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FINAL REPORT

Space Station Human Productivity Study

 *Lockheed* / *BOEING* / ILC SPACE SYSTEMS / *A*  / **SUNDBERG • FERAR**

Volume I: FINAL REPORT

 *Lockheed Missiles & Space Company*

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NOVEMBER 1985

Space Station Human Productivity Study

FINAL REPORT VOLUME I

CONTRACT # NAS9-17272
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PREPARED FOR
MAN-SYSTEMS DIVISION
NASA Lyndon B. Johnson Space Center

BY

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FOREWORD

This document is Volume I of the Space Station Human Productivity Study Final Report, performed under NASA-JSC Contract NAS9-17272. The complete set of volumes for this final report consists of:

- Volume I — Final Report (Study Description)
- Volume II — Executive Summary (and Oral Review)
- Volume III — Requirements
- Volume IV — Issues
- Volume V — Management Plans

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Section 1
INTRODUCTION

The Space Station Human Productivity Study was formulated to aid in NASA's overall program to maximize human productivity in Space Station operations. The importance of providing adequate support for human productivity in manned space systems was made explicit by the National Academy of Sciences in 1972*. The continuing manned space flight experience has brought even greater recognition to this subject. Further impetus derived from the President's stated goal for NASA to promote private sector investment. To achieve that goal, the Space Station system must ensure efficient performance capabilities to merit the confidence and increased investment by the private sector, as well as to serve the need for effective space research.

During Phase A of the Space Station Program, NASA Headquarters formed NASA- Contractor Concept Development Working Groups, and the sub-group on Habitability and Human Productivity led to the definition of the present study, which was sponsored by Johnson Space Center. In fact, two related studies were formulated (and implemented): the Advanced EVA (Extra-Vehicular Activity) System Design Requirements Study, on RFP 9BE2-727-4-37P, and the Human Productivity Study, to address Intra-Vehicular Activity (IVA) and IVA/EVA interface concerns (NASA contract NAS9-17272). The primary goal of this study was to develop design and operations requirements for direct support of IVA crew performance and productivity. It was recognized that much work had already been accomplished which provided sufficient data for the definition of the desired requirements. It was necessary, therefore, to assess the status of such data to extract definable requirements, and then to define the remaining study needs. The explicit objectives of the study were to:

- Review existing data to identify potential problems for Space Station crew productivity and to define requirements for support of productivity insofar as they could be justified by current information
- Identify those areas that lack adequate data
- Define approaches for developing the lacking data
- Prepare plans for managing studies to develop the lacking data, so that results can be input to the Space Station Program in a timely manner.

This study was conducted by a joint NASA and contractor team whose key members are shown in Fig. 1-1. A total of about 36 contractor analysts, selected for their respective expertise, participated in initiating the data generated by the study. Throughout the performance of the study, contributions were received from many NASA offices and other recognized experts in their respective fields.

The primary products resulting from this study are:

- The Space Station Human Productivity Requirements document (Volume III of this report) to be made available to all Space Station Program (SSP) participants.
- Definitions of needed study topics, called "Issues" (Volume IV)
- Management Plans for the performance of studies needed to resolve defined Issues (Volume V)
- Personal Computer (PC) data files, containing all data developed for the study.

The study has been extended in order to develop a Relational Data Base from the evolved data files for broad Space Station Program utility. This is discussed in paragraph 2.2 and in Section 5.

*"Human Factors in Long Duration Spacecraft", Space Sciences Board, National Research Council, National Academy of Sciences, 1972.

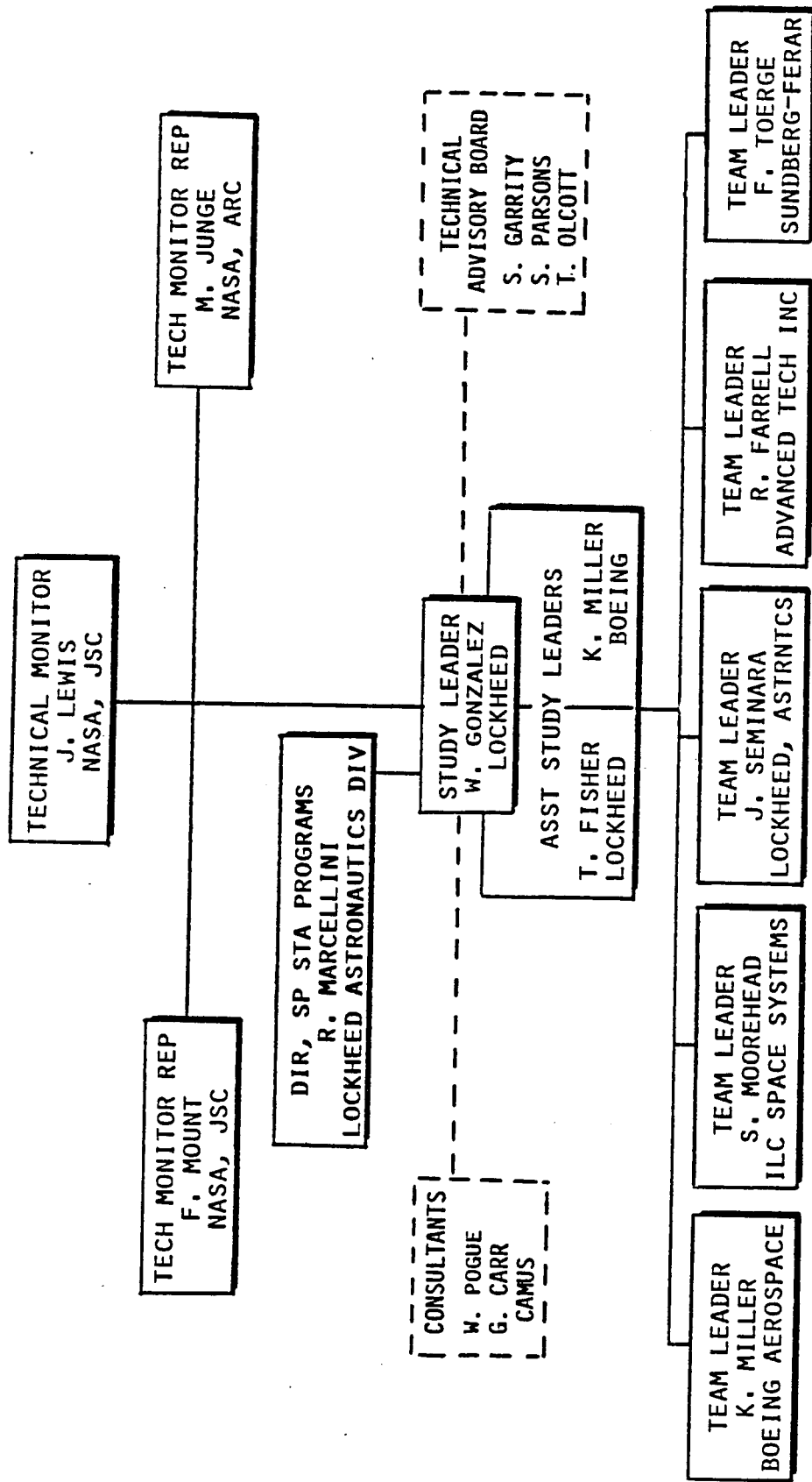


Fig. 1-1 The Space Station Human Productivity Study Team

Section 2 TECHNICAL APPROACH

2.1 OVERVIEW

An overview of the study approach is depicted in Fig. 2-1. An initial literature search provided a data resource for identifying the IVA and IVA/EVA Interface Space Station Elements which affect human productivity. The data search then continued throughout the study in support of all tasks. This search disclosed many areas in which data was sufficient to enable the definition of requirements. These were documented and, in many cases, candidate solutions were also documented based on the research. In order to proceed with the study, certain critical assumptions about Space Station design or operations were necessarily defined. References throughout the study were fully documented. Research also disclosed problem areas for which requirements could not be fully defined, because of the inadequacy of existing data. Such data gaps were noted as unresolved requirements. Unresolved requirements were then synthesized to form distinctly defined study topics, called Issues.

The joint NASA-contractor team then evaluated the identified Issues through several iterations to confirm the content of each Issue and to estimate the relative importance of each to the Space Station Program. A comparison was then made to existing or firmly planned NASA studies to determine which Issues would be resolved by those programs. Those Issues not already in that process were addressed by the contractor team for the development of needed study approaches and study management plans. In many cases, the management plans combined several Issues in order to formulate comprehensive topical areas for meaningful research, correlating study completion schedules to need dates based on the Space Station Program (SSP) milestones. Each management plan contains several sections, including background, specific tasks, and schedule. As the described studies are completed, NASA will update the published requirements.

2.2 DATA MANAGEMENT

The large amount of data, collected and processed by the widely located study team members, required the support of a networked PC data collection system. The system architecture and network is shown in Fig. 2-2. Because of the large data exchange requirements, most data "networking" was handled by exchange of diskettes or tapes. Message communi-

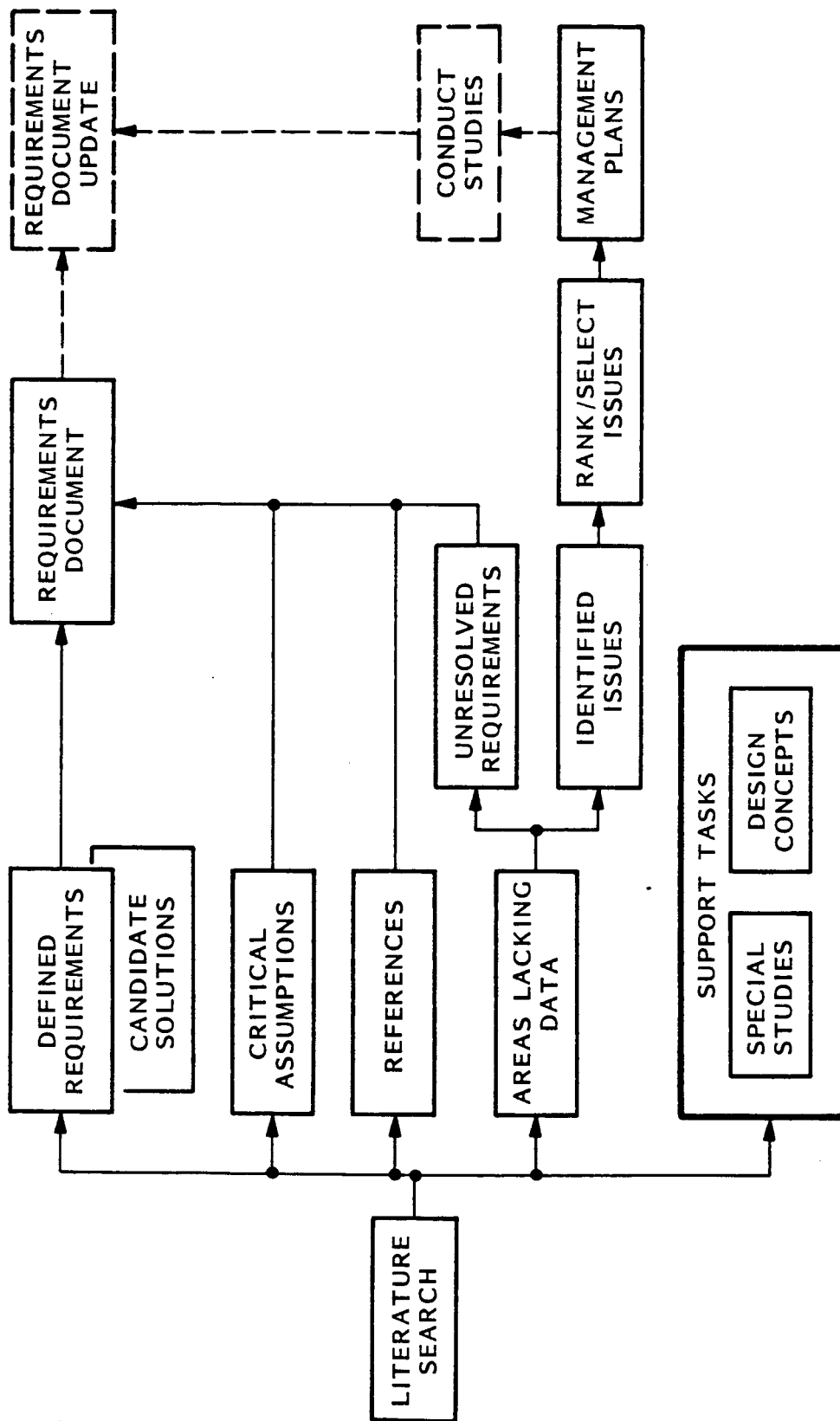
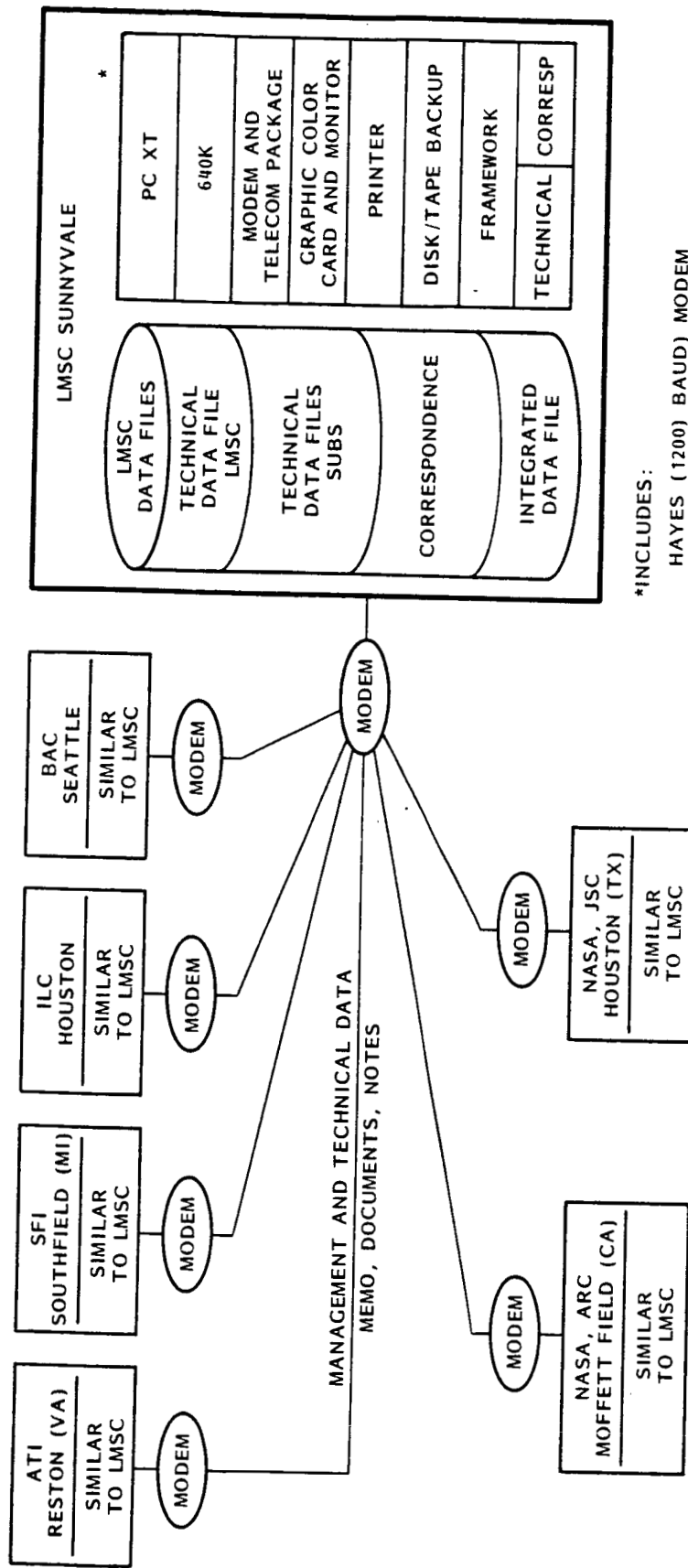


Fig. 2-1 Technical Approach Overview



*INCLUDES:

- HAYES (1200 BAUD) MODEM
- TURN-ON (H/W AND S/W) TELECOM PACKAGE
- AST 6 PAK-PLUS EXPANSION CARD WITH CLOCK
- DAVONG 40 M-BYTE DISK WITH TAPE BACKUP
- DOS 2.0 (OR 2.1)
- FRAMEWORK
- APPLICATION TEMPLATES

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Fig. 2-2 The Human Productivity Study Data Management System Architecture

cations and transmittals of smaller data could occur daily. Inclusion of the TURN-ON unit (hardware and software) permitted access to Send or Receive files when one PC was powered off. The off PC was temporarily powered at the request of the active terminal, then unpowered at the conclusion of the transmittal, making communication across time zones convenient and economical.

All inputs and output reports were preformatted and standardized for control and convenience among the many users. As the study progressed, minor modifications to report formats occurred.

The described data files will be retained for conversion to a Relational Data Base. The conversion effort, underway as an extension to the presently described study, will enhance the utility of the developed data, making it available to NASA-designated participants in the SSP. This topic, the Human Productivity Data Management System, is discussed in greater detail in Section 5.

2.3 TASK FLOW

The flow of tasks, detailed in this study, is shown in Fig. 2-3. Only top level interfaces among tasks are shown. The many iterations and the needs to correlate data as the study evolved are not shown. The following section describes each task in detail.

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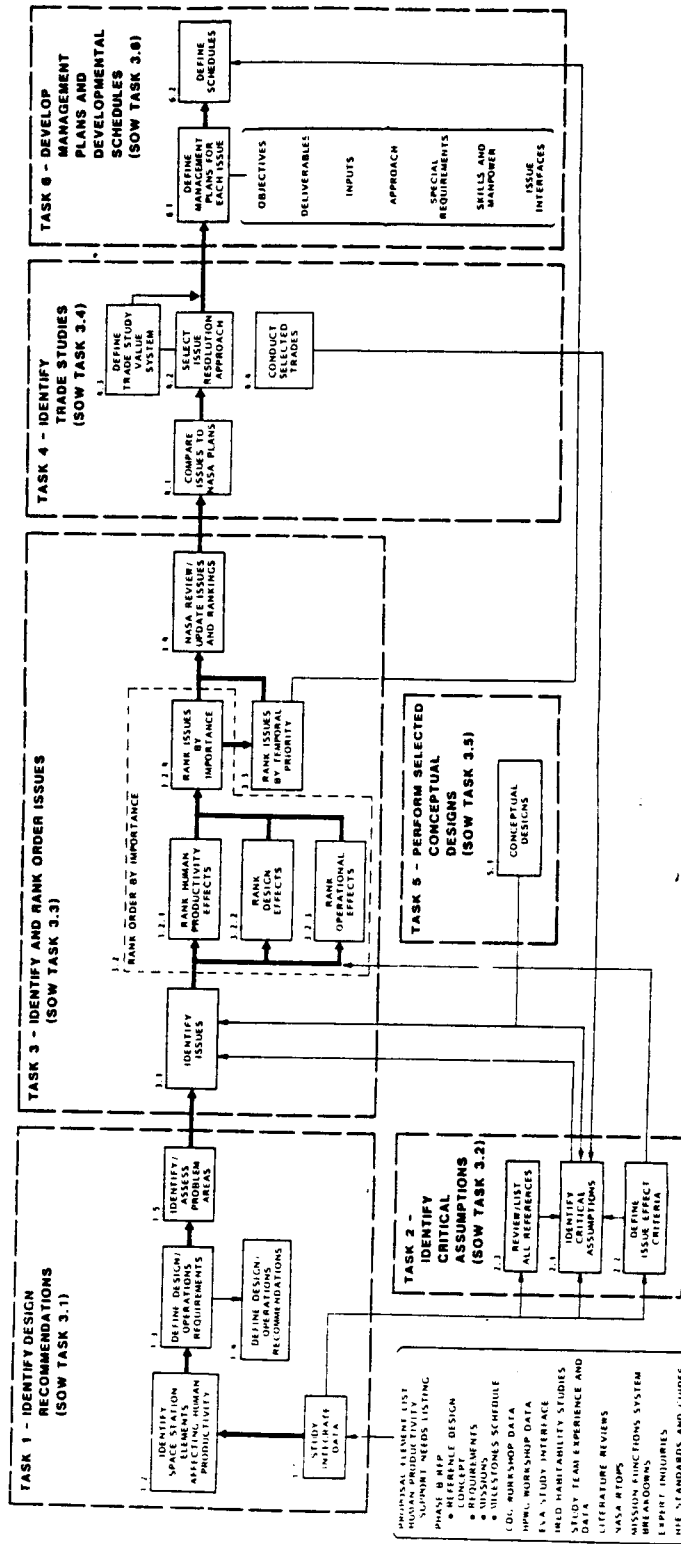


Fig. 2-3 Space Station Human Productivity Study, Technical Approach Task Flow

Section 3
TASK DISCUSSION

3.1 TASK 1, IDENTIFY DESIGN RECOMMENDATIONS

The objectives of Task 1 were to compile and review the literature in order to scope the study by identifying Space Station Elements (SSEs) affecting Human Productivity (HP), then to define requirements and identify problem areas where adequate data was lacking.

3.1.1 Task 1.1, Study/Integrate Data

The study began with an existing library of documents which synthesized a broad array of literature (e.g., from Space Station analog studies, Soviet experience, Skylab and other NASA program experiences, and studies which had evolved data in areas covered by identified HP elements). The data search was expanded through use of the Space Station Program RFP and its listed references, through contacts with various NASA offices, and through resources brought and expanded by the analysts on the study team, who were selected because of their experience and expertise within their assigned topical areas. No constraints were placed on team members in the collection of data, other than to confirm the reasonableness of a resource with their Team Leaders and to fully document all references. A valuable resource for this purpose was provided by CAMUS, formed by W. Pogue and G. Carr, Skylab astronauts.

While the most concentrated literature research occurred early, the collection of data continued throughout the study. The primary objective of the data collection was to formulate supportable requirements and to identify problem areas. All directly utilized references were documented.

3.1.2 Task 1.2, Identify Space Station Elements Affecting Human Productivity

A candidate listing of Space Station Elements (SSE), potentially affecting HP, was provided with the RFP. The objective of this subtask was to review that list to revise and expand as necessary to achieve a comprehensive coverage of SSEs affecting human productivity. For this purpose, it was necessary to develop an operational definition of human productivity which could act as guidance in selecting topics for coverage.

It is recognized that there is not a commonly accepted definition of human productivity, especially as it relates to a space vehicle environment. There is an even greater lack of common acceptance on the definition and quantification of factors which will support such productivity. While our study did not pretend to solve these thorny concerns, we recognized the fact that neither industry nor NASA could afford to await the results of studies which might derive the appropriate answers. The Space Station Program will proceed, and a rational attempt must be made to maximize the opportunity for efficient, productive operations.

The data research confirmed that we have, today, a large amount of good data for defining the requirements for the support of efficient task performance and productiveness in a 1-g environment. This literature is supplemented by a good deal of data collected through NASA sponsorship on past space programs, disclosing problems and providing direction for meaningful recommendations and requirements. Existing criteria for support of efficient task performance, combined with criteria for human productivity provided by the studies of disciplines concerned with organizational and job effectiveness, provide a meaningful basis for establishing a definition and "checklist" for evaluation of whether a candidate Space Station Element was a fruitful area for investigation.

Human Productivity was defined in terms of crew performance:

Sustained performance of all assigned crew functions in a timely, accurate manner, with sustained quality throughout the assigned flight duration, at the least feasible cost.

Then a study team representing the disciplines of Human Factors, Systems Engineering, and Industrial Psychology, was formed to assess what the top level needs are to provide adequate support for the defined (Space Station) crew performance. The assessment led to the formulation of nine broadly defined "crew performance support needs". Stress was placed on the use of simplified language for common team understanding, and on the intent to incorporate diverse but directly relevant concerns. The nine crew performance support needs are:

- **Physical Health.** Aspects of life and fitness support which could contribute to the defined crew performance
- **Psychological Health.** Including such things as sense of security, personal freedom, and an adequate social environment

- **Motivation.** Aspects of design and operations which could act to support motivation
- **Access.** Both visual and physical access within the 0-g environment
- **Information/Knowledge.** Broadly incorporating real time information requirements, e.g., displayed system feedback, and knowledge gained through training, documentation, etc.
- **Organizational Structure.** Aspects of organizational considerations which support the needed dynamics of a favorable team effort
- **Tools and Equipment.** Provision and design of items needed to perform tasks, relating to broad aspects typically considered by human engineering concerns
- **Performance Capabilities.** Stressing capabilities and compatibility related to selection for the program, missions and crew
- **Stability in 0-g.** Aspects of restraint and orientation (physical and visual) which contribute to stability needs.

Each support need was analyzed and divided into its component parts, as shown in Fig. 3-1. Each support need requires providing an appropriate system, a means of monitoring that system, and an approach for maintaining the system. (The term "system" is used in its broad sense.) Ground support was addressed only to the extent that a specific relationship or function contributed to station crew performance. There was less stress placed on the use of exact terms (relating to the represented disciplines) than there was on the use of terms which could be best understood by all team members.

In summary, the purpose of the nine crew performance support needs and their analyzed parts was to utilize them as guidance to avoid omissions and to assess whether a candidate topic (SSE) was within scope of the study. A working meeting among all key team members was held at the beginning of the study to reach a general understanding of this concept and to confirm the initial list of Space Station Elements for allocation among all team members.

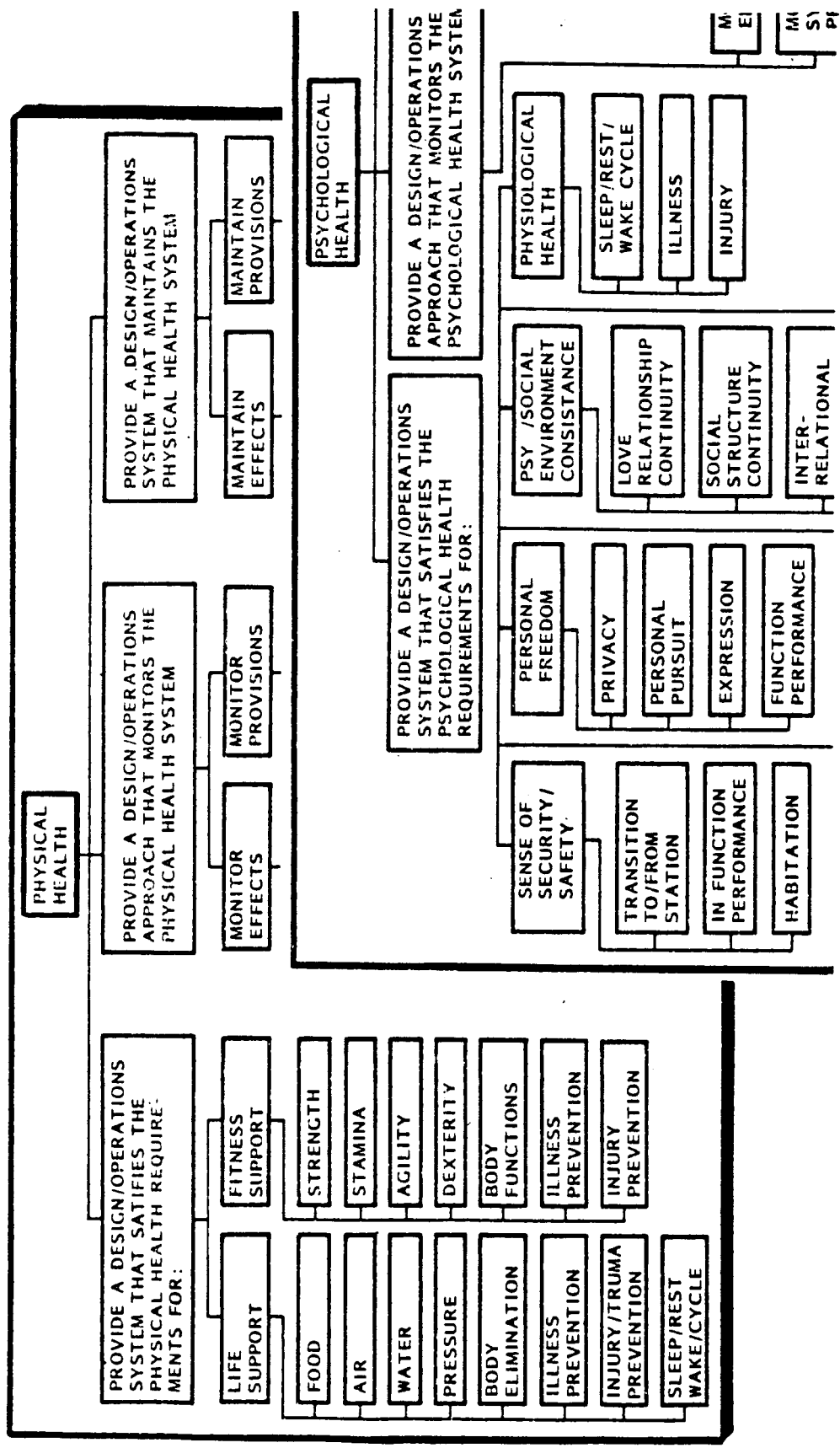


Fig. 3-1 Sample Analysis for Definition of Crew Performance Support Needs

The selected and defined Space Station Elements were organized into five numerically-designated groups:

1. Interior Architecture
2. Crew Support
3. Crew Activities
4. IVA systems
5. IVA/EVA Interface

Elements were listed within these respective groups and assigned subcategorized numbers (e.g., 101, 102, 103, etc.). Each Element was further subdivided into Subelements with a corresponding numbering scheme (e.g., 10101, 10102, 10103, etc.). The listing was revised as the study evolved, in some cases adding subelements, but in most cases by consolidation of subelements for more meaningful requirements and Issue description entities. The hierarchical scheme facilitated traceability and use within the PC files. The final topical Subelement List is provided as Appendix A.

A decision was also made to clearly identify requirements and Issues unique to Space Station Growth. Each Element, therefore, contains a Subelement titled "Growth", enabling easy access to this topic within the broader Element context.

The investigation and organization of IVA/EVA interface elements presented a special problem. It is clear that requirements concerning Airlock design, as well as other obvious IVA/EVA interfacing areas, belonged in the Group 5 category. There were other concerns, however, that were basically IVA topics but which also presented at least points of interest for review and consideration by EVA-focused study. For example, the development of requirements for volume and clearance criteria nominally addressed IVA, shirt sleeved crew members. Contingency operations, however, such as leak repair, might require the temporary use of Extra-Vehicular Maneuvering Unit (EMU) suits until a safe IVA environment could be regained. This contingency poses a fundamental restriction on clearances and access requirements. Thus, the material contained within Groups 1 through 4 also addresses these EVA-related contingency requirements and similar concerns. Certain other topical areas led to uniquely-IVA requirements/Issues which might also be of interest to the EVA study members (e.g., window design and location as it relates to concern for monitoring EVA activities and backup communication). All of these fundamentally-IVA topics with potential EVA study interest were retained within Groups 1 through 4, but were duplicated to form a separate file, identified by an E suffix on the subelement numbers.

Initial planning for this study was to gain the benefit of a thorough technical interface with the EVA Study (Advanced EVA System Design Requirements Study, RFP 9BE2-727-4-37P) contractors in order to refine requirements and Issues related to IVA/EVA interface. The later start of the three awarded studies, however, and differences in manner of data development allowed only a preliminary technical exchange. The solution for this concern was to forward copies of the "E" and Group 5 (five) files to each of the EVA study contractors and to the NASA Technical Manager. Management Plans were not prepared for Group 5 elements, and requirements and Issues within that group are viewed as preliminary.

3.1.3 Task 1.3, Define Design/Operations Requirements, and Task 1.4, Define Design/Operations Recommendations

The objectives of this combined task were to identify and define presently justified requirements and to provide selected recommendations for candidate solutions to these requirements. Requirements and candidate solutions were defined within subelements and documented on standardized report formats.

The inclusion of any specific candidate solutions was not a requirement. Where included, they are alternative solutions only, and do not convey a NASA sanction. Also, they in no way preclude identified study needs.

3.1.4 Task 1.5, Identify/Assess Problem Areas

The search for the definition of requirements led to the disclosure of problem areas for which it was recognized that requirements should be defined to ensure adequacy of support for crew performance, but for which purpose sufficient data was not available. Depending on the nature of the problem, one of these three approaches was taken:

- a. Make only a generic requirement statement, subject to later refinement
- b. Specify a requirement but include a "TBD" for the unknown data
- c. Omit any statement at all until meaningful data is available

It is understood that until resolution, SSP users should use currently available NASA standards and references insofar as they pertain to the shown concerns. As NASA completes the studies needed to resolve problems represented by unresolved requirements, revisions will be published to refine and clarify needed requirements.

3.1.5 Requirements Document

The Design/Operations Requirements for support of crew performance/productivity underwent extensive review and modification to generate the requirements document represented by Volume III of this final report. The review team, representing NASA levels A, B, and C and a broad base of expertise, is listed in Appendix B.

A sample page of requirements is provided in Appendix C, with a detailed format description. The format includes entry of Critical Assumptions, which are described below.

3.2 TASK 2, IDENTIFY CRITICAL ASSUMPTIONS

In many cases, it was necessary to make certain assumptions about the Space Station design and/or operations in order to define requirements. The objectives of this task were to identify these assumptions and to provide rationale, as appropriate. This task was also defined for the documentation of references and for the definition of criteria to be used in assessing the importance of Issues (see paragraph 3.3.2).

3.2.1 Task 2.1, Identify Critical Assumptions

Critical assumptions were defined in three ways:

1. System Level, concerning all subelements
2. Subelement-specific assumptions
3. Assumptions needed for support of Issue study management plans

System-level critical assumptions were needed as a baseline against which to define all requirements. This was handled by stipulating reliance on the Phase B RFP document, Space Station Reference Configuration Description JSC-19989. Additionally, SSP Milestones were defined and dated for common use by all team members.

Other system-level assumptions defined the man-tended mode in order to scope relevant requirements and issues. A decision was made to define man-tended as utilizing a single, unpressurized lab module, which would be reoutfitted for manned IOC. The resulting requirements and Issues for man-tended operations provide a perspective on the impact of these critical assumptions, insofar as they relate to effects on crew performance. (For a

pressurized environment, IVA requirements and Issues remain applicable, as appropriate.) The Subelement coding scheme enables easy identification of the man-tended requirements and Issues, under 55XXX. The described assumptions are listed as System Level Critical Assumptions and appear in Appendix D.

As each subelement was addressed for the definition of requirements, other specific assumptions were needed. For example, requirements for waste/trash stowage assume that long term storage for return to earth will be in the logistics module; requirements for physiological conditioning and countermeasures are based on several assumptions, such as, that some type of cardiovascular loading is required. A change in any stipulated assumptions is likely to require a change in one or more requirements listed for the subelement. Each such critical assumption appears at the bottom of the requirements report format.

A final set of critical assumptions was made where the assumptions represented contingencies upon which recommended study approaches and management plans were defined. Each such assumption is shown within the appropriate management plan. (See paragraph 3.6.)

3.2.2 Task 2.2, Define Issue Effect Criteria

In order to assess the importance of Issues, their potential effects on design, operations, and crew performance were estimated. The assessment scheme and the criteria utilized for that purpose were developed under this task and are described in detail in paragraph 3.3.2.

3.2.3 Task 2.3, Review/List All References

The search for data was not restricted except to require that all data sources were approved by the Team Leaders and to require that each resource be identified and documented against a standardized format. Because of the very wide search which occurred, only those references which provided direct support for the definition of requirements were documented. A consolidated listing of all references was generated and each entry was assigned a number. These numbers, with corresponding section, chapter, or page information, were shown for each requirement statement, enabling easy reference by the reader. A complete copy of the reference list is provided with the Requirements (Volume III of this report).

3.3 TASK 3, IDENTIFY AND RANK ORDER ISSUES

The objectives of this task were to evolve Issue definitions, to rank Issues according to their importance, and to separately generate a ranking according to temporal priority.

3.3.1 Task 3.1, Identify Issues

Issue definitions evolved through the review of the unresolved requirements in order to form integrated study topics. An initial list of about 450 Issues, generated by team analysts, was finally consolidated to 214. As consolidation occurred, corresponding consolidation changes to requirements and the subelement designations were made. This tedious (and hazard laden) process involved contractor and NASA coordination. (NASA review team members are listed in Appendix B.) As noted earlier, the expected technical coordination with EVA study contractors did not occur. Consequently, all Issues under Group 5 (IVA/EVA Interface) remain preliminary. Adding these preliminary Issues (not scored) to the final IVA Issues, the total count becomes 305. All Issue descriptions appear in Volume IV of this final report.

3.3.2 Task 3.2, Rank Order by Importance

Assessing the importance of Issues first required a definition of importance and then the development of criteria for a standardized assessment approach. The objective in assessing importance was to aid in the decision process for allocation of resources to the resulting defined studies. It was decided early that, given the program objectives of supporting human productivity/crew performance, those issues which had the highest potential for affecting crew performance would carry a correspondingly higher importance. Also, greater significance should be given to those that had the greatest potential for impacting design and/or operations. Thus, the definition of importance was based on the relative estimated effects on crew performance, design, and operations. The finally selected criteria for this assessment were standardized and applied as guidance for assigning effect scores to each Issue. The significance (or effect score) of the impact was defined as occurring either in a positive or negative direction. A summary of the Issue scoring criteria is shown in Fig. 3-2. An Issue, for example, whose resolution might add or decrease weight by the same estimated amount would be assessed equally significant on this parameter.

DESIGN IMPACT	1	2	3	4	5
WEIGHT + -	0-1 lb	2-25 lbs	26-75 lbs	76-100 lbs	> 100 lbs
POWER + -	0-99 w	100-500 w	501-1000 w	1.01-2 Kw	> 2 Kw
VOLUME + -	0-2 ft ³	2.1-3 ft ³	3.1-4 ft ³	4.1-5 ft ³	> 5 ft ³
CONFIGURATION (affects design of:)	Installed equipment configuration	Compartment arrangement	Module interior arrangement	Module exterior envelope or interconnect	Any combination of configuration affects

OPERATIONS IMPACT	1	2	3	4	5
* SS CREW WORK TIME: + -	0-15 MIN	15.1-30 MIN	30.1-45 MIN	45.1-60 MIN	1 HOUR
* GROUND CREW WORK TIME: + -	0-2 HRS	2.1-4 HRS	4.1-6 HRS	6.1-8 HRS	8 HOURS
FUNCTION COMPLEXITY + -	NIL TO LOW	LOW TO MOD	MODERATE	MOD TO MAJOR	MAJOR

*Average per work day

C.P. IMPACT	1	2	3	4	5
POTENTIAL POSITIVE: OR NEGATIVE EFFECT	Nil or Low	Low to Medium	Medium or Moderate	Medium to Very High	Very High, Significant

Fig. 3-2 Summary of the Issue Scoring Guidance

A NASA-contractor team was selected and convened (Appendix B) for the final assessment process, representing NASA levels A, B, and C, and a broad combination of backgrounds. The result of this assessment was three ranked listings, based on average scores assigned to each Issue by team members. The scoring process, occurring over a period of several days, included panel discussions to ensure common understandings among members as to the content and intent of each Issue study topic. Various manipulations were then applied to synthesize the results, such as determining which issues appeared in the top quartile of all three listings. These listings were an aide in the selection of Issues for study (see Task 4).

3.3.3 Task 3.3, Rank Issues by Temporal Priority

The defined objective of this task was two-fold:

- To set a basis of priority for scheduling the preparation of management plans during the study
- To act as a reference point for the recommended study performance schedules within the management plans.

A date was estimated for each Issue, based on the requirements to be resolved, as to when resolution was needed in order to provide reasonably timely guidance to the SSP. Related milestone decision points were selected and study completion dates were typically selected as 5 to 6 months prior to the corresponding milestone. This approach formed a compromise between maximizing the time allowance for an appropriate study and achieving timely impact on the SSP. These estimations were made for the original set of 450 (IVA) Issues. A list, ranked by date, was then generated. As described above, however, the Issues were finally consolidated to a revised set of 214. Also, the duration of the consolidation process condensed the amount of time remaining in the study for preparation of management plans. It became unrealistic, therefore, to schedule the preparation of study management plans per this priority criterion alone. As management plan formation began, it was realized that several Issues might be addressed by a single plan, so that a range of "temporal priority" need dates might be represented.

As a consequence, it was determined that management plan approaches and schedules were driven more by the SSP need dates of specific and originating unresolved requirements. These, in turn, became the focus for scheduling the study management plans,

described in paragraph 3.6. Issue need dates for temporal priority assignment, therefore, were not further updated for this task, but were updated (based on requirements) for management plans.

3.3.4 Task 3.4, NASA Review/Update Issues and Rankings

This task occurred concurrently with Tasks 3.1 and 3.2 through the joint participation of NASA and contractors, as described above. Final assessment resulted from a comparison of Issue descriptions to studies in process within NASA, described under Task 4.1 (paragraph 3.4.1).

3.4 TASK 4, IDENTIFY TRADE STUDIES

This task definition incorporated multiple objectives. Following a comparison to ongoing NASA studies, the next step was to select the appropriate study approach. Definition of a trade study value system was also a part of this task. Lastly, the task called for the conduct of any trade studies which might be needed to select among alternate critical assumptions.

3.4.1 Task 4.1, Compare Issues to NASA Plans

The study intent was for the contractor team to compare Issues to ongoing NASA studies in order to assess potential overlaps and to avoid redundancy. The Research Technology Operating Plans (RTOPS) and the Project Operations Plans (POP) were to be used for this purpose. It became evident, however, that the proposed approach was untenable, given the unclear status of studies and difficulty in confirming a comprehensive search by a contractor. Hence, the task was performed by NASA from the offices of the Technical Monitor Representatives at Ames Research Center and at Johnson Space Center. Reviewing Issue descriptions against ongoing and already formulated studies resulted in the elimination of several Issues from further consideration for the development of study approaches. Thus, in many cases, the derivation of data for the definition of requirements, yet unresolved within the requirements document, will come from studies not identified for the preparation of management plans within the present study scope. The result of this process was a final formulation of Issues, grouped by broad topical areas. Joint NASA-contractor discussions led to the selection of 108 Issues, which were grouped into 67 study management plans. The complete list of submitted management plans and their subsumed Issues appears in Appendix E. All plans are contained in Volume V of this report.

3.4.2 Task 4.2, Select Issue Resolution Approach

A critical factor in the selection of an approach for the issue resolution studies was the determined SSP need dates. For example, an extended research approach was inappropriate for answers needed by IRR (January 1986). Candidate approaches, therefore, were evaluated against the permissible time frames. An assumption was made that studies could be started in October 1985, and no sooner. (It is noted that management plans were submitted as they were completed during the program.) Recommended study approaches incorporate a combination of subtasks, as appropriate (e.g., literature search, expert analysis, specific trade studies, mockup evaluation, surveys, simulations, etc.). Each study specifies its unique approach in terms of the defined subtasks.

3.4.3 Task 4.3, Define Trade Value System

Where trade studies were incorporated in a Management Plan study approach, the development of options and nature of the trade was prescribed. Because of the diversity of the trades and because trades were typically subtasks among several tasks which were defined, a common trade value system was not recommended.

3.4.4 Task 4.4, Conduct Selected Trades

This task was defined to support the potential needs to select from among optional critical assumptions. In all cases which led to the selection of needed critical assumptions, however, the process was reasonably straightforward. Rationale for the selection of certain critical assumptions was provided with the System Level Critical Assumptions and within subelement requirement formats, as appropriate. Therefore, no trade studies were conducted for this purpose.

3.5 TASK 5, PERFORM SELECTED CONCEPTUAL DESIGNS

The need to develop certain conceptual designs was recognized in order to ease the depiction of problem areas, identified within Issues. In-depth description of problem areas (with associated conceptual designs) was appropriate for the study management plans. In all cases, these took the form of line drawings, providing three-dimensional perspectives for illustration. In many cases, the depiction of a candidate solution served best to illustrate a described problem. The design concepts are called out as figures within the management plans which use them.

3.6 TASK 6, DEVELOPMENT MANAGEMENT PLANS AND DEVELOPMENTAL SCHEDULES

The objective of this task was to generate the plans for the management of recommended studies. These plans were to describe approaches, special needs, resource requirements and schedules. Three standardized formats provide this information. The first format is an overview which describes objectives, background, and summary information. The second format details the study approach, and the third format provides an integrated task schedule and summary of resource requirements. Plans were written by team analysts, reviewed by Team Leaders, further reviewed by the prime contractor, and finally accepted by the NASA Technical Monitor. A total of 108 Issues were covered by 67 Management Plans, each describing independent approaches for the development of data needed to define previously unresolved requirements for the support of crew performance. The Management Plan formats and rationale are described below.

3.6.1 Management Plan Overview (Format 13)

This format is shown in Fig. 3-3. A management plan numbering scheme was utilized for continued traceability. It was based on the topic Element number, an "M", and sequence number. For example, plan 101M03 is the third study management plan written for element 101, General Layout. Titles were selected to be as descriptive as possible of the unique subject matter. If only one Issue was addressed, the title of the Issue was normally used.

The Issue numbers and titles, subsumed by the study plan, were shown along with resolution need dates. The specific objectives of the study were itemized as succinct statements. The Background then provides a brief basis for the proposed study, indicating the study significance and providing a summary of previous work in this area which led to the present study description. Specific Input needs are next listed. If the generation of the needed inputs was scoped for Issues and/or management plans within the HP study, the appropriate numeric designators were also shown.

In many cases, Critical Assumptions were needed to justify specified approaches, task schedules, or other parts of the plan. Each such assumption was described. A Special Remarks section provided a place for the analyst to highlight special comments, and/or explanations about other parts of the plan. A final entry for this format was a listing of the

PAGE 2

INPUTS:
A.

CRITICAL ASSUMPTIONS:
(01)

SPECIAL REMARKS:
(01)

REFERENCES:
(01)

REPORT FORMAT 13

MANAGEMENT PLAN OVERVIEW

NUMBER	ISSUE #	ISSUE	DATE	NEED DATE

OBJECTIVES:
(01)

BACKGROUND:

Fig. 3-3 Management Plan Format 13

References, alluded to in the Background. Where illustrations were used (see Task 5) they were attached to Format 13 as figures called out within the Background or Special Remarks.

3.6.2 Study Plan (Format 14)

The Study Plan detailed the study approach. As shown in Fig. 3-4, following the Management Plan number, title, and preparation date, the study tasks are described. These were listed as concise task statements in numbered, chronological order. Special Study Needs might be access to specific facilities, access to the astronaut population, or other unique needs that could have a significant impact on cost or schedule. Each such special need is listed against corresponding study tasks. Special Skills are separately listed, also by study task. Special Skills might include physicians, identified experts, mockup fabricators, etc.

Entries under Performing Organization represent recommendations for study management and performance. These recommendations may be generic or specific, depending on the nature of the study. The Study Products are specified to correspond to the objectives set forth at the beginning of the plan. The last entry for the format provides a cross-reference to the unresolved requirements which led to this study. Subelement numbers and titles are shown with specific requirement numbers.

3.6.3 Schedule-Task Flow (Format 15)

This form, shown in Fig. 3-5, has two sections. The first section provides a separate page for each fiscal year, beginning with Fiscal Year 1985. Study tasks are listed by title and number, taken from Format 14, and a timeline is shown within the body of the schedule. Input Needs are listed by their alpha designations (from Format 13) at appropriate points on the timelines. Also shown for each timeline are the total manmonths per task.

The second section is a Summary Schedule/Cost Factors for the planning of study resources. Resource categories are listed per a standardized format, and each entry is followed by specified cost drivers (e.g., special skill manmonths, and, where appropriate, dollar cost estimates).

REPORT FORMAT 14

STUDY PLAN

NUMBER TITLE DATE

STUDY TASKS:

(01)

SPECIAL STUDY NEEDS:

TASK(S)	NEED

PAGE 2

SPECIAL SKILLS:

TASK(S)	SKILL

PERFORMING ORGANIZATION:

(01)

STUDY PRODUCTS:

Detailed design specifications for:

(01)

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

SUBELEMENT NO. & TITLE Undefined_Rant_#

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Fig. 3-4 Management Plan Format 14

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER TITLE DATE

1985 ; 1986
 CALENDAR:0--N--D--J--F--M--A--M--J--J--A--
 FISCAL:FY 85 MONTH:1 2 3 4 5 6 7 8 9 10 11 12
 PHASE B C

STUDY TASKS

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER TITLE DATE

1986 ; 1987
 CALENDAR:0--N--D--J--F--M--A--M--J--J--
 FISCAL:FY 86 MONTH:1 2 3 4 5 6 7 8 9 10 11
 PHASE B:O:IRR C OSRR

STUDY TASKS

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER TITLE DATE

1987 ; 1988
 CALENDAR:0--N--D--J--F--M--A--M--
 FISCAL:FY 87 MONTH:1 2 3 4 5 6 7 8
 PHASE B C

STUDY TASKS

REPORT FORMAT 15 SCHEDULE-TASK FLOW

NUMBER TITLE DATE

SUMMARY SCHEDULE/COST FACTORS

STUDY SPAN: FACTOR/MM(CM)* COST \$

*CM =

CATEGORY

LABOR

- NASA Project Mgmt
- Study Mgmt
- Study Tasks
- Analyst, Eng'g
- Special Skills:

SPECIAL FACILITIES

TRAVEL

MATERIALS

TEST PROGRAM

OTHER (List)

* MM = Manmonths; CM = Calendar Months

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Fig. 3-5 Management Plan Format 15

Each plan was independently written and schedules were not integrated across study plans. As a tool for NASA in performing the final analysis of study integration and allocation of resources, an Input-Output Relationship matrix was produced to aid in tracking that relationship among Issues and Plans produced by the HP Study. Further discussion concerning the integration of study schedules is in Section 4, Recommendations.

For the interested reader, a sample management plan is provided in Appendix E.

Section 4

RECOMMENDATIONS

4.1 INTEGRATION OF STUDY SCHEDULES

Management Plan schedules were formulated to target the specified need dates for each study. The approach did not integrate schedules across all plans, therefore, the completion of a plan which has been designated as providing an input for a second plan may be scheduled for completion after the second plan. One tool for evaluation of this condition was described in paragraph 3.6.3, that is, an Input-Output Relationship matrix among defined Management Plans and Issues: A copy of the matrix is provided in Volume V of this report. Resolution of identified conflicts could take several forms, such as:

- Decide that the input is not sufficiently critical and so delete the input stipulation
- Substitute a Critical Assumption for the input need
- Substitute the convening of an expert panel to formulate the designated input information (and make a decision whether to continue or supersede the previously planned "input producing" study)
- Reschedule one or both related studies in order to achieve the desired schedule integration
- Alter the study approach for one or both plans in order to condense previously described schedules (in order to achieve schedule integration).

This complex analysis and decision process must include consideration not only of the described management plans, but also of those other studies already in process within NASA which could generate inputs for HP Study-defined studies, but for which management plans (and perhaps issues) were not prepared. Listed input needs must be reviewed to identify where described data inputs can be provided by these other studies. This review should examine both non-issues and issues for which Management Plans were not prepared. Further complexity comes from the fact that Inputs may be needed at any designated point after start of the study. In some cases, the input-output relationships may form multiple study links, so that rescheduling one study will have corresponding impacts on the

schedule of other similarly related studies. Care is needed throughout the process to ensure SSP (milestone) need dates are met.

It is recommended that a panel be designated to perform this analysis, having sufficient authority and access to information to permit early resolutions. A part of this analysis must evaluate the feasibility of utilizing recommended facilities (or other special needs) in light of schedule availability and resources. It is expected that in some cases advantage could be gained by combining some described studies for concurrent facility use or by achieving concurrency with other previously scheduled studies. It is noted that the planned relational data base will provide a tool for identifying conflicts and assessing alternate solutions.

4.2 RESEARCH AND TECHNOLOGY DEVELOPMENT STATUSING

During the conduct of the study it was disclosed that the RTOPS and POP documents do not provide adequate information concerning the current status of research and technology development efforts within NASA. Such information will become even more valuable as the Space Station Program (and other NASA programs) continues and as the list of study participants grows. Coordination of efforts and dissemination of information will become critical. It is understood that satisfaction of this critical need is an important objective of the Technical Management Information System (TMIS).

In anticipation of that system and possibly as an adjunct to its implementation, it is recommended that a NASA-wide program be implemented similar to that currently in use by the Department of Defense for the statusing of research and technology efforts. A standard format is updated at least once per year by all researchers. Results are pooled and entered on one data base for common access. Figure 4-1 shows a completed DD Form 1498. Periodic updating of such a form for all ongoing NASA studies, and the use of key words and/or a coding scheme, such as shown in Item 12, could make needed information immediately available.

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RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				1 AGENCY ACCESSION ¹	2 DATE OF SUMMARY ²	REPORT CONTROL SYMBOL DD-DRAE(AR)636	
3 DATE PREV SUMMARY	4 KIND OF SUMMARY A. NEW	5 SUMMARY ICTY ³ U	6 FORM SECURITY ⁴ U	7 REGRADING ⁵	8 DRG'S INSTR ⁶ NL	9. SPECIFIC DATA - CONTRACTOR ACCESS <input type="checkbox"/> YES <input type="checkbox"/> NO	
10 NO. CODES ⁷		PROGRAM ELEMENT	PROJECT NUMBER	TASK AREA NUMBER	WORK UNIT NUMBER		
A. PRIMARY		62717A					
B. CONTRIBUTING			20162717A790				
C. CONTRIBUTING			STOG				
11 TITLE (Precede with Security Classification Code) ⁸ U - ASSESSMENT OF ADVANCED TERRAIN REPRESENTATION FOR BATTLE SIMULATION (Tech Base)							
12 SCIENTIFIC AND TECHNOLOGICAL AREAS ⁹ 013400 Psy Ind Gp Behav 009400 Man-Machine Relat							
13 START DATE 15, Sept, 81		14. ESTIMATED COMPLETION DATE August, 1984		15 FUNDING AGENCY DA		16. PERFORMANCE METHOD B. Contract	
17 CONTRACT/GRANT MDA 903-81- C 0568 4. DATES/EFFECTIVE: 15 Sept, 81 5. NUMBER: 6. TYPE: 7. KIND OF AWARD: NEW				18. RESOURCES ESTIMATE FISCAL YEAR: 81 CURRENCY: 82		9. PROFESSIONAL MAN YRS 1.75 10. FUNDS (in thousands) 60 120	
19 RESPONSIBLE OGD ORGANIZATION NAME: DA Army Research Inst (TRL) Simulation Systems Technical Area ADDRESS: 5001 Eisenhower Ave Alexandria, VA 22333 RESPONSIBLE INDIVIDUAL NAME: Mitchell, N. B. TELEPHONE: (202) 274-9420				20. PERFORMING ORGANIZATION NAME: Decisions and Designs, Inc ADDRESS: 8400 Westpark Drive, Suite 600 McLean, VA 22101 PRINCIPAL INVESTIGATOR (Precede SSAN if U.S. Armywide participation) NAME: John F. Patterson TELEPHONE: (703) 821-2828 SOCIAL SECURITY ACCOUNT NUMBER: ASSOCIATE INVESTIGATORS NAME: Robert N. Kraft NAME: Terry A. Bresnick			
21. GENERAL USE FINC							
22. KEYWORDS (Precede EACH with Security Classification Code) (U) Leader Training (U) NCO Training (U) Combat Simulation (U) Tactics							
23. TECHNICAL OBJECTIVE, 24. APPROACH, 25. PROGRAM (Precede individual programs identified by number. Precede text of each with Security Classification Code.) 23. Objective. (U) The goal of this effort is to enhance the effectiveness and efficiency of small unit battle simulation training systems through the application of advanced technology for terrain representation. A prototype terrain representation system based on the recently developed "surrogate travel" techniques which integrate videodisk, microprocessor and computer generated imagery technologies, will be developed and evaluated against conventional approaches. 24. Approach. (U) Initial work involves an empirical analysis of the temporal and spatial resolution requirements of a "surrogate travel" system, including interaction of resolution requirements with type of terrain to be represented, mode of travel, and other variables relevant to battle simulation applications. The resulting specification of minimum structural and performance requirements for application to particular battle simulation training objectives and control functions will be used to select a specific configuration for prototype development. The prototype advanced terrain representation system will in turn, be subjected, in a battle simulation training context, to a cost and training effectiveness analysis (CTEA) in comparison with conventional terrain representation methods, including tactical maps, map boards, and three dimensional terrain boards.							

DD FORM 1498
1 MAR 68

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE DD FORMS 1488A 1 NOV 66 AND 1488-1, 1 MAR 68 (FOR ARMY USE) ARE OBSOLETE.

U.S. GPO: 1972-540-843/8681

Fig. 4-1 Example Report of Technology Development Study (DD form 1498)

Section 5

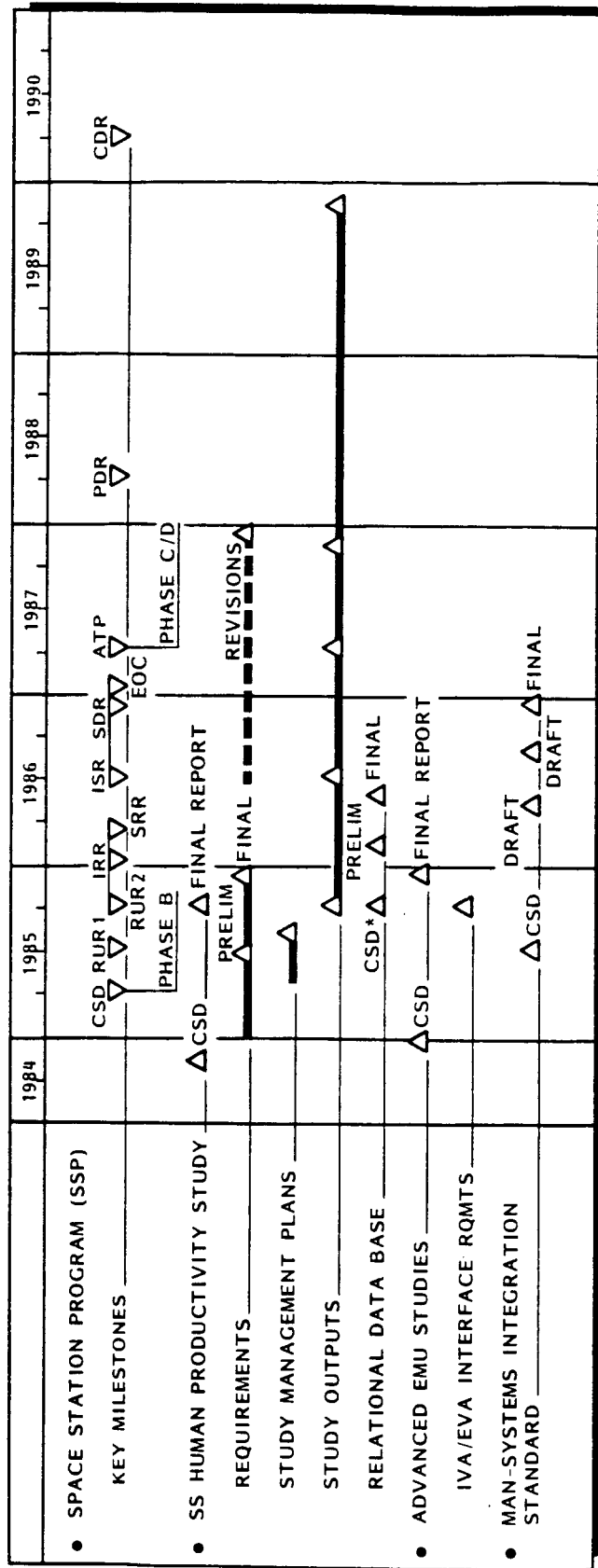
SPACE STATION HUMAN PRODUCTIVITY PROGRAM INTEGRATION

The study described by this report achieves one milestone in the broader program undertaken by NASA to incorporate human productivity concerns in the Space Station Program. The Introduction noted that this has been a long-standing and continuing effort. Fig. 5-1 provides key Space Station Program Milestones, related to currently key events within the Human Productivity program. Not shown are the continuing NASA-industry meetings to further the exchange of technology in this area, and the several focused studies, sponsored by NASA, to develop concepts and requirements for specific Space Station concerns.

The Space Station Human Productivity Study began in November 1984. This led to the generation of currently definable requirements, which will be disseminated to all SSP participants. The Management Plans produced by this study, remain preliminary until final review and integration with related studies. (See Section 5.) Implementation of these studies has in fact begun. For the definition of study "need dates," a six-month lead time concept was adopted. For example, if the study results were required for SRR, (scheduled for March 1986), the specified need date was RUR 2, (scheduled for October 1985). IRR is viewed as a preliminary milestone to SRR; selection of RUR 2 is intended to give sufficient time for responding to the newly defined requirements in time for impact on SRR. In similar fashion, requirement needs for SRR impact were assigned a need date at ISR. Remaining need dates were based on having requirements defined by start of Phase C/D, or by 6 months prior to PDR and CDR, respectively. The milestone dates indicated by the schedule in Fig. 5-1 were defined in May, 1985, and are listed as Critical Assumptions for this purpose.

The data from the present study will be converted to a relational data base, on which effort has begun. This data base will facilitate access and updates while serving as a prototype for similar data bases, as they are developed.

The Human Productivity Data Management System (relational data base) will enable easy access for Space Station Program participants, while providing several functions, such as identifying requirements which may be affected by the change of a critical assumption, or by identifying the effects of a change in a key Space Station Program Milestone. Importantly, the cross-file traceability of the data base will ensure adequate updating of correlated data.



*APPROXIMATE

Fig. 5-1 Human Productivity Program and Space Station Program Integration (Schedule)

The advanced EMU studies are conducting studies and developing requirements to improve productivity for Space Station EVA tasks. Results from these studies will be generated at about the same time as IRR and should be finalized for Space Station Program implementation by ISR.

Another study in process will lead to the development of Man-Systems Integration Standards (MSIS). That study will incorporate and expand the results of the Human Productivity Study to integrate them with previously produced standards and guidelines for IVA and EVA crew performance support. The MSIS will provide standards for space systems, in general, but will provide obvious guidance for the Space Station Program. The result will be an updated and integrated standard for man-systems interface requirements in time for application in Phase C/D. Incorporation of these results in a relational data base, as described above, is also planned.

APPENDIX A

SUBELEMENTS LISTING

(See Paragraph 3.1.2, Task 1.2)

SUBELEMENT LIST

ORIGINAL PAGE IS
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ELEMENT
SUBELEMENT)1 INTERIOR ARCHITECTURE

101 GENERAL LAYOUT

- * 10102 ACTIVITY VOLUME PER CREWMEMBER/FUNCTION
- 10104 DEDICATED VS MULTIPURPOSE SPACE UTILIZATION
- * 10106 EQUIPMENT & FURNISHING REQUIREMENTS
- 10107 PHYSICAL/FUNCTIONAL ADJACENCIES
- 10108 INTER/INTRA-MODULE EQUIPMENT ORIENTATION
- * 10109 GROWTH

102 TRAFFIC FLOW

- 10201 FREQUENCY OF TRANSIT
- * 10202 EQUIPMENT ACCOMMODATIONS
- 10203 CONGESTION MINIMIZATION
- * 10204 PASSAGE IMPINGEMENT
- 10205 EMERGENCY EGRESS/INGRESS
- * 10206 CREW/EQUIPMENT TRANSLATION & HANDLING AIDS

103 DECOR

- 10301 COLOR, TEXTURE, GRAPHICS & LIGHTING
- 10302 INTERIOR DESIGN MODIFIABILITY
- 10303 CODING

104 MATERIALS

- 10400 GENERAL
- * 10401 HEALTH AND SAFETY
- * 10402 MAINTENANCE AND REPAIR
- 10403 DURABILITY & SUSCEPTABILITY TO DAMAGE
- 10404 AUDITORY, OLFACTORY & TACTILE EFFECTS
- 10405 ELECTROMAGNETIC PROPERTIES

105 ANTHROPOMETRY

- * 10501 POPULATION CHARACTERISTICS
- * 10502 RANGE OF ACCOMMODATION
- * 10503 PHYSICAL DIMENSIONS & LIMITS IN MICRO-G

106 MODULARITY

- * 10601 GENERAL
- * 10603 EXISTING STANDARDS AND CONVENTIONS
- * 10605 MAINTAINABILITY SUPPORT
- * 10607 GROWTH

107 WINDOW/REMOTE VIEWING

- 10701 VIEWING REQUIREMENTS
- 10702 WINDOW OPTICAL CHARACTERISTICS
- * 10703 WINDOW CONFIGURATION
- 10704 WINDOW ACCESS
- * 10705 WINDOW LOCATION AND NUMBER
- * 10706 WINDOW MAINTENANCE/PROTECTION
- * 10707 INDIRECT VIEWING OPTIONS

109 STOWAGE/STORAGE

- 10901 CREW EQUIPMENT STOWAGE

10902 FOOD/GALLEY STOWAGE EQUIPMENT
10903 TRASH-WASTE STOWAGE/STORAGE
10904 DATA FILE STOWAGE
10905 STOWAGE VOLUME CONFIGURATION
10906 GROWTH

2 CREW SUPPORT

201 INTERNAL ENVIRON

* 20101 ATMOSPHERE REVITALIZATION
* 20102 WATER MANAGEMENT
20103 CONTAMINATION/ODOR CONTROL
20107 GROWTH

202 EXTERNAL ENVIRON

* 20201 RADIATION - PARTICLES
* 20202 TRAPPED PROTONS
* 20203 TRAPPED ELECTRONS
* 20204 HIGH-Z, HIGH-E PARTICLES
* 20205 SOLAR FLARES
* 20206 ULTRAVIOLET/INFRARED
* 20208 MICROMETEOROIDES
* 20210 GROWTH
* 20212 GROUND SUPPORT

203 INDUCED ENVIRON (Int/Ext)

* 20302 ELECTROMAGNETIC
* 20304 LASER
* 20305 GROWTH

204 AREA LIGHTING

* 20401 ILLUMINATION & DISTRIBUTION REQUIREMENTS
* 20402 GLARE CONTROL
* 20403 FIXTURES/LUMINAIRES
* 20404 CONTROLS
* 20405 GROWTH

205 ACOUSTICS

* 20501 NOISE CONTROL
* 20502 PHYSIOLOGICAL EFFECTS
* 20503 PSYCHOLOGICAL EFFECTS
* 20504 FUNCTIONAL TASK/WORK AREA ENVIRONMENTS

206 SAFETY

* 20601 CREW SAFETY

207 HEALTH MAINTENANCE

* 20701 PHYSIOLOGICAL CONDITIONING/COUNTERMEASURES
* 20702 PHYSIOLOGICAL STATUS MONITORING
* 20703 DISEASE PREVENTION
* 20704 ACCIDENT PREVENTION
* 20705 STRESS MANAGEMENT

208 MEDICAL CARE

20801 DIAGNOSIS & TREATMENT
20804 MEDICAL RECORDS, COMM, & INFO MGMT
20805 GROWTH

- 209 RECREATION
 - 20901 TYPES
 - 20902 FACILITIES
 - 20903 EQUIPMENT
 - 20904 SUPPORT
 - 20906 PLANNING

- 210 PERSONNEL HYGIENE
 - 21001 BODY WASTE MANAGEMENT
 - 21002 WHOLE-BODY CLEANING
 - 21003 PARTIAL-BODY CLEANING
 - 21004 BODY GROOMING
 - 21005 GROWTH

- 211 FOOD/WATER SYSTEMS
 - 21101 MENU
 - 21103 FOOD PACKAGING
 - 21104 FOOD DISPENSING
 - 21105 FOOD PREPARATION
 - 21106 FOOD SERVING
 - 21107 FOOD CLEAN-UP
 - 21108 POTABLE WATER
 - 21109 GROWTH

- 212 HOUSEKEEPING
 - 21201 CONTAMINATION
 - 21202 CLEANING EQUIPMENT
 - 21203 TASKS
 - 21204 SCHEDULES
 - * 21205 CLOTHES WASHER/DRYER
 - 21206 DISHWASHER

- 213 WASTE/TRASH MANAGEMENT
 - 21301 TRASH GENERATION
 - 21302 TRASH COLLECTION
 - 21303 TRASH SORTING
 - 21304 MICROBIAL STABILIZATION
 - 21305 WASTE/TRASH TRANSFER
 - 21306 VOLUME REDUCTION
 - 21307 WASTE/TRASH DISPOSAL
 - 21308 GROWTH

- 214 SUPPLY SUPPORT
 - * 21401 RESUPPLY REQUIREMENTS
 - * 21402 INVENTORY MANAGEMENT AND CONTROL
 - * 21404 TRANSPORTATION AND HANDLING
 - * 21407 PRESERVATION, PACKING & PACKAGING

- 215 RESTRAINT SYSTEMS
 - 21501 FOOT RESTRAINTS
 - 21502 BODY RESTRAINTS
 - 21503 EQUIPMENT RESTRAINTS
 - 21504 SLEEP RESTRAINTS
 - * 21505 PORTABLE RESTRAINTS
 - 21506 HANDHOLDS

- 216 MOBILITY AIDS
 - 21601 INSTALLED EQUIPMENT
 - 21602 PORTABLE GEAR

- 217 COMMUNICATIONS
 - * 21701 SYSTEMS
 - * 21702 LOCATIONS
 - * 21703 FUNCTIONAL TYPES
 - * 21705 RECORDKEEPING
 - * 21706 NONNORMAL COMMUNICATIONS

- 218 QUALITY ASSURANCE
 - * 21801 PROCEDURES VERIFICATION
 - * 21802 CONDITION VERIFICATION
 - * 21803 CONTROL
 - * 21804 EQUIPMENT CALIBRATION/CERTIFICATION
 - * 21805 ANOMOLY INVESTIGATION, ANALYSIS & EVALUATION
 - * 21806 REPORTING AND RECORDING
 - * 21807 DETECTION, ISOLATION AND IDENTIFICATION

- 219 CLOTHING
 - 21901 IV CLOTHING (UNDERWEAR AND OUTERWEAR)
 - 21903 GROWTH

- 220 VIBRATION
 - * 22001 VIBRATION CONTROL

3 CREW ACTIVITIES

- 301 CREW TRAINING
 - 30101 TRAINING METHODS
 - 30102 TRAINING DEVICES & MEDIA
 - 30103 TRAINING LOCATION
 - 30105 TRAINING FOR ORGANIZATIONAL EFFECTIVENESS
 - 30107 GROWTH

- 303 MAINTAINABILITY
 - * 30301 ACCESSIBILITY
 - * 30302 COMMONALITY
 - * 30303 MAINTAINABILITY HARDWARE CHARACTERISTICS
 - * 30304 TESTABILITY/DIAGNOSTICS
 - * 30305 ORU DEFINITION/CONFIGURATION
 - * 30306 MAINTAINABILITY AIDS
 - * 30307 CREW SKILLS
 - * 30308 GROWTH

- 304 MAINTENANCE
 - * 30401 MAINTENANCE CONCEPT
 - * 30402 SCHEDULED MAINTENANCE TASKS
 - * 30403 UNSCHEDULED MAINTENANCE TASKS
 - * 30404 TECHNICAL DOCUMENTATION
 - * 30405 CUSTOMER SCHEDULED MAINTENANCE TASKS
 - * 30406 CUSTOMER UNSCHEDULED MAINTENANCE TASKS
 - * 30407 CUSTOMER TECHNICAL DOCUMENTATION

- 305 SUPPORT EQUIPMENT
 - * 30501 FUNCTIONAL LIMITATION
 - * 30502 COMMONALITY/STANDARDIZATION
 - * 30503 ARRANGEMENT
 - * 30504 LOCATION
 - * 30505 IDENTIFICATION/LABELING

306 ACTIVITY PLANG/SCHEDG
* 30601 DUTY CYCLES
* 30602 JOB ROTATION
* 30603 SCHEDULING METHODS

307 MAN-MACHINE ROLES
* 30701 MAN-MACHINE ROLE
* 30702 GROUND MAN-MACHINE ROLES
* 30703 GROWTH

308 ORGANIZATION
30801 ORGANIZATIONAL STRUCTURE
30802 METHODS TO ENHANCE COMPATIBILITY

309 STATION AUTONOMY
* 30901 AUTONOMY
* 30903 GROWTH

4 IVA SYSTEMS

401 WORKSTATIONS
* 40101 WORKSTATION DEFINITION
* 40102 WORKSTATION GENERAL REQUIREMENTS
* 40103 WORKSTATION UNIQUE REQUIREMENTS
40104 PORTABLE WORKSTATION

402 DATA MANAGEMENT
* 40201 GENERAL DATA MANAGEMENT
40203 OPERATING SYSTEM
40205 MEMORY CAPABILITY
* 40206 INTERFACE COMPATIBILITY
40207 MAINTENANCE/REPAIR
40209 APPLICATION PROGRAMS

5 IVA/EVA INTERFACE

501 AIRLOCK
50101 SYSTEMS
50102 FUNCTIONAL/PERFORMANCE REQUIREMENTS
50103 HYBERBARIC
50104 EVA SUPPORT
50105 MAINTAINABILITY
50106 MATERIALS PROCESSES
50107 COMMONALITY
50108 SAFETY/TRAINING

** 502 SERVICING AREA

** 503 SUPPLY SUPPORT

504 STOWAGE/STORAGE
50401 EMU EQUIPMENT
50402 EEU EQUIPMENT
50403 RESTRAINTS/TETHERS/EVA TOOLS
50404 EMU/EEU SERVICING & CHECKOUT EQPT. STORAGE
50405 MAINTENANCE & REPLACEMENT PARTS

50406 PAYLOAD SUPPORT EQUIPMENT STOWAGE
50407 GROWTH

** 505 ATMOSPHERE

506 PERSONNEL HYGIENE
50601 IN-SUIT BODY WASTE MANAGEMENT
50602 SUIT HYGIENE

507 TRAINING/PROCEDURES
50701 GENERAL

** 508 COMMUNICATIONS

** 509 DATA MANAGEMENT

55x MAN-TENDED

55101 GENERAL LAYOUT
55102 TRAFFIC FLOW
55103 DECOR
55104 MATERIALS
55105 ANTHROPOMETRY
55106 MODULARITY
55107 WINDOWS/REMOTE VIEWING
55109 STOWAGE/STORAGE
55201 INTERNAL ENVIRONMENT
55202 EXTERNAL ENVIRONMENT
55203 INDUCED ENVIRONMENT
55204 AREA LIGHTING
55205 NOISE & VIBRATION
55206 CREW SAFETY
55213 WASTE/TRASH MANAGEMENT
55214 SUPPLY SUPPORT
55215 RESTRAINT SYSTEMS
55216 MOBILITY AIDS
55217 COMMUNICATIONS
55218 QUALITY ASSURANCE
55301 CREW TRAINING
55303 MAINTAINABILITY
55304 MAINTENANCE
55305 SUPPORT EQUIPMENT
55306 ACTIVITY PLANNING AND SCHEDULING
55307 MAN-MACHINE ROLES
55309 STATION AUTONOMY
55401 WORKSTATIONS
55402 DATA MANAGEMENT

* IVA Subelements having Requirements and Issues of concern to EVA Systems.

** Requirements generated by Advanced EVA Systems Design Requirement Study.

APPENDIX B

NASA-CONTRACTOR REVIEW TEAM

(See Paragraph 3.1.5, Requirements Document, and
Paragraph 3.3.1, Task 3.1, Identify Issues.)

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APPENDIX C

SAMPLE REQUIREMENTS PAGE

(See Paragraph 3.1.5, Requirements Document)

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REPORT FORMAT 3.1

DESIGN/OPERATIONS REQUIREMENTS

1 INTERIOR ARCHITECTURE
106 MODULARITY
10603 EXISTING STANDARDS AND CONVENTIONS

CROSS REFERENCE TO RFP PARAGRAPH No: C-4(2.1.5;2.2.10.1)

Revised: 9/23/85

REQUIREMENTS

REFER. NO.

-01 *(Design equipment racks per TBD criteria to provide flexibility in various module configurations.)*	145(p 2-5)
-02 Equipment racks shall accommodate a standard 19 inch (single) and 38 inch (double) width (48.26 cm and 96.52 cm).	143(p 7-3, pp. 7.1.3.2) 144(p 3-84, pp. 3.4.1.1.1), 145
-03 *(Provide standardized utility interfaces in modular design.)*	144(p 3-84, 85, pp. 3.4.1.2, 3.4.1.3, 3.4.1.4), 145

CANDIDATE SOLUTIONS

REFER. NO.

None

CRITICAL ASSUMPTIONS

REFER. NO.

None

* An "ISSUE" has been defined for study to confirm or complete definition of this preliminary requirement.

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Format 3.1, with Detailed Description

APPENDIX D

SYSTEM LEVEL CRITICAL ASSUMPTIONS

(See Paragraph 3.2.1, Task 2.1, Critical Assumptions)

SYSTEM LEVEL CRITICAL ASSUMPTIONS

1. Space Station, Manned, is as described in Phase B RFP Reference Configuration, with crew of six. See JSC-19989, Aug. 84.
2. Phase B Milestones are:

CSD	19 April 85
RUR #1	3-19 July 85
RUR #2	4-18 Oct 85
IRR	3-17 Jan 86
SRR	7-21 Mar 86
ISR	1-15 Jul 86
SDR	17 Nov-1 Dec 86
EOC	18 Jan 87
ATP-Phase C/D	18 Apr 87
PDR	18 Apr 88
CDR	18 Apr 90
3. EMU-suited access within the modules will be only for regaining an environment for safe IVA entry, e.g., for leak repair and ECLS system (pressure, contamination control) repair in any habitable module. Minimal depressurized entry may also be required at module depressurization for growth, i.e., attaching additional modules.
4. Space Station, Man-Tended, is as described in Phase B Reference Configuration (See 7th paragraph, page 5 of JSC-19989) and RFP page C-5-11, paragraph 2.4.
5. The Man-Tended station (Lab module) is non-pressurized. (This critical assumption is relevant only to Subelements 55XXX.)
6. Man-Tended operations will be supported by an STS crew living on the shuttle.
7. The Man-Tended module will be reoutfitted for manned IOC. (Requirements do not incorporate considerations for conversion to a pressurized module.)

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D-3

Because the man-tended module will be pressurized the IVA requirements within Groups 1 through 4 are applicable to both man-tended and nominal options. Section 55XXX is applicable to non-pressurized work areas.

NOTE:

1. The Requirements of 55XXX do not apply if the man-tended module is pressurized, i.e., the 55XXX Requirements were written for unpressurized conditions during man-tended operations.
2. If the man-tended module is pressurized, those Requirements in Groups 1 through 4 should be utilized as applicable.

APPENDIX E

LIST OF MANAGEMENT PLANS WITH INCORPORATED ISSUES

LIST OF MANAGEMENT PLANS

MGMT PLAN NO.	ISSUE NO.	TITLE
101M01		Compartment Arrangement and Volume Guidelines
	1010201	Minimum Activity Area Volume Requirements
	1010401	Multi-Use vs. Dedicated Space Criteria
	1010701	Compartment/Area Adjacency Criteria
	1010801	Module/Activity Area Orientation Standard
102M01		Traffic Frequency and Workstation Location
	1020101	Traffic Frequency Determination
	1020301	Workstation Locations Criteria
103M01		Interior Design Guidelines
	1030101	Interior Design Guidelines
	1030201	Interior Design Modifiability Provisions
	1030301	Color, Label, and Pattern Coding Criteria
103M02	1030302	Interior Location Coordinate System
104M01	1040001	Hab Interior Materials Selection Requirements
105M01		Anthropometric Data Development
	1050201	Anthropometric Range
	1050301	Neutral Body Posture Data Development
	1050401	Growth and Anthropometric Criteria
106M01	1060101	Interior Volume Rearrangement Requirements
106M02	1060102	Standard Hardware and Interface Requirements
109M01		Equipment and Food Stowage; IOC and Growth
	1090101	Stowage Configuration
	1090601	Stowage Volume and Configuration for Growth

LIST OF MANAGEMENT PLANS (Cont.)

MGMT PLAN NO.	ISSUE NO.	TITLE
109M02	1090401	Data File Stowage Requirements
109M03	1090301	Trash-Waste Stowage and Storage
201M01	2010101	Atmosphere Specification
201M03	2010202	Maintain/Test Potable Water Purity
201M04	2010203	Water Allocation for Crew Support
201M05		Contamination: Limits and Gaseous Load Model
	2010301	Gaseous Contaminant Load Model
	2010302	Microbial Load Model
201M06	2010303	Contamination Limits
202M01		Radiation Monitoring System
	2020101	Radiation Monitoring System
	2020102	Personnel Dosimetry
202M02		Shielding Protection
	2020103	Optimal Shielding Distribution
	2020104	Window Radiation Protection
	2020105	Shielded Storage
	2020801	Micrometeorite and Debris Protection
	2021001	Radiation Shielding Strategy for Growth
202M03		Solar Flare Protection
	2020502	Solar Flare Protection
	2020501	Solar Flare Risk
	2020503	Solar Flare Contingency Planning
	2020504	Solar Flare Warning System

LIST OF MANAGEMENT PLANS (Cont.)

MGMT PLAN NO.	ISSUE NO.	TITLE
202M04	2020401	HZE Particle Protection Feasibility
202M05	2021201	Ground Support for Radiation Protection
202M06	2020106	Radiation Awareness Training
203M01		Induced Environment Protection
	2030201	EM Leakage Specifications
	2030202	RF/Microwave Exposure Levels
	2030401	Laser Light Protection Options
	2030501	Synergistic Induced Environ Effects
204M01	2040101	Physiological Effects of Light
205M01	2050101	Prediction of Low Frequency Noise
205M02	2050102	Low Frequency Noise Control
205M03	2050201	Long Duration 0-G Noise Exposure Limits
207M01	2070104	Zero-G Sports and Games
207M02	2070301	Animal Payload Bioisolation
207M03		Task Performance Assessment
	2070401	Zero-G Visual Performance Criteria
	2070402	Critical Task Performance Assessment
209M01		Zero-G Recreation
	2090101	Individual Recreational Preferences
	2090102	Zero-G Recreational Activities, Equipment, and Matls
	2090201	Facility for Group Recreation
	2090202	Facility for Individualized Recreation

LIST OF MANAGEMENT PLANS (Cont.)

MGMT PLAN NO.	ISSUE NO.	TITLE
	2090301	Off-Shelf Recreational Equipment Feasibility
	2090302	Innovative Recreational Provisions
	2090501	Recreation Objectives
211M01	2110801	Portable Water
212M01		Housekeeping Items and Equipment
	2120201	Cleaning Materials
	2120202	Housekeeping Equipment
	2120701	Housekeeping Equipment - Growth
213M01	2130202	Waste and Trash Collection Methods
213M02	2130701	Contingency Trash Disposal Methods
213M03	2130101	Waste Trash Generation Model
213M05	2130501	Waste/Trash Equipment Transfer
213M06	2130601	Trash Compactor Requirements
214M02	2140102	Module Docking Aides
214M03	2140201	Inventory Management System Development
215M01		Restraints
	2150101	Standardized Footwear/Foot Restraint System
	2150301	Cable and Hose Management System
	2150302	Equipment Restraints
	2150201	Body Restraints
	2150501	Crew Portable Restraint System
216M01		Equipment Restraint and Transfer
	2160201	Containment and Translation of Equipment
	2160101	Crew Translation Aids

LIST OF MANAGEMENT PLANS (Cont.)

MGMT PLAN NO.	ISSUE NO.	TITLE
	2160102	Inadvertent Impact Protection
218M01	2180601	On-Orbit Configuration Mods Verification
218M02	2180501	On-Orbit Problem Reporting System
218M03	2180301	Fluid System Conn Integrity Verification
218M04	2180701	Habitable Volume Leak Point Location
218M05		QA Verification
	2180201	QA On-Orbit Verification Requirements
	2180202	QA Verification Tools and Equipment
218M07	2180203	Fluid System Verification
218M08	2180302	Equipment Status Marking On-Orbit
218M09	2180602	On-Orbit Quality Assurance Records
218M10	2180401	On-Orbit System Certification Requirements
220M01		Equipment Standards
	2200101	Equipment Vibration/Mounting Standards
	2050103	Zero-G Equipment Noise Standards
301M01		On-Orbit Training
	3010103	On-Orbit OJT Training Cost and Benefits
	3010403	On-Orbit Refresher Training
	3010301	Non-Critical Task Training On-Orbit
303M01	3030102	Wall Access/Repair
306M01		Crew Activity Scheduling
	3060102	Shift Options
	3060103	Mission Length Requirements
	3060104	Varied Crew Schedule Models

LIST OF MANAGEMENT PLANS (Cont.)

MGMT PLAN NO.	ISSUE NO.	TITLE
	3060106	Rec/Leisure Time Requirements
	3060108	Rest Break Requirements
	3060111	Shift Effects on Performance
	3060301	Factors for Work Scheduling
306M02	3060302	Develop Expert Sched System Requirements
306M03	3060101	IVA/EVA Tasks and Learning Curves
306M04	3060304	Grd Support for Long-Range Planning
306M05	3060201	Important/Essential Skills for Job Rotation
306M06	3060107	Productivity Factors
308M01	3080101	Organizational Structure
308M02	3080204	Air-to-Ground Problem Resolution
309M01	3090101	Autonomy Tech Selection/Time Phasing
309M02	3090103	On-Orbit vs. Grd Off-Nominal Act. Protocols
309M03	3090102	On-Orbit vs. Grd Task Assignment
310M01	3100101	Anthropometric Computer Modeling
310M02	3100201	Workload Assessment Computer Model
401M01	4010201	Workstation Design Guidelines
401M02	4010202	Task Verification at Workstations

APPENDIX F

SAMPLE STUDY MANAGEMENT PLAN

Interior Design Guidelines (103M01)

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REPORT FORMAT 13

MANAGEMENT PLAN OVERVIEW

<u>NUMBER</u>	<u>TITLE</u>	<u>DATE</u>
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

<u>ISSUE #</u>	<u>TITLE</u>	<u>NEED DATE</u>
1030101	INTERIOR DESIGN GUIDELINES	May 88
1030201	INTERIOR DESIGN MODIFICABILITY PROVISIONS	May 88
1030301	COLOR,LABEL & PATTERN CODING CRITERIA	May 88

OBJECTIVES:

- (01) Develop interior design guidelines for color, texture, graphics and lighting to provide a comfortable, stimulating, non-monotonous work and off-duty environment.
- (02) Devise and evaluate interior design features that will allow variations in color, lighting or textures to maintain a varied and stimulating living and work environment.
- (03) Develop integrated coding criteria using color, graphics, textures, and labeling approaches for identification/orientation purposes that avoid visual clutter or information overload.

BACKGROUND:

There is evidence to indicate that interior design features such as color affect human performance. For example, Soviet Space Station experience indicates that monotonous surroundings lead to boredom, fatigue, and possibly loss of job interest. Based on Soviet experience, there may also be a relationship between color and motion sickness. (1) The human factors literature (2) reveals that color and lighting produces the following responses:

- o Certain colors make a space appear larger than it actually is while others cause a space to "close in" on the observer.
- o Certain colors cause a space to seem "warm" while others make it seem "cool".
- o Some colors appear to have a definite effect on the mood of the observer, i.e., some colors may be stimulating while other are quieting.
- o Some colors seem to clash with each other and therefore produce a feeling of irritation to observers who are especially sensitive to color incompatibilities.

While it is generally acknowledged that interior design features can have a significant effect on human performance, our knowledge base does not allow clearcut specification of interior design guidelines without a detailed study of specific space station needs.

The present issue resolution management plan provides a technical approach for developing interior design guidelines and specifications. It also addresses design features for modifying the interior decor for stimulus variation purposes. Finally, the technical approach considers the development of coding criteria that are harmonious with the decor scheme to facilitate identification of spaces and maintaining orientation in the zero-g environment.

INPUTS:

- A. Work and living space configurations
- B. MULTI-USE VS DEDICATED SPACE DETERMINATIONS (Issue 1010701)
- C. HABITABILITY INTERIOR MATERIALS SELECTION REQUIREMENT (Issue 1040001)
- D. ACTIVITY AREA VOLUMES (Issue 1010201)
- E. Crew characteristics
- F. Crew activities in specific locations
- G. Crew information needs
- H. MODULE/ACTIVITY AREA ORIENTATION STANDARD (Issue 1010801)
- I. SS MOTION SICKNESS COUNTERMEASURES (Issue 2070107)

CRITICAL ASSUMPTIONS:

- (01) The interior decor scheme should be tailored primarily to the needs of the U.S. crew population. Secondary attention should be given to accommodating foreign participants.
- (02) A full scale, one-g, space station mission simulation will be developed to simulate 90 day missions.

SPECIAL REMARKS:

- (01) Judgement regarding aesthetic preferences in relation to color, graphics, texture and lighting are highly subjective. Consequently interior design guidelines require close coordination with the candidate crew population to meet their specific needs.
- (02) Concern with labeling, in the context of this study plan, is confined to the color of label characters and the color of label backgrounds in relation to the overall Space Station color-decor scheme.
- (03) Consideration of lighting in the present study plan is confined to the interactive effects of light and color from an aesthetic standpoint rather than general lighting requirements for effective task accomplishment.
- (04) The interrelationship between color and motion sickness will be addressed separately in the management Issue #2070107 SPACE STATION MOTION SICKNESS COUNTERMEASURES.

REFERENCES:

- (01) Boeing Aerospace Co., Soviet Space Stations as Analogs,
D180-28182-1, Oct 1983
- (02) W. Woodson, Human Factors Design Handbook, 1981

NUMBER
103M01

TITLE
INTERIOR DESIGN GUIDELINES

DATE
06-26-85

STUDY TASKS:

- (01) Literature review to establish known effects of color, texture, graphics and lighting on human performance. Consult with subject matter experts within NASA and academia.
- (02) Develop design concepts for varying the interior design characteristics, allowing for personalization of living spaces and accommodating the culturally-shaped preferences of foreign visitors.
- (03) Data-gathering from space station design efforts to establish crew activities in specific space station locations and the information-orientation needs of the crew.
- (04) Develop scale models that can be used to develop, present, and evaluate candidate color-decor schemes. Also establish coding practices for identification and orientation purposes that are compatible with the candidate color-decor schemes.
- (05) Conduct a structured survey of a representative sample of the crew population and subject-matter experts in evaluating the candidate decor schemes and in selecting a preferred approach. Include foreign test subjects in this evaluation.
- (06) Develop full scale mockups or utilize existing mockups of space station living and work areas and implement the preferred decor scheme selected on the basis of the scale model evaluation.
- (07) Use full-scale mockups to verify the suitability of color-decor schemes, modifiability of features and identification-orientation coding features utilizing representative members of the crew population.
- (08) Assuming the separate development of a full scale, one-g space station mission simulator for ninety-day confinement studies, implement the selected color-decor identification scheme and obtain subjective evaluation data from test subjects. Perform as add-on to primary study.
- (09) Formulate interior design specifications for the space station.

SPECIAL STUDY NEEDS:

<u>TASK(S)</u>	<u>NEED</u>
4	Model-making capability
6,7	Access to full scale mockups
8	Access to mission simulation
3,2	Availability of space station configuration data, crew task analyses data, and material selection guidelines.
5,7	Access to the candidate crew population and

|NASA experts.
|
|
|

SPECIAL SKILLS:

<u>TASK(S)</u>	<u>SKILL</u>
2,4,6	Industrial Design
1,2,5,7,8	Human Factors; Environmental Psychologist
1,2,7	Crew Syst Design, Interior Design Specialists

PERFORMING ORGANIZATION:

- (01) Managing: NASA Laboratories
- (02) Doing: Aerospace Firms (Prime)
Industrial Design Firms (Sub)

STUDY PRODUCTS:

Detailed design specifications for:

- (01) Space Station interior design features for the various living and work spaces: color, graphics, texture, and lighting in terms of their impact on decor.
- (02) Design features to allow modificability of decor to provide stimulus variation and personalization of spaces.
- (03) Recommended coding-labeling approaches that are harmonious with the overall decor scheme and that provide effective indication and orientation cues for crew members.

PRODUCTS WILL PERMIT COMPLETION OF THE UNDEFINED REQUIREMENTS:

<u>SUBELEMENT NO. & TITLE</u>	<u>Undefined Rgmt #</u>
10301 Decor, Texture, Graphics & Lighting	-01
10302 Interior Design Modifiability	-01
10303 Coding	-10

NUMBER
103M01

TITLE
INTERIOR DESIGN GUIDELINES

DATE
06-26-85

STUDY TASKS	1985			1986									
	CALENDAR	O	N	D	J	F	M	A	M	J	J	A	S
	FISCAL	FY 86											
	MONTH	1	2	3	4	5	6	7	8	9	10	11	12
	PHASE B	oIRR											oSRR
	C												
1. Literature Review													
2. Modifiability Design Concepts													
3. SS Design Data-Gathering													

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REPORT FORMAT 15

SCHEDULE-TASK FLOW

NUMBER
103M01

TITLE
INTERIOR DESIGN GUIDELINES

DATE
06-26-85

STUDY TASKS	1986						1987					
	CALENDAR MONTH											
	1	2	3	4	5	6	7	8	9	10	11	12
4. Develop Scale Models												
5. Structured Survey												
6. Full-scale Mockups												

REPORT FORMAT 15

SCHEDULE-TASK FLOW

<u>NUMBER</u>	<u>TITLE</u>	<u>DATE</u>
103M01	INTERIOR DESIGN GUIDELINES	06-26-85

SUMMARY SCHEDULE/COST FACTORS

<u>CATEGORY</u>	<u>STUDY SPAN: Oct 85-May 88 *CM = 31</u>	<u>FACTOR/MM(CM)*</u>	<u>COST \$</u>
LABOR			
- NASA Project Mgmt			
- Study Mgmt		16.0 mm	
- Study Tasks			
- Analyst, Eng'g		2.0 mm	
- Special Skills:			
Ind Design		6.0 mm	
HF, Env. Psych.		19.5 mm	
CS, Int Design		4.5 mm	
SPECIAL FACILITIES			
1-g SS Simulator		4 cm	
TRAVEL			
Coordination w/NASA, Aerospace Co's.			15 K
MATERIALS			
Mockup fabrication			10 K
TEST PROGRAM			
Test Subjects for mockup evaluation			10 K
OTHER (List)			

* MM = Manmonths; CM = Calendar Months