responsibility for the implementation of the configuration management function is delegated by the program manager.

The configuration management responsibilities are as follows:

- 1) Update configuration management plan
- 2) Identify existing, modify, or develop procedures for implementation
- 3) Surveillance of procedures/work effort compatibility
- 4) Surveillance of engineering data identification and release
- 5) Surveillance and verification of hardware serialization
- 6) Develop requirements for vendor contracts and monitor performance
- 7) Implement change control system
- 8) Chair change commitment board
- 9) Participate in design reviews
- 10) Develop KIPS configuration baseline document

The combination of the in-place Sundstrand configuration management system reporting to the KIPS Program Office will assure that the KIPS will have the configuration control and visibility required to meet all program objectives.

2.3 Quality Assurance

The Sundstrand management approach to quality assurance management activities is the positive application of resources which will yield defect-free products. This involves three fundamental activities – assurance, control, and inspection.

ASSURANCE

Quality Assurance is the determination of the type of program required. It must focus upon the prevention of problems and defects. This is accomplished through participation with any and all management and line functions for assurance of a total quality program.

CONTROL

Control is the selection of and implementation of inspection techniques, definition of inspection resources and the analysis of inspection data to assure maximum confidence in the soundness of products. Control must be established at every operation throughout the manufacture, assembly, and test of a product.

INSPECTION

Inspection is the function of examining processes and hardware to insure conformance to quality standards.

Quality assurance is a vital function at Sundstrand. Both the Rockford, Illinois, and Denver, Colorado, facilities have quality assurance organizations. At the Denver manufacturing plant, major emphasis is on control and inspection. The Sundstrand Operations manager of quality assurance is responsible for all quality functions within the Unit. On the KIPS program, the quality assurance manager will continue to interface with the engineering and program control organizations to determine unique quality requirements or new technical requirements.

Another essential function is close contact with the engineering activity during the development of the FSCD to understand 1) the call for "old" machining processes, special processes, or manufacturing techniques with a history of manufacturing and control problems, and 2) new processes, materials, or configurations/tolerances which could cause problems. Quality assurance will establish a plan so that the KIPS program has positive control and known inspectability of all such items.

Although quality assurance is a preventive arm, it must be active in failure analysis in order to effectively avoid repeat failures. It must have sufficient technical ability to, with other technical functional organizations, completely identify the base cause of failures and effect corrective action.

Quality assurance is responsible for preparing and controlling the quality assurance procedures and instructions which establish the operating systems. It also produces the inspection portion of manufacturing work instructions which directs the level of sampling, the point of inspection, and the gages/equipment to be used. Quality assurance, therefore, directs the inspection technique and defines the application of resources, with responsibility to assure the positive control of materials at every operation so that the result is defect-free products.

In the area of testing, engineering will define and control test specifications. The test specifications, however, are approved and monitored by quality assurance.

Quality assurance is responsible to keep abreast of the technological improvements in inspection equipment, nondestructive test techniques, etc., and provide capital requests/justifications. It analyzes inspection data to determine that positive control exists or revises the plan or takes other corrective action as necessary to insure positive control.

Inspection implements the Quality Assurance Plan and establishes the conformance of hardware and processes to the quality standards. Nonconforming hardware must be identified and segregated and presented for technical review.

Inspection management is responsible for the effectiveness and productivity of the inspectors and for the interface with manufacturing, assembly, and program control so that the inspection is timely in support of schedules.

Inspection must produce records and data with completeness and accuracy. The data and records are essential for "Proof of Inspection", and for trend/problem analysis.

These criteria have been incorporated into the KIPS Quality Assurance Plan which will insure a total quality program. Quality assurance is described in more detail in Volume V.

APPENDIX B — PROCUREMENT AND SUBCONTRACT MANAGEMENT

Procurement and subcontract management is a major part of the KIPS program. Historically, procured items - material, processing, components or subsystems - have represented about 30% of Sundstrand's manufacturing cost dollar. This ratio will be higher for the KIPS program due to the heat source and radiator subcontracts.

The Sundstrand procurement and subcontracting organization is an experienced organization which has shown its effectiveness in major subcontracting programs such as the KIPS Phase I, Space Shuttle APU, Mark 48 torpedo propulsion system, B-1 wing sweep system, as well as with less complex programs. This experience combined with a proven in-place procurement organization and system will provide the cost, schedule, and performance effectiveness required by the KIPS program.

The manufacturing manager will assume overall responsibility for the procurement function as it relates to the KIPS program. He will define, oversee, and measure the effort by the functional procurement organization. A buyer from the major systems subcontract office has been assigned to the program and will interface with the program engineering manager and the Program Manager for major contracts such as Teledyne.

The following sections describe Sundstrand's procurement and subcontracting approach to the KIPS Phase II Program.

1.0 PROCUREMENT MANAGEMENT

Sundstrand's procurement system is organized to provide the coordination and implementation of the material procurement task. It is functionally organized within the Materiel Department, a part of the Operations Unit. Within the Materiel Department are the functions of Production Planning, Production Control and Inventory Control. These functions, when combined with procurement, provide a single point responsibility for scheduling and hardware availability.

Procurement is organized on a commodity basis, as shown in Figure B-1, due to the wide variety of products and models of specific products, all reflecting many common parts and materials. These commodity areas are raw material, end items, capital equipment, major systems and components. A clerical group supports all the buying groups.

Although not providing any direct procurement effort, procurement specialists on the corporate staff provide guidance and counseling when required. The corporate procurement staff also helps in establishing corporate-wide procedures; overriding agreements where applicable to the overall corporation; provide guidelines to corporation-wide activity and emphasis with small business, labor surplus and minority business programs; and provides for the audit of individual division procurement activities with relation to established procedures and corporate objectives.

The Procurement Management function can be divided into three phases — selection, implementation, and control as shown in Figure B-2.

1.1 Selection

The selection process is initiated by the release of a purchase requisition by production planning and the assigning by purchasing supervision of the requisition to a specific commodity group.

Figure B-1 Sundstrand Procurement Organizations

Figure B-2 Procurement Process

Sources are selected from the approved source list and proposals are solicited through specifications, drawings and/or catalog designation. The approved source list is derived from past or present performance and activities and/or from Sundstrand purchasing and quality assurance survey or audits.

Wherever possible, a minimum of three sources are solicited. Price proposals or confirming quotations are required from all sources. When competitive pricing does not exist, maximum use is made of "should cost" analysis and cost audit. In all instances, purchasing establishes target costs based on actual or similar historical costs.

Contract requirements are defined by the program control manager and become a part of the purchase order. Such items as data, configuration control, quality assurance, price certification and logistic requirements become an integral part of the purchase order.

From the analysis of price, delivery, technical compliance, past experience and audit results, a vendor is selected. Levels of approval for the selection based on price level and/or potential program impact will be a part of the program plan.

1.2 Implementation

Upon the selection and approval of the vendor, the purchase order is negotiated by the buyer. Where necessary, conditional specialists from engineering, contracts, legal, pricing, and other areas are utilized to insure clear definition of the task to be accomplished and vendor responsiveness to it. If required, price audit will be accomplished with analysis by functional cost analysts. In all instances, maximum emphasis is to insure cost, schedule, and performance adherence to the KIPS program cost, schedule, and performance requirements.

1.3 Control

Cost control is maintained through emphasis on fixed price purchase orders with tight control of changes. On major subcontracts, cost is monitored by utilizing cost reports and termination cost schedules required from the vendor. Such control is supplemented by on-site surveillance.

Schedule performance of all contracts is monitored on a regular basis by the individual buyer. Delivery schedules are enforced consistent with the purchase order terms and conditions. Delivery dates are projected on a monthly basis and incorporated into the automated "Purchase Parts Status Report." Status of pacing items are determined on a more regular basis, daily if necessary. This report provides the buyer with visibility for all purchased items in the KIPS program. This information also informs production control and the program manager of present deliveries and quantities. The program manager can then reflect any change into the detailed program schedules and logic diagram to determine overall program impact and required follow-up action.

The configuration management plan will define the detail procedures for implementing changes. In general, production control issues a purchase order change request defining the change, parts utilization, and effectivity date.

For any major subcontract, such as with Teledyne Energy Systems, program management plans, including baseline schedule and expenditure plans, will be required. In addition, monthly cost, schedule, and progress reports are obtained to insure adherence to the plan and provide the

necessary reporting information being supplied to DOE by Sundstrand. Where required, quality assurance and engineering personnel will be utilized to aid procurement in assuring compliance with all aspects of the contract. On-site surveillance, including the use of resident personnel, would be utilized when required.

2.0 MAKE OR BUY PROGRAM

Sundstrand's "make or buy system" is a viable part of the procurement system and regulated by established procedures. Basically, the system strives to provide the lowest cost consistent with quality delivery and technical or other special considerations. It is applied to those components or subsystems where Sundstrand has the technological and manufacturing expertise to accomplish the job. It can relate to simple piece parts, where the decision might be simply delivery or cost or to a major subsystem requiring extensive design and development effort.

To assure that the facts are available to make the proper decision, constant reviews are made of design progress, technology advancements, quality assurance, as well as factory loading and schedule capability in-house.

Consideration of the following items becomes a part of the Sundstrand make or buy decision.

- 1) Is it more effective to have design and engineering liaison "in-house"?
- 2) Does reliability, safety, maintainability or other special considerations require strong "in-house" control?
- 3) Can it be subcontracted for a "true" lower cost? (Consideration must be given to the "in-house" cost to support a selected vendor.)
- 4) What are the delivery requirements?
- 5) What is the availability of engineering, test, and manufacturing resources?
- 6) Is the item a catalog or off-the-shelf item?
- 7) Are there specialty vendors available whose business is to produce the item?
- 8) Will the procurement complement the small business or minority business enterprises programs?
- 9) What are the quality assurance requirements?
- 10) Will the procurement benefit the geographical distribution of the KIPS program dollars?
- 11) What is the impact of facility needs?
- 12) Can previously funded government technology programs be utilized to obtain maximum return on investment?

Based on consideration of these and like items, decisions will be made for each applicable item. Items with a substantial dollar value or of potential critical impact on the program will be approved by the program manager.

2.1 KIPS Make or Buy Decisions and Impact

Considerations of make or buy for the KIPS program indicate that the procured or "buy" hardware items will be similar to items used in current Sundstrand units. Therefore, about 30% of the unit cost (less heat source and radiator) will be subcontracted. The major subcontracted item is the design, development, test, and manufacture of the heat source and radiator. This particular subcontract represents a sizable portion of the program cost.

3.0 SOCIO-ECONOMIC PROGRAMS APPROACH

Sundstrand endorses and actively supports the socio-economic programs of small business subcontracting, minority business enterprises and labor surplus area subcontracting. The focal point for all these programs is the small business contracting manager. The manager of materiel is the designated Small Business Liaison Officer and has been assigned division responsibility for:

- 1) Encouraging the participation of small business in the Sundstrand subcontracting program.
- 2) Providing information to all members of procurement on regulations and requirements concerning small business.
- 3) Maintaining and providing to all procurement personnel the availability of small business sources.
- 4) Representing Sundstrand in discussions with the DCASO small business administrator, particularly, in relation to developing new sources and compliance with existing regulations.

The program has been developed in accordance with ASPR 1-707-3 and presently carries the DCASO contracting officer's rating of "approved."

Sundstrand was recently awarded a "Certificate of Appreciation" by the Small Business Administration for "...service to the nation's Small Business Community and to the Small Business Administration for participation in the nationwide series of Small Business Subcontracting Conferences."

Within this framework, emphasis is given to provide subcontracting to labor surplus areas. To aid in this effort, utilization is made of the Labor Department's publications, "Area Trends", to assist in locating vendors in labor surplus areas. Continual updating is accomplished through addendums for the "Labor Surplus Area Zip Code Reference Guide."

Sundstrand has actively pursued subcontracting to minority businesses, and it is a very important part of the small business subcontracting activity.

3.1 Relationship to the KIPS Program

As indicated previously, the small business, labor surplus and minority business enterprise subcontracting is an inherent and aggressive part of the Sundstrand procurement system. These

plans will automatically become a part of the procurement plan for the KIPS Phase II program. Additionally, further consideration will be given in the make or buy decisions and in all procurement actions.

The importance of this area in the overall KIPS program will be emphasized to all buyers and personnel directly involved in the vendor selection cycle. Where major subcontractors are utilized, their terms and conditions will reflect mandatory compliance with the applicable government regulations. Also, they will be encouraged to voluntarily exceed the mandatory requirements. Development of additional sources will be considered within the cost and schedule restraints of the program.