DEVELOPMENT OF FLIGHT EXPERIMENT TASK REQUIREMENTS

FINAL REPORT

VOLUME II - TECHNICAL REPORT

PART I - PROGRAM REPORT AND APPENDICES A-G

JUNE 1, 1972

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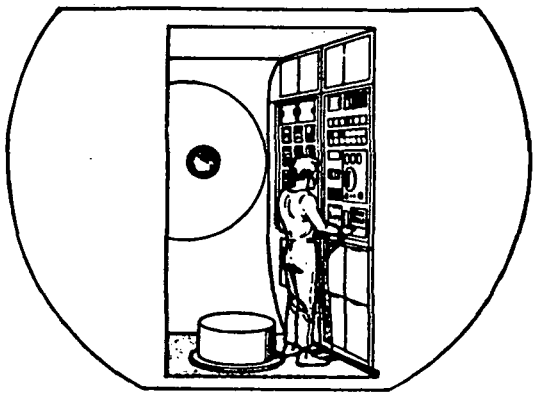

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DEVELOPMENT OF FLIGHT EXPERIMENT TASK REQUIREMENTS

FINAL REPORT

CONTRACT NASW-2192

VOLUME II - TECHNICAL REPORT

PART I - PROGRAM REPORT AND APPENDICES A-G

PREPARED FOR:

BIOENGINEERING DIVISION, OFFICE OF LIFE SCIENCES
HEADQUARTERS
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON D.C. 20546

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PREPARED BY:

G. RICHARD HATTERICK

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URS/MATRIX COMPANY
MAN SYSTEMS DIVISION
4702 GOVERNORS DRIVE, WEST
HUNTSVILLE, ALABAMA 35805

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The Principal Investigator for the contract was Kenneth M. Mallory, President, URS/Matrix Company, URS Systems Corporation. Project Director for URS/Matrix was G. Richard Hatterick. Principal contributors from URS/Matrix Co., Man Systems Division, to the conduct of the analyses reported herein were Dennis C. DeWitt, Leland C. Jones, and C. Dennis Pegden.

FOREWORD

This study contract (NASW-2192) was awarded by NASA Headquarters to develop the means to identify skills required of scientist passengers on advanced missions related to the Space Shuttle and RAM programs. The scope of the study was defined to include only the activities of on-orbit personnel which are directly related to, or required by, on-orbit experimentation and scientific investigations conducted on or supported by the Shuttle Orbiter.

This report provides a description of the methodology developed, an overview of the activities performed during the conduct of the study, and a presentation of the results obtained through application of the methodology.

The report is packaged in three parts, as follows:

Volume I : PROGRAM SUMMARY
Volume II: TECHNICAL REPORT
Part I : Program Report and Appendices A-G
Part II: Appendix H - Task-Skill Data Sheets.

SUMMARY

Preliminary NASA studies aimed at definition of experiments and payloads for orbiting with the Space Shuttle system have included various types of crew skill requirements identification. The skill identification methods used, however, were inadequate, especially when applied to relatively undefined systems and configurations.

This study addressed the problem of determining, at an early stage in system/mission definition, the skills required of on-orbit crew personnel whose activities will be related to the conduct or support of earth-orbital research. The experiment data base was selected from proposed experiments in NASA's Earth Orbital Research and Application Investigation program as related to Space Shuttle missions.

Activities during the study, documented in this report, include identification of baseline Shuttle system/subsystem research functions and ten basic functions dealing with man's research and/or servicing activities on orbit. A Crew Function Taxonomy was developed relative to these activities. Likely candidate experiments for Shuttle Sortie and Shuttle supported free flyer missions were selected through extensive review of experiment and mission descriptions.

Crew tasks were identified for forty-eight representative earth orbital experiments, and a comprehensive task analysis was conducted on these tasks. Operating environments constraining each crew function in these tasks were defined.

Crew skill requirements for performance of the forty-eight representative on-orbit experiments were identified through a new technique, developed in this study, called Task-Skill Requirements Identification. The concept and procedure of this technique, including development of the Task Dependency Reference System, is discussed, along with conversion of Task-Skills to Occupational Skill Classifications. In addition, off duty/nonoperational task requirements for Shuttle experiment crew personnel are identified.

A comprehensive data base of crew functions, operating environments, task dependencies, and task-skills applicable to a representative cross section of earth orbital research experiments is presented. All data has been coded alphanumerically to permit efficient, low cost exercise and application of the data through automatic data processing.

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DEVELOPMENT OF FLIGHT EXPERIMENT TASK REQUIREMENTS

NASW-2192

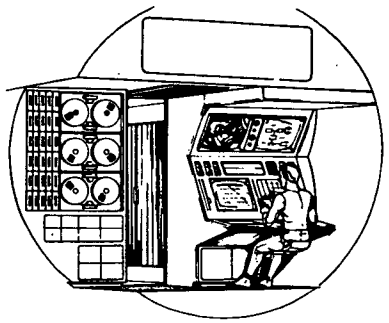
FINAL REPORT

VOLUME II - TECHNICAL REPORT

PART I - PROGRAM REPORT AND APPENDICES A-G

SECTION 1.0

INTRODUCTION



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1.0 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

The contract under which the study reported herein was conducted (NASW-2192) had two primary objectives: (1) to develop a method by which the skills required of crew personnel for support of earth orbital research programs could be identified before system/mission configuration became fixed and (2) to apply the new methodology to a representative cross section of planned earth orbital research flight experiments in order to develop a data base of task and skill information relative to early Shuttle missions. Input data to be used in achieving these objectives were the most current descriptions of experiments and missions then available, encompassed primarily by the NASA Preliminary Edition of Reference Earth Orbital Research and Applications Investigation (Blue Book), NHB 7150.1, dated January 15, 1971 (ref. 1).

1.2 BACKGROUND

1.2.1 Early Man-in-Space

NASA's manned spaceflight programs during the 1960s were primarily aimed at qualifying man and machine systems for spaceflight and lunar exploration. In the 1970s, emphasis will change to utilization of manned spaceflight to perform research and technology experimentation in earth orbit, beyond the restrictions and constraints of the earth's atmosphere. Several such experiments have been conducted in the Apollo program, subsidiary to the primary mission of lunar exploration. The Skylab project will go further with experiments such as the Apollo Telescope Mount (ATM) studies of the sun. The primary purpose of Skylab, however, is to study the ability of man to perform effectively in space for long durations. Each of these programs, from Project Mercury through Skylab, will have added valuable knowledge about man in space, his spacecraft, the tools he needs in space, and the space environment. All of the crewmen on these missions will have been highly trained and dedicated astronauts, many having been military aircraft test pilots and some having commendable scientific credentials as well.

1.2.2 Automated Research

For a number of years, automatic satellites have been gathering data on the earth-proximal space environment and making observations of the earth's surface and atmosphere from earth orbit. Valuable as these investigations are, they are technologically expensive to prepare, difficult to control, and relatively inflexible in their application. Automatic satellites will undoubtedly continue to be aptly utilized for dedicated research and applications missions and/or where the environment is too hazardous for man in space.

1.2.3 Space Shuttle/Earth Orbital Research

With the Space Shuttle (now in early development and expected to be available in the late 1970s), the United States will have the capability of placing experiment payloads in earth orbit for observation of the earth's surface, conduct of experiments and investigations regarding the space environment, or research into scientific and technological areas which capitalize on the unique characteristics of the orbital spaceflight environment. These experiment payloads will vary in content and purpose from small, self-contained orbital laboratories to orbiting automated research satellites to eventual experiment modules for a permanent orbiting Space Station. Preliminary definition studies are being conducted to identify the characteristics of the candidate experiments and the ways they may be grouped and/or combined into Shuttle mission payloads.

1.3 FLIGHT EXPERIMENT TASK REQUIREMENTS STUDY (NASW-2192)

1.3.1 Problem Identification

Just as the nature of the missions being planned has changed, the duties of the experiment personnel will be very different from those of the pre-Skylab crewmen. These duties will involve setup and maintenance of sophisticated experiment equipment, decision making and control functions regarding the conduct of experiments, and, in many instances, the interpretation of collected data. Pre-Phase A studies of experiment requirements have recognized these changes by identifying and categorizing Functional Program Elements (FPEs)* and experiments by the "skill" areas which are reflective of the primary purpose of the experiment and the professional discipline or occupation involved. The methods utilized to identify these skill areas were inadequate, however, when applied to relatively undefined systems and configurations. A need was recognized for a valid, flexible skill identification technique which could be applied during the early stages of system definition.

In support of the new role for man-in-space, a study was initiated to develop the means to identify the task performance requirements of the experiment module scientific and technical crews for the conduct of the planned types of orbital experimentation. This study, based on a sampling of representative experiments, is now complete and has confirmed the wide variety of skills which will be needed by the crew to work successfully with the projected experiment payloads. In the conduct of this study, Matrix Man Systems Division has successfully developed and demonstrated a technique for skill identification which is not dependent on traditional occupational titles with their inherent and frequently misleading connotations of expertise in technical and scientific areas. Rather, the technique permits identification of specific task performance requirements based on the purposes and objectives

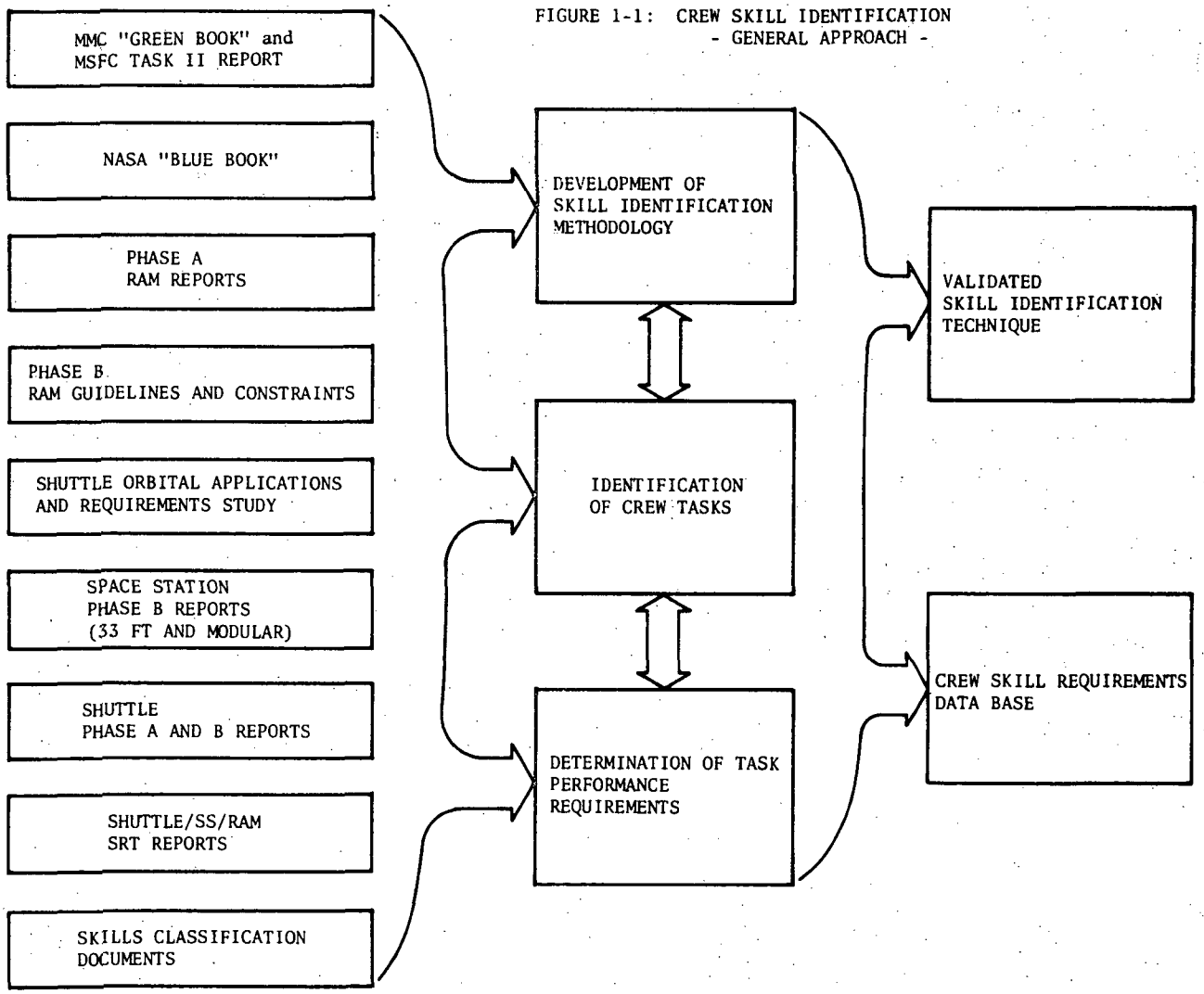
*The term "Functional Program Element (FPE) describes a gross grouping of experiments that are each mutually supportive of a particular area of research or investigation and that impose similar or related demands on the orbiting research facility.

of either general or specific tasks and subtasks and the interfaces with certain items of equipment, facilities, and environmental factors. While avoiding the occupational implications during the analytical phase of determining task performance capabilities, the method retains compatibility with occupational and professional designations. This feature will simplify the early identification of candidate personnel with the most nearly correct combination of task performance capabilities.

1.3.2 Study Approach

The basic approach followed in this study is shown graphically in Figure 1-1. The primary data source for descriptions of typical earth orbit experiments was the NASA Preliminary Edition of Reference Earth Orbital Research and Applications Investigations (Blue Book), dated January 15, 1971 (ref. 1). The information contained therein has been modified, amplified, challenged, and in some cases contradicted by other source data considered

FIGURE 1-1: CREW SKILL IDENTIFICATION
- GENERAL APPROACH -



during the study. Information regarding missions, functions, experiments, equipment, and personnel tasks was extracted from these source documents and ordered into a form which permitted determination of the requisite experiment module crew skills. The study was initiated with a review of applicable mission data, and it progressed through analysis of functions, tasks, and environmental constraints. Off duty, nonoperational tasks which may be imposed on Shuttle mission crews were identified. Various skill identification methodologies were reviewed using this preliminary data base and the objectives and constraints of the earth orbital research program. A concept for identification of "task-skills" was formulated. Performance requirements were integrated, through identification of task dependencies, and task-skills for each experiment were determined. Finally, the method for relating task-skills to occupational skills was developed and validated.

Section 2.0 of this report is comprised of a description of the Task-Skill/Occupational Skill development technique formulated during this study. Section 3.0 presents a discussion of the application of the Task-Skill analysis to a representative cross section of planned flight experiments. Results and conclusions based on the study are in Section 4.0, and a discussion of the New Technology aspects of the method developed for skill determination is in Section 5.0. Data tables and references are included in the Appendices.

DEVELOPMENT OF FLIGHT EXPERIMENT TASK REQUIREMENTS

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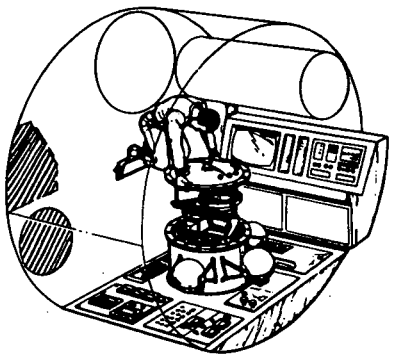
SECTION 2.0

METHODOLOGY FOR
IDENTIFYING FLIGHT
EXPERIMENT TASK-SKILL
REQUIREMENTS



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2.0 METHODOLOGY FOR IDENTIFYING FLIGHT EXPERIMENT TASK-SKILL REQUIREMENTS

This section presents a discussion of the concept of "Task-Skill" identification and a step-by-step description of the manner in which the technique is applied.

2.1 THE "TASK-SKILL" CONCEPT

One objective of this study was to determine the kinds of skills that would be required of on-orbit personnel in support of research and application experiments. The source documentation reviewed as part of this study, however, included listings of "skills" required for the experiments. An early conclusion reached, in reviewing the experiment descriptions, was that the documented "skill" assignments were, in fact, references to occupational and professional titles that appeared related to the type of experimentation or other activities to be performed. Little evidence could be found that these "skill" assignments were based on an analysis of the actual tasks to be performed by orbiting crewmen. It was decided that, in order to determine the skills that would be required, the activities and tasks generating the requirements for particular skills needed analysis and that skills should be defined in such a way that they were independent of the connotations and associations of standard occupational and professional titles. It was further concluded that skills should be defined at a level that would be independent of factors such as crew size, specific equipment configurations, mission duration, experiment grouping within the payload, or facility characteristics. This led to the concept of "Task-Skills".

2.1.1 Task-Skill Definition

The concept, basically, is to describe the skill requirement in terms which identify a particular function (e.g., inspect, control, evaluate) which a man must perform and the item or factor (e.g., spectrometer, subsatellite, stellar data) with respect to which the function must be performed. A task-skill is, in effect, a brief phrase or description which denotes a specific equipment or procedure-oriented crew function (e.g., Spectrometer Inspector, Subsatellite Controller, Stellar Data Evaluator).

Task-skills can be defined at any level which can be supported by the input data. Very preliminary definition can take place even before the specific types of equipment involved in a task are identifiable. For example, it may be known that an experiment on-orbit will require various types of observational equipment, and that, at some point in the mission, the equipment will need to be inspected for damage, cleanliness, etc. A general task-skill requirement can be stated immediately, e.g., Observation Equipment Inspector.

Later, as the experiment becomes better defined, more specific task-skill titles can be substituted, e.g., Optical Equipment Inspector, Electronic Sensor Inspector, etc. When specific types of equipment are identifiable, these become the level of definition of the task-skill, e.g., Spectrometer Inspector, Telescope Inspector, etc. When the nature of the crew function with respect to an item of equipment is sufficiently complex and/or demanding, task-skill identification may be required at an even more specific level, e.g., Ion Mass Spectrometer Repairer. The task-skill should be defined at the lowest level which will incorporate the essence of the demands of the equipment item (or other factor) and the function to be performed on the knowledge, experience and training of the crewman.

In the preceding discussion, frequent reference has been made to "crew function" and "equipment item" in the context of task-skill development. These phrases have been formalized and incorporated in the task-skill development methodology. Crew functions are discussed in paragraph 2.1.2. The "equipment items" or other factors are called Task Dependencies, and these are discussed in paragraph 2.1.3. To complete this general discussion of the task-skill identification concept, paragraph 2.1.4 is comprised of a brief discussion of the "Operating Environment", the environment in which the crewman performs his assigned function, and paragraph 2.1.5 is a discussion of "Occupational Skills Classification", the final step of the task-skill technique.

2.1.2 Crew Function Taxonomy

Essential to the identification of task-skills is the knowledge of the kinds of functions which a crewman is, or may be, expected to perform. Definition of these functions can take many forms but should, to the greatest extent possible, be mutually exclusive, provide insight to the intellectual, sensory, and motor activities of the crewman, and be independent of the nature of the equipment or experiment with respect to which the function is to be performed. During this study, and for purposes of utilization in the task-skill identification, the taxonomy of crew functions shown in Table 2-1 was developed. Definitions of these crew functions are included as Appendix B to this report.

Crew functions 01 through 28 were identified during the initial definition activity and were utilized throughout the subsequent analyses. Crew function 29 (Unknown) was reserved for cases where the nature of the crewman's function could not be determined. Crew Function 30 (Subject for Experiment) was used to identify instances where a crewman's activities were being evaluated as part of experiment conduct. Crew functions 31 through 34 were not initially identified, but were assigned during the detailed analysis of Life Science experiments. This was necessary to cover rather unique crew functions which did not "fit" the basic crew function taxonomy.

The utilization of crew functions in task-skill identification is discussed in general terms in paragraph 2.1.1 and is described more specifically in paragraph 2.2.

TABLE 2-1: CREW FUNCTION TAXONOMY

No.	Title	No.	Title
01	Status Monitoring	18	Unstow
02	Observation	19	Clean and Decontaminate
03	Inspection	20	Assemble
04	Pattern Recognition	21	Disassemble
05	Communication	22	Translocation
06	Data Processing	23	Deployment
07	Fault Isolation	24	Retrieval
08	Calibration	25	Locomotion
09	Alignment	26	Removal
10	Control	27	Replacement
11	Evaluation	28	Repair
12	Analysis	29	Unknown
13	Decision Making	30	Subject for Experiment
14	Test and Checkout	31	Occupy
15	Actuation	32	Wear
16	Deactuation	33	Receive
17	Stow	34	Donate

Definitions of Crew Functions are included in Appendix B.

2.1.3 Task Dependency Reference List (TDRL)

Within the context of task-skill identification, a "task dependency" is a factor upon which successful performance of a crew function depends. The nature of such factors covers a very broad range, and all have implications for the knowledge, training, and/or experience which must be possessed by the crewman. It was determined, during the early stages of this study, that any efforts to identify crew skill requirements must of necessity identify the factors upon which performance depends. Further, these factors, or task dependencies, must be identified at the most specific level supportable by the input data, but they must not preclude progress of the analysis if specific identification is not possible. To achieve this goal, a determination was made of the major types of factors upon which successful performance depended. These major factors were categorized as:

1. System and Facilities
2. Experiment Equipment and Materials
3. Object or Area Under Investigation
4. Support Equipment
5. Environment

The five major categories of task dependencies were divided into subcategories based on major functional differences. Then, as each new item of equipment or object of investigation was identified, it was placed in one of the subcategories. Each item was given an alphanumeric code designation to permit ready recognition of the category and subcategory to which it belonged and to promote rapid data retrieval. In addition to these three levels, a fourth level was assigned, where appropriate, to identify specific equipment items or characteristics. For example, within the major category of "Experiment Equipment and Materials" (#2), the second level might be "Observation Equipment" (#2.A), and the third level of dependency could be "Spectrometers" (#2.A.03). The fourth level, then, would be various specific types of spectrometers (e.g., "Ion Mass Spectrometer"), and each type would be assigned a dash number (#2.A.03-6). An illustration of the structure and use of the Task Dependency Reference System is shown in Figure 2-1.

The utilization of the TDRL enables the analyst to specify the equipment, environment, conditions, etc. on which task performance depends to whatever level of specificity is supportable by program definition status and/or is needed by the purpose of the analysis. There is no need to determine precise equipment characteristics or to obtain serial numbers in order to document the item's relationship to the task. In fact, an equipment item which does not yet exist can be included and can have the same consideration as those which are well defined. The TDRL further recognizes and incorporates the less tangible or less visible factors which affect task performance, (e.g., an area of knowledge) and ensures that consideration is not limited to a specific item of hardware. It is expandable, condensable, and flexible and is designed to be a tool to aid in the conduct of analyses rather than a documentation of what has transpired.

As described in paragraph 2.1.1, the title of the primary task dependency and the appropriate crew function title are combined to prepare the task-skill title. The actual procedure used for accomplishing this is described in paragraph 2.2.

2.1.4 Operating Environments

The "operating environment" was defined in this study as the environmental conditions under which the crewman must perform his assigned functions. The purpose of this identification is twofold. First, by identifying the operating environment, constraints imposed by the environment on task performance can be identified. Secondly, identification of the operating environment provides an input to the Task Dependency Reference List, since "Environment" is one of the five major categories of dependencies (see Figure 2-1).

The analysis conducted during this study determined that there were eight separately identifiable operating environments, as shown and defined in Table 2-2. Since all experiment module crew tasks are performed on-orbit, zero gravity was assumed to be the usual environment. For this reason, the gravitational environment was identified in the task-skill analysis (see Section 3.0) only when it was other than zero gravity. The listing in Table 2-2 is not intended to be all inclusive but, rather, to account for those operating

Figure 2-1: Example of Task Dependency Reference List (TDRL)

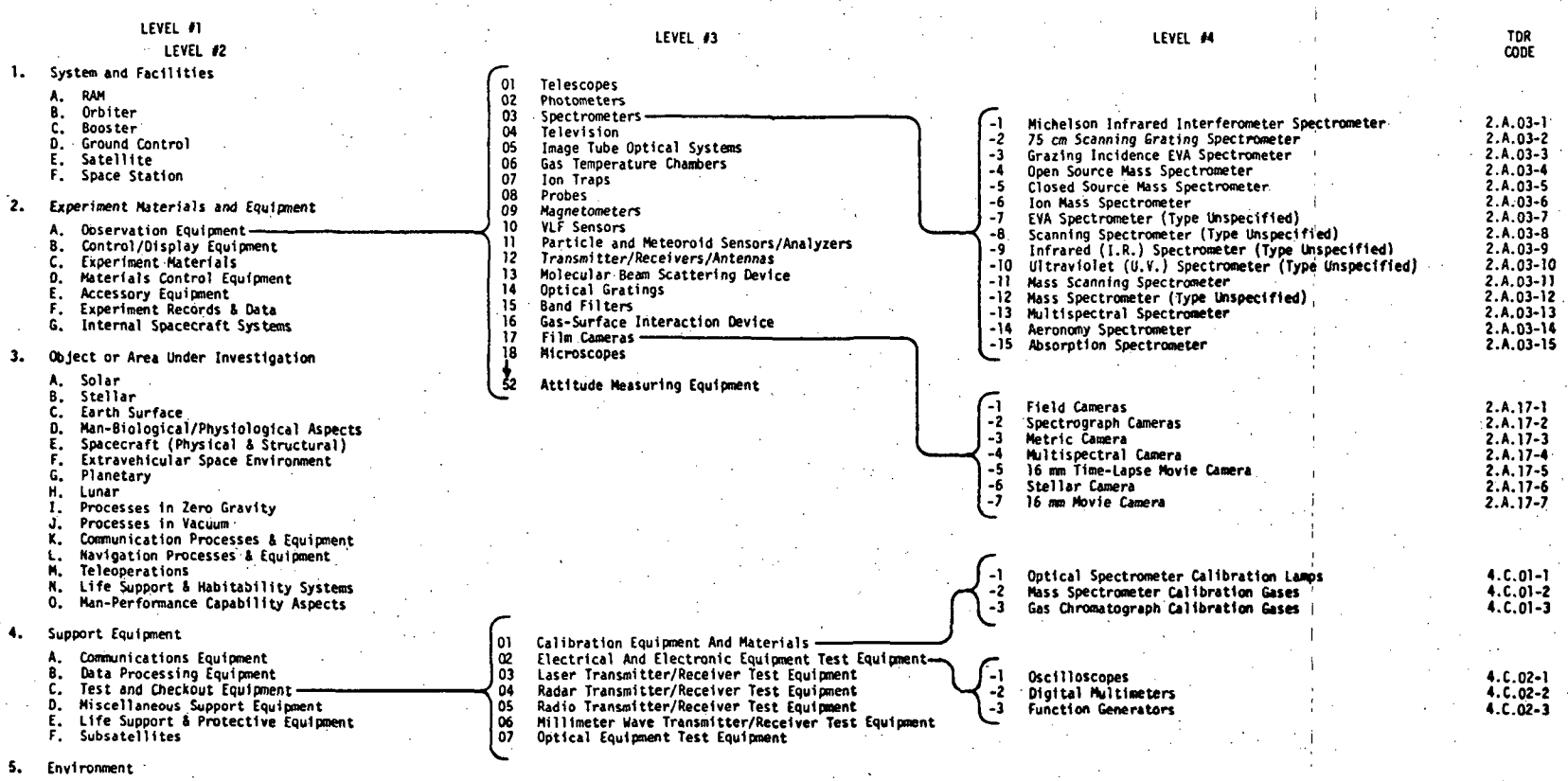


TABLE 2-2: OPERATING ENVIRONMENT TAXONOMY AND DEFINITIONS

OPER. ENVIR. NO.	OPERATING ENVIRONMENT TITLE	OPERATING ENVIRONMENT DEFINITION
00.	ZERO GRAVITY	An environmental condition in which gravitational and other external forces acting on the experiment module or scientific crew member produce no stress, either internal or external; weightlessness.
01.	SHIRTSLEEVE	A "shirtsleeve" environment is one in which the facility housing the crew provides all the life support and temperature maintenance. There is no requirement for pressure suits or umbilical connections. Except for zero gravity or low gravity, it is a normal, earth-type environment. A further exception may be the existence of a one gas atmosphere at low oxygen pressure.
02.	EVA (Extravehicular Activity)	In this environment, the crewman is in full pressure suit and is operating external to the spacecraft (i.e., in free space). Life support may be provided either by umbilical connection or through utilization of an independent, portable Extravehicular Life Support System. Further, the EVA crewman may be either tethered or untethered depending on the particular function he is performing.
03.	IVA (Intravehicular Activity)	This environment is essentially the same as the EVA environment except that the crewman remains within the structural envelope of the spacecraft. The environment will be unpressurized, full pressure suits are required, and either umbilical or portable life support systems must be utilized.
04.	POSITIVE GRAVITY	An environmental condition in which gravitational or other external forces are acting on the experiment module or scientific crew member in a "downward" or footward direction. The force is defined as something greater than 10^{-2} "G", and may range well upwards of one "G". The G-forces may be a result of vehicle maneuvering, terrestrial gravitational pull, or an experimental procedure (e.g., a centrifuge).
05.	NEGATIVE GRAVITY	An environmental condition in which gravitational or other external forces are acting on the experiment module or scientific crew member in an "upward" or headward direction; the opposite of POSITIVE GRAVITY. The G-forces may be the result of vehicle maneuvering, terrestrial gravitational pull, or an experimental procedure (e.g., a centrifuge).
06.	ROTO-GRAVITY	An environmental condition wherein G forces are acting on the body through rotation or spinning of the body. The axis of rotation passes through some part of the body, or, because of body orientation to the axis, the forces act differentially on various parts of the body. ROTO-G may include both POSITIVE and NEGATIVE G forces.
07.	TOXIC ATMOSPHERE	An environmental condition in which the atmosphere upon which the crewman depends contains, or has a high potential for including, elements or materials which are capable of causing serious injury or illness. Such elements may be either gaseous or particulate and of chemical or biological origin.
08.	SPECIAL GARMENT	A condition in which the environment immediately adjacent to the body is altered by the wearing of some special types of clothing or protective gear beyond that which qualifies as "shirtsleeve". The EVA and IVA environments are specifically excluded from this category.

environments identified in experiments analyzed during this study.

The manner of incorporation of operating environments into the task-skill requirements analysis is described in paragraph 2.2. As a general rule, however, the operating environment data is used in evaluation of the task-skill characteristics, although it is not reflected in the task-skill title.

2.1.5 Occupational Skill Classification

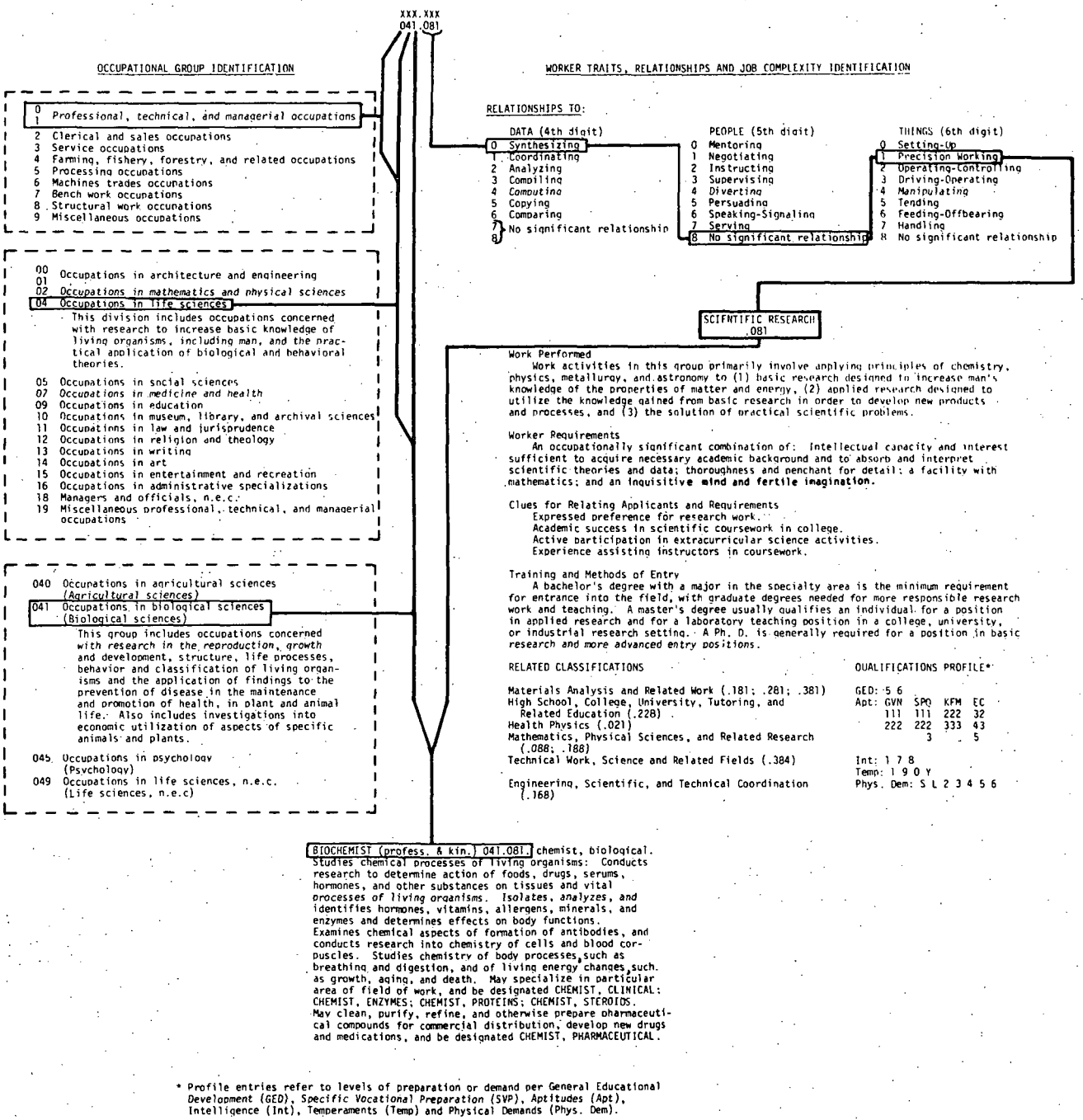
An important feature of the Task-Skill concept discussed in the preceding paragraphs is the development of a method by which the skill requirement identification at the task level could be realistically equated to the source of these skills for specific missions, i.e., the scientists, engineers, and technicians who will ultimately be needed to perform the on-orbit activities. An initial premise was that requirements for experiment or mission-specific training should be held to a minimum and that the experiment crew would be selected from the scientific and technical population to provide the best "fit" to the required task skills. Various methods of job skill and occupational skill definition were evaluated, including those presently in use by the military services. As a result of those evaluations, it was decided that the broadest, most easily applied method was that being utilized by the U.S. Department of Labor. This method is described in detail in the two volume Dictionary of Occupational Titles (ref. 16) issued by the Manpower Administration of the Labor Department. The Dictionary contains titles and definitions of 21,741 separate occupations, plus 13,809 additional, or alternate, titles for those occupations. In the Dictionary, a 6-digit coding system is used with the first 3 digits identifying the applicable occupational group and the last 3 digits providing a profile of characteristic worker traits, interrelationships, and job complexities. A diagrammatic summary of the classification method is presented in Figure 2-2. It is estimated that the occupational group definitions in the Dictionary will encompass greater than 90% of the required on-orbit research and applications skills, and the method will be applicable to all skill requirements.

A description of the application of Occupational Skill Classification to the Task-Skill Requirements Analysis is included in paragraph 2.2. An example of the results obtained is presented in Section 3.0 of this report.

2.2 PROCEDURE FOR FLIGHT EXPERIMENT TASK-SKILL REQUIREMENTS IDENTIFICATION

The paragraphs which follow describe the procedure to be followed in implementation of the Task-Skill Requirements Identification methodology. A flow diagram depicting the basic procedural steps involved is presented in Figure 2-3. The procedure begins by collecting all information which is currently available regarding the experiment/mission of concern. Well-defined experiments will lead to results of greatest precision and validity, but the procedure can be initiated with nothing more than a general description of the type of research and general characteristics of the mission/experiment. The examples which are used to illustrate the steps of the procedure are based on a moderately well-defined experiment for which major items of equipment have been specified. The forms used to show tabulation of data in these

Figure 2-2: Example of Approach to Occupational Group Classification (Biochemist)



* Profile entries refer to levels of preparation or demand per General Educational Development (GED), Specific Vocational Preparation (SVP), Aptitudes (Apt), Intelligence (Int), Temperaments (Temp) and Physical Demands (Phys. Dem).

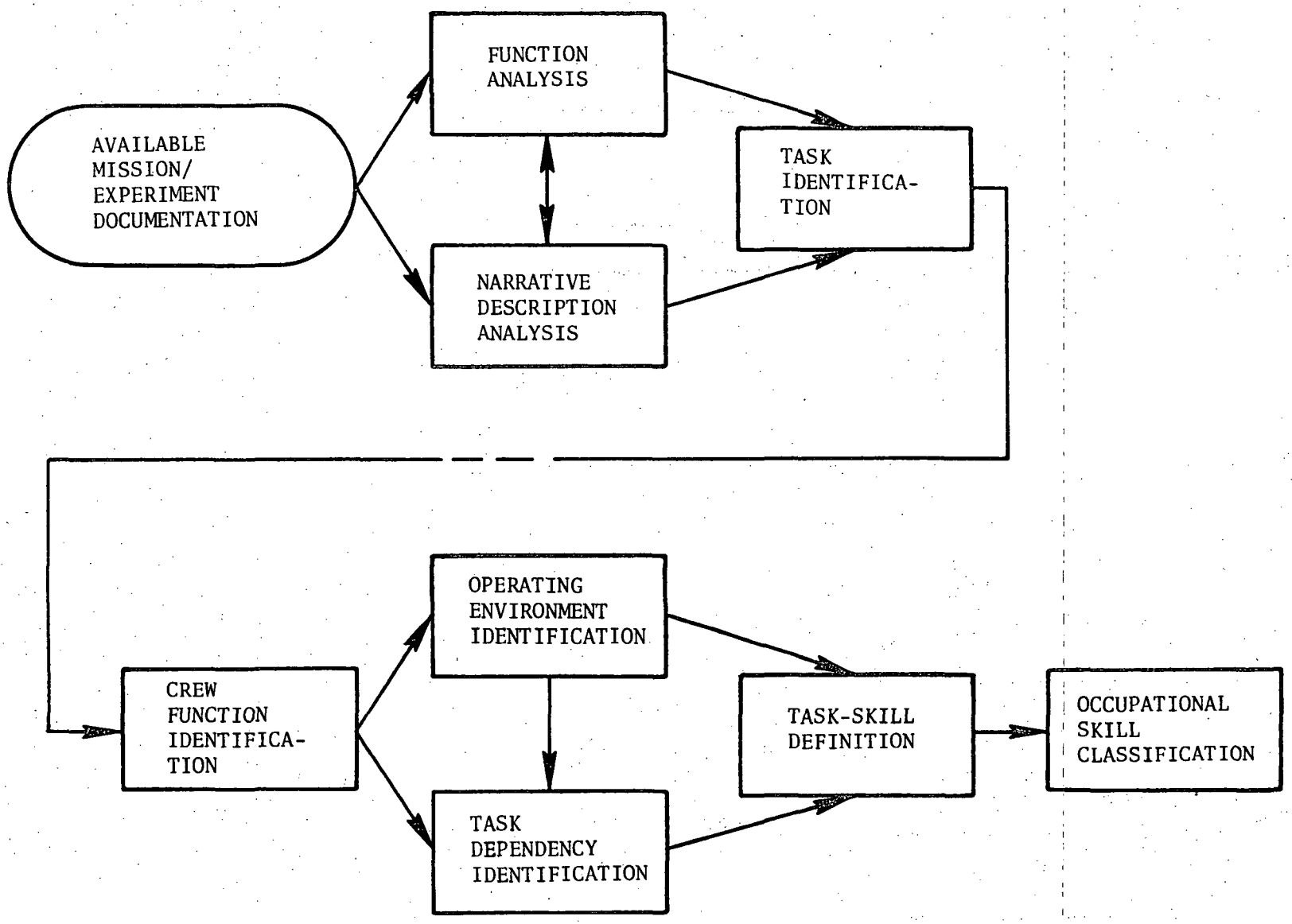


Figure 2-3: Procedural Steps for Task-Skill Requirements Identification

examples were those used in the conduct of the study performed under contract NASW-2192; other formats which permit collection of this information should prove equally useful.

2.2.1 Analysis of Narrative Descriptions

This initial step of the Task-Skill Requirements Identification procedure has the objective of determining the nature and objectives of the mission/experiment and identifying the information needed for subsequent steps of the analysis. The level of specificity of these descriptions will vary widely. However, if a potential mission/experiment has been identified, descriptive material of some sort will be available. In some cases it may be necessary to obtain verbal descriptions of the potential mission/experiment from the appropriate planners, if the Task-Skill Requirements Identification is initiated at the same time as the mission/experiment planning. The more usual case will be to review published experiment descriptions and/or experiment protocols and to amplify them as necessary with verbal descriptions. An extract of such a description is illustrated in Figure 2-4. In addition to determining the objectives of the experiment, the analyst should attempt to determine the types of activity which the experiment will require, duration of the mission, extent of anticipated automation, the anticipated role of crew personnel, specific equipment identifications, etc. All these materials should be compiled into a reference volume indexed to promote rapid retrieval of the data.

2.2.2 Function Analysis

In order to establish the relationship of the activities of crew personnel to the overall mission or program, a formal analysis of functions should be conducted. If program definition of the mission/experiment of concern is far enough along, the function identification and allocation may already have been accomplished and made available in the documentation. Otherwise, the analyst will need to perform this activity himself. The basic philosophy and methodology of function analysis is well known and will not be repeated here. The function analysis must delineate, however, the top level functions which the system as a whole must perform. Those functions which are applicable to the particular experiment of interest to the analyst can then be further analyzed to establish a baseline of functions to be performed in conjunction with Shuttle-based or Shuttle-supported orbital research.

The following subparagraphs describe the function analysis conducted under Contract NASW-2192 and may be useful as a guide.

2.2.2.1 System Functions Definitions

A thorough review of experiment descriptions indicated that a convenient top-level breakout of functions would be by their relationship to the mission experiments. Accordingly, the functional activities involved in any Shuttle mission were separated into the following system function categories:

1.4 EXPERIMENT PROGRAM

1.4.1 ATMOSPHERIC AND MAGNETOSPHERIC SCIENCE (INCLUDING AURORA)

1.4.1.1 Scientific Objectives. A scientific objective of the SPRL is to provide a facility for investigating the chemical and energy conversion processes which control the structure of the thermosphere through simultaneous measurements of its structural properties, the energy input parameters which control these properties, and the airglow parameters which provide information on the rates of controlling aeronomic processes.

The principal goal of the atmospheric science portion of the program is to elucidate the chemical processes and the processes of energy absorption, conversion, and transport, which control the structure of .....

1.4.1.2 Program Description. Most of the controlling chemical and energy conversion processes occur in the low-altitude region between 100 km and 250 km. It is here that ultraviolet radiation from the sun is absorbed, producing the ions and electrons of the ionosphere. The ions and electrons also recombine in this low-altitude region, and electron and ion densities at .....

The magnetospheric and auroral observation program has the following parts:

a. Measurement of energetic neutrals, protons, other positive ions, and electrons in the energy region from 10 eV to 100 keV over all pitch angles with a fine time resolution

b. Measurement of magnetic field changes in three directions

c. TV observations of auroral forms

d. Three-axis electric field measurements

e. Spectrometric measurements of .....

1.4.1.2.1 Optical Instrumentation. Three categories of instruments comprise the optical instrumentation for auroral and airglow observations: photometric, spectrometric and television. The photometric instrumentation is particularly well suited to the auroral observations by virtue of its ability to measure rapidly varying phenomena in several spectral ranges. Three spectrometers will provide an ability to produce finely detailed spectra over the range .....

1.4.1.3 Observation/Measurement Program. The observations and measurements to be made, are the following:

a. Optical measurements of auroras and airglow

b. Auroral imaging

c. Particle measurements including energy and angular distribution of electrons and protons

d. Ambient environment measurements

Targets to be viewed for the auroral observation programs are in the latitude regions from +45° to +90°. Polar orbits will be particularly effective for these zones, and will allow simultaneous use of particle sensors and optical sensors since the satellite will pass through the incident particle stream. During orbits of inclinations of the order of magnitude of 45° to 60° and greater, ...

1.4.1.4 Interface, Support and Performance Requirements. A summary of requirements of the Atmospheric and Magnetospheric Science observation program is shown in Table 1-2. During the early portions of the observation program, it is recommended that the instruments be operated more or less continuously for a period of four days. This initial data run will provide basic information .....

1.4.1.5 Potential Role of Man. The most important role of the astronaut-physicist will be the selection of observations to be run after the initial data run. In addition he will exercise judgment with respect to selecting specific times and zones in which to take data by observing spontaneous auroral and .....

1.4.1.6 Available Background Data.

Reference No.	Reference
1.	William T. Roberts, Memorandum to W. T. Carey, General Guidelines for Blue Book Rewrite of FPE's 5.6, 5.7, 5.8, 5.12, 5.27, Physics Experiments, July 17, 1970.
2.	Candidate Experiment Program for Manned Space Stations, September 15, 1969, NASA NHB7150.XX.
3.	Earth Orbital Experiments Program and Requirements Study, Task 4 Report, June, 1970, TRW Systems draft report to McDonnell-Douglas Astronautics Co.

Figure 2-4: Example of Experiment Descriptions (Extract of Space Physics Research Laboratory Experiment Program from Reference No. 1)

- Flight Operations (F)
- Research Operations (R)
- Servicing Operations (S)
- Habitation Functions (H)
- Distant-Remote Control Operations or Automated Operations (D)
- Flight Preparation Operations (P)
- Flight Termination Operations (T)

Each system function in this list was given an alphabetic designator (e.g., "R") to simplify subsequent reference to the system function categories. System functions R and S were determined to be directly applicable to the NASW-2192 study and were subjected to further analysis to determine the second-level functions. Habitability functions (H) were also applicable to the scientific crewman's activities, but these were analyzed separately since they are largely independent of the type of mission and would be superimposed across all other mission functions. It was determined that nine (9) primary subfunctions were included in the "R" function, and two (2) primary subfunctions in the "S" function. Definition of system functions and subfunctions, as used in this study, is included in Appendix C to this report.

The next step in the function analysis is to determine the variations in system function and subfunction combinations as characterized by the different types of Shuttle missions. To accomplish this, "typical" functional flows were constructed representing three basic Shuttle mission types (Sortie man-operated, Sortie automatic, Shuttle-supported free flyer). These functional flows, shown in Figures 2-5, 2-6, and 2-7 respectively, established the baseline reference for all on-orbit activities of the experiment crewman. Flight operations and ground or remote operations subfunctions are shown in the flow diagrams only to the extent necessary for clarification of the flow of Research (R) and Servicing (S) subfunctions.

2.2.2.2 Basic Function Identification

Review of the functional flow charts, against the characteristics of Shuttle mission types for missions being considered, revealed that system subfunctions dealing with man's research or servicing activities on-orbit could be encompassed by ten (10) "basic functions", and in all subsequent analyses these ten "basic functions" are utilized exclusively. Cross-reference between "basic" functions and "system" functions and subfunctions is shown in Table 2-3.

Each experiment/mission being analyzed should be evaluated against this list of basic functions to identify their applicability. This will provide necessary information for later steps in the analysis. It should be kept in mind during this evaluation that alternate modes of performing the mission may be possible. Each realistic alternative should be evaluated for "basic function" applicability. Several typical examples of such an evaluation are shown in Figure 2-8.

2.2.3 Task Identification

The next step in the Task-Skill Requirements Identification procedure is to determine tasks which on-orbit crew personnel may be called upon to

FIGURE 2-5: FUNCTIONAL FLOW, RESEARCH AND APPLICATION MISSION, MODE A (TYPE 1)

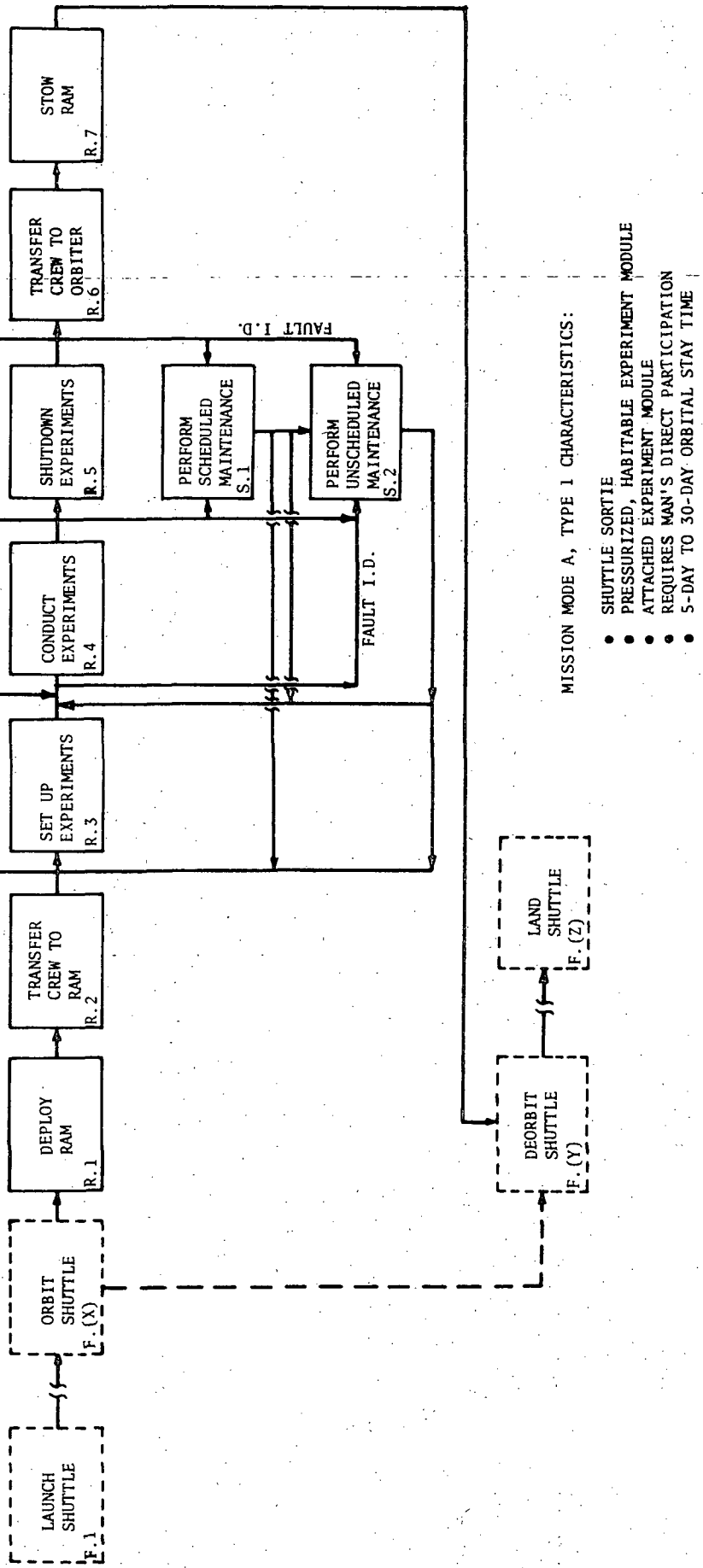
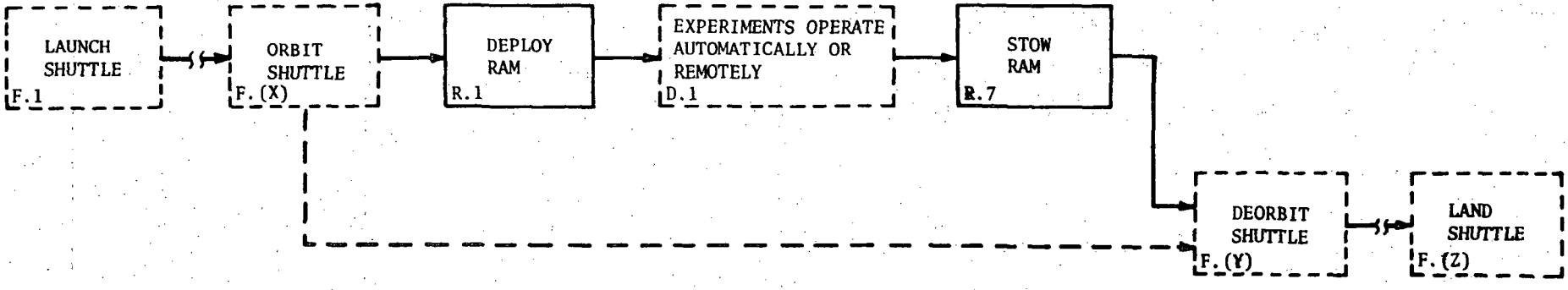


FIGURE 2-6: FUNCTIONAL FLOW, RESEARCH AND APPLICATION MISSION, MODE A (TYPE 2)



MISSION MODE A, TYPE 2 CHARACTERISTICS:

- SHUTTLE SORTIE
- UNPRESSURIZED, UNINHABITABLE EXPERIMENT MODULE
- ATTACHED EXPERIMENT MODULE
- AUTOMATIC OR REMOTE OPERATION
- 5-DAY TO 30-DAY ORBITAL STAY TIME

FIGURE 2-7: FUNCTIONAL FLOW, RESEARCH AND APPLICATION MISSION, MODE B (TYPE-1)

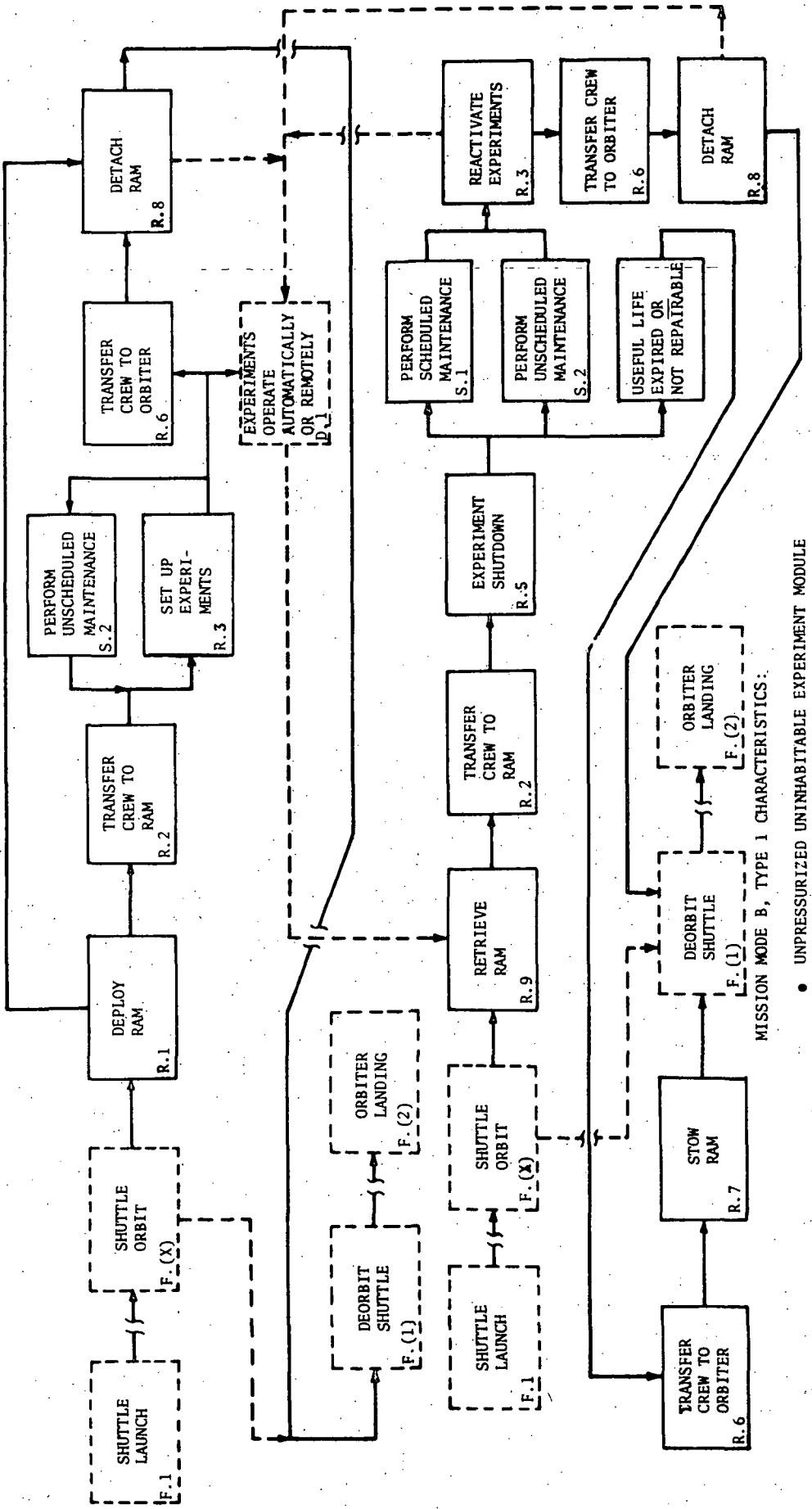


TABLE 2-3: CROSS-REFERENCE BETWEEN BASIC FUNCTIONS AND SYSTEM FUNCTIONS/SUBFUNCTIONS

SYSTEM FUNCTIONS AND SUBFUNCTIONS \ BASIC FUNCTIONS	Experiment Module Deployment	Experiment Module Stowage	Crew Transfer	Experiment Setup	Experiment Shutdown	Experiment Conduct	Experiment Module Detachment	Experiment Module Retrieval	Scheduled Maintenance	Unscheduled Maintenance
	01	02	03	04	05	06	07	08	09	10
R. Research Operations	0	0	0	0	0	0	0	0		
R.1 Deploy RAM	●									
R.2 Transfer Crew to RAM/RSM			●							
R.3 Setup Experiments				●						
R.4 Conduct Experiments						●				
R.5 Shutdown Experiments					●					
R.6 Transfer Crew to Orbiter			●							
R.7 Stow RAM		●								
R.8 Detach RAM							●			
R.9 Retrieve RAM								●		
S. Servicing Operations									0	0
S.1 Perform Scheduled Maintenance									●	
S.2 Perform Unscheduled Maintenance										●
H. Habitation Functions	0	0	0	0	0	0	0	0	0	0

0 General Applicability

● Specific Applicability

FUNCTIONAL PROGRAM ELEMENT (FPE) OR SUBGROUP		MISSION MODE	BASIC FUNCTIONS										NOTES
			EM DEPLOYMENT	EM STOWAGE	CREW TRANSFER	EXPERIMENT SETUP	EXPERIMENT SHUTDOWN	EXPERIMENT CONDUCT	EM DETACHMENT	EM RETRIEVAL	SCHEDULED MAINTENANCE	UNSCHEDULED MAINTENANCE	
			01	02	03	04	05	06	07	08	09	10	
P-1	Space Physics Research Lab	B(1)	●		●	●			●			○	(1) Initial placement of payload in orbit (2) Periodic servicing (3) Return payload to earth after its mission is complete (4) Including cryogenic resupply (5) Some experiments under direct crew control; others are partly or fully automated Legend A: 5-day or 30-day Shuttle-Sortie B: Shuttle-supported free flyer EM: Experiment Module
		B(2)			●	●	●		●	●	●	○	
		B(3)		◉	◉		◉			◉			
ES-1A	Meteorological and Atmospheric Science	A	◉	◉	◉	◉	◉	◉			○	○	
C/N-1A	Comm/Nav Research Lab. I	A	●	●	●	●	●	●			○	○	
C/N-1B	Comm/Nav Research Lab. II	B(1)	◉		●	●	◉		●			○	
		B(2)			●	●	◉		●	●	◉	○	
		B(3)		◉	◉					◉			
A-1	X-Ray Stellar Astronomy	B(1)	●		●	●	●		●			○	
		B(2)			●	●	◉		●	●	◉ (4)	○	
		B(3)		◉	◉					◉			
MS-1IA	Materials Science, 5-day Group, Biological	A			●	●	◉	◉ (5)			◉	○	

Figure 2-8: Typical Examples of Basic Functions Applicability Evaluation

perform. Sources of this information will be the experiment description data (Step #1) and the function analysis (Step #2). If a formal function analysis has been carried out to the point of allocating functions to man and/or equipment, the level at which each function allocation to man is made can be considered as a potential crew task (e.g., "Maintain Experiment Equipment"). In addition to the function analysis data (or in its absence), the experiment descriptive material should be reviewed in detail to identify task statements. Each potential task identified should be listed on a sheet for that experiment, without regard to level of generality or specificity. In addition, no special attempt should be made to put the task statements in sequential order. They should merely be listed and numbered in the order of their identification. Figure 2-9 shows a partial listing of such task statements from the analysis conducted under this contract. As shown in the figure, if there are alternative modes of operation for the experiment, it is appropriate at this time to identify the applicability of each mode to each task statement. In addition, either during or following the listing of task statements, the applicability of each task statement to one or more of the "basic functions" (see Figure 2-8 and paragraph 2.2.2.2) should be indicated.

While listing the task statements, it may become apparent to the analyst that there are "gaps", that is, not all of the implicit crew activities are covered by task statements. (For example, a task statement such as "initiate experiment operation" may not be balanced by "terminate experiment operation".) Such "gaps" should be approached cautiously, since they may be intentional on the part of mission planners. If the analyst can be certain that the "missing" task statements are intended to be performed, even though not explicitly identified in the descriptive material, he can add them to his listing of task statements.

2.2.4 Crew Function Identification

Perusal of the task statement lists resulting from the preceding step will generally reveal a wide range of generality and specificity in the statements. For this reason, a crew function taxonomy has been developed for application to each of the tasks. The development and use of the crew function taxonomy has been discussed in paragraph 2.1.2. Table 2-1 lists each crew function by title and code number; working definitions are included in Appendix B to this report.

This taxonomy was developed to permit identification of the intellectual, sensory, and motor activities of crew personnel against standard criteria. To accomplish this, the task statement lists (Figure 2-9) are now expanded to include notations of the crew function(s) encompassed by each statement. Highly specific task statements may have but one or two crew functions. Some task statements will have many associated crew functions. The example in Figure 2-10 shows the application of the crew function taxonomy to the task statements. This assessment is based on the analyst's familiarity with the requirements and objectives of the experiment and is for guidance in a later step of the analysis, during which it may be refined.

Date: 9/28/71

DISCIPLINE: Physics

FPE NO: P-1 | TITLE: Space Physics

Research Laboratory

ANALYSIS LEVEL: Experiment Area

EXPERIMENT TITLE: Atmospheric and Magnetospheric Science (Including Aurora)

TASK STATEMENT	MODE APPLICABILITY A	B	BASIC FUNCTION 01 EM DEPLOY	02 EM STOW	03 CREW TRANSFER	04 EXP. SETUP	05 EXP. SHUTDOWN	06 EXP. CONDUCT	07 EM DETACH	08 EM RETRIEVAL	09 SCHED. MAINT.	10 UNSCHED. MAINT.
22. Close airlock	X	X				X						
23. Evacuate airlock to space	X	X				X						
24. Open airlock outside gate	X	X				X						
25. Move instrument assy. on rails to outside	X	X				X						
26. Activate instrument power	X	X				X						
27. Set instrument controls to proper setting	X					X						
on control panel		X				X						
28. Monitor displays for proper operation of instrument	X	X				X						
29. Determine that instrument is operating properly	X	X				X						
30. Initiate data transfer to magnetic tape	X							X				
31. Place calibration lamps in front of entrance apertures	X	X									X	X
32. Calibrate instruments, in situ	X	X									X	X
33. Interchange Infrared Interferometer spectrometer detectors	X											
34. Interchange Scanning Grating Spectrometer gratings	X											
35. Control wavelength scan rate on SGS	X							X				
36. Interchange SGS detectors	X											
37. Interchange SGS photomultipliers	X											
38. Interchange SGS electronics	X											
39. Attach camera to SGS	X	X				X						
40. Record SGS spectrum photographically	X							X				
41. Observe low light level auroral emissions using TV	X							X				
42. Mount high purity target foil outside of S/C	X	X							X			

Date: 9/28/71

DISCIPLINE: Physics

FPE NO: P-1 | TITLE: Space Physics

Research Laboratory

ANALYSIS LEVEL: Experiment Area

EXPERIMENT TITLE: Atmospheric and Magnetospheric Science (Including Aurora)

TASK STATEMENT	MODE APPLICABILITY A	B	BASIC FUNCTION 01 EM DEPLOY	02 EM STOW	03 CREW TRANSFER	04 EXP. SETUP	05 EXP. SHUTDOWN	06 EXP. CONDUCT	07 EM DETACH	08 EM RETRIEVAL	09 SCHED. MAINT.	10 UNSCHED. MAINT.
1. Decide on instrument utilization	X					X						
2. Study complex and time-varying phenomena	X							X				
3. Use image isocom TV camera as acquisition aid	X							X				
4. Record morphological data using TV camera	X							X				
5. Use TV camera for pointing other instruments	X							X				
6. Select photometer assy. pointing angle	X							X				
7. Mount spectrometer on extendable rails of airlock	X	X				X						
8. Perform spectrometric altitude scans	X							X				
9. Observe visible horizon thru spectrometer auxiliary eye-piece	X							X				
10. Establish visible horizon as reference point	X							X				
11. Observe CO_2 15μm radiation profile	X							X				
12. Establish CO_2 15μm radiation profile as fiducial mark	X							X				
13. Select spectrometer to be used	X					X						
14. Remove spectrometer from storage area	X	X				X						
15. Carry spectrometer to appropriate airlock	X	X				X						
16. Ensure that airlock is secure	X	X				X	X					
17. Open airlock	X	X				X	X					
18. Remove unneeded or conflicting instruments from airlock (ea. beam mounted equip.)	X	X					X					
19. Select appropriate cabling for spectrometer	X	X				X						
20. Route cables through airlock feed thru	X	X				X						
21. Connect cabling to spectrometer	X	X				X						

Figure 2-9: Example of Task Statement Listing for Task Identification

CREW FUNCTION WORKSHEET

Date: 9/28/71

DISCIPLINE: Physics

TYPE NO: P-1 TITLE: Space Physics Research Laboratory

ANALYSIS LEVEL: Experiment Area

EXPERIMENT TITLE: Atmospheric and Magnetospheric Science (Including Aurora)

TASK STATEMENT	MODE A	MODE B	BASIC FUNCTION 01 EM DEPLOY	02 EM STOW	03 CREW TRANSFER	04 EXP. SETUP	05 EXP. SHUTDOWN	06 EXP. CONDUCT	07 EM DETACH	08 EM RETRIEVAL	09 SCHED. MAINT.	10 UNSCHED. MAINT.	CREW FUNCTION 01 STATUS MONITOR	02 OBSERVATION	03 INSPECTION	04 PATTERN RECOG	05 COMMUNICATION	06 DATA PROCESSING	07 FAULT ISOLATION	08 CALIBR/ALIGN	09 CONTROL	10 EVALUAT/ANAL	11 DECISION MAKING	12 TEST & CHECKOUT	13 ACTUAT/DEACT	14 STOW/UNSTOW	15 CLEAN/DECONTAM.	16 ASSEMB/DISASSB	17 TRANSLOCATION	18 DEPLOY/RETR	19 LOCOMOTION	20 REMOV/REPLAC	21 REPAIR	22 (UNKNOWN)	23 SUBJECT FOR EXP	24 OTHER	25	26	27	28	29	30
22. Close airlock	X	X				X							X																			X								
23. Evacuate airlock to space	X	X				X							X												X														
24. Open airlock outside gate	X	X				X							X												X														
25. Move instrument assy. on rails to outside	X	X				X							X	X											X														
26. Activate instrument power	X	X				X							X												X														
27. Set instrument controls to proper setting	X					X							X										X		X														
on control panel		X				X							X												X														
28. Monitor displays for proper operation of instrument	X	X				X							X																										
29. Determine that instrument is operating properly	X	X				X							X										X																
30. Initiate data transfer to magnetic tape	X							X																	X														
31. Place calibration lamps in front of entrance apertures	X	X									X	X																			X								
32. Calibrate instruments, in situ	X	X									X	X								X																		
33. Interchange Infrared Interferometer spectrometer detectors	X												X												X														
34. Interchange Scanning Grating Spectrometer gratings	X												X												X														
35. Control wavelength scan rate on SGS	X							X					X								X																		
36. Interchange SGS detectors	X												X												X														
37. Interchange SGS photomultipliers	X												X												X														
38. Interchange SGS electronics	X												X												X														
39. Attach camera to SGS	X	X				X																										X							
40. Record SGS spectrum photographically	X							X																	X														
41. Observe low light level auroral emissions using TV	X							X						X																									
42. Mount high purity target foil outside of S/C	X	X				X																						X	X			X							

Figure 2-10: Example of Crew Function Identification for Experiment Task Statements

2.2.5 Operating Environment Identification

The next step in the Task-Skill Requirements Identification procedure is to determine the environment in which the identified crew functions are to be performed. Operating environments, as part of the Task-Skill concept, have been discussed in paragraph 2.1.4. The operating environment taxonomy and definitions used in the NASW-2192 study are presented in Table 2-2.

Identification of operating environments may be performed by further expansion of the task statement listing form (see Figure 2-10) which already shows alternative mode applicability, basic function applicability, and crew function applicability for each task statement. Utilization of this method will result in a data display similar to the example in Figure 2-11. Identification can be accomplished simultaneously with crew function identification, or in serial order. There is no need to identify "zero gravity (code number 00)" since this is the "normal" environment for all orbital research and application missions. It should be noted that a single crew function within a task statement may have more than one potential operating environment. The analyst should indicate all that are reasonably applicable. As with the crew function identifications, this step is for guidance in a later stage of the analysis, during which it also may be refined.

The analyst now has a concise, yet comprehensive, data display of alternative mission modes, basic functions, crew functions, and operating environments for each experiment. This "worksheet" is the baseline for initiating the next step of the Task-Skill Requirements Identification procedure.

2.2.6 Task Dependency Identification

The conceptual basis of the Task Dependency Reference System has been discussed in paragraph 2.1.3 and illustrated in Figure 2-1. Within the context of Task-Skill Requirements Identification, a task dependency is a factor upon which successful performance of a crew function depends. These "factors" comprise facilities and equipment, the object or area of experimentation, and the environment. The environmental task dependencies may be either the "operating environment" (see paragraph 2.2.5) or other environmental influences which may affect the performance of a crew function. The five major categories of task dependencies which have been identified for orbital research and application are:

1. System and Facilities
2. Experiment Equipment and Materials
3. Object or Area Under Investigation
4. Support Equipment
5. Environment

These five categories, together with the subcategories shown as "Level #2" in Figure 2-1, serve as the basis for initiating a task dependency analysis for any orbital research program. Additional second level categories may be added as required. A complete categorization of task dependencies

Date: 9/28/71

CREW FUNCTION WORKSHEET

Series:

DISCIPLINE: Physics

FIE NO: P-1 | TITLE: Space Physics Research Laboratory

ANALYSIS LEVEL: Experiment Area

EXPERIMENT TITLE: Atmospheric and Magnetospheric Science (Including Aurora)

TASK STATEMENT	MODE APPLICABILITY A	MODE APPLICABILITY B	BASIC FUNCTION 01 EM DEPLOY	02 EM STOW	03 CREW TRANSFER	04 EXP. SETUP	05 EXP. SHUTDOWN	06 EXP. CONDUCT	07 EM DETACH	08 EM RETRIEVAL	09 SCHED. MAINT.	10 UNSCHED. MAINT.	CREW FUNCTION 01 STATUS MONITOR	02 OBSERVATION	03 INSPECTION	04 PATTERN RECOG	05 COMMUNICATION	06 DATA PROCESSING	07 FAULT ISOLATION	08 CALIBR/ALIGN	09 CONTROL	10 EVALUAT/ANAL	11 DECISION MAKING	12 TEST & CHECKOUT	13 ACTUAT/DEACT	14 STOW/UNSTOW	15 CLEAN/DECONTAM.	16 ASSEMB/DISASS	17 TRANSLOCATION	18 DEPLOY/RETR	19 LOCOMOTION	20 REMOV/REPLAC	21 REPAIR	22 (UNKNOWN)	23 SUBJECT FOR EXP	24 OTHER	OPER. ENVIRON. 01 SHIRTSLEEVE	02 EVA	03 IVA	OTHER	NOTES
22. Close airlock	X	X				X							X																			X					X			
23. Evacuate airlock to space	X	X				X							X												X											X			
24. Open airlock outside gate	X	X				X							X												X											X			
25. Move instrument assy. on rails to outside	X	X				X							X	X											X											X			
26. Activate instrument power	X	X				X							X												X											X			
27. Set instrument controls to proper setting	X					X							X										X		X											X			
on control panel		X				X							X												X											X			
28. Monitor displays for proper operation of instrument	X	X				X							X																							X			
29. Determine that instrument is operating properly	X	X				X							X										X																
30. Initiate data transfer to magnetic tape	X							X																	X											X			
31. Place calibration lamps in front of entrance apertures	X	X									X	X																				X				X			
32. Calibrate instruments, in situ	X	X									X	X								X																X			
33. Interchange Infrared Interferometer spectrometer detectors	X												X												X											X			
34. Interchange Scanning Grating Spectrometer gratings	X												X												X											X			
35. Control wavelength scan rate on SGS	X							X					X								X															X			
36. Interchange SGS detectors	X												X												X											X			
37. Interchange SGS photomultipliers	X												X												X											X			
38. Interchange SGS electronics	X												X												X											X			
39. Attach camera to SGS	X	X				X																										X				X			
40. Record SGS spectrum photographically	X							X																	X											X			
41. Observe low light level auroral emissions using TV	X							X						X																						X			
42. Mount high purity target foil outside of S/C	X	X				X																							X	X		X				X			

Figure 2-11: Example of Operating Environment Identification for Experiment Task Statements

developed during this study, identified to the third and fourth levels, is presented in Appendix D to this report. The procedure description which follows, however, assumes that the Task Dependency Reference List has been developed only through Level #2.

2.2.6.1 Use of Task-Skills Data Sheets

The Task Dependency Analysis initially requires the transferral of selected data from the worksheet (Figure 2-11) to a new format, similar to the Flight Experiment Task-Skills data sheet shown in Figure 2-12. This

FLIGHT EXPERIMENT TASK-SKILLS

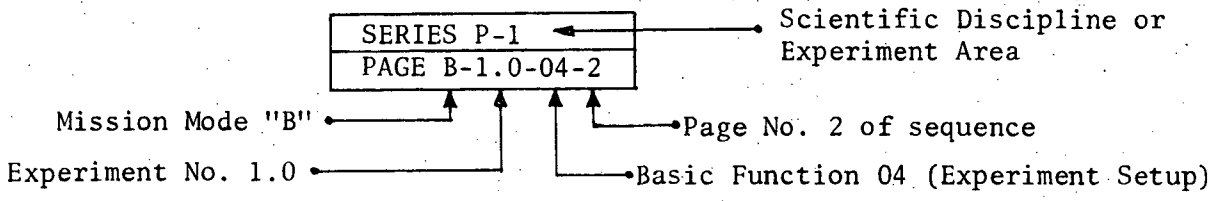
SERIES P-1
PAGE B-1.0-04-2

DISCIPLINE: Physics
FPE/SUBGROUP: P-1 - Space Physics Research Laboratory
EXPERIMENT: 1.0 Atmospheric and Magnetospheric Science (Including Aurora)
MISSION MODE: B
BASIC FUNCTION: 04 Experiment Setup

CREW TASK STATEMENT		CREW FUNCT NO.	OPER ENVIR NO.	DEPENDENCY NO.	TASK - SKILL	
NO.	DESCRIPTION				TITLE	NO.

Figure 2-12: Heading Information for Flight Experiment Task-Skills Data Sheet

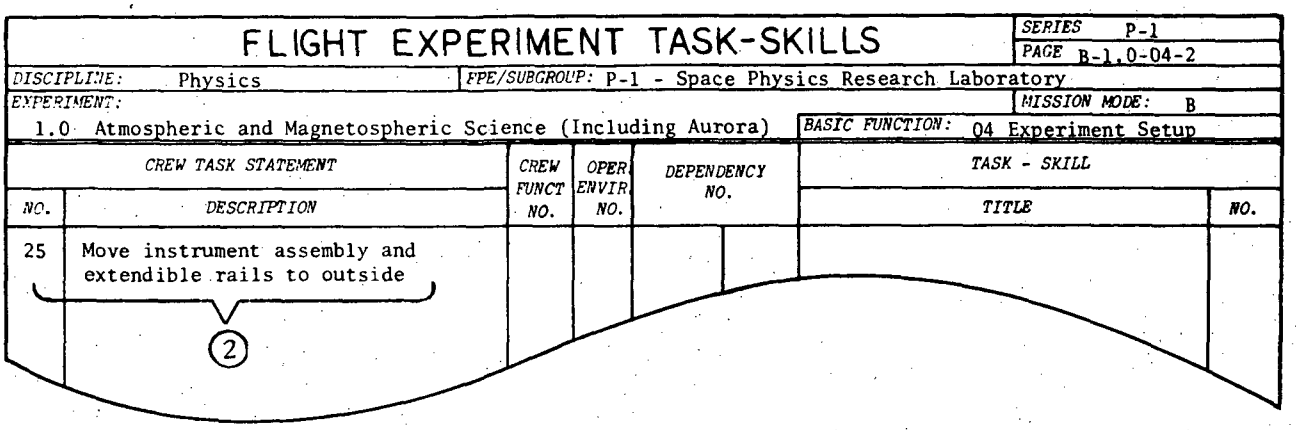
format is used both for the task dependency analysis and the task-skill requirements analysis in the next step. The heading information for entry in this format is obtained from the headings of the worksheet completed in the previous step (paragraph 2.2.5). As can be seen, the procedure requires that the experiment to be analyzed be treated separately for each mission mode alternative (if alternatives exist) and for each "basic function". The series and page number for each data sheet are derived from the alphanumeric coding of the heading information, as follows:



2.2.6.2 Sequential Steps of Dependency Analysis

① Having completed the heading information for the mission mode and basic function to be initially analyzed, review the worksheet for the first task statement in the listing which has been checked for that mission mode and basic function.

② Enter the task statement number and description in the appropriate column of the Task-Skill data sheet, as illustrated in Figure 2-13.



FLIGHT EXPERIMENT TASK-SKILLS

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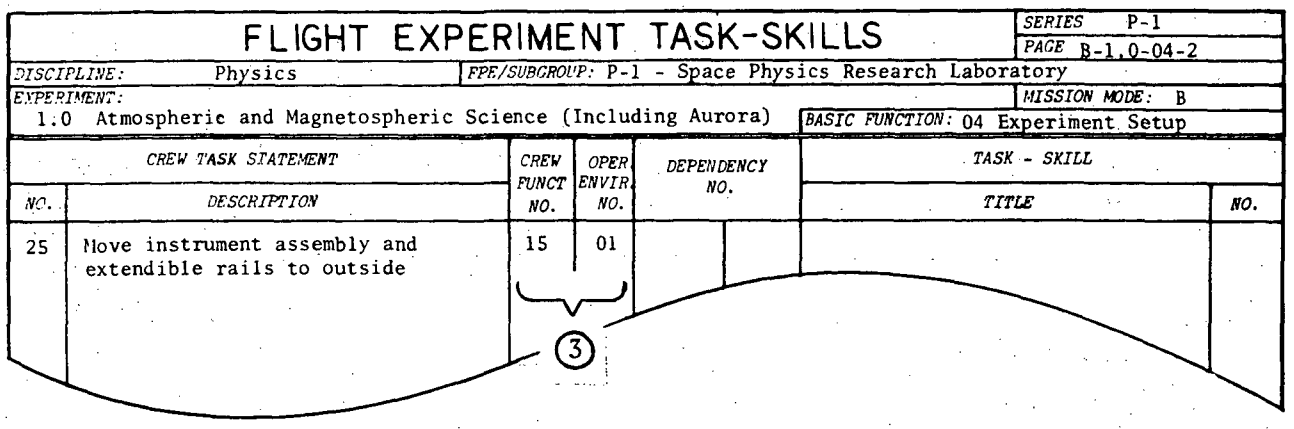
DISCIPLINE: Physics
FPE/SUBGROUP: P-1 - Space Physics Research Laboratory
EXPERIMENT: 1.0 Atmospheric and Magnetospheric Science (Including Aurora)
MISSION MODE: B
BASIC FUNCTION: 04 Experiment Setup

CREW TASK STATEMENT		CREW FUNCT NO.	OPER ENVIR NO.	DEPENDENCY NO.	TASK - SKILL	
NO.	DESCRIPTION				TITLE	NO.
25	Move instrument assembly and extendible rails to outside					

②

Figure 2-13: Entry of Crew Task Statement on Task-Skills Data Sheet

③ Next, move across the same line of the worksheet to the first crew function which has been checked. Enter the crew function number and the appropriate operating environment number in the applicable columns of the Task-Skill data sheet. (Take this opportunity to reevaluate the initial assessment shown on the worksheet, and refine or correct it as necessary). The entry of this information is illustrated in Figure 2-14.



FLIGHT EXPERIMENT TASK-SKILLS

SERIES P-1
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DISCIPLINE: Physics
FPE/SUBGROUP: P-1 - Space Physics Research Laboratory
EXPERIMENT: 1.0 Atmospheric and Magnetospheric Science (Including Aurora)
MISSION MODE: B
BASIC FUNCTION: 04 Experiment Setup

CREW TASK STATEMENT		CREW FUNCT NO.	OPER ENVIR NO.	DEPENDENCY NO.	TASK - SKILL	
NO.	DESCRIPTION				TITLE	NO.
25	Move instrument assembly and extendible rails to outside	15	01			

③

Figure 2-14: Entry of Crew Function Number and Operating Environment Number on Task-Skills Data Sheet

④ For the task statement, crew function, and operating environment entered on the data sheet, determine the primary factor or interface which will influence the completion of the task. This can be accomplished by reviewing the data compilation prepared at the beginning of the analysis procedure (see paragraph 2.2.1) and any additional data that has since been added. If the interface which is selected has no identifiable name, give it a name (e.g., Extendible Rail Control).

⑤ Categorize the interface selected in one of the five major categories of the Task Dependency Reference List (Level #1 in Figure 2-1, e.g., 1. System and Facilities).

⑥ Determine the applicable subcategory (Level #2) of the category selected (e.g., 1.A., RAM System and Facilities). If no applicable subcategory exists, assign a new one and add it to the Task Dependency Reference List.

⑦ Determine whether further subcategorization of the interface selected is feasible or necessary by comparing the interface definition (e.g., Extendible Rail Control) with the Level #2 definition (e.g., RAM System and Facilities). If so, select the appropriate Level #3 category title (e.g., RAM System Controls and Displays), and assign the appropriate sequence number (e.g., 1.A.02). Add the designator and title to the Task Dependency Reference List, if it is not already listed.

⑧ Assign the first available alphanumeric designator in the Level #4 sequences to the interface identified (e.g., 1.A.02-4, Extendible Rail Control). Add the number and dependency name to the Task Dependency Reference List. (It is suggested that a loose-leaf notebook or card file be used for the Task Dependency Reference List, since it will grow rapidly as new dependencies are identified). Enter the dependency number which has been developed in the appropriate column of the Task-Skills Data Sheet, as illustrated in Figure 2-15.

⑨ Repeat steps ④, ⑤, ⑥, ⑦, and ⑧ for any subsidiary dependencies applicable to the crew function and operating environment, entering the subsidiary dependencies beneath the primary dependency on the data sheet.

⑩ Repeat steps ③, ④, ⑤, ⑥, ⑦, ⑧ and ⑨ for all other combinations of crew functions and operating environments applicable to the task statement.

⑪ Repeat steps ① through ⑩ for each additional task statement applicable to the mission mode and basic function. Figure 2-16 illustrates a Task-Skill Data Sheet for which the Dependency Analysis has been completed.

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DISCIPLINE: Physics
FPE/SUBGROUP: P-1 - Space Physics Research Laboratory
EXPERIMENT: 1.0 Atmospheric and Magnetospheric Science (Including Aurora)
MISSION MODE: B
BASIC FUNCTION: 04 Experiment Setup

CREW TASK STATEMENT		CREW FUNCT NO.	OPER ENVIR. NO.	DEPENDENCY NO.		TASK - SKILL	
NO.	DESCRIPTION					TITLE	NO.
25	Move instrument assembly and extendible rails to outside	15	01	1.A.02	-4		

⑧

Figure 2-15: Entry of Dependency Number on Task-Skills Data Sheet

⑫ Repeat all steps for other basic functions and mission modes.

2.2.7 Task-Skills Definition

The concept of "task-skills" has been discussed in paragraph 2.1. The partially completed data sheets resulting from the Task Dependency Analysis in the preceding step (paragraph 2.2.6 and Figure 2-16) are used as the basis of task-skill definition. The requirement in this step of the procedure is to construct a brief phrase, or title, from the combination of the crew function and the primary task dependency, e.g., Spectrometer Fault Identifier. The title should be worded to incorporate the essence of the demands of the task dependency and the crew function on the knowledge, experience, and training of the crewman. The primary task dependency name (or a paraphrasing of it) forms the first part of the task-skill title; the second portion is formed from the applicable crew function name (or related name). Caution should be used to avoid the tendency to paraphrase the task statement rather than constructing the task-skill title from the dependency and crew function.

For each combination of crew functions and primary task dependencies, within each task statement, construct a Task-Skill Title as described above. For cross-referencing and data retrieval purposes, it is suggested that task-skill titles and their assigned identification numbers be maintained in both alphabetic and numerical files. An index card file works extremely well for the alphabetic file. As each task-skill title is constructed, check it against the alphabetic file to determine whether that title (or a closely related one) has previously been identified. If it has, a task-skill number will have been assigned, and the title and number can be entered on the Task-Skills Data Sheets, as illustrated in Figure 2-17. If the task-skill title is new, enter it in the numerical list with the next available task-skill number; enter both title and number in the alphabetic listing and on the

FLIGHT EXPERIMENT TASK-SKILLS

SERIES P-1
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DISCIPLINE: Physics
FPE/SUBGROUP: P-1 - Space Physics Research Laboratory
EXPERIMENT: 1.0 Atmospheric and Magnetospheric Science (Including Aurora)
MISSION MODE: B
BASIC FUNCTION: 04 Experiment Setup

CREW TASK STATEMENT		CREW FUNCT NO.	OPER ENVIR NO.	DEPENDENCY NO.		TASK - SKILL	
NO.	DESCRIPTION					TITLE	NO.
25	Move instrument assembly and extendible rails to outside	15	01	1.A.02 1.A.01	-4 -9		
26	Activate instrument power	15	01	2.B.02	-2		
27	Set spectrometer controls to proper settings on control panel	15	01	2.B.02 2.A.03	-3		
28	Monitor displays for proper operations of spectrometer	01	01	2.B.02 2.A.03	-3		
29	Determine that spectrometer is operating properly	13	01	2.A.03 2.B.02	-3		
39	Attach camera to scanning grating spectrometer	27	01	4.D.04 2.A.03	-3 -2		
42	Mount high purity target foil on exterior of spacecraft	22	02	2.A.11 1.A.01 5.A.01 4.E.02	-1 -1		
		27	02	2.A.11 1.A.01 4.E.02 5.A.01	-1 -6		

Figure 2-16: Task Dependency Analysis, Example of Partially Completed Data Sheet

FLIGHT EXPERIMENT TASK-SKILLS

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DISCIPLINE: Physics
FPE/SUBGROUP: P-1 - Space Physics Research Laboratory
EXPERIMENT: 1.0 Atmospheric and Magnetospheric Science (Including Aurora)
MISSION MODE: B
BASIC FUNCTION: 04 Experiment Setup

CREW TASK STATEMENT		CREW FUNCT NO.	OPER ENVIR NO.	DEPENDENCY NO.		TASK - SKILL	
NO.	DESCRIPTION					TITLE	NO.
25	Move instrument assembly and extendible rails to outside	15	01	1.A.02 1.A.01	-4 -9	Rail/Boom Extension Actuator	0034
26	Activate instrument power	15	01	2.B.02	-2	Instrument Power Actuator	0035
27	Set spectrometer controls to proper settings on control panel	15	01	2.B.02 2.A.03	-3	Spectrometer Control Actuator	0036
28	Monitor displays for proper operations of spectrometer	01	01	2.B.02 2.A.03	-3	Spectrometer Operating Status Monitor	0037
29	Determine that spectrometer is operating properly	13	01	2.A.03 2.B.02	 -3	Spectrometer Fault Identifier	0038
39	Attach camera to scanning grating spectrometer	27	01	4.D.04 2.A.03	-3 -2	Camera Installer	0039
42	Mount high purity target foil on exterior of spacecraft	22	02	2.A.11 1.A.01 5.A.01 4.E.02	-1 -1	Target Foil Translocator	0047
		27	02	2.A.11 1.A.01 4.E.02 5.A.01	-1 -6	Target Foil Installer	0048

Figure 2-17: Flight Experiment Task Skills, Example of Completed Data Sheet

Task-Skills Data Sheet. This procedure avoids duplication in assigning task-skill titles and numbers.

With the completion of this step of the procedure, the Task-Skill Requirements Identification is essentially complete. Task-Skill titles and code numbers will have been identified for each crew function/dependency combination across all task statements, basic functions, mission mode alternatives, and experiments included in the study, all in a form compatible with automatic data processing. The data can be "exercised" at this level, or upon the completion of the Occupational Skill Classification step (paragraph 2.2.8), the final step of the procedure.

2.2.8 Occupational Skill Classification

The background and basic theory of this step of the procedure is discussed in paragraph 2.1.5. The relationship of the Occupational Skill Classification to Task-Skill titles is also defined and need not be repeated here. The basic procedure in making this conversion is described below.

Each identified task-skill is compared to the occupational title definitions in the Dictionary of Occupational Titles (ref. 16) in order to arrive at one or more 3-digit Occupational Titles (the listings illustrated at the bottom of Figure 2-2) to which the task-skill is applicable. Each related entry in the occupational titles is then compared to the task-skill (including consideration of task dependencies) to determine the best "fit". This process should result in placing nearly all task-skills in one or more occupational skills. Some task-skills may be so unique to on-orbit activities that a valid placement in an existing occupational skill area would not be possible. When this occurs, a "new" occupational skill title and definition is developed utilizing the same procedure used by the authors of the Dictionary. These occupational skill requirements can then be filled through mission/experiment-specific training of selected personnel having the basic qualifications. It should also be expected that a significant number of task-skills will be unrelated to specialized knowledge or experience (i.e., "anyone can do it"). Task-skills of this kind would not be subject to the occupational skill analysis but would be "assigned" to a crewman on the basis of workload and/or availability, rather than on the basis of skills.

Application of this method in subsequent programs will provide identification of the scientific, engineering, and technical skill requirements for all experiment/mission combinations, which can be satisfied through selection of candidates from the general population, by specialized training, or by assignment to available personnel.

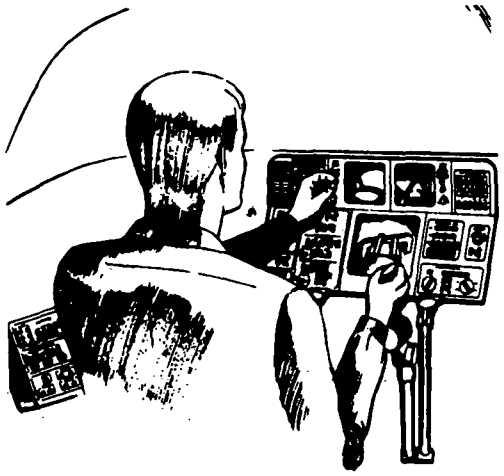
DEVELOPMENT OF FLIGHT EXPERIMENT TASK REQUIREMENTS

NASW-2192

FINAL REPORT

VOLUME II - TECHNICAL REPORT

PART I - PROGRAM REPORT AND APPENDICES A-G



SECTION 3.0

TASK-SKILL ANALYSIS OF SELECTED FLIGHT EXPERIMENTS

MATRIX MAN SYSTEMS

3.0 TASK-SKILL ANALYSIS OF SELECTED FLIGHT EXPERIMENTS

Objectives of the Development of Flight Experiment Task Requirements Study included development of a feasible method for the determination of skills required by on-orbit crew personnel for the conduct of experiments, the development of a data base of task requirements for these personnel, and definitions of the skills required for selected Shuttle flight experiments. The methodology developed to determine skill requirements is described fully in Section 2.0 of this report.

This section of the final report is comprised of a description of the activities performed in selecting flight experiments for analysis and the results achieved by the conduct of the task-skill analysis on those experiments.

3.1 SELECTION OF FLIGHT EXPERIMENTS FOR TASK-SKILL ANALYSIS

An in-depth review of the available experiment/mission descriptions was conducted to determine which experiment activities could reasonably be incorporated into this study that would also provide a representative cross section of typical experiment activities and, subsequently, skill requirements. As the review progressed and new source data emerged, mission options and proposed combinations of experiments became quite numerous and complex.

3.1.1 Selection Criteria and Source Documentation

For purposes of selecting flight experiments to subject to the task-skills analysis, four criteria were defined:

(1) Experiments should be sufficiently well-defined in the experiment descriptions to permit effective application of the Task-Skill Requirement Identification technique;

(2) Experiments should be selected to provide a cross section of research and application activities in all disciplines described in the "Blue Book" (ref. 1) program;

(3) Experiments should be selected to provide a cross section of feasible Shuttle mission modes;

(4) Experiments should be selected so as to permit a wide range of feasible combinations of experiments for Shuttle payloads.

The following documents and publications are a partial list of those which were obtained and reviewed specifically for their applicability to the determination of experiment module skill requirements and were the primary source documents for this effort:

Reference No.	Title
1.	Preliminary Edition of Reference Earth Orbital Research and Applications Investigations (Blue Book), NHB 7150.1, NASA, Washington, D.C., Jan. 15, 1971.
2.	Experiment Requirements Summary for Modular Space Station and Space Shuttle Orbital Applications and Requirements (Green Book), Rev. #1, Martin-Marietta Corp., Denver, Colo., April 28, 1971.
3.	Task II Output of MSFC In-House Study, NASA/MSFC, Huntsville, Ala., March 1971.

A complete reference list of documents and publications reviewed as part of this study is contained in Appendix A of this report.

3.1.2 Mission Mode Analysis

An in-depth analysis of acceptable mission modes and experiment combinations for each projected payload was conducted. Three primary reference documents (refs. 1, 2 and 3) were compared for data on the combinations of experiments which could be considered acceptable in one or more of the primary mission modes. As mentioned above, the total number of such combinations was extensive and varied in nature. For example, the Blue Book (ref. 1) describes individual experiments which are combined into groups called Functional Program Elements (FPEs). The FPEs are further grouped into general areas of investigation, or disciplines. The "Green Book" (ref. 2) and the Task II Report (ref. 3) present both FPEs and other combinations of experiments called "Subgroups". In some cases a Subgroup is a single experiment within an FPE; in other cases two or more experiments from an FPE (but not the total FPE) make up a Subgroup; a third combination was the selection of several total FPEs within a discipline, as in Life Sciences, to make up a Subgroup. Consequently, a Mission Mode Analysis was conducted for each FPE and Subgroup, followed by an evaluation to specify which mission/FPE combinations should be included within the study coverage.

The Blue Book (ref. 1) indicated that three possible mission modes were being considered. These were identified as: Mode A, Limited on-orbit stay-time with the Shuttle Orbiter; Mode B, Extended on-orbit stay time as a free flyer, periodically revisited by the Shuttle Orbiter; Mode C, Extended on-orbit stay time in conjunction with the Space Station. References 2 and 3 further subdivide Mode A into on-orbit stay times of approximately 5 days and 30 days. Thus, four mission modes were potentially feasible (A-5; A-30; B; C), and all FPEs and Subgroups identified in each of the three primary reference documents were evaluated as to their acceptability in each mission mode. The results of this comparison are shown in Table 3-1. In most cases, fairly good agreement between these source documents was evident. The greatest lack of agreement was the result of an inability to identify in the Blue Book

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (ASTRONOMY)		Mission Mode												Remarks
		Shuttle-Based									Space Station-Based			
		Operation						Service						
		A-5			A-30			B			C			
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
A-1	X-Ray Stellar Astronomy	⊗	⊗	⊙ 3,6	○	⊙	⊙ 3,6	●	○	⊗ 3	⊙	⊙	⊙ 3	● Preferred mode ⊙ Acceptable mode ◒ Partially acceptable mode ⊗ Not acceptable mode ○ Mode not mentioned △ FPE/Subgroup/ Experiment not identifiable in this document
A-2	Advanced Stellar Astronomy	◒ 1	◒ 1	◒ 1,7	◒ 1	⊙	◒ 1,7	⊙	⊙ 10	⊙	●	⊙	●	
A-2A	Intermediate Stellar Telescope	◒ 1	◒ 1	◒ 1,7	◒ 1	⊙	◒ 1,7	⊙	⊙ 10	⊙	◒	⊙	◒	
A-3	Advanced Solar Astronomy	◒ 1	◒ 1	◒ 1,7	◒ 1	⊙	◒ 1,7	◒	○	⊙	⊙	⊙	⊙	
A-3A	1.5 M. Photohel./0.25 M. Spectrohel/ 0.5 M. X-Ray Telescope	◒ 1	◒ 1	○	◒ 1	⊙	○	◒	○	○	⊙	⊙	○	1) Initial system check out and debugging. 2) "Mission A" with increased time on orbit 3) Discrepancy: Text says must be manned operation w/Shuttle. Tables say automatic/ revisit or Space Station, permanent orbital stay. 4) Experiments of modified design. 5) Delete "Sky Survey". 6) Possible; duration not specified, although is referred to as permanent orbital stay. 7) Duration not specified. 8) Initial deployment only; not revisited. 9) Initial deployment only; uses kick stage (cont'd.)
A-3B	Solar Coronograph	◒ 1	⊗	⊗	◒ 1	⊙	⊗	◒	○	●	⊙	⊙	⊙	
A-3C	Photoheliograph	△	⊗	△	△	⊙	△	△	○	△	△	⊙	△	
A-3D	X-Ray Spectroheliograph	△	⊗	⊙ 7	△	⊙	⊙ 7	△	○	○	△	⊙	⊙	
A-3E	U.V. Long Wave Spectrometer	△	⊗	⊙ 7	△	⊙	⊙ 7	△	○	○	△	⊙	⊙	
A-4	Intermediate Size U.V. Telescopes	⊙	◒ 11	△	⊙ 2	◒ 11	△	⊙	○	△	⊙	⊙	△	
A-4A	0.9 M. Narrow-Field U.V. Telescopes	⊙	⊙ 13	⊙ 7	⊙ 2	⊙ 13	⊙ 7	○	○	⊗	○	⊙	○	
A-4B	0.3 M. Wide-Field U.V. Telescopes	⊙	⊙ 13	⊙ 7	⊙ 2	⊙ 13	⊙ 7	○	○	⊗	○	⊙	○	
A-4C	Small U.V. Survey Telescopes	△	⊙	● 7	△	⊙	● 7	△	○	⊗	△	⊙	○	
A-5	High Energy Stellar Astronomy	◒	◒ 4	⊙ 6	○	⊙	⊙ 6	●	○	⊙	⊙	⊙	⊙	
A-5A	Low Energy X-Ray Telescope Experiment	○	◒ 4	○	○	⊙	○	●	○	○	○	⊙	○	
A-5B	High Energy Gamma Ray Measurements	○	◒ 4	○	○	⊙	○	●	○	○	○	⊙	○	
A-6	Infrared Astronomy	⊙	◒ 5	◒ 5	○	◒ 12	◒ 5	⊙	○	●	⊙	⊙	⊙	
-	65cm Photoheliograph	△	△	●	△	△	●	△	△	⊗	△	△	○	
-	OSO-K	△	△	○	△	△	○	△	△	●	△	△	○	Date 6/8/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (ASTRONOMY)		Mission Mode												Remarks
		Shuttle-Based									Space Station-Based			
		Operation						Service						
		A-5			A-30			B			C			
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
-	Radio Interferometer Telescope	△	△	⊗	△	△	⊗	△	△	● 9	△	△	⊗	● Preferred mode ◉ Acceptable mode ◒ Partially acceptable mode ⊗ Not acceptable mode ○ Mode not mentioned △ FPE/Subgroup/ *Experiment not* identifiable in this document
-	Solar Orbital Pair: OSO A+B	△	△	⊗	△	△	⊗	△	△	● 9	△	△	⊗	
-	Optical Interferometer	△	△	⊗	△	△	⊗	△	△	◒	△	△	⊗	
-	Kilometer Wave Orbiting Telescope (KWOT)	△	△	⊗	△	△	⊗	△	△	●	△	△	⊗	
-	Astronomy Explorer	△	△	⊗	△	△	⊗	△	△	● 8	△	△	⊗	
-	Radio Astronomy Explorer (RAE)	△	△	⊗	△	△	⊗	△	△	● 9	△	△	⊗	
-	Large Radio Observatory (LRO)	△	△	⊗	△	△	⊗	△	△	●	△	△	⊗	

for delivery to operating location. Not revisited.
10) Experiments are operable from remote location, e.g., ground.
11) Reduced narrow-field sequence; increased repetition sequences per day.
12) Reduced sky survey.
13) Increased repetition sequences per day.

Date 6/8/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (PHYSICS)		Mission Mode												Remarks
		Shuttle-Based									Space Station-Based			
		Operation						Service						
		A-5			A-30			B			C			
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
P-1	Space Physics Research Lab	◒	◒ 9	⊙	◒	⊙	⊙	⊙	○	⊗	●	⊙	○	● Preferred mode
P-1A	Atmospheric and Magnetospheric Science	◒	⊙	⊙	⊙	⊙	⊙ 4	⊙	○	⊗	⊙	◒ 11	○	⊙ Acceptable mode
P-1B	Cometary Physics	⊙	⊙	⊙	⊙	⊙	⊙ 4	⊙	○	⊗	⊙	⊙	○	◒ Partially acceptable mode
P-1C	Meteoroid Science (Excludes TMMPD)	◒	◒ 12	⊙	◒	⊙	⊙ 4	⊙	○	⊗	⊙	⊙	○	⊗ Not acceptable mode
P-1D	Thick Material Meteoroid Penetration	⊗	⊗	△	⊗	⊙	△	⊙	○	△	⊙	⊙	△	○ Mode not mentioned
P-1E	Small Astronomy Telescopes	⊙	⊙	⊙	⊙	⊙	⊙ 4	⊙	○	⊗	⊙	⊙	○	△ FPE/Subgroup/ Experiment not identifiable in this document
P-2	Plasma Physics and Environmental Perturbation Lab	⊗	⊙ 10	◒	⊗	⊙	◒	◒ 1	○	◒	◒ 1	⊙	○	1) Preferred mode of operation is given as initial service in automated free-flying module, progressing to experiments in conjunction with S.S.
P-2A	Wake Measurements From Station and Booms	⊗	⊙ 10	△	⊗	⊙	△	⊙ 1 2	○	△	⊙ 1 2	⊙	△	2) No far-wake measurements.
P-2B	Wake Measurements From Subsatellites	⊗	⊙ 10	△	⊗	⊙	△	⊗	○	△	⊙	⊙	△	3) Same as 1) except start in manned, Shuttle-supported mode of short duration.
P-2C	Plasma Resonances	◒ 3	⊙ 10	△	◒ 3	⊙	△	◒ 3	○	△	⊙ 3	⊙	△	4) This mode not specifically mentioned, but based on nature of the experiments it should be at least as acceptable as 5-day Shuttle-sortie.
P-2D	Wave-Particle Interactions	◒ 3	⊙ 10 13	△	◒ 3	⊙ 13	△	◒ 3	○	△	⊙ 3	⊙ 13	△	5) Laser experiments could possibly be automated; contamination coupons could be retrieved on servicing visits. (cont'd.)
P-2E	Electron and Ion Beam Interaction	◒ 3	⊙ 10 13	△	◒ 3	⊙ 13	△	◒ 3	○	△	⊙ 3	⊙ 13	△	
P-3	Cosmic Ray Physics Lab (CRPL)	⊗	⊗	⊗	⊗	⊗	◒	⊙	⊙	●	●	⊙	○	
P-3A	CRPL Without Total Absorption Device	△	⊗	△	△	⊗	△	△	⊙	△	△	⊙	△	
P-3B	CRPL With 1/2 Total Absorption Device	△	⊗	△	△	⊗	△	△	⊙	△	△	⊙	△	
P-3C	Plastic/Nuclear Emulsions	△	⊗	△	△	⊙	△	△	⊙	△	△	⊙	△	
P-4	Physics and Chemistry Laboratory	⊙	⊙	◒	⊙ 4	⊙	⊙	⊗	○	⊗	⊙	⊙	○	
P-4A	Airlock and Boom Experiments	⊙	⊙	⊙	⊙ 4	⊙	⊙	⊗	○	⊗	⊙	⊙	○	
P-4B	Flame Chemistry and Laser Experiments	⊙	⊙	△	⊙ 4	⊙	△	◒ 5	○	△	⊙	⊙	△	Date 6/9/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (PHYSICS)		Mission Mode												Remarks
		Shuttle-Based									Space Station-Based			
		Operation						Service						
		A-5			A-30			B			C			
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
P-4C	Test Chamber Experiments	△	⊙	○	△	⊙	⊙	△	○	⊗	△	⊙	○	● Preferred mode ⊙ Acceptable mode ◐ Partially acceptable mode ⊗ Not acceptable mode ○ Mode not mentioned △ FPE/Subgroup/ Experiment not identifiable in this document
-	Low Magnetosphere Satellite	△	△	○	△	△	○	△	△	● 6	△	△	○	
-	Mid Magnetosphere Satellite	△	△	○	△	△	○	△	△	● 6	△	△	○	
-	High Magnetosphere Satellite	△	△	○	△	△	○	△	△	● 6	△	△	○	
-	Plasma Physics Modification Satellite	△	△	○	△	△	○	△	△	● 6 7	△	△	○	6) Most or all will require kick-stage to achieve final orbit. Not revisited for servicing. 7) Vehicle for FPE P-2 may be required as observation platform when manned.
-	Gravity-Relativity Satellites	△	△	○	△	△	○	△	△	● 8	△	△	○	
-	Solar System Escape Satellite	△	△	○	△	△	○	△	△	● 6	△	△	○	
														8) Redshift satellite will require kick-stage: none revisited for servicing. 9) Delete Thick Material Meteoroid Penetration Device. 10) Requires 2-shift operation. 11) Delete Particle Sensor Cluster & Aluminum Foil Exposure Device. 12) Includes small meteoroid W & V Sensors and OPMD only. 13) Assumes P-2D and P-2E will operate together.
														Date 6/9/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (EARTH OBSERVATIONS)		Mission Mode												Remarks
		Shuttle-Based									Space Station-Based			
		Operation						Service						
		A-5			A-30			B			C			
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
ES-1	Earth Observations Facility	◒ 4	⊗	△	◒ 4	⊙	△	○ 5	○	△	⊙	⊙	△	● Preferred mode ◉ Acceptable mode ◒ Partially acceptable mode ⊗ Not acceptable mode ○ Mode not mentioned △ FPE/Subgroup/ Experiment not identifiable in this document
ES-1A	Meteorological and Atmospheric Sci.	⊙	⊙	◒ 3	⊙	⊙	⊙	⊙	○	○	⊙	⊙	○	
ES-1B	Land Use Mapping	◒ 6	⊙ 3	⊙	◒ 1	⊙	⊙	⊙	○	○	⊙	⊙	○	
ES-1C	Air and Water Pollution	⊙	⊙ 3	⊙	⊙	⊙	⊙	⊙	○	○	⊙	⊙	○	
ES-1D	Resource Recognition	◒ 6	⊙ 3	⊙	◒ 1	⊙	⊙	⊙	○	○	⊙	⊙	○	1) Identification of some kinds of data may require more than 30 days observation. If serial shuttle-sorties can extend to 90 days observation, this is acceptable. 2) Orbit is fixed; A disaster might occur off ground track where it is not observable. 3) Reduced number of cycles; reduced value. 4) Complete FPE payload too large for Shuttle. 5) Not considered as mode for total FPE. 6) Acceptability uncertain.
ES-1E	Natural Disaster Assessment	⊙	⊙ 3	◒	⊙	⊙	⊙	⊙	○	○	◒ 2	⊙	○	
ES-1F	Ocean Resources	⊙	⊙ 3	◒	⊙	⊙	⊙	⊙	○	○	⊙	⊙	○	
ES-1G	Minimum Payload	△	⊙ 3	△	△	⊙	△	△	○	△	△	⊙	△	
-	Special Research	◒ 6	△	△	◒ 6	△	△	⊙	△	△	⊙	△	△	
														Date 6/29/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (COMMUNICATIONS/NAVIGATION)		Mission Mode												Remarks
		Shuttle-Based									Space Station-Based			
		Operation						Service						
		A-5			A-30			B			C			
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
C/N-1	Communications/Navigation Research Facility	⊗	⊗	△	◒ 1	⊙ 6	△	◒ 2	○	△	●	⊙	△	● Preferred mode ⊙ Acceptable mode ◒ Partially acceptable mode ⊗ Not acceptable mode ○ Mode not mentioned △ FPE/Subgroup/ Experiment not identifiable in this document
C/N-1A	Com/Nav Subgroup A (Experiments 1-7) [CNRL I]	⊗	⊙ 7	⊙	⊙ 3	⊙	⊙	⊙ 3	○	○	⊙ 3	⊙	○	
C/N-1B	Com/Nav Subgroup B (Experiments 1-7, 12, 13) [CNRL II]	⊗	⊙ 7	⊙	◒ 4	⊙	⊙	⊙ 3	○	○	⊙ 3	⊙	○	
-	Com/Nav Research Lab III (All Experiments except 7)	⊗	△	○	⊗	△	⊙	⊗	△	○	●	△	⊙	
-	Medical Network Satellite	△	△	○	△	△	○	△	△	● 5	△	△	○	1) Three experiment areas are not compatible with this mode. 2) Two experiment areas are not compatible with this mode. 3) In most experiments, Mode B or C is preferable, with C more preferable than B. 4) Experiment #13 is not compatible with this mode. 5) Unknown whether periodic servicing will be required. 6) Multiple serial missions required. 7) Requires 2 or 3 shifts for operation; set-up time is on ascent day; multiple serial missions required.
-	Education Broadcast Satellite	△	△	○	△	△	○	△	△	● 5	△	△	○	
-	Follow-On Systems Demonstration S/C	△	△	○	△	△	○	△	△	● 5	△	△	○	
-	Applications and Technology Satellite	△	△	○	△	△	○	△	△	● 5	△	△	○	
-	Small Applications Technology Satellite	△	△	○	△	△	○	△	△	● 5	△	△	○	
-	Cooperative Applications Satellite	△	△	○	△	△	○	△	△	● 5	△	△	○	
														Date 6/10/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (MATERIALS SCIENCE AND MANUFACTURING)		Mission Mode: Shuttle-Based: Operation: A-5			Operation: A-30			Service: B			Space Station-Based: C			Remarks
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
MS-1	Materials Science and Manufacturing In Space	◐ 1 2	⊗	◐	⊙ 1	⊙	⊙	⊙ 1	○	⊙ 5	●	⊙	○	● Preferred mode
MS-1IA	5-Day Group, Biological (4A, 4B)	○	● 8	⊙	⊙ 4	○	● 6	⊙ 4	○	○	⊙ 3	○	○	⊙ Acceptable mode
MS-1IB	5-Day Group, Levitation (2D, 3A; partial 2A, 2B, 2C)	○	◐	⊙ 7	⊙ 4	○	◐ 6 7	⊙ 4	○	○	⊙ 3	○	○	◐ Partially acceptable mode
MS-1IC	5-Day Group, Furnace(1A+Zone Refining)[Convectionless Solidification]	○	◐	⊙	⊙ 4	○	◐ 6 7	⊙ 4	○	○	⊙ 3	○	○	⊗ Not acceptable mode
MS-1ID	5-Day Group, Small and Low Temperature (5A)	○	●	⊙	⊙ 4	○	● 6	⊙ 4	○	○	⊙ 3	○	○	○ Mode not mentioned
MS-1IIA	30-Day Group, Biological (2A, 2B, 4A, 4B, 5A)	○	○	△	⊙ 4	● 8	△	⊙ 4	○	△	⊙ 3	○	△	△ FPE/Subgroup/ Experiment not identifiable in this document
MS-1IIB	30-Day Group, Levitation (1A, 1B, 1D, 3A, 3B)	○	○	△	⊙ 4	●	△	⊙ 4	○	△	⊙ 3	○	△	
MS-1IIC	30-Day Group, Furnace (1C, 2C, 2D)	○	○	△	⊙ 4	◐	△	⊙ 4	○	△	⊙ 3	○	△	
MS-1IIIA	Space Station Group (2A, 2B, 4A, 4B, 5A)	○	○	△	⊙ 4	○	△	⊙ 4	○	△	⊙ 3	●	△	
MS-1IIIB	Space Station Group (2C)	○	○	△	⊙ 4	○	△	⊙ 4	○	△	⊙ 3	●	△	
MS-1IIIC	Space Station Group (1A, 1B, 3A)	○	○	△	⊙ 4	○	△	⊙ 4	○	△	⊙ 3	●	△	
MS-1IIID	Space Station Group (1D, 3B)	○	○	△	⊙ 4	○	△	⊙ 4	○	△	⊙ 3	●	△	
MS-1IIIE	Space Station Group (2D)	○	○	△	⊙ 4	○	△	⊙ 4	○	△	⊙ 3	●	△	

1) Not all experiments can be flown simultaneously in this mode; requires repeated missions.
2) Some experiments require more than 5 days on orbit.
3) Document does not discuss Mission Mode at the experiment level so can't determine exactly; acceptability is based on acceptability of total FPE in this mode.
4) Notes 1) & 3) apply.
5) Discrepancy: Calls out periodic revisiting by Shuttle during extended on-orbit stay, but requires man for all experiments.
6) Preferred by 1985, with dedicated RAM accommodating all four FPE subgroups.
7) May not be exactly the same experiments as listed under Title.
8) Multiple serial missions required.

Date 6/10/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (TECHNOLOGY)		Mission Mode: Shuttle-Based: Operation: A-5			Operation: A-30			Service: B			Space Station-Based: C			Remarks
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
T-1	Contamination Measurements	◒ 1	⊙ 9	△	◒ 1	⊙	△	◒ 2	○	△	⊙	⊙	△	● Preferred mode
T-1A	Contamination Pkg. #1	△	⊙	◒ 8	△	⊙	◒ 8	△	○	◒ 8	△	⊙	○	⊙ Acceptable mode
T-1B	Contamination Pkg. #2	△	⊙	⊙	△	⊙	⊙	△	○	⊙	△	⊙	○	◒ Partially acceptable mode
T-2	Fluid Management	⊗	⊗	△	⊗	⊙ 10	△	◒ 4	⊙ 10	△	●	⊙	△	⊗ Not acceptable mode
T-2A	Long Term Cryogenic Storage [Fluid Mgt. Pkg. #4]	⊗	⊗	⊗	⊗	⊙ 10	⊗	⊙	⊙ 10	● 7	⊙	⊙	○	○ Mode not mentioned
T-2B	Short Term Cryogenic Storage	△	⊙	△	△	⊙	△	△	○	△	△	⊙	△	△ FPE/Subgroup/ Experiment not identifiable in this document
T-2C	Slush Propellant	○	⊙	△	○	⊙	△	○	○	△	⊙	⊙	△	
T-2D	Non-Cryogenics #1	△	⊙	△	△	⊙	△	△	○	△	△	⊙	△	
T-2E	Non-Cryogenics #2	△	⊙	△	△	⊙	△	△	○	△	△	⊙	△	
T-3	Extravehicular Activity	⊙	⊙	△	⊙	⊙	△	⊗	○	△	⊙	⊙	△	
T-3A	Astronaut Maneuvering Unit (AMU)	⊙	⊙ 12	⊗	⊙	⊙ 12	⊙	⊗	○	⊗	⊙	⊙	⊙	
T-3B	Manned Work Platform (MWP) [Maneuvering W. P.]	⊙	⊙ 12	⊗	⊙	⊙ 12	⊙	⊗	○	⊗	⊙	⊙	⊙	
T-4	Advanced Spacecraft Systems Tests	◒ 5	⊗	△	◒ 5	◒ 11	△	◒ 5	○	△	●	⊙	△	
T-4A	Long Duration Systems Tests (13)	△	⊗	⊗	△	⊗	⊗	△	○	⊙	△	⊙	○	
T-4B	Medium Duration Tests (13)	△	⊗	⊗	△	⊗	⊗	△	○	⊙	△	⊙	○	
T-4C	Short Duration Tests (13)	△	⊗	⊗	△	⊙	⊙	△	○	⊗	△	⊙	○	
T-5	Teleoperations	⊙ 6	⊙	⊗	⊙ 6	⊙	⊙	⊗	○	○	⊙ 6	⊙	○	
T-5A	Initial Flight	⊙	⊙	△	⊙	⊙	△	⊗	○	△	⊙	⊙	△	
T-5B	Functional Manipulation	⊙	⊙ 12	△	⊙	⊙	△	⊗	○	△	⊙	⊙	△	

Remarks:

1) Exp. #3 not compatible with this mode; insufficient duration.
2) Exp. #1, 4, 5 & 7 are not compatible with this mode; manned operation required.
3) Acceptable if have extended work-day. Normal work-day will require 5 to 6 days of experiment operations.
4) Some experiments which require frequent attention of man are not compatible with this mode.
5) Some experiments of the FPE are not compatible with this mode.
6) Each potential operating mode should be evaluated.
7) Not serviced; returned to earth @ 6 months. (cont'd.)

Date 6/21/1971

TABLE 3-1: MISSION MODE ANALYSIS OF FLIGHT EXPERIMENTS

FPE/Subgroup (TECHNOLOGY)		Mission Mode: Shuttle-Based, Operation, A-5			Shuttle-Based, Operation, A-30			Shuttle-Based, Service, B			Space Station-Based, C			Remarks
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
T-5C	Ground Control	⊙	⊙ [12]	△	⊙	⊙	△	⊗	○	△	⊙	⊙	△	● Preferred mode ⊙ Acceptable mode ◒ Partially acceptable mode ⊗ Not acceptable mode ○ Mode not mentioned △ FPE/Subgroup/ Experiment not identifiable in this document
-	Interface Stability, etc. (Fluid Mgt. Pkg. #1)	△	△	⊙	△	△	⊙	△	△	⊗	△	△	○	
-	Propellant Transfer Methods (F. Mgt. Pkg. #2)(B.B. Exp. #6)	○	△	⊙	○	△	⊙	○	△	⊗	○	△	○	
-	Storage & Supply Tank Systems (F. Mgt. Pkg. #3)	△	△	⊙ [3]	△	△	⊙	△	△	⊗	△	△	○	
														8) Surface degradation expt. is not compatible with Mode A; can be flown in Mode B. 9) Increased number of experiments per day. 10) Operating Sequence chart says this should be a free-flyer(e.g.,B), not a Shuttle-sortie. 11) Short duration experiments only. 12) Multiple missions required; serial. 13) Experiments in sub-group are not identified.
														Date 6/21/1971

FPE/Subgroup (LIFE SCIENCES)		Mission Mode: Shuttle-Based: Operation: A-5			Operation: A-30			Service: B			Space Station-Based: C			Remarks
No.	Title	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	Blue Book	Green Book	Task II Report	
LS-1	Medical Research Facility	⊙ 1	○ 11	◒ 7	⊙ 1	○ 11	◒ 9	⊗	○ 11	○	●	○ 11	⊙ 10	● Preferred mode
LS-2	Vertebrate Research Facility	⊗	○ 11	○	◒	○ 11	◒ 9	◒ 2	○ 11	○	●	○ 11	◒ 10	⊙ Acceptable mode
LS-3	Plant Research Facility	◒	○ 11	○	◒	○ 11	◒ 9	◒ 2	○ 11	○	◒	○ 11	◒ 10	◒ Partially acceptable mode
LS-4	Cells and Tissue Research Facility	◒	○ 11	○	◒	○ 11	◒ 9	◒ 2	○ 11	○	●	○ 11	◒ 10	⊗ Not acceptable mode
LS-5	Invertebrate Research Facility	◒ 3	○ 11	○	◒	○ 11	◒ 9	◒ 2	○ 11	○	●	○ 11	◒ 10	○ Mode not mentioned
LS-6	Life Support and Protective Systems	⊗	○ 11	◒ 7	◒ 4	○ 11	◒ 9	⊗	○ 11	○	●	○ 11	⊙ 10	△ FPE/Subgroup/ Experiment not identifiable in this document
LS-7	Manned System Integration	○	○ 11	◒ 7	◒ 5	○ 11	◒ 9	⊗	○ 11	○	●	○ 11	◒ 10	
LS-ST/A	Minimal Medical Research Facility (Station)	△	○	△	△	○	△	△	○	△	△	● 11	△	
LS-ST/B	Life Science Facility (Station)	△	○	△	△	○	△	△	○	△	△	● 11	△	
LS-ST/C	Interim Life Science Facility (Station)	△	○	△	△	○	△	△	○	△	△	● 11	△	
LS-ST/D	Dedicated Life Science Facility (Station) [LS-1 thru LS-7]	△	○	○	△	○	○	△	○	○	△	● 11	● 6	
LS-SH/A	5-Day Life Science Facility (Shuttle) [LS-1, LS-6, LS-7]	△	● 11	● 6	△	⊙ 11	○	△	○	⊗	△	○	○	
LS-SH/B	30-Day Life Science Facility (Shuttle)	△	◒ 11	◒	△	● 11	● 6	△	○	○	△	○	○	
-	Bioresearch Module (Shuttle-sortie) (LS-2 thru LS-5)	△	○	○	△	○	○	△	● 11	● 8	△	○	○	

1) Low value due to short duration.
2) Dependent on length of interval between visits.
3) Expt. #5412 only.
4) None of twelve experiments can be accomodated.
5) Class 2 and 4 can be accomodated; Note 1) applies.
6) Does not include all Blue Book experiments.
7) Included in LS-SH/A.
8) Servicing not required.
9) Included in LS-SH/B.
10) Included in LS-ST/D.
11) Portions of LS-1 thru LS-7 are included in subgroups LS-ST/A thru LS-SH/B and Bioresearch Module; unable to determine which portions of which experiments.

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some of the Subgroups which were described in the other source documents.

This mission mode analysis covered twenty-five (25) Functional Program Elements (FPEs) and sixty-nine (69) Subgroups in seven (7) scientific and technical disciplines. Also included in the analysis were twenty-seven (27) experiment packages that were identifiable neither as FPEs nor Subgroups across the seven disciplines. A large group of experiments, identified in Reference 3 as "Planetary Programs", was excluded from consideration. A summary of the results of this Mission Mode Analysis, at the discipline level and for the total experiment program, is presented in Table 3-2.

3.1.3 Mission Mode/DFETR Study Coverage Analysis

Working from the data in Table 3-1, tables were constructed which represented the concensus of the primary reference documents. This "concensus" is shown in Table 3-3. For those FPEs/Subgroups where agreement did not exist, an attempt was made to determine the more justifiable position. Where this was not possible, the position presented in the Blue Book was selected. This was partly due to the Blue Book's greater depth of description and partly due to its status as the baseline document for the Earth Orbital Research and Application long-range program.

Having determined the extent of acceptability of each of the FPEs and Subgroups for each of the mission modes, identification was made of those which were potential candidates for inclusion in this study. Since Space Station specific activities were beyond the scope of this program, any FPE or Subgroup which must be orbited as Mode C was eliminated from further consideration. Where choices existed (e.g., Modes A-5, A-30, B), one or more of these modes was selected as feasible for coverage in the study. This selection is shown as ☐ superimposed on the acceptability symbols in Table 3-3. Where possible, the selection was made based on the mode most likely to be specified eventually by NASA for the particular FPE or Subgroup. The results of this analysis are shown in summary form in Table 3-4.

3.1.4 Identification of FPEs/Subgroups for Detailed Analysis

The feasible experiments, listed as FPEs and Subgroups in Table 3-3, were evaluated against the selection criteria specified initially (see paragraph 3.1.1). Based on this evaluation of the "most representative cross section" of experiments and on consultation with NASA representatives, some FPEs and Subgroups were deleted from further consideration during this study. The FPEs and Subgroups identified for further detailed analysis are listed in Table 3-5 and depict the mission mode selected in each case. Inspection of Table 3-5 indicates that a representative cross section of mission modes, disciplines, and experiments has been achieved. The resulting candidates for detailed analysis include at least one FPE and/or Subgroup from each of the seven (7) disciplines. In addition, at least two FPE Subgroups were identified for each of the three potential mission modes (i.e., 5-day Shuttle-Sortie [A-5], 30 day Shuttle-Sortie [A-30], and Shuttle Servicing missions [B]). In one case (Comm/Nav, C/N-1), it was decided to analyze a group of experiments in both the Shuttle-Sortie and Servicing modes, to point up differences in skill

TABLE 3-2: MISSION MODE ACCEPTABILITY ANALYSIS SUMMARY[1]

DISCIPLINE	MISSION MODE ACCEPTABILITY LEVELS OF FPEs AND SUBGROUPS	ACCEPTABILITY SYMBOLS	MISSION MODE[2]											
			SHUTTLE-BASED									SPACE STATION - BASED		
			OPERATION						SERVICE					
			A-5			A-30			B			C		
			BLUE BOOK	GREEN BOOK	TASK II REPORT	BLUE BOOK	GREEN BOOK	TASK II REPORT	BLUE BOOK	GREEN BOOK	TASK II REPORT	BLUE BOOK	GREEN BOOK	TASK II REPORT
ASTRONOMY	Preferred mode of operation[3]	●	-	-	2	-	-	2	7	-	10	2	-	2
	Acceptable mode of operation[3]	⊙	4	3	6	3	15	6	4	2	4	7	17	7
	Partially acceptable mode of operation	◐	6	9	4	5	2	4	-	-	-	-	-	-
	Not acceptable mode of operation	⊗	1	5	8	-	-	8	-	-	5	-	-	7
	Mode acceptability not identifiable	○	2	-	4	5	-	4	2	15	5	4	-	8
	FPE/Subgroup not identifiable	△	13	9	2	13	9	2	13	9	2	13	9	2
COMM/NAV	Preferred mode of operation[3]	●	-	-	-	-	-	-	-	-	6	2	-	-
	Acceptable mode of operation[3]	⊙	-	2	2	1	3	3	2	-	-	2	3	1
	Partially acceptable mode of operation	◐	-	-	-	2	-	-	1	-	-	-	-	-
	Not acceptable mode of operation	⊗	4	1	-	1	-	-	1	-	-	-	-	-
	Mode acceptability not identifiable	○	-	-	7	-	-	6	-	3	3	-	-	6
	FPE/Subgroup not identifiable	△	6	7	1	6	7	1	6	7	1	6	7	1
EARTH OBS.	Preferred mode of operation[3]	●	-	-	-	-	-	-	-	-	-	-	-	-
	Acceptable mode of operation[3]	⊙	4	7	3	4	8	6	7	-	-	7	8	-
	Partially acceptable mode of operation	◐	4	-	3	4	-	-	-	-	-	1	-	-
	Not acceptable mode of operation	⊗	-	1	-	-	-	-	-	-	-	-	-	-
	Mode acceptability not identifiable	○	-	-	-	-	-	-	1	8	6	-	-	6
	FPE/Subgroup not identifiable	△	1	1	3	1	1	3	1	1	3	1	1	3
LIFE SCIENCE	Preferred mode of operation[3]	●	-	1	1	-	1	1	-	1	1	7	4	1
	Acceptable mode of operation[3]	⊙	1	-	-	1	1	-	-	-	-	-	-	2
	Partially acceptable mode of operation	◐	3	1	4	6	-	7	4	-	-	-	-	5
	Not acceptable mode of operation	⊗	2	-	-	-	-	-	3	-	1	-	-	-
	Mode acceptability not identifiable	○	1	12	6	-	12	3	-	13	9	-	10	3
	FPE/Subgroup not identifiable	△	7	-	3	7	-	3	7	-	3	7	-	3
MAT. SCIENCE	Preferred mode of operation[3]	●	-	4	-	-	3	4	-	-	-	1	5	-
	Acceptable mode of operation[3]	⊙	-	-	4	13	1	1	13	-	1	12	1	-
	Partially acceptable mode of operation	◐	1	-	1	-	-	-	-	-	-	-	-	-
	Not acceptable mode of operation	⊗	-	1	-	-	-	-	-	-	-	-	-	-
	Mode acceptability not identifiable	○	12	8	-	-	9	-	-	13	4	-	7	5
	FPE/Subgroup not identifiable	△	-	-	8	-	-	8	-	-	8	-	-	8
PHYSICS	Preferred mode of operation[3]	●	-	-	-	-	-	-	-	-	7	2	-	-
	Acceptable mode of operation[3]	⊙	5	13	6	6	17	8	8	4	-	13	19	-
	Partially acceptable mode of operation	◐	6	2	2	5	-	2	5	-	1	1	1	-
	Not acceptable mode of operation	⊗	5	5	1	5	3	-	2	-	8	-	-	-
	Mode acceptability not identifiable	○	-	-	7	-	-	6	-	16	-	-	-	16
	FPE/Subgroup not identifiable	△	10	6	10	10	6	10	10	6	10	10	6	10
TECHNOLOGY	Preferred mode of operation[3]	●	-	-	-	-	-	-	-	-	1	2	-	-
	Acceptable mode of operation[3]	⊙	7	14	4	7	17	8	1	2	3	10	20	2
	Partially acceptable mode of operation	◐	2	-	1	2	1	1	3	-	1	-	-	-
	Not acceptable mode of operation	⊗	2	6	7	2	2	3	7	-	6	-	-	-
	Mode acceptability not identifiable	○	2	-	-	2	-	-	2	18	1	-	-	10
	FPE/Subgroup not identifiable	△	10	3	11	10	3	11	10	3	11	10	3	11
TOTAL	Preferred mode of operation[3]	●	-	5	3	-	4	7	7	1	25	16	9	3
	Acceptable mode of operation[3]	⊙	21	39	25	35	62	32	35	8	8	51	68	12
	Partially acceptable mode of operation	◐	22	12	15	24	3	14	13	-	2	2	1	5
	Not acceptable mode of operation	⊗	14	19	16	8	5	11	13	-	20	-	-	7
	Mode acceptability not identifiable	○	17	20	24	7	21	19	5	86	28	4	17	54
	FPE/Subgroup not identifiable	△	47	26	38	47	26	38	47	26	38	47	26	38

(1) Summary of data presented in Table 3-1, by discipline. Numbers in each column are the number of FPEs, Subgroups, and Experiment Groups having the level of acceptability indicated in the left-hand column, by the source document and for the mission mode indicated by the column headings.

(2) Mission mode as defined in the "Blue Book" (Reference #1). See paragraph 3.1.2 of report.

(3) Acceptable Mode totals do not include Preferred Mode totals.

TABLE 3-3. MISSION MODE ANALYSIS/ DFETR COVERAGE Page 1 of 5

AREA	FPE NO.	TITLE	MISSION MODE: Shuttle-based operation A-5	Shuttle-based operation A-3O	Shuttle-based service B	Space Station C
ASTRONOMY	A-1	X-Ray Stellar Astronomy	⊗	⊗	●	⊙
	A-2	Advanced Stellar Astronomy	⊗	⊗	⊙	●
	A-2A	Intermediate Stellar Telescope	⊗	⊗	⊙ 1	●
	A-3	Advanced Solar Astronomy	⊗	⊗	●	⊙
	A-3A	1.5 M. Photoheliograph, 0.25 M. Spectroheliograph, 0.5 M. X-Ray Telescope	⊗	⊗	● 1	⊙
	A-3B	Solar Coronograph	⊗	⊗	● 1	⊙
	A-3C	Photoheliograph	⊗	◇⊙	◇	⊙
	A-3D	X-Ray Spectroheliograph	⊗	◇⊙	◇	⊙
	A-3E	U.V. Long Wave Spectrometer	⊗	◇⊙	◇	⊙
	A-4	Intermediate Size U.V. Telescopes	⊙	⊙	⊙	⊙
	A-4A	0.9 M. Narrow-Field U.V. Telescopes	⊙ 1	⊙ 1	⊗	⊙
	A-4B	0.3 M. Wide-Field U.V. Telescopes	⊙ 1	⊙ 1	⊗	⊙
	A-4C	Small U.V. Survey Telescopes	● 2	● 2	⊗	⊙
	A-5	High Energy Stellar Astronomy	⊗	⊙	●	⊙
	A-5A	Low Energy X-Ray Telescope Experiment	⊗	⊙	● 1	⊙
	A-5B	High Energy Gamma Ray Measurements	⊗	⊙	● 1	⊙
	A-6	Infrared Astronomy	⊗	⊗	●	⊙
	-	65 c.m. Photoheliograph	● 2	● 2	⊗	◇
	-	OSO-K	◇	◇	● 2	◇
	-	Radio Interferometer Telescope	⊗	⊗	● 2	⊗
	-	Solar Orbital Pair: OSO A+B	⊗	⊗	● 2	⊗
	-	Optical Interferometer	⊗	⊗	● 2	⊗
	-	Kilometer Wave Orbiting Telescope	⊗	⊗	● 2	⊗
	-	Astronomy Explorer	⊗	⊗	● 2	⊗
	-	Radio Astronomy Explorer	⊗	⊗	● 2	⊗
	-	Large Radio Observatory	⊗	⊗	● 2	⊗

REMARKS

⊗ Not feasible or acceptable mode
⊙ Acceptable mode
● Preferred mode

□ Study coverage feasible
⌓ No coverage; out of scope
◇ Definition not adequate for study coverage

1) Study coverage only to the extent covered at the FPE level.
2) Out of scope since not contained in Blue Book FPEs.

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TABLE 3-3. MISSION MODE ANALYSIS/DFETR COVERAGE

AREA	FPE NO.	TITLE	MISSION MODE: Shuttle-based operation A-5	Shuttle-based operation A-30	Shuttle-based service B	Space Station C
PHYSICS	P-1	Space Physics Research Lab	⊗	⊗	⊙	●
	P-1A	Atmospheric and Magnetospheric Science	⊙ 1	⊙	⊙ 2	⊗
	P-1B	Cometary Physics	⊙	⊙	⊙ 2	⊙
	P-1C	Meteoroid Science (Excludes TMMPD)	⊗	⊗	⊙ 2	⊙
	P-1D	Thick Material Meteoroid Penetration	⊗	⊗	⊙ 2	⊙
	P-1E	Small Astronomy Telescopes	⊙	⊙	⊙ 2	⊙
	P-2	Plasma Physics & Environmental Perturbation Lab	⊗	⊗	⊗	⊙
	P-2A	Wake Measurements From Station and Booms	⊗	⊙	⊙	⊙
	P-2B	Wake Measurements From Subsatellites	⊗	⊙	⊗	⊙
	P-2C	Plasma Resonances	⊗	⊙	⊙	⊙
	P-2D	Wave-Particle Interactions	⊗	⊙	⊙	⊙
	P-2E	Electron & Ion Beam Interaction	⊗	⊙	⊙	⊙
	P-3	Cosmic Ray Physics Lab (CRPL)	⊗	⊗	⊙	●
	P-3A	CRPL Without Total Absorption Device	⊗	⊗	◇	⊙
	P-3B	CRPL With 1/2 Total Absorption Device	⊗	⊗	◇	⊙
	P-3C	Plastic/Nuclear Emulsions	⊗	◇	◇	⊙
	P-4	Physics and Chemistry Laboratory	⊙	⊙	⊗	⊙
	P-4A	Airlock and Boom Experiments	⊙ 2	⊙ 2	⊗	⊙
	P-4B	Flame Chemistry & Laser Experiments	⊙ 2	⊙ 2	⊗	⊙
	P-4C	Test Chamber Experiments	◇	◇	⊗	⊙
	-	Low Magnetosphere Satellite	⊗	⊗	● 3	⊗
	-	Mid Magnetosphere Satellite	⊗	⊗	● 3	⊗
	-	High Magnetosphere Satellite	⊗	⊗	● 3	⊗
	-	Plasma Physics Modification Satellite	⊗	⊗	● 3	⊗
	-	Gravity-Relativity Satellites	⊗	⊗	● 3	⊗
	-	Solar System Escape Satellite (Out Of Ecliptic)	⊗	⊗	● 3	⊗

REMARKS

⊗ Not feasible or acceptable mode
⊙ Acceptable mode
● Preferred mode

□ Study coverage feasible
⌓ No coverage; out of scope
◇ Definition not adequate for study coverage

1) Initial survey only.
2) Study coverage only to the extent covered at the FPE level.
3) Out of scope since not contained in Blue Book FPEs.

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TABLE 3-3. MISSION MODE ANALYSIS/ DFETR COVERAGE

AREA	FPE NO.	TITLE	MISSION MODE: Shuttle-based operation A-5	Shuttle-based operation A-30	Shuttle-based service B	Space Station C
EARTH OBSERVATIONS	ES-1	Earth Observations Facility	⊗	⊗	⊗ 1	◎
	ES-1A	Meteorological & Atmospheric Science	⊗	◎	⊙	◎
	ES-1B	Land Use Mapping	⊗	⊗	◎	◎
	ES-1C	Air and Water Pollution	⊗	◎	⊙	◎
	ES-1D	Resource Recognition	⊗	⊗	◎	◎
	ES-1E	Natural Disaster Assessment	⊗	◎	⊙	⊗
	ES-1F	Ocean Resources	⊗	◎	⊙	◎
	ES-1G	Minimum Payload	⊗	◇	◇	◎
	-	Special Research	◇	◇	◇	◇
COMMUNICATIONS/NAVIGATION	C/N-1	Communications/Navigation Research Facility	⊗	⊗	⊗	●
	C/N-1A	Com/Nav Experiments #1 - #7	⊗	◎	⊙	◎
	C/N-1B	Com/Nav Experiments #1 - #7, #12,#13	⊗	⊗	◎	◎
	-	CNRL III-Experiments #1 - #6,#8-#13	⊗	⊗	⊗	●
	-	Medical Network Satellite	◇	◇	● 2	◇
	-	Education Broadcast Satellite	◇	◇	● 2	◇
	-	Follow-On Systems Demonstration S/C	◇	◇	● 2	◇
	-	Applications and Technology Satellite	◇	◇	● 2	◇
	-	Small Applications Technology Satellite	◇	◇	● 2	◇
	-	Cooperative Applications Satellite	◇	◇	● 2	◇

REMARKS

⊗ Not feasible or acceptable mode
⊙ Acceptable mode
● Preferred mode

□ Study coverage feasible
⌓ No coverage; out of scope
◇ Definition not adequate for study coverage

1) This mission mode is not considered as a potential mode of operation for the total FPE in the Blue Book.
2) Out of scope since not contained in Blue Book FPEs.

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TABLE 3-3. MISSION MODE ANALYSIS/DFETR COVERAGE Page 4 of 5

AREA	FPE NO.	TITLE	MISSION MODE: Shuttle-based operation A-5	Shuttle-based operation A-30	Shuttle-based service B	Space Station C	REMARKS
MATERIALS SCIENCE AND MANUFACTURING	MS-1	Materials Science & Manufacturing	⊗	⊙	⊙	●	⊗ Not feasible or acceptable mode ⊙ Acceptable mode ● Preferred mode Study coverage feasible No coverage; out of scope Definition not adequate for study coverage 1) Study coverage only to the extent covered at the FPE level. 2) Out of scope since not contained in Blue Book FPEs. 3) Some indirect coverage of the experiments will be provided by the analyses conducted at the FPE level and for other subgroups. Since these subgroups are defined as Space Station, however, they are treated as out of scope of this study.
	MS-1IA	5 Day Group, Biological	●[1]	⊙[1]	⊙	⊙	
	MS-1IB	5 Day Group, Levitation	●[1]	⊙[1]	⊙	⊙	
	MS-1IC	5 Day Group, Furnace	●[1]	⊙[1]	⊙	⊙	
	MS-1ID	5 Day Group, Small & Low Temperature	●[1]	⊙[1]	⊙	⊙	
	MS-1IIA	30 Day Group, Biological	◇	●[1]	⊙	⊙	
	MS-1IIB	30 Day Group, Levitation	◇	●[1]	⊙	⊙	
	MS-1IIC	30 Day Group, Furnace	◇	●[1]	⊙	⊙	
	MS1IIIA	Space Station Group	◇	⊙[3]	⊙	●	
	MS1IIIB	Space Station Group	◇	⊙[3]	⊙	●	
	MS1IIIC	Space Station Group	◇	⊙[3]	⊙	●	
	MS1IIID	Space Station Group	◇	⊙[3]	⊙	●	
	MS1IIIE	Space Station Group	◇	⊙[3]	⊙	●	
LIFE SCIENCE	LS-1	Medical Research Facility	⊗	⊗	⊗	●	
	LS-2	Vertebrate Research Facility	⊗	⊗	⊗	●	
	LS-3	Plant Research Facility	⊗	⊗	⊗	●	
	LS-4	Cells & Tissue Research Facility	⊗	⊗	⊗	●	
	LS-5	Invertebrate Research Facility	⊗	⊗	⊗	●	
	LS-6	Life Support and Protective Systems	⊗	⊗	⊗	●	
	LS-7	Manned System Integration	⊗	⊗	⊗	●	
	LS-ST/A	Minimal Medical Research Facility	◇	◇	⊗	●	
	LS-ST/B	Life Science Facility, Minimal	◇	◇	⊗	●	
	LS-ST/C	Interim Life Science Facility	◇	◇	⊗	●	
	LS-ST/D	Dedicated Life Science Facility	◇	◇	⊗	●	
	LS-SH/A	5 Day Life Science Facility	●	⊙	⊗	◇	
	LS-SH/B	30 Day Life Science Facility	◇	◆	⊗	◇	
	-	Bioresearch Module	◇	◇	●[2]	◇	

Date 6/14/71

TABLE 3-3. MISSION MODE ANALYSIS/DFETR COVERAGE

AREA	FPE NO.	TITLE	MISSION MODE: Shuttle-based operation A-5	Shuttle-based operation A-30	Shuttle-based service B	Space Station C
TECHNOLOGY	T-1	Contamination Measurements	⊗	⊗	⊗	⊙
	T-1A	Contamination Package #1	⊙	⊙	◇	⊙
	T-1B	Contamination Package #2	⊙	⊙	⊙	⊙
	T-2	Fluid Management	⊗	⊗	⊗	●
	T-2A	Long Term Cryogenic Storage	⊗	⊗	●	⊙
	T-2B	Short Term Cryogenic Storage	◇	◇	◇	⊙
	T-2C	Slush Propellant	⊙	⊙	◇	⊙
	T-2D	Non-Cryogenics #1	◇	◇	◇	⊙
	T-2E	Non-Cryogenics #2	◇	◇	◇	⊙
	T-3	Extravehicular Activity	⊙	⊙	⊗	⊙
	T-3A	Astronaut Maneuvering Unit	⊗	⊙[2]	⊗	⊙
	T-3B	Manned Work Platform	⊗	⊙[2]	⊗	⊙
	T-4	Advanced Spacecraft Systems Tests	⊗	⊗	⊗	●
	T-4A	Long Duration Systems Tests	⊗	⊗	⊙◇	⊙
	T-4B	Medium Duration Tests	⊗	⊗	⊙◇	⊙
	T-4C	Short Duration Tests	⊗	⊙◇	⊗	⊙
	T-5	Teleoperations	⊙	⊙[3]	⊗	⊙
	T-5A	Initial Flight	⊙[2]	⊙[2]	⊗	⊙
	T-5B	Functional Manipulation	⊙[2]	⊙[2]	⊗	⊙
	T-5C	Ground Control	⊙	⊙[2,3]	⊗	⊙
	-	Interface Stability, etc. (F.M. Pkg #1)	⊙[1]	⊙[1]	⊗	◇
	-	Propellant Transfer Methods (F.M. Pkg. #2)	⊙[1]	⊙[1]	⊗	◇
	-	Storage & Supply Tank Systems (F.M. Pkg. #3)	⊗	⊙[1]	⊗	◇

REMARKS

- ⊗ Not feasible or acceptable mode
- ⊙ Acceptable mode
- ● Preferred mode
- □ Study coverage feasible
- ⌐ No coverage; out of scope
- ◇ Definition not adequate for study coverage

1) Out of scope since not contained in Blue Book FPEs.
2) Study coverage only to the extent covered at the FPE level.
3) Analyses limited to activities of orbiting crew.

Date 6/21/71

TABLE 3-4: MISSION MODE/DFETR STUDY FEASIBILITY SUMMARY

DISCIPLINE		No. of FPEs & Subgroups(1)	Mission Mode(3) Acceptability Concensus(2)				DFETR Study coverage feasibility in mode		
			A-5	A-30	B	C	A-5	A-30	B
ASTRONOMY	FPEs	6	1	2	6	6	1	1	5
	Subgroups	11	3	8	5	11	2	2	5
	Total	17	4	10	11	17	3	3	10
PHYSICS	FPEs	4	1	1	2	4	1	1	2
	Subgroups	16	6	12	12	15	2	7	5
	Total	20	7	13	14	19	3	8	7
EARTH OBSERVATIONS	FPEs	1	0	0	0	1	0	0	0
	Subgroups	7	0	5	6	6	0	4	2
	Total	8	0	5	0	7	0	4	2
COMMUNICATIONS/ NAVIGATION	FPEs	1	0	0	0	1	0	0	0
	Subgroups	2	0	1	2	2	0	1	1
	Total	3	0	1	2	3	0	1	1
MATERIALS SCIENCE AND MANUFACTURING	FPEs	1	0	1	1	1	0	1	0
	Subgroups	12	4	12	12	12	4	7	0
	Total	13	4	13	13	13	4	8	0
LIFE SCIENCE	FPEs	7	0	0	0	7	0	0	0
	Subgroups	6	1	2	0	4	1	0	0
	Total	13	1	2	0	11	1	0	0
TECHNOLOGY	FPEs	5	2	2	0	5	0	2	0
	Subgroups	15	9	12	4	15	2	8	1
	Total	20	11	14	4	20	2	10	1
TOTAL	FPEs	25	4	6	9	25	2	5	7
	Subgroups	69	23	52	41	65	11	29	14
	Total	94	27	58	50	90	13	34	21

(1) Does not include "unnumbered" experiment groups from Table 3-3.

(2) Concensus is based on data in Table 3-3.

(3) Mission Mode as defined in "Blue Book". See paragraph 3.1.2.

TABLE 3-5: FPEs/SUBGROUPS SELECTED FOR DETAILED ANALYSIS

No.	FPE/SUBGROUP TITLE	MISSION MODE A-5	A-30	B
A-4	Intermediate Size UV Telescopes	X		
A-4A	0.9 M. Narrow Field UV Telescopes	X		
A-4B	0.3 M. Wide Field UV Telescopes	X		
P-1	Space Physics Research Lab			X
P-1A	Atmospheric and Magnetospheric Sciences			X
P-1B	Cometary Physics			X
P-1C	Meteoroid Science (Excludes TMMPD)			X
P-1D	Thick Material Meteoroid Penetration (TMMPD)			X
P-1E	Small Astronomy Telescopes			X
P-4	Physics and Chemistry Lab	X		
P-4A	Airlock and Boom Experiments	X		
P-4B	Flame Chemistry and Laser Experiments	X		
ES-1	Earth Observations Facility	*	*	*
ES-1A	Meteorological and Atmospheric Sciences		X	
ES-1B	Land Use Mapping			X
ES-1C	Air and Water Pollution		X	
ES-1D	Resource Recognition			X
ES-1E	Natural Disaster Assessment		X	
ES-1F	Ocean Resources		X	
C/N-1	Communication/Navigation Research Laboratory (CNRL)	*	*	*
C/N-1A	Comm/Nav Research Lab I (Experiments #1-#7)		X	
C/N-1B	Comm/Nav Research Lab II (Experiments #1-#7, #12, #13)			X
MS-1	Materials Science and Manufacturing		X	
MS-1IA	5-Day Group - Biological	X		
MS-1IB	5-Day Group - Levitation	X		
MS-1IC	5-Day Group - Furnace	X		
MS-1ID	5-Day Group - Small and Low Temperature	X		
MS-1IIA	30-Day Group - Biological		X	
MS-1IIB	30-Day Group - Levitation		X	
MS-1IIC	30-Day Group - Furnace		X	
LS-1	Medical Research Facility	*	*	*
LS-6	Life Support and Protective Systems	*	*	*
LS-SH/A	5-Day Life Science Facility	X		
T-5	Teleoperations	*	*	*
T-5A	Initial Flight	X		
T-5B	Functional Manipulation	X		

Legend: A-5 - 5 day on-orbit Shuttle Sortie mission
A-30 - 30 day on-orbit Shuttle Sortie mission
B - Extended duration, Shuttle-serviced free flyer
X - FPE/Subgroup to be analyzed for this mission mode
* - FPE analyzed only to the extent required for analysis of subgroups

requirements when orbiting crewmen participate in experiment conduct vs those times when they do not.

It should be noted that although task-skill analyses for the Shuttle-Sortie mission modes were classified into 5-day (A-5) and 30-day (A-30) orbital stay times, this division is important only from the standpoint of FPE/Subgroup selection and mission/payload planning. The tasks to be performed (and the task dependency and task-skill data developed in the analyses) for a particular experiment will not change significantly with respect to mission duration.

3.2 RESULTS OF TASK-SKILLS ANALYSES

This section of the report discusses the task-skill analysis results in terms of the specific skills required of on-orbit personnel to successfully perform the experiment tasks assigned to the experiment crew for those missions covered by the study.

3.2.1 Skill Requirements Identification

An initial thrust and purpose of this study was to determine the kinds of skills that would be required of on-orbit personnel in support of a Research and Application Program. The source documentation reviewed as part of this study includes listings of "crew skills" required for the experiments. These listings have been generally recognized, however, as merely being references to occupational and professional titles that appeared related to the type of experimentation or other activities to be performed. In order to determine the skills that would be required, the activities, functions, and tasks generating the requirements for particular skills were analyzed, and the skills were defined in such a way that they were independent of the connotations and associations of standard occupational and professional titles. Further, the skills were defined at such a level as to be independent of factors such as crew-size, mission duration, experiment grouping within the payload, or facility characteristics. This concept of "Task-Skills", and the method used to determine task-skills, has been described in Section 2.0 of this report.

3.2.2 Flight Experiment Task-Skill Requirements

The approach developed to accomplish skill determination was to convert the brief task statement, or applicable portion thereof, into a task-skill title. A task-skill title is a brief phase which denotes a specific equipment or procedure-oriented crew function. The task-skill is derived from the primary task dependency and the primary crew function, within the context of the experiment and the task. As can be seen in Figure 2-17, some task statements have but one associated task-skill; others, because of the level of complexity or generality of the task-statement, have generated two or more task-skill titles. Each task-skill was given a 4-digit code number to avoid duplication in the task-skill processing. Over 2000 task-skills were identified across the forty-eight (48) experiments subjected to detailed analysis. A complete listing, in numerical order, of the identified task-skill titles is included as Appendix E to this report. The data sheets

(see Figure 2-17) for each of the forty-eight (48) experiments, identifying basic functions, task statements, crew functions, operating environments, dependencies, and the associated task-skills, are compiled into Appendix H in Part 2 of Volume 2 of this report.

3.2.3 Experiment Commonality to FPEs and Subgroups

One of the criteria for selection of flight experiments to include in this study was the need to obtain a representative cross section of experiments proposed for the Earth Orbital Research and Application program. The various mission modes and grouping alternatives suggested in the primary source documents (refs. 1, 2, and 3) presented such a large number of possible options that it was infeasible to subject them to the task-skills analysis as complete and separate groupings. To satisfy the criteria for representativeness, the selected FPEs and Subgroups (identified in Table 3-5) were analyzed at the individual experiment level, keeping the FPE designation for reference purposes. With the task-skill analysis so structured, interested persons can identify task-skills for specific Subgroup experiments by selecting the appropriate Task-Skill Data Sheets (Appendix H) from the applicable FPEs. Table 3-6 provides a cross-reference between the FPEs and experiments subjected to detailed analysis in this study and the Subgroups with which they were identified. Thus, Subgroup ES-1C worksheets are obtained by selecting the Air and Water Pollution experiment worksheets from FPE ES-1. Likewise, Subgroup LS-SH/A worksheets are obtained by combining the appropriate worksheets from FPEs LS-1 and LS-6. (Note: Reference 2 indicates that FPE LS-7 should also be included in Subgroup LS-SH/A. Analysis of LS-7 experiment objectives led to the conclusion, however, that very little valid data could be obtained during a 5-day orbital duration. LS-7 experiments were therefore excluded from LS-SH/A detailed analyses.)

3.2.4 Task-Skill Commonality Across Experiments

In keeping with the objective of representativeness pursued in selecting flight experiments for analysis and the efforts of experiment program definition study contractors to propose groupings of experiments based on their compatibility and commonality, it was of interest in this study to determine the extent of identified task-skill commonality across all experiments subjected to the analysis. An initial effort at determining this commonality was performed and documented (see Appendix F, Task-Skill Location By Experiment). The tables in this appendix provide a means of determining in which experiments, and in how many experiments, each task-skill is required. No statistical analysis has been made of these data, since analysis would serve no useful purpose. Inspection of the tables reveals numerous instances of both single- and multiple-experiment applicability of the listed task-skills. Several task-skills appear quite frequently (e.g., #0038, #0112, #0158, etc.) across different experiments and FPEs. As a general rule, this increased frequency of multiple-FPE applicability indicates that the task-skill is related to an item of widely-used, common equipment, or that the task-skill is relatively unassociated with the type of experiments being performed. In subsequent programs, as task-skills are grouped into occupational skills and then, further, into occupational skill groupings, the commonality between experiments,

subgroups, and FPEs will undoubtedly be much greater.

3.2.5 Conversion of Task-Skills to Occupational Skills

Preliminary trade-off analyses were conducted to arrive at a feasible method for obtaining the needed skills through specification of appropriate occupational skill categories. Factors such as performance effectiveness, acquisition lead time, availability, cost, and the number and criticality of the task-skills encompassed by the occupational skill were considered.

3.2.5.1 Skill Definition Feasibility

The principle objective of this task was to develop a method by which the skill requirement identification at the task level (see Appendices E and H) could be realistically equated to the source of these skills for specific missions, i.e., the scientists, engineers, and technicians who will ultimately be needed to perform the on-orbit activities. An initial premise was that requirements for experiment or mission-specific training should be held to a minimum, and that the experiment crew would be selected from the scientific and technical population to provide the best "fit" to the required task skills. Various methods of job skill and occupational skill definition were evaluated, including those presently in use by the military services. As a result of those evaluations, it was decided that the broadest, most easily applied method was that being utilized by the U.S. Department of Labor. This method is described in detail in the two volume Dictionary of Occupational Titles (ref. 16) issued by the Manpower Administration of the Labor Department. The Dictionary contains titles and definitions of 21,741 separate occupations, plus 13,809 additional, or alternate, titles for those occupations, coded in a 6-digit numerical system. The first 3 digits identify the applicable occupational groups, and the last 3 digits provide a profile of characteristic worker traits, interrelationships, and job complexities. A diagrammatic summary of the classification method is presented in Figure 2-2. It is estimated that the occupational group definitions in the Dictionary will encompass greater than 90% of the required on-orbit research and application skills, and the method will be applicable to all skill requirements.

3.2.5.2 Occupational Skill Definition

It was beyond the scope of the present study to conduct the analyses which would group the identified task-skills (Appendices E and H) into one or more Occupational Skills. A preliminary evaluation was made, however, to ensure that the method selected (paragraph 3.2.5.1 above) would in fact be suitable. It was determined that each identified task-skill would be compared to the occupational title definitions in the Dictionary to arrive at one or more 3-digit Occupational Titles (the listings illustrated at the bottom of Figure 2-2) to which the task-skill was applicable. Each related entry in the occupational titles would be compared to the task-skill (including consideration of task dependencies) to determine the best "fit". This process should result in placing nearly all task-skills in one or more occupational skills. It is anticipated that some task-skills will be so unique to on-orbit activities that a valid placement in an existing Occupational Skill area

TABLE 3-6: Cross Reference Between FPE Experiments and Subgroup Experiments

SUBGROUPS	EXPERIMENTS	1.0 Narrow Field UV Telescope	2.0 Wide Field UV Telescope	1.0 Optical Frequency Demonstration	2.0 Millimeter Wave Communication System and Propagation Demonstration	3.0 Surveillance and Search and Rescue Systems Demonstration	4.0 Satellite Navigation Techniques for Terrestrial Users	5.0 On-Board Laser Ranging	6.0 Autonomous Navigation Systems for Space	7.0 Transmitter Breakdown Tests	12.0 Plasma Propagation Measurements	13.0 Multipath Measurements	1.0 Meteorology and the Atmospheric Sciences	2.0 Land Use Mapping	3.0 Air and Water Pollution	4.0 Resource Recognition and Identification	5.0 Natural Disaster Assessment	6.0 Ocean Resources	1.1 Human Vestibular Function	2.1 Use of LBNP Device to Prevent CV Deconditioning	3.1 Renal Blood Flow	7.1 Blood Volume and Red Cell Life Span	10.1 Exercise Conditioning	5.0 Advanced Two-Gas Atmosphere Supply and Control System	11.0 EVA Suit and Biopack	1.1 Composite Materials	1.2 Metal Foams and Controlled-Density Materials	1.3 Free Casting of Metals	1.4 Liquid Dispersions	2.1 Crystal Growth From Solution	2.2 Single Crystal Growth From Melts	2.3 Crystal Growth From Vapor	2.4 Supercooling and Homogeneous Nucleation	3.1 Preparation of Glasses	3.2 Glass Processing	4.1 Electrophoretic Separation	4.2 Lyophilization	5.1 Convection	1.0 Atmospheric and Magnetospheric Science (Including Aurora)	2.0 Cometary Physics - Gaseous Release of NH_3 and ICN[16]	3.0 Meteoroid Science	4.0 Small Astronomy Telescopes	1.0 Molecular Beam Scattering	2.0 Gas-Surface Interactions	3.0 Flame Chemistry and Reaction Kinetics at Zero "G"	4.0 Chemical Lasers	6.0 Gas Reactions In Space	1.0 Initial Flight Experiment	2.0 Functional Manipulation Experiment
DISCIPLINE		ASTRONOMY		COMMUNICATION/NAVIGATION									EARTH OBSERVATIONS						LIFE SCIENCES							MATERIALS SCIENCE AND MANUFACTURING													PHYSICS									TECHNOLOGY	
FUNCTIONAL PROGRAM ELEMENT		A-4 INTERMEDIATE SIZE UV TELESCOPES		C/N-1 COMMUNICATION/NAVIGATION RESEARCH FACILITY									ES-1 EARTH OBSERVATIONS FACILITY						LS-1 MEDICAL RESEARCH FACILITY					LS-6 LIFE SUPPORT AND PROTECTIVE SYSTEMS		MS-1 MATERIALS SCIENCE AND MANUFACTURING IN SPACE													P-1 SPACE PHYSICS RESEARCH LABORATORY				P-4 PHYSICS AND CHEMISTRY LABORATORY					T-5 TELEOPERATIONS	
EXPERIMENT GROUPS																			1.0 Neurological Function	2.0 Cardiovascular Function	3.0 Renal Function	7.0 Hematological Function	10.0 Clinical/Therapeutic Function			1.0 Metallurgical Processes				2.0 Crystal Growth				3.0 Glass Processes		4.0 Biological Processing		5.0 Physical Properties of Fluids											
A-4A	0.9 M. Narrow Field UV Telescopes	●																																															
A-4B	0.3M. Wide Field UV Telescopes		●																																														
C/N-1A	Comm/Nav Research Lab I			●	●	●	●	●	●	●																																							
C/N-1B	Comm/Nav Research Lab II			●	●	●	●	●	●	●	●	●																																					
ES-1A	Meteorological and Atmospheric Sciences												●																																				
ES-1B	Land Use Mapping													●																																			
ES-1C	Air and Water Pollution														●																																		
ES-1D	Resource Recognition															●																																	
ES-1E	Natural Disaster Assessment																●																																
ES-1F	Ocean Resources																	●																															
LS-SH/A	5-Day Life Sciences Facility																		●	●	●	●	●	●	●																								
MS-1 IA	5-Day (MS) Group - Biological																																			●	●												
MS-1 IB	5-Day (MS) Group - Levitation																													○	○	○	●	●															
MS-1 IC	5-Day (MS) Group - Furnace																									●																							
MS-1 ID	5-Day (MS) Group - Small and Low Temperature																													○								●											
MS-1 IIA	30-Day (MS) Group - Biological																													●	●					●	●	●											
MS-1 IIB	30-Day (MS) Group - Levitation																									●	●		●					●	●														
MS-1 IIC	30-Day (MS) Group - Furnace																											●				●	●																
P-1A	Atmospheric and Magnetospheric Sciences																																						●										
P-1B	Cometary Physics																																							●									
P-1C	Meteoroid Science (Excludes TMMPD)																																								●								
P-1D	Thick Material Meteoroid Penetration																																								●								
P-1E	Small Astronomy Telescopes																																									●							
P-4A	Airlock and Boom Experiments																																										●	●		●	●		
P-4B	Flame Chemistry and Laser Experiments																																												●	●			
T-5A	Initial Flight (T/D)																																															●	
T-5B	Functional Manipulation (T/D)																																																●

Legend: ● Total Applicability
○ Partial Applicability

MATRIX MAN SYSTEMS

Figure 3-1: OCCUPATIONAL SKILL CLASSIFICATION OCCUPATIONAL TITLE SEARCH. (SEARCH FOR RADAR TRANSMITTER OPERATION MONITOR. TASK SKILL NO. 0812)

Alphabetic Title Listings were searched for Radar and Transmitter entries, identifying the listings in this column.	References in the listings in the alphabetic search identified the entries in this column.	It was determined that the task-skill requirement can be met satisfactorily by these occupational titles.	Workers with the occupational titles shown in the third column should have these worker traits.
RADAR ENGINEER (profess. & kin.) see RADIO-DESIGN ENGINEER under RADIO ENGINEER.	RADIO ENGINEER (profess. & kin.) 003.081. Designs and constructs radio, television, and allied equipment and conducts research and experimentation, such as developing tubes, condensers, transmitters, and facsimile equipment.		
	RADIO-DESIGN ENGINEER (profess. & kin.). Designs and coordinates construction and installation of radio, television, and allied equipment, such as radar and frequency-modulation transmitters and receivers, facsimile equipment, ships' receivers, and radiosonde apparatus, performing duties as described under DESIGN ENGINEER. May be designated according to speciality as ANTENNA ENGINEER; RADAR ENGINEER; TELEVISION ENGINEER.		
	RADIO-RESEARCH ENGINEER (profess. & kin.) radio technician. Specializes in technical phases of radio experimentation in various fields, such as radar, blind-flying and landing systems, television-modulation receivers, wave propagation, and effects of weather on radio and television.		
	DESIGN ENGINEER (profess. & kin.) I. proposal engineer. Applies established engineering principles to design and develop mechanical, electrical, electronic, structural, or chemical-processing equipment, products, facilities, or processes and prepares related installation, operation, and maintenance specifications and instructions: Analyzes product or equipment specifications and performance requirements to conceive practical designs which can be produced by existing manufacturing and erection facilities and methods. Consults with customer representatives and personnel in research, production planning, product styling, and other departments to resolve design problems. Analyzes engineering proposals process requirements, and related technical data pertaining to industrial equipment design to determine feasibility and practicability of designing new plant equipment or modifying existing facilities from standpoint of costs, available space, time limitations, company planning, availability of standard equipment, and other technical and economic factors affecting engineering decisions. Provides technical information concerning construction and manufacturing techniques, materials properties, and process advantages and limitations affecting long-range plant and product engineering planning. Compiles and analyzes operational data and directs or performs complex tests and research to establish performance standards for newly designed or modified equipment or products. Studies engineering literature and constantly experiments to keep abreast of engineering progress. Classifications are made according to specialization as AIRCRAFT DESIGNER (aircraft mfg.); ELECTRICAL EQUIPMENT ENGINEER; TOOL ENGINEER.	003.081 RADAR ENGINEER	ENGINEERING RESEARCH AND DESIGN .081 WORK PERFORMED: Work activities in this group primarily involve using and adapting earth substances, properties of matter, natural sources of power, and physical forces to satisfy human needs and desires. Typically, workers are engaged in conducting analyses and experiments of materials and systems by application of known laws and relationships; in conceiving and designing new structures, machines, tools, precision instruments, and other devices; in devising and constructing cooling, heating, lighting, communication, transportation, and other productive systems; in developing the most practical forms of new techniques, processes, and products; in performing structural, functional, and compositional tests of materials and parts; and in preparing technical reports of investigations. WORKER REQUIREMENTS: An occupationally significant combination of: Ability to learn and apply basic engineering principles and methods; good visual acuity with respect to graphic representations; creative talent or imagination; ability to perceive or visualize spatial relationships of plane and solid objects; logical mind; organizational ability; and facility in mathematics. CLUES FOR RELATING APPLICANTS AND REQUIREMENTS: Level of attainment in language and mathematics as indicated by scores on aptitude tests and grades in educational courses. Previous drawings or sketches produced, either freehand or mechanical. Kind of literature read (whether scientifically or technically oriented). Clear, coherent verbal expression. Interest in scientific and technological developments. TRAINING AND METHODS OF ENTRY: A bachelor's degree in engineering is usually the minimum educational requirement for entrance into this field. However, some draftsmen and engineering technicians have extensive experience together with some college-level training may qualify for entry. Most employers require either advanced graduate degrees or significant experience on the basic engineering level for entry into research work. Students interested in engineering should acquire a stron background in mathematics and the physical sciences. RELATED CLASSIFICATIONS Sales Engineering (.151) p. 373 Engineering, Scientific, and Technical Coordination (.168) p. 375 Engineering and Related Work (.187) p. 381 Technical Work, Engineering and Related Fields (.181; .281) p. 379 Industrial Engineering and Related Work (.188; .288) p. 383 Drafting and Related Work (.181; .281) p. 377 QUALIFICATIONS PROFILE GED: 6 SVP: 8 7 Apt: GVN SPQ KFM EC 111 124 333 54 22 23 Int: 7 8 Temp: 4 0 Y Phys. Dem: S L 4 6
RADAR-EQUIPMENT FOREMAN (electronics) see FOREMAN ELECTRONIC ASSEMBLIES	FOREMAN, ELECTRONIC ASSEMBLIES (electronics) 726.130. Supervises and coordinates activities of ELECTRONICS ASSEMBLERS engaged in assembly of electronic equipment, such as radar and sonar units, missile control systems, computers, cables and harnesses, and test equipment: Demonstrates wiring and soldering techniques, using handtools and soldering iron. Analyzes test reports and examines defective equipment to determine cause of equipment malfunctions. Installs dies, using handtools, and adjusts guides and feeding mechanisms to set up wire cutting and stripping machines, and component lead wire forming machines. Turns dial controls to regulate heat of ovens used in soldering, baking, or fusing operations. Performs other duties as described under FOREMAN (any ind.). May be designated according to equipment assembled, as RADAR-EQUIPMENT FOREMAN.		
RADAR MECHANIC (any ind.) see ELECTRONIC MECHANIC.	ELECTRONICS MECHANIC (any ind.) 828.281. communication technician; electronics-equipment mechanic; electronics-maintenance man; electronics specialist; electronics-system mechanic; electronics technician. Repairs electronic equipment, such as computers, industrial controls, radar systems, telemetering and missile control systems, transmitters, antennas, and servomechanisms, following blueprints and manufacturers' specifications, and using handtools and test instruments: Tests faulty equipment and applies knowledge of functional operation of electronic units and systems to diagnose cause of malfunction. Tests electronic components and circuits to locate defects, using instruments, such as oscilloscopes, signal generators, ammeters, and voltmeters. Replaces defective components and wiring and adjusts mechanical parts, using handtools and soldering iron. Alines, adjusts, and calibrates equipment according to specifications. Calibrates testing instruments. Maintains records of repairs, calibrations, and tests. May install equipment in industrial or military establishments and in aircraft and missiles. May operate equipment, such as communication equipment and missile control systems in ground and flight tests and be required to hold license from governmental agency. May be designated according to type of equipment repaired as ELECTRONICS MECHANIC, COMPUTER; RADAR MECHANIC.	828.281 RADAR MECHANIC	CRAFTSMANSHIP AND RELATED WORK .281; .381 WORK PERFORMED: Work activities in this group primarily involve fabricating, processing, inspecting, or repairing materials products, or structural units. Activities in this group are characterized by the emphasis placed upon manual skills, and the application of an organized body of knowledge related to materials, tools, and principles associated with various crafts. WORKER REQUIREMENTS: An occupationally significant combination of: Ability to learn and apply craft techniques, processes, and principles; ability to use independent judgment in planning sequence of operations and in selecting proper tools and materials; ability to assume responsibility for attainment of prescribed qualitative standards; ability to, apply shop mathematics to practical problems, such as computing dimensions and locating reference points from specifications data when laying out work; spatial perception to visualize arrangement and relationships of static or moving parts and assemblies represented in blueprints and diagrams; form perception as required in such activities as inspecting finished work to verify acceptability of surface finish; and some combination of finger and manual dexterity and eye-hand coordination to use handtools and manually controlled power tools when executing work to close tolerances. CLUES FOR RELATING APPLICANTS AND REQUIREMENTS: Hobbies, such as model building or ceramics, which involve hand craftsmanship. Successful completion of high school industrial arts or vocational education courses. Military training and experience in craft-related activities. Preference for work activities offering tangible productive satisfaction. TRAINING AND METHODS OF ENTRY: Apprenticeships providing 2 to 6 years of on-the-job training and trade instruction are generally accepted as the best methods of entry into craft work. Many firms have established on-the-job training programs in which entry workers are placed under the supervision of a journeyman or a foremen and are advanced from elementary tasks to progressively more difficult work as they demonstrate increased proficiency in the skills of the craft. Training received in vocational, trade, or technical schools or the armed services enhance entry and advancement prospects, and may shorten training periods in some crafts. Craftsmen who become throughly familiar with all aspects of their trade through apprenticeship training generally stand the best chance for advancement to supervisory positions. RELATED CLASSIFICATIONS Drafting and Related Work (.181; .281) p.377 Manipulating (.884) p. 322 Cooking and Related Work (.281; .381) p. 310 Precision Working (.781) p. 319 QUALIFICATIONS PROFILE GED: 4 3 SVP: 7 6 8 Apt: GVN SPQ KFM EC 333 234 333 55 244 342 222 4 2 23 3 2 Int: 1 9 0 Temp: 0 Y Phys. Dem: L M H 2 3 4 6
TRANSMITTER ASSEMBLER (elec. equip.) see ELECTRIC-MOTOR-CONTROL ASSEMBLER.	ELECTRIC - MOTOR - CONTROL ASSEMBLER (elec. equip.) 721.381. control-panel assembler; panelboard assembler; Assembles electric-motor units, such as transmitters relays, switches, voltage controls, and starters, and mounts them on panel according to drawings and specifications, using handtools and power tools: Cleans parts, using liquid cleaner, airhose, and cloth. Assembles units, using handtools, pneumatic nut runners, power press, and torque wrenches. Lays out and drills mounting holes and mounts units to panel, using scribers, rule, dividers, drill press, portable power drill, reamer, screwdrivers, and wrenches. Adjusts and slines parts to maintain specified airgap, contact wipe, dimensions, and part movement, using feeler gages and micrometers. Solders electric wire connections and secures spring guides, setscrews, and spring post to units, using soldering iron and acetylene torch. Tests electrical circuits for resistance, current, and potential difference, using instruments, such as ohmmeter, ammeter, and voltmeter. May be designated according to control assembled as TRANSMITTER ASSEMBLER; VOLTAGE-REGULATOR ASSEMBLER. May also operate sheet metal forming machines to fabricate housing for synchro-units and be designated as SYNCHRO-UNIT ASSEMBLER.		
TRANSMITTER ENGINEER (radio & tv broad.) see TRANSMITTER OPERATOR.			
TRANSMITTER OPERATOR (radio & tv broad.) 957.282. transmitter engineer. Operates and maintains radio transmitter to broadcast radio and television programs: Moves switches to cut in power to units and stages of transmitter. Monitors lights on console panel to ascertain that components are operative and that transmitter is ready to emit signal. Turns controls to set transmitter on FM, AM, or TV frequency assigned by Federal Communications Commission. Monitors signal emission and spurious radiations outside of licensed transmission frequency to insure signal is not infringing on frequencies assigned other stations. Notifies broadcast studio when ready to transmit. Observes indicators and adjusts controls to maintain constant sound modulation and insure that transmitted signal is sharp and clear. Maintains log of programs transmitted. Tests and monitors Conelrad (civil-defense radio system) daily. Tests components of malfunctioning transmitter to diagnose trouble, using test equipment, such as oscilloscope, voltmeters, and ammeters. Disassembles and repairs equipment, using handtools (RADIO MECHANIC II (any ind.)). May operate microwave transmitter and receiver to receive or send programs to or from other broadcast stations. Must possess First Class Radio-telephone License issued by Federal Communications Commission.			
TRANSMITTER REPAIRMAN (any ind.) see ELECTRICIAN, RADIO.	ELECTRICIAN, RADIO (any ind.) 825.281. radio-communications mechanician; radio-maintenance repairman; radio mechanic; station-maintenance man; station mechanic; transmitter repairman. Adjusts and repairs high-powered stationary and mobile radio transmitting equipment, using handtools and testing istruments and following wiring diagrams: Adjusts controls and tests frequencies of transmitters, using frequency meter. Listens to radio range station at frequent intervals during broadcasts to detect flaws in transmission and adjusts controls to eliminate flaws in transmission. Operates emergency truck transmitter to insure its readiness for immediate use. Examines equipment and replaces defective condensers, switches, tubes, and transistors. Tests equipment with instruments, such as circuit analyzer, audiometers, and voltmeters. Repairs components of radio transmitting equipment and intercommunication telephone system, using handtools.	RADIO - COMMUNICATIONS - EQUIPMENT - INSTALLER-SERVICEMAN (tel.& tel.). Installs, tests, and repairs stationary and portable radio transmitters, receivers, and two-way radio communications systems, such as are used for ship-to-shore, service trucks, emergency vehicles, and walkie-talkies. Workers who hold Radio Operator's license and send and receive readiotelegraph messages may be designated RADIO-TELEGRAPH OPERATOR-SERVICEMAN. Workers who specialize in serving ship-to-shore communications equipment may be designated MARINE-RADIO INSTALLER-SERVICEMAN.	
TRANSMITTER TESTER (electronics) see TESTER, SYSTEMS.	TESTER, SYSTEMS (electronics) 729.381. electronic systems tester; electronic test technician; master tester; quality control assembly test technician; trouble shooter, computer systems. Tests complete electronic systems, such as radio or television transmitters and computer memory units, using electronic testing equipment and following work orders, test manuals, and schematic and wiring diagrams: Constructs test circuits, using handtools and soldering iron and following schematic diagrams and test specifications. Connects system to be tested to equipment, such as test-circuits, oscilloscope, signal generator, frequency meters, spectrum analyzers, voltmeters, ohmmeters, and milliammeters. Reads dials that indicate electrical characteristics of system, such as output, power, frequency, voltage, current distortion, inductance, and capacitance. Compares dial reading with specifications and records test data or plots test results on graph. Calibrates system to obtain specified dial readings of characteristics, such as frequency or inductance. Traces circuits of defective systems, using knowledge of electronic theory and electronic test equipment, to locate defects, such as wiring errors, open wires, shorts, and faulty components. Examines switches, dials, and other hardware for conformance to specifications. Replaces defective wiring and components, using handtools and soldering iron, or records defects on tag attached to system and returns system to production department for repair. Performs functional tests of system under specified environmental conditions, such as temperature change, vibration, pressure, and humidity to evaluate performance, using devices such as temperature cabinets, shaketest machines, and centrifuges. May verify dimensions of pins, shafts, and other mechanical parts, using calipers, vernier gages, and micrometers. May be designated according to test performed as CALIBRATION TESTER; CONTINUITY TESTER; ELECTRICAL TESTER; TROUBLE SHOOTER, or according to item tested as MEMORY-UNIT TEST TECHNICIAN; TELEVISION-RECEIVER ANALYZER; TRANSMITTER TESTER.	729.381 TRANSMITTER TESTER, RADAR	

would not be possible. When this occurs, a "new" occupational skill title and definition could be developed utilizing the same procedure used by the authors of the Dictionary. These occupational skill requirements would presumably be filled through mission/experiment-specific training of personnel having the basic qualifications.

It was also determined in the course of this evaluation that a significant number of task-skills are unrelated to specialized knowledge or experience, i.e., "anyone can do it". Task-skills of this kind would not be subject to the occupational skill analysis, but would be "assigned" to a crewman on the basis of workload and/or availability, rather than on the basis of skills.

Application of this method in subsequent programs will provide identification of the scientific, engineering, and technical skill requirements for all experiment/mission combinations which can be satisfied through selection of candidates from the general population, by specialized training, or by assignment to available personnel.

3.2.5.3 Example of Occupational Skill Classification

Figure 3-1 presents a graphic illustration of determination of appropriate occupational skill(s) for each identified task-skill. For this example, Task-Skill #0812, Radar Transmitter Operation Monitor, was subjected to a search in the Dictionary under the Occupational Title/Definitions listings. The key words Radar and Transmitter from the occupational titles in the Dictionary were used to find potentially applicable occupational titles. In this example, it was determined that any of three existing occupational titles would satisfy the requirements of the task-skill, based on the definitions. The appropriate worker traits profiles for these titles were then extracted from the Dictionary, providing a complete description.

The actual process of the Occupational Title Search is not as complex as it may appear in Figure 3-1, because only the listings which do fit will be documented. This example has also documented the titles which would normally be discarded as not applicable.

3.2.5.4 Skill Groupings

Using the methods described in the preceding paragraphs, it is expected that an occupational skill will be common to many task-skills. This will provide for the first level of combining, which will be necessary in determining crew skill complements for planned missions. Further combinations are possible through groupings of all occupational titles which have the same 6-digit code number within areas of work. This kind of grouping is illustrated in Figure 3-2 for occupational code #003.081, the code number for the Radar Engineer in the preceding example. Each of the titles in this grouping are interrelated by the basic nature of the work and by the applicable worker traits profile. Suitable specialized training may also be required to satisfactorily fill the needs of the composite task-skills, however. Further combinations are possible, of course, but the interrelationship weakens with each

level of combination, leading to greater requirements for specialized training.

Figure 3-2: Occupational Title Grouping Within Areas of Work.

ENGINEERING RESEARCH & DESIGN@

00, 01 — ARCHITECTURE AND ENGINEERING

003. Electrical Engineering

003.081 ELECTRICAL ENGINEER (profess. & kin.)
ELECTRICAL-EQUIPMENT ENGINEER (profess. & kin.)
ELECTRICAL-PROSPECTING ENGINEER (petrol. production)
SIGNAL ENGINEER (profess. & kin.)
ELECTRICAL-RESEARCH ENGINEER (profess. & kin.)
ELECTRONIC ENGINEER (profess. & kin.)
AUDIO ENGINEER (profess. & kin.)
ELECTRONIC-ORGAN ENGINEER (profess. & kin.)
ILLUMINATING ENGINEER (profess. & kin.)
BUILDING-ILLUMINATING ENGINEER (profess. & kin.)
ILLUMINATING-RESEARCH ENGINEER (profess, & kin.)
INDUSTRIAL-ILLUMINATING ENGINEER (profess. & kin.)
OUTDOOR-ILLUMINATING ENGINEER (profess. & kin.)
POWER-PLANT ENGINEER (light, heat, & power)
* RADIO ENGINEER (profess. & kin.)
RADIO-DESIGN ENGINEER (Profess. & kin.)
RADIO-RESEARCH ENGINEER (profess. & kin.)
ROCKET-ENGINE-TEST ENGINEER (aircraft mfg.)
TELEGRAPH ENGINEER (tel. & tel.)
TELEPHONE ENGINEER (tel. & tel.)
EQUIPMENT ENGINEER (tel. & tel.)
LINE-CONSTRUCTION ENGINEER (tel. & tel.)
TELECOMMUNICATIONS-SERVICE ENGINEER (tel. & tel.)

*Reference Figure 3-1
@Notes area of work

3.2.6 Off Duty/Nonoperational Task Requirements

In parallel with the identification of crew personnel skill requirements directly related to the experimentation, an effort was made to define the task requirements for flight experiment crews which are necessary to their survival, health, and well-being in space (i.e., habitation tasks) but which are normally unrelated to performance of on-orbit experimentation. There is, however, some overlap between these functions and some of the Life Sciences research functions. The task was performed through identification of functions and tasks to be imposed on orbiting mission personnel in order to preserve their health and well-being and to ensure their survival. The source document chosen for this effort was Habitability Guidelines and Criteria (ref. 4) by AiResearch Manufacturing Co. This publication includes detailed function/subfunction lists

relating to habitability and off duty activities, and, although it is oriented primarily to long duration Space Station missions, it encompasses the functions required on Shuttle missions.

The analysis consisted of reviewing the functions/subfunctions in that document and making a determination of which of the functional requirements would be applicable to Shuttle-sortie and Shuttle servicing missions. A listing of those considered applicable was prepared and is contained in Appendix G of this report. A subjective evaluation was made of those functions/subfunctions likely to require some special skill or training of nonastronaut personnel; the results of this evaluation are indicated in the function listing in Appendix G.

No attempt was made to integrate off duty functional requirements with experiment-oriented requirements, since the former are largely independent of the type of research being performed and would be equally applicable to all on-orbit personnel.

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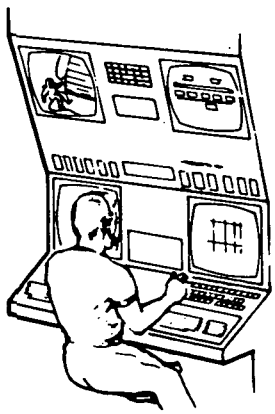
SECTION 4.0

STUDY RESULTS AND CONCLUSIONS



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4.0 STUDY RESULTS AND CONCLUSIONS

4.1 EXPECTED RESULTS

As defined in paragraph 1.1, the Development of Flight Experiment Task Requirements study (NASW-2192) had two primary objectives: (1) to develop a method by which the skills required of crew personnel for support of earth orbital research programs can be identified before system/mission configuration becomes fixed and (2) to apply the new methodology to a representative cross section of planned earth-orbital research flight experiments to develop a data base of task and skill information relative to early Shuttle missions.

4.2 RESULTS OBTAINED

The results obtained in satisfaction of the objectives of the study are discussed in the following paragraphs.

4.2.1 Identification of Required Skills

The analyses conducted during this study have resulted in the identification of 2,044 task-skills that will be required of on-orbit personnel during the setup, conduct, shutdown, and maintenance of 47 experiments in 7 different scientific and technical disciplines. One additional experiment contained no task-skill requirements of on-orbit personnel. While the listing of task-skills (itemized in Appendix E) is preliminary, it is believed to be completely valid with respect to the experiment descriptions on which the study was based and to provide a representative set of skills for each of the encompassed experiments. The task-skills have been identified and documented with respect to primary elements of each of the tasks generating the skill requirement (Appendix H). This was done to facilitate rearrangement, modification, and/or substitution of skills apace with changes in task and/or equipment definition. In addition, the task-skill titles are in most cases self-defining, especially when they are considered together with the associated crew function definition and task dependency identification. Task-skill complexity ranges from intellectually demanding requirements for decision making and pattern recognition (e.g., #0208 and #0330) to physically demanding requirements for motor skills (e.g., #0061) to relatively undemanding requirements for status monitoring (e.g., #0355).

4.2.2 Candidate Personnel Source Identification

The study has succeeded in identifying a method by which the task-skills determined to be applicable to a specific mission/experiment can be related to standardized occupational classifications. This method is described in Section 2.0 of this report, and a graphic illustration of the method is given

in Figure 3-1. When available, mission crewmen can be selected from a candidate population of applicants meeting the standardized classification criteria. Many levels of occupational classification grouping are demonstrated as being feasible. As groupings are made, training requirements will generally increase. These training requirements are highlighted by determining which task-skills are involved in each of the occupational skill classification groupings and by the worker traits profiles which form a part of the classification system.

No attempt was made during this study to specify crew-skill complements for actual experiment missions. Considering the status of payload definition at the time this study was initiated, application of the criteria for selecting/training candidate personnel was not practical. This method is amenable to effective utilization in future NASA programs, however.

4.2.3 Techniques for Identification of Crew Skills

Several new techniques for crew skill identification were developed during the course of this study. The techniques are described in Section 2.0 of this report; unique features of the techniques, qualifying as "New Technology", are discussed in Section 5.0. These latter items include the Task Dependency Reference List, the Task-Skill Requirement Identification technique, and the approach to Occupational Skill Classification.

4.2.4 Task and Crew Skill Data Base Development

Appendix H to this report contains a detailed analysis of the task requirements for each of the 48 experiments included in this study. These data sheets list the task statements, the applicable crew functions, the operating environment in which the task must be performed, the task dependencies, and the appropriate task-skill identification. The data sheets for each experiment are subdivided into the basic functions identified as applicable to the experiment/mission. Each of the factors included on these data sheets has been given a numerical, or alphanumerical, code designation to facilitate automatic data processing in subsequent program efforts. Complete definitions of these factors have been prepared where appropriate, and numerical listings are included in separate tables or appendices.

A secondary objective of this study, self-imposed when NASA payload definition studies began to subdivide and/or combine complete Functional Program Elements (FPEs), was to determine the extent to which crew skill requirements were common to different experiments, both within and across FPEs and Subgroups. The extent to which this objective was realized during the course of the study is documented in Appendix F and Table 3-6; through utilization of the Task-Skill identifications and associated occupational skill classifications, the objective can be more completely realized in subsequent efforts. The tables in Appendix F provide a means of determining in which experiments, and in how many experiments, each task-skill is required. No statistical analysis has been made of these data, but inspection of the tables reveals numerous instances of both single- and multiple-experiment applicability of the listed task-skills. Several task-skills appear

quite frequently (e.g., #0038, #0112, #0158, etc.) across different experiments and FPEs. As a general rule, this increased frequency of multiple-FPE applicability indicates that the task-skill is related to an item of widely-used, common equipment, or that the task-skill is relatively unassociated with the type of experiments being performed. In subsequent programs, as task-skills are grouped into occupational skills, and these into occupational skill groupings, the commonality between experiments, subgroups, and FPEs will undoubtedly be greater.

4.3 SUMMARY OF DFETR ACTIVITIES AND ACHIEVEMENTS

The following items represent the more significant activities and achievements during the performance of this study:

- Development of a comprehensive listing of items and factors upon which successful performance of crew functions in each experiment task depends -- the Task Dependency Reference List.

- Development of a methodology to permit identification of the skills required in the performance of on-orbit experimentation and payload servicing -- the Task-Skill Requirements Identification system.

- Identification of the task-skills required in support of the representative cross section of forty-eight experiments in the Reference Earth Orbital Research and Application Program.

- Development of a methodology to relate task-skill requirements to occupational/professional skill classifications for eventual selection and/or training of required on-orbit experiment personnel.

- Construction of a comprehensive data-base of functions, crew functions, operating environments, task dependencies, and task-skills applicable to a representative cross section of Earth Orbital Research Experiments.

Other activities and achievements include:

- Identification of baseline system/subsystem functions to be performed in conjunction with Shuttle-based or Shuttle-supported orbital research.

- Identification of ten basic functions which deal with man's research and/or servicing activities on-orbit with the Shuttle.

- Development of a crew function taxonomy inclusive of all experiment-related crew operations required during orbital research flights.

- Identification of off duty/nonoperational functions which Shuttle experiment crews will need to perform to promote their health, well-being, safety and survival in space.

- An examination of all experiments comprising the Reference Earth Orbital Research and Applications Program to determine likely candidates for Shuttle-Sortie and Shuttle-supported free flyer missions.

- Identification of crew tasks which are required on-orbit for research and servicing operations for a representative cross section of forty-eight experiments.

- Performance of a comprehensive task analysis of research and servicing crew tasks for representative experiments.

- Identification of the operating environments constraining performance of crew functions in each of the representative experiment tasks.

- Development of an alphanumeric coding system for all elements in the data base and any subsequent additions, to permit efficient, low-cost exercising and application of the data through automatic data processing.

4.4 CONCLUSIONS

The analyses and investigations conducted during the course of this study, and the results obtained, lead to the following conclusions:

a. It is feasible to identify skills required of crew members early in the definition phase of development programs. It is neither necessary nor appropriate to wait for complete definition of equipment, facilities, or objectives prior to initiating a skill requirements analysis.

b. Assessment of skill requirements must be based on an objective evaluation of the activities and tasks which personnel may be required to perform. The assessment should be at as detailed a level as is possible considering the status of program definition. Subjective evaluations which result in instant "skill requirement" specification should be avoided. Too often this practice has been followed in experiment definition studies, and the evaluator has based his skill requirement specification on what the experiment seems to require in the way of personnel support because of the nature of the objectives of a group of experiments. Such an approach is invalid, and it can be misleading to mission planners. When subjective evaluations are used to develop prime crew skill complements, an infinitely large and varied population of skilled personnel must be available at the experiment site to compensate for the planning oversights which inevitably occur.

c. Determination of skill requirements at the elemental level, i.e., Task-Skills, will permit crew complements to be partially structured as a direct output of timeline analysis. This is true since each element in a detailed timeline analysis will have one or more identified task-skills already associated with it. Appropriate use of automatic data processing and sorting methods will provide immediate identification of conflicts between requirements for and availability of specified skills.

d. There appears to be a tendency on the part of experiment definition personnel to overemphasize the requirements for scientific skills at the expense of technical skill requirements. The validity of such emphasis cannot be confirmed until the process of grouping task-skills into occupational skill groups has been completed, and it may simply be an artifact of the skills data compilation. Certainly, much will depend on the finalized configuration and operating philosophy, as well as the maintenance and repair philosophy, for each experiment in each payload.

e. A method is available for utilization of skill requirements information as an aid to experiment and mission planners in making decisions regarding configurations, policy, procedures, and objectives. It is hoped that this method will be widely utilized in concert with other valid decision criteria, since man's flexibility as a system element, while broad, is not limitless.

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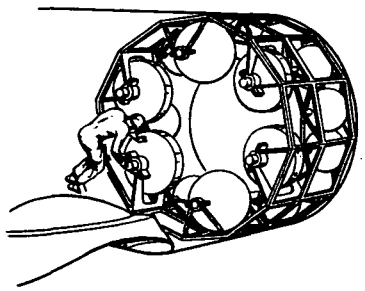
SECTION 5.0

NEW TECHNOLOGY



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5.0 NEW TECHNOLOGY

The study encompassed by this report incorporates several interrelated areas reportable under the New Technology Reporting provisions of Contract NASW-2192. The uniqueness of these areas perhaps lies less in the techniques themselves than in the manner in which they interlock to provide a broad data base of valid personnel skills information, at a point in program definition heretofore not feasible. In this sense, the program as a whole (reported in Sections 2.0 and 3.0) is the "new" technology. More conservatively, however, the areas discussed below are believed to be sufficiently different from existing methods to warrant such consideration.

5.1 TASK DEPENDENCY REFERENCE LIST (TDRL)

The development of the TDRL, discussed in Sections 2.1.3 and 2.2.6, enables the analyst to specify the equipment, environment, conditions, etc. on which task performance depends to whatever level of specificity is supportable by program definition status and/or is needed to achieve the purpose of the analysis. There is no need to determine precise equipment characteristics or obtain serial numbers in order to document the item's relationship to the task. In fact, an equipment item which does not yet exist can be included and can have the same consideration as those items which are well-defined. The TDRL further recognizes and incorporates the less tangible or less visible factors which affect task performance (e.g., an area of knowledge), and it ensures that consideration is not limited to a specific item of hardware. It is expandable, condensable, and flexible, and it is designed to be a tool to aid in the conduct of analyses rather than to be a documentation of what has transpired.

The TDRL was used in this study for developing requirements for crew skills needed in support of earth-orbit research programs. The same approach can easily be used in other types of programs for skills analysis. It can also prove valuable as an analytical tool for preliminary studies in areas such as logistics flow, workstation interface analysis, etc. -- areas which are unrelated or indirectly related to the analysis of skill requirements. Use of the alphanumeric coding system makes the system easy to incorporate into automatic data processing systems.

5.2 TASK-SKILLS

The concept of task-skills, discussed in Sections 2.1 and 2.2.7, has been developed for utilization as an analytical tool in mission/experiment definition. The concept, basically, is to define the skill requirement in terms which reflect a particular function which a man must perform and the particular item (i.e., task dependency) with respect to which the function

must be performed. The task-skill title is a "description" of the primary dependency and the crew function. To illustrate:

A project such as building a house involves many different procedural steps (tasks) and many different kinds of skills. In addition, a multitude of equipment items and areas of knowledge are involved (dependencies). The "skills" involved would normally be derived from many different occupations (e.g., carpenters, plumbers, designers, architects, electricians, etc.). In a consideration of these occupational titles, one recognizes that a multiplicity of "skills" is involved in each, yet there exists a tendency to assign the procedural steps (the tasks) at the occupation level rather than at the skill level due in part to labor unions, professional societies, etc. The actual "skills" involved are at a much lower level. If it were required that the house be built by only two people or with a crew made up of the "wrong" occupations, how would the tasks be assigned? Should a carpenter and an electrician be selected? An architect and a plumber? Obviously, an attempt should be made to make the assignments based on the actual skill requirements of each procedural step. Thus, one would need "Saw Controllers" for cutting lumber, "Shingle Installers" for applying roofing materials, etc. This is precisely the way in which task-skills are used in this study. When the task-skills required to conduct an experiment are known, chances are much improved of successfully assigning the tasks to the appropriate occupational areas and of realizing that some other means will have to be found to accomplish the remaining tasks (e.g., training, having it accomplished elsewhere, automating it, etc.). The more accurate the initial assignments, the less demanding will be these "compensatory" actions.

This study has identified 2,044 task-skills needed to set up, conduct, shutdown and service 48 experiments in orbit. The study further defines the method by which these task-skills can be "assigned" to appropriate occupational skill areas (see paragraphs 2.2.8 and 5.3).

5.3 OCCUPATIONAL SKILL CLASSIFICATION

Development of criteria for eventual use in the selection and/or training of candidate personnel for manning the Shuttle-Sortie experiment missions was a goal of this study. The solution of this objective is described in Sections 2.2.8 and 3.2.5 of the report. This solution makes use of the method, data, and information prepared by the U.S. Department of Labor (for application in civilian industries and state and local government agencies) to identify occupational skill classifications for specialized projects in another branch of the federal government.

Many systems were available for adoption as the method for specifying criteria for personnel selection and/or training. The federal government encompasses several such classification systems, such as the U.S. Army's Military Occupational Specialty (MOS) system, the U.S. Air Force's system of Air Force Specialty Codes (AFSCs), or the U.S. Navy's Naval Enlisted Classification (NEC) system. The most far-reaching of all, of course, is the GS system used in all civilian branches of the federal government. Each of these systems incorporates detailed and meaningful job descriptions,

qualifications for the position, and training and educational requirements for moving from one position to another. Each system has many merits. The option was also available for "reinventing the wheel" and developing a completely new system. The latter solution was quickly discarded as impractical in view of the limited resources available to support this study.

Foremost of the factors which led to the decision to use the Labor Department's Occupational Classification system was the fact that it is based on "civilian" job qualifications and descriptions. NASA has on many occasions expressed its intent to select (to the greatest extent possible) qualified civilians from industry and the universities to support the earth orbit research and application program. In view of this, and the detailed classification system comprising the Dictionary of Occupational Titles, the Labor Department's system is the logical choice. The manner in which the system relates to task-skill identification and eventual specification of orbital research crew makeup is described in Sections 2.2 and 3.2.5.

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APPENDIX A

BIBLIOGRAPHY OF
REFERENCE PUBLICATIONS

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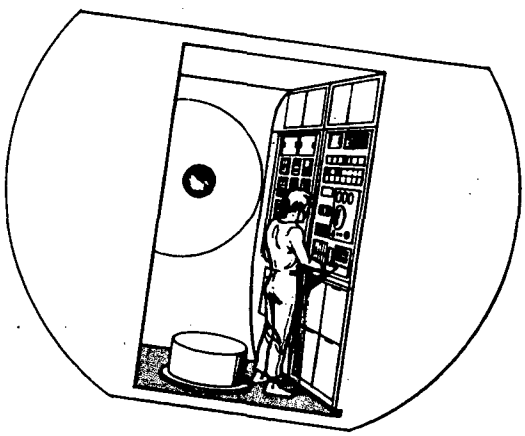
APPENDIX B

CREW FUNCTIONS
DEFINITIONS



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APPENDIX B

DEFINITIONS OF FLIGHT EXPERIMENT CREW FUNCTIONS

01. STATUS MONITORING - Maintain cognizance of progress of events and operations by reviewing status indicators. Indicators may be visual, aural, etc. MONITORING requires use of intervening equipment between subject (object) system and monitor. It is either automatic or semiautomatic, never manual. This function is system or equipment oriented, and displays require little or no interpretation, being primarily go/ no go, or "within pre-established limits", or direct readouts of quantitative data, e.g., pressure, temperature, elapsed time, etc.

02. OBSERVATION - Attentiveness to status of, or changes in status of, the object or subject of experimentation. OBSERVATION may be indirect through the use of supporting equipment and instruments. This function is experiment oriented, and the observed parameters may be either quantitative or qualitative in nature. Interpretation of the observed parameters will generally be required in light of the nature of the experiment and the object or subject being observed.

03. INSPECTION - Performance of critical visual examination of operating equipment units for a specific condition, in order to determine whether the equipment should continue in operation or use, or whether repair or replacement is required. Also included will be the examination of parts and materials for evidence of wear, deterioration, or defects. This function is equipment and facility oriented and is primarily related to maintenance activities.

04. PATTERN RECOGNITION - Classification of phenomena or events based on current data. The classification rules will be either deterministic or probabilistic but will be unknown prior to recognition. This function is experiment oriented, and the OBSERVATION function is generally a prerequisite. The function may be thought of as the integration of observations, ambient conditions, and other factors to form a relevant conclusion.

05. COMMUNICATION - Transmittal of pertinent information regarding any aspect of the experiment or equipment to other locations. COMMUNICATION may be direct (through voice, touch, or signal) or may be indirect through the use of electronic equipment.

06. DATA PROCESSING - Accepting data, information or experiment related material in one form, and, through mental, manual, or machine manipulations, transforming it into another form. This function is common to all aspects of Experiment Module operation and maintenance, although emphasis will be given to areas related to experiments. Examples may be tasks such as film developing, transforming CRT-displayed data to hard-copy, making straight forward arithmetic calculations, and entering data into the computer to be run against a pre-established program.

07. FAULT ISOLATION - Determination of the type, cause and location of a failure or malfunction which has occurred in experiment equipment or in experiment support equipment. In many instances, the location of the failed item may be provided by the status monitoring instrumentation or by Built-In Test Equipment (BITE). In other cases, some level of equipment disassembly may be required to locate the malfunctioning part to the lowest replaceable module.

08./09. CALIBRATION/ALIGNMENT - CALIBRATION is the determination of accuracy, deviation from norm, or variation, by special measurement or by comparison with a standard. ALIGNMENT is the adjustment of controls (in some cases direct movement of equipment units) so as to match visual indicators such as pointers, wave forms, and lines of sight, or to alter aural signals until coincidence is achieved. These two functions are very similar, and are therefore grouped together. In CALIBRATION, the objective is to determine the amount of difference; in ALIGNMENT, the objective is to eliminate the difference even though the amount of the difference may be unknown. In some cases, the function will be largely automatic, so the crewman's task is primarily one of initiating the sequence when it is needed and monitoring its progress. In other cases, the function may be completely automatic and will require no crew attention at all.

10. CONTROL - Active provision of inputs to a system, equipment, or operation, to insure that it remains within the limits selected by the controller and/or follows a definite sequence of operations determined by the controller. CONTROL may be continuous, sequential, or even intermittent, and it requires that inputs be made to the system or equipment while it is operating or to the operation while it is in progress. The primary information on which CONTROL is based is feedback from the system, equipment, or operation to the controller, and the relationship of that feedback information to what is desired by the controller.

11./12. EVALUATION/ANALYSIS - Careful examination and interpretation of test or experiment results, or of the characteristics of the subject/object of a test or experiment, to determine the conditions represented by those results and/or characteriestics. EVALUATION generally involves a purely mental process wherein the results of characteristics are weighed against the evaluator's prior knowledge of what is expected. ANALYSIS generally goes a step further and may require that data be transformed, calculations be made, or results or characteristics be quantitatively and/or qualitatively matched against some pre-established standard.

13. DECISION MAKING - Selection of a course of action based on a probabilistic estimate on which of several courses is most likely to result in success. A simple "decision" to proceed as planned involves DECISION MAKING only if new information has created some reasonable alternative courses of action. One or more other functions, such as STATUS MONITORING, OBSERVATION, PATTERN RECOGNITION, and EVALUATION/ANALYSIS, will almost always precede this function.

14. TEST AND CHECKOUT - Performance of operational readiness testing on components, equipment, and systems to determine that they are operating, or will operate, within acceptable limits. This function will almost always include the use of some specialized instrumentation to enable the crewman to more readily ascertain the state of readiness of the equipment. The process may, in fact, be almost totally automated, requiring only that the TEST AND CHECKOUT sequence be initiated by the crewman. This function is very similar to FAULT ISOLATION except that no failure is known to have occurred when it is initiated. The same testing equipment/instrumentation will generally be used for both functions.

15./16. ACTUATION/DEACTUATION - Initiating/stopping a process or operation by the fairly basic means of turning power on/off, pushing start/stop buttons, etc. Only when the process is time-critical does the function become other than routine. In many cases, it will be preceded by functions such as PATTERN RECOGNITION, DECISION MAKING, etc. In other cases, it will be accomplished in accordance with a pre-established program of events. This function is basically a motor task.

17./18. STOW/UNSTOW - STOW is the process of packaging an item of equipment, test sample, etc., placing it in a previously designated storage location, and securing it against normal, expected outside influences, as well as preventing the item from interfering with other activities. UNSTOW is, of course, the opposite of STOW. The UNSTOW function will generally occur during experiment setup; the STOW function will generally occur following experiment conduct, during experiment shutdown. The function may be interrupted by other functions such as ASSEMBLY/DISASSEMBLY, TRANSLOCATION, and INSPECTION.

19. CLEAN/DECONTAMINATE - Removal of dirt, grime, dust, or other contaminants (including biological). This is a very broad function which may range from simply wiping off an object (e.g., optics) with a soft, clean cloth, to subjecting experiment equipment to an ultrasonic "bath". The function may follow the INSPECTION function which determines that cleaning is necessary or it may be a preprogrammed event, and it may or may not be followed by INSPECTION. The complexity of the function will vary with the nature of the item being cleaned, the contaminant being removed, the method of cleaning, and the conditions under which it is being performed (e.g., EVA).

20./21. ASSEMBLY/DISASSEMBLY - ASSEMBLY is the performance of the various manual operations of fitting and securing together two or more equipment items in order to complete a subunitary or unitary assembly. DISASSEMBLY is the reverse of ASSEMBLY. The function may be performed as a maintenance activity (during repair, replacement, cleaning, etc.) or as an experiment-oriented activity (during experiment set-up or shutdown). The function is primarily motor, but will in many cases require detailed knowledge of the equipment to be assembled or disassembled.

22. TRANSLOCATION - Movement of a mass (e.g., cargo, film magazine, equipment unit, or test sample) from one point to another point. Complexity is determined by factors such as origin, destination, available routes, size, mass and translocation assistance. The function may be semiautomatic or manual, and it may be

within a given environment or between different types of environments. When the function is manual, it may or may not include crewman LOCOMOTION.

23./24. DEPLOYMENT/RETRIEVAL - DEPLOYMENT is positioning an item of experiment equipment in its operational location and configuration and securing it in that position and configuration. RETRIEVAL is the reverse process. If movement of the item of equipment from point to point is required, TRANSLOCATION is a necessary, integral function. DEPLOYMENT/RETRIEVAL may be manual, semi-automatic or automatic.

25. LOCOMOTION - Movement of the body from one point to another point at some finite distance from the first. LOCOMOTION may be completed unaided (e.g., walking, floating, jumping, "swimming") or partially aided (e.g., self-propulsion devices, carriers, moving treadways, etc.). LOCOMOTION refers to the movement of the crewman; it does not refer to an item of equipment, a test specimen, or cargo. LOCOMOTION may be involved in TRANSLOCATION of such an item, however.

26./27. REMOVAL/REPLACEMENT - REMOVAL is the performance of the various manual operations necessary to take an equipment item, test specimen, or module out of the next larger assembly or system. REPLACEMENT is the opposite of REMOVAL, and further includes initial "placement" or installation of the item in the larger assembly. A distinction must be made between REMOVAL/REPLACEMENT and ASSEMBLY/DISASSEMBLY. In REMOVAL/REPLACEMENT, the major assembly remains basically intact, although it may or may not be operable with the equipment unit removed. In ASSEMBLY/DISASSEMBLY, the major assembly or system does not remain intact, and, when disassembled, it is always inoperable.

28. REPAIR - The act of restoring damaged, worn-out, or malfunctioning equipment to a serviceable, usable, or operable condition. REPAIR may include both ASSEMBLY/DISASSEMBLY and REMOVAL/REPLACEMENT functions, and it will usually require the use of special tools, equipment and materials for successful accomplishment of the function. The FAULT ISOLATION function will be a frequent prerequisite.

29. UNKNOWN - The nature of the crew functions cannot be determined due to insufficient information and/or detail.

30. SUBJECT FOR EXPERIMENT - A function in which one or more crewmen are evaluated as to their performance, response to stimuli, physiological state, etc. They represent "test specimens", experiment variables, etc., and, in such capacity, they may be called upon to perform any of the other crew functions which have been identified. In this analysis, crew functions performed as a SUBJECT FOR EXPERIMENT will always be shown in addition to the crew functions performed as experimenters, experiment controllers, etc.

31. OCCUPY - This is a specialized crew function wherein the crewman must be located in or on a particular item of equipment or a specific location with respect to the equipment. OCCUPY includes sit, stand, lie, etc. It is a passive function in that no particular activity is expected.

32. WEAR - This is a specialized crew function, similar to number 31, where the crewman is clothed in a particular kind of garment, or is bearing certain items of equipment that are strapped or otherwise fastened to his body (e.g., helmets, harnesses, etc.). Other crew functions are generally performed at the same time.

33. RECEIVE - A specialized crew function, wherein the crewman is the recipient of some experiment-related substance or material. As used in this study, the function includes ingestion of foodstuff or medication, receiving hypodermic injections, etc.

34. DONATE - A specialized crew function, the reverse of RECEIVE. The crewman gives up material for the purpose of the experiment. Such activities include the taking of blood, urine and fecal material sampling, and provision of salvia for tests.

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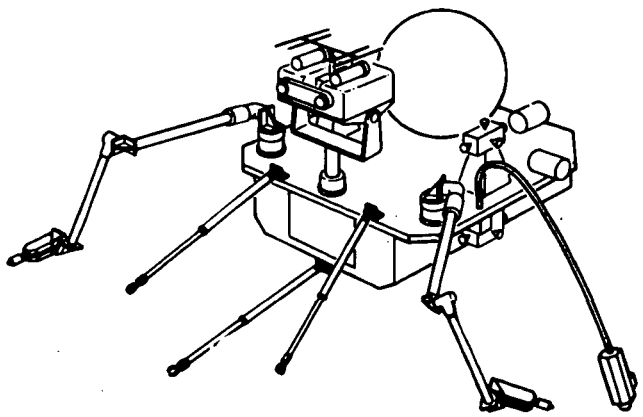
DEFINITIONS OF SYSTEM FUNCTIONS/SUBFUNCTIONS



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APPENDIX C

DEFINITIONS OF SYSTEM FUNCTIONS/SUBFUNCTIONS

- SYSTEM FUNCTIONS -

F-FUNCTIONS: These are Shuttle flight functions and are basically independent of the nature of the R&A mission, except as they affect orbit selection, etc. All operating functions are the responsibility of the flight crew. The experiment module (EM) crew, if present, will be impacted in their role as passengers and will have habitability tasks to perform.

R-FUNCTIONS: These functions are those which are directly related to the R&A mission, and these will show wide variation depending on the FPE or experiments being flown. All functions are the responsibility of the EM crew, or, in certain instances, the flight crew*. The functions have in common the performance of experiments in orbit and the activities which must take place preceding and subsequent to that performance.

S-FUNCTIONS: These functions are servicing functions related to the R&A missions, and they may be the responsibility of the EM crew or the flight crew depending on type of mission. These functions will be included in all missions except Mission Mode A, Type 2. The servicing functions deal with maintenance, repair, and replacement of experiment equipment.

H-FUNCTIONS: These functions are habitability functions and are basically independent of the nature of the R&A mission. The H-functions are superimposed over all other functions to ensure the safety, comfort, and survival of the crew members. All crew members will be involved in H-functions.

D-FUNCTIONS: These functions are the responsibility of the ground control team or a Space Station team, and deal with automatic or remotely controlled conduct of experiments. It is possible that an Orbiter flight crew may act in the capacity of remotely controlling the experiments in Mission Mode A, Type 2, but no information is presently available pertaining to this possibility.

Summary: Function descriptions for R- and S-functions follow, and the DFETR study will be based on further breakdown and definition of those functions. The habitability implications of the missions (H-functions) are included in Appendix G. Operating aspects of F- and D-functions are not included.

- SUBFUNCTIONS -

R.1 DEPLOY RAM

This function may be the responsibility of the EM crew*, the flight crew,

*On servicing missions or automatic missions, there may be no separate EM crew, in which case the flight crew has this responsibility.

or both together. Deploying the RAM will be primarily automatic and will be initiated from the orbiter command area. Crewmen will monitor, through use of visual observations (instruments, TV, etc.) the progress of the deployment. In most cases, this will consist of opening the payload hatch doors, extending the RAM outside the orbiter envelope, and bringing it to the appropriate attitude for either experiment conduct or detachment. In some cases, the RAM may stay within the payload bay, so that only opening of the payload hatch doors will be involved.

Manual override of the automatically controlled process will be possible, in case problems of deployment threaten the integrity of the spacecraft.

Major subfunctions are:

- Secure spacecraft (orbiter, etc.)
- Self-test deployment systems
- Open payload hatch
- Initiate deployment sequence
- Monitor deployment progress
- Inhibit deployment sequence (in case of fault)

Some RAM-specific variations may exist, but crew tasks should be very similar for all missions. The shirtsleeve environment is envisioned for all currently anticipated missions.

R.2 TRANSFER CREW TO RAM/RSM

This function is the responsibility of the EM crew*, with the flight crew monitoring progress and providing some general support. The transfer will be manual in all envisioned missions and will be comprised of the EM crewmen opening the airlock hatch to the RAM or RSM, and passing themselves and their belongings through the passageway into the RAM/RSM. Some configurations may require a RAM pressurization sequence, prior to entry. Others may require the translation to be made in full pressure suits (e.g., if RAM is not habitable).

On Shuttle-sortie missions there should be very little cargo transfer involved, limited primarily to the personal belongings which the EM crewmen carry with them in the Orbiter. (All experiment equipment will normally be stowed in the RAM or RSM before launch).

On servicing missions, cargo transfer requirements will be much higher, since fresh logistics supplies, spare parts, tools, and perhaps new/additional instruments will be transferred.

Major subfunctions:

- Pressurize RAM (if required)
- Self-test RAM/RSM habitability

*On servicing missions, there may in some cases be no separate EM crew, in which case the members of the flight crew have this responsibility.

- Open airlock(s)
- Transport self and cargo through passageway
- Secure airlock(s)

R.3 SET UP EXPERIMENTS

This function is the responsibility of the EM crew. Depending on the nature of the FPE and the extent to which experiment equipment and instrumentation has been secured/stowed for launch and ascent, this function may be either very simple or very complex. The simplest mission will be that where all equipment is prelocated in its operating position or is deployed automatically. A self-test and calibration sequence will probably be initiated (this could be done from the orbiter or ground, not requiring the EM crew in the RAM), and if everything is in order, no further EM crew tasks exist in this function.

At the other extreme, in those experiments where man is a direct participant (either as controller, subject, or both), the EM crew will determine which experiments are to be conducted, select appropriate equipment, assemble the experiment equipment arrays, deploy them as appropriate, and test and checkout for proper operation. The process may be repeated many times, depending on duration of the flight, experiment results, and other similar factors.

The environment in which this function is performed may likewise show wide variation. In most cases, this should be a shirtsleeve environment; in some cases it will be IVA, requiring full pressure suits; in a few cases (e.g., where instruments must be mounted on the exterior surface of the RAM), EVA may be required. Details regarding IVA and EVA requirements are quite limited, but these modes must be anticipated.

Major subfunctions are:

- Determine experiments to be run (A/R)
- Select experiment equipment (A/R)
- Assemble experiment equipment
- Deploy experiment equipment
- Test, checkout, calibrate, align, etc., experiment equipment
- Initiate experiments

R.4 CONDUCT EXPERIMENTS

This function is the responsibility of the EM crew, except in those cases where experiment conduct is controlled automatically or remotely from ground or Space Station (see function D.1).

The nature of the function to the crew will vary widely, from simple monitoring requirements (where actual performance is almost completely automatic), to step-by-step participation by both crew and instruments, to those experiments where crew members are both experimenters and subjects. Crew skills must reflect the nature of the equipment being utilized, the

subject of the experimentation, and the type of data being collected.

Major subfunctions:

- Control experiment equipment
- Observe object/subject of experiment
- Monitor experiment progress
- Evaluate experiment results

R.5 SHUTDOWN EXPERIMENTS

This function will normally be the responsibility of the EM crew. Exceptions would occur when the experiments are to be totally automated, when controlled remotely from ground or Space Station, or when the mission is to be of the servicing type with this function being designated to the orbiter flight crew.

The function will be performed at the completion of a sequence of experiments, at the completion of the orbital mission, or for purposes of performing scheduled or unscheduled maintenance. The nature of the function is typically the reverse of B.3 (SET UP EXPERIMENTS), although there should be little requirement for judgmental decisions. In addition, depending on the reason for shutdown, the function may consist only of temporary deactivation or may require complete shutdown, packaging, and stowage of equipment and data. The skills required will be largely mechanical skills.

Major subfunctions are:

- Determine experiments to be shutdown (A/R)
- Deactivate operating equipment
- Disassemble equipment arrays
- Retrieve data held by equipment
- Package equipment for stowing
- Stow equipment

R.6 TRANSFER CREW TO ORBITER

This function is the responsibility of the EM crew, or in the case of servicing missions, possibly the flight crew. (See R.2 TRANSFER CREW TO RAM). The same constraints and conditions apply here as in R.2, and the functional sequence should be reversed in most cases.

See R.2 for major subfunctions.

R.7 STOW RAM

This function may be the responsibility of the EM crew, the flight crew, or both, depending on the type of mission. In any case, it will be primarily automatic. All constraints, conditions, and subfunctions should be as in R.1 (DEPLOY RAM), but reversed.

Normally, this function will be performed only when the mission is completed and the RAM/Orbiter combination is to be returned to earth. It may, in addition, be required when the mission cannot be completed due to equipment malfunction, personnel illness, etc., and the deficiency cannot be corrected in orbit.

R.8 DETACH RAM

This function will be the responsibility of the EM crew, the flight crew, or both. Only two types of missions requiring this function are foreseen: (1) after initial setup of a long-duration, automated, free flying RAM, and (2) after completion of periodic servicing in orbit of the automated, free flying RAM. A third reason is also possible, e.g., when, because of a malfunction, the RAM cannot be properly stowed in the Orbiter for return to earth. In such a case, the EM crew (if occupying the RAM) would return to the Orbiter, and the RAM would be left in orbit.

The function will consist primarily of assuring that all appropriate spacecraft and RAM systems are secure and operating as intended, and then performing undocking. Actual undocking will probably be mechanical unlatching of the retaining mechanisms, followed either by passive separation (drifting apart) of the Orbiter and RAM or by active separation wherein either the RAM or Orbiter uses propulsive power to achieve separation.

Major subfunctions are:

- Secure Orbiter-RAM interfaces
- Initiate undocking

All remaining subfunctions are expected to be totally flight-crew functions, although the EM crew (if present) may provide some general support. It is possible that EM crew members may remotely "fly" the RAM away from the Orbiter, if the RAM has an active propulsion/separation system.

See also R.9 (RETRIEVE RAM)

R.9 RETRIEVE RAM

This function will in all likelihood be primarily the responsibility of the flight crew, although the EM crew may provide some support, and in the case of a self-propelled, free flying RAM, may actually fly the RAM to the orbiter through remote control, to the initiation of docking.

Major subfunctions are as in R.8 (DETACH RAM), but in reverse. Constraints and conditions are the same.

S.1 PERFORM SCHEDULED MAINTENANCE

This function will be the responsibility of the EM crew or the flight crew, depending on the specific mission being serviced. This function may occur as part of periodic servicing of an automated, free flyer, or it may

be part of the schedule of events to be performed during a manned R&A mission.

The functions will include items such as cleaning, lubricating, realignment, recalibration, testing, and inspection of experiment equipment, as well as scheduled replacement of equipment components and modules. In most cases the functions will be performed in a shirtsleeve environment, although it is possible that some elements may require IVA or EVA.

Crew skills required are envisioned as being primarily technical, rather than scientific, and in many cases no special skills will be required.

S.2 PERFORM UNSCHEDULED MAINTENANCE

This function is very similar to S.1, with the additional functional requirements of trouble-shooting, malfunction analysis, and equipment repair. Unscheduled maintenance may be required at any time, as indicated by the identification of a malfunction, fault, or abnormal operation of equipment. Functional performance may be by either the EM crew, the flight crew, or both, depending on the problem and the type of mission.

The environment for performance of this function may be shirtsleeve, IVA or EVA. Crew Skill requirements should be similar to those in Function S.1.

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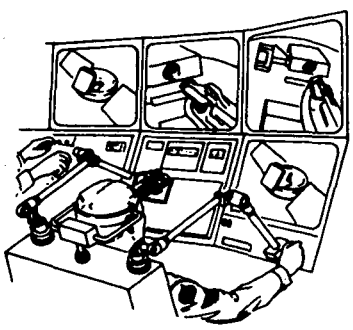
TASK DEPENDENCY
REFERENCE LIST -
NUMERICAL LISTING



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APPENDIX D

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

EXPLANATION OF TASK DEPENDENCY REFERENCE LIST

During the analysis of crew functions (Section 2.2.4), a determination was made of the major types of factors upon which successful task performance depended. These major factors were categorized as:

1. System and Facilities
2. Experiment Equipment and Materials
3. Object or Area Under Investigation
4. Support Equipment
5. Environment

The five major categories of task dependencies were divided into subcategories based on major functional differences. Then, as each new item of equipment or object of investigation was identified, it was placed in one of the subcategories. Each item was given an alphanumeric code designation to permit ready recognition of the category and subcategory to which it belonged and to promote rapid data retrieval. In addition to these three levels, a fourth level was assigned, where appropriate, to identify specific equipment items, or characteristics. For example, within the major category of "Experiment Equipment" (#2), the second level might be "Observation Equipment" (#2.A), and the third level of dependency could be "Spectrometers" (#2.A.03). The fourth level, then, would be various specific types of spectrometers and each type would be assigned a dash number, e.g. "Ion Mass Spectrometer" (#2.A.03-6). An illustration of the structure and use of the Task Dependency Reference System is shown in the following diagram. The complete Task Dependency Reference List comprises the remainder of this appendix to the report.

Example of Task Dependency Reference List (TDRL)

LEVEL #1 / LEVEL #2	LEVEL #3	LEVEL #4	TDR CODE
1. System and Facilities			
A. RAM			
B. Orbiter			
C. Booster			
D. Ground Control			
E. Satellite			
F. Space Station			
2. Experiment Materials and Equipment			
A. Observation Equipment	01 Telescopes		
	02 Photometers		
	03 Spectrometers	-1 Michelson Infrared Interferometer Spectrometer	2.A.03-1
		-2 75 cm Scanning Grating Spectrometer	2.A.03-2
		-3 Grazing Incidence EVA Spectrometer	2.A.03-3
		-4 Open Source Mass Spectrometer	2.A.03-4
		-5 Closed Source Mass Spectrometer	2.A.03-5
		-6 Ion Mass Spectrometer	2.A.03-6
		-7 EVA Spectrometer (Type Unspecified)	2.A.03-7
		-8 Scanning Spectrometer (Type Unspecified)	2.A.03-8
		-9 Infrared (I.R.) Spectrometer (Type Unspecified)	2.A.03-9
		-10 Ultraviolet (U.V.) Spectrometer (Type Unspecified)	2.A.03-10
		-11 Mass Scanning Spectrometer	2.A.03-11
		-12 Mass Spectrometer (Type Unspecified)	2.A.03-12
		-13 Multispectral Spectrometer	2.A.03-13
		-14 Aeronomy Spectrometer	2.A.03-14
		-15 Absorption Spectrometer	2.A.03-15
	04 Television		
	05 Image Tube Optical Systems		
	06 Gas Temperature Chambers		
	07 Ion Traps		
	08 Probes		
	09 Magnetometers		
	10 VLF Sensors		
	11 Particle and Meteoroid Sensors/Analyzers		
	12 Transmitter/Receivers/Antennas		
	13 Molecular Beam Scattering Device		
	14 Optical Gratings		
	15 Band Filters		
	16 Gas-Surface Interaction Device		
	17 Film Cameras	-1 Field Cameras	2.A.17-1
		-2 Spectrograph Cameras	2.A.17-2
		-3 Metric Camera	2.A.17-3
		-4 Multispectral Camera	2.A.17-4
		-5 16 mm Time-Lapse Movie Camera	2.A.17-5
		-6 Stellar Camera	2.A.17-6
		-7 16 mm Movie Camera	2.A.17-7
	18 Microscopes		
	52 Attitude Measuring Equipment		
B. Control/Display Equipment			
C. Experiment Materials			
D. Materials Control Equipment			
E. Accessory Equipment			
F. Experiment Records & Data			
G. Internal Spacecraft Systems			
3. Object or Area Under Investigation			
A. Solar			
B. Stellar			
C. Earth Surface			
D. Man-Biological/Physiological Aspects			
E. Spacecraft (Physical & Structural)			
F. Extravehicular Space Environment			
G. Planetary			
H. Lunar			
I. Processes in Zero Gravity			
J. Processes in Vacuum			
K. Communication Processes & Equipment			
L. Navigation Processes & Equipment			
M. Teleoperations			
N. Life Support & Habitability Systems			
O. Man-Performance Capability Aspects			
4. Support Equipment			
A. Communications Equipment			
B. Data Processing Equipment			
C. Test and Checkout Equipment	01 Calibration Equipment And Materials	-1 Optical Spectrometer Calibration Lamps	4.C.01-1
		-2 Mass Spectrometer Calibration Gases	4.C.01-2
		-3 Gas Chromatograph Calibration Gases	4.C.01-3
	02 Electrical And Electronic Equipment Test Equipment		
	03 Laser Transmitter/Receiver Test Equipment	-1 Oscilloscopes	4.C.02-1
	04 Radar Transmitter/Receiver Test Equipment	-2 Digital Multimeters	4.C.02-2
	05 Radio Transmitter/Receiver Test Equipment	-3 Function Generators	4.C.02-3
	06 Millimeter Wave Transmitter/Receiver Test Equipment		
	07 Optical Equipment Test Equipment		
D. Miscellaneous Support Equipment			
E. Life Support & Protective Equipment			
F. Subsatellites			
5. Environment			
A. Acceleration and Gravity			
B. Illumination			
C. Pressure			
D. Temperature			
E. Noise			
F. Radiation (Ionizing)			
G. Radiation (Radio Frequency)			
H. Extravehicular Environment (B + C + D ± [F + G])			
I. Earth Atmosphere			
J. Fire and/or Explosion Hazard			
K. Intravehicular Activity Environment (B + C + D)			
L. Object/Vehicle Relationship			

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

1.	SYSTEM AND FACILITIES
1.A	Research and Application Module (RAM)
1.A.01	RAM Structure
1.A.01-1	Locomotion Aids
1.A.01-2	Passageways
1.A.01-3	Airlock Latches
1.A.01-4	Airlock Cable Feedthroughs
1.A.01-5	Extendible Rail/Boom Instrument Mounting Platforms
1.A.01-6	Stability Aids (Dutch Shoes, etc.)
1.A.01-7	Interior Instrument Mounting Platforms
1.A.01-8	Exterior Surface Instrument Mounting Platforms
1.A.01-9	Extendible Rail/Boom
1.A.01-10	Airlock
1.A.01-11	Airlock Hatch Cover
1.A.01-12	Telescope Chamber
1.A.01-13	Telescope Chamber Hatch
1.A.01-14	Viewing Ports
1.A.01-15	External Surfaces
1.A.01-16	Reaction Control System
1.A.01-17	Airlock Mounting Platforms
1.A.01-18	Interior Surfaces
1.A.02	RAM System Controls and Displays
1.A.02-1	Airlock Security Displays
1.A.02-2	Airlock Pressure Displays and Controls
1.A.02-3	Airlock Latch Controls (Remote Actuating) and Displays
1.A.02-4	Extendible Rails/Boom Controls
1.A.02-5	Extendible Rails/Boom Status and Position Displays
1.A.02-6	Rail/Boom Instrument Platform Position/Orientation Displays/Controls
1.A.02-7	Telescope Chamber Security Displays
1.A.02-8	Telescope Chamber Pressure Displays and Controls
1.A.02-9	Telescope Chamber Temperature Displays and Controls
1.A.02-10	Telescope Chamber Hatch Controls (Remote Actuating)
1.A.03	Facility Equipment
1.A.03-1	Instrument/Equipment Storage Cabinets
1.A.03-2	Toxic Materials Storage Cabinets
1.A.03-3	Data Storage Cabinets
1.A.03-4	Water Recovery System
1.A.03-5	Waste Management System
1.A.03-6	Cooling System
1.A.03-7	(Not Assigned)
1.A.03-8	Atmosphere Supply and Control System
1.A.03-9	Carbon Dioxide Collection System

TASK DEPENDENCY REFERENCE LIST
- NUMERICAL LISTING -

1. SYSTEM AND FACILITIES (Continued)
1.A Research and Application Module (RAM) (Continued)
1.A.03 Facility Equipment (Continued)
1.A.03-10 Medical Research Facility/Equipment
1.A.03-11 (Not Assigned)
1.A.03-12 Food Storage, Preparation and Feeding Equipment

1.B Shuttle Orbiter

1.C Shuttle Booster

1.D Ground Control

1.E Satellites

1.F Space Station

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2.	EXPERIMENT EQUIPMENT AND MATERIALS
2.A	Observation Equipment
2.A.01	Telescopes
2.A.01-1	0.9 M. Narrow Field UV Telescope
2.A.01-2	16 Inch Cassegrain Telescope
2.A.01-3	Wide Field UV Telescope
2.A.01-4	Special Aiming Telescope (Comm/Nav Acquisition Aid)
2.A.01-5	Observation Telescope (Earth Observations)
2.A.02	Photometers
2.A.02-1	Photometric Instrument Cluster (Single Beam, Large Aperture)
2.A.02-2	Spectrophotometer
2.A.03	Spectrometers
2.A.03-1	Michelson Infrared Interferometer Spectrometer
2.A.03-2	75 CM Scanning Grating Spectrometer (Ebert-Fastie or Zerny-Turner)
2.A.03-3	Grazing Incidence EUV Spectrometer
2.A.03-4	Open Source Mass Spectrometer
2.A.03-5	Closed Source Mass Spectrometer
2.A.03-6	Ion Mass Spectrometer
2.A.03-7	EUV Spectrometer (Type Unspecified)
2.A.03-8	Scanning Spectrometer (Type Unspecified)
2.A.03-9	Infrared (IR) Spectrometer (Type Unspecified)
2.A.03-10	Ultraviolet (UV) Spectrometer (Type Unspecified)
2.A.03-11	Mass Scanning Spectrometer
2.A.03-12	Mass Spectrometer (Type Unspecified)
2.A.03-13	Multispectral Spectrometer
2.A.03-14	Aeronomy Spectrometer
2.A.03-15	Absorption Spectrometer
2.A.04	Television Systems
2.A.04-1	Image Isocon TV System
2.A.04-2	Multispectral TV System
2.A.04-3	TV Camera, Standard Hi Resolution
2.A.05	Image Tube Optical Systems
2.A.05-1	Space Image Tube Optical System W/Schmidt Corrector Plate
2.A.06	Gas Temperature Chambers
2.A.06-1	Neutral Gas Temperature Chambers
2.A.07	Ion Traps
2.A.07-1	Planar Ion Trap
2.A.08	Probes
2.A.08-1	Electrostatic Probe

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.A Observation Equipment (Continued)
2.A.08 Probes
2.A.08-2 Electric Field Probe
2.A.08-3 Electron Probe

2.A.09 Magnetometers
2.A.09-1 Flux Gate Magnetometer
2.A.09-2 Magnetometer Search Coil

2.A.10 VLF Sensors
2.A.10-1 (Undefined - See P-1 and P-2)

2.A.11 Particle and Meteoroid Sensors/Analyzers
2.A.11-1 Aluminum Foil Exposure Device
2.A.11-2 Cluster, Electron and Proton Detectors
2.A.11-3 Thick Aluminum Hinged Recovery Panels
2.A.11-4 Cosmic Dust Analyzer Target Plate Assembly
2.A.11-5 Cosmic Dust Analyzer Ion Collector
2.A.11-6 Optical Meteoroid Detector
2.A.11-7 Small Meteoroid Mass and Velocity Sensor Arrays
2.A.11-8 Thick Material Meteoroid Penetration Device (TMMPD)

2.A.12 Transmitter/Receivers/Antennas
2.A.12-1 Laser Communication Transmitter
2.A.12-2 Laser Communication Receiver
2.A.12-3 Millimeter Wave Antennas and Antenna Feeds (Radio)
2.A.12-4 Millimeter Wave Transmitter (Radio)
2.A.12-5 Millimeter Wave Receiver (Radio)
2.A.12-6 Emergency Location Transmitter (ELT) Transponder (Radio)
2.A.12-7 Interferometer Antenna Array (Radio)
2.A.12-8 VHF Transmitter (Radio)
2.A.12-9 L-Band Transmitter (Radar)
2.A.12-10 VHF Receiver (Radio)
2.A.12-11 L-Band Receiver (Radar)
2.A.12-12 VHF Antennas (Radio)
2.A.12-13 Frequency Synthesizer (Radio)
2.A.12-14 Laser Radar Transmitter
2.A.12-15 Laser Radar Receiver
2.A.12-16 Microwave Radar Transmitter
2.A.12-17 Microwave Radar Receiver
2.A.12-18 X-Band Transmitter (Radar)
2.A.12-19 X-Band Receiver (Radar)
2.A.12-20 Narrow Beam Tracking Antenna (Radar)
2.A.12-21 Broad Beam Transmitting Antenna (Radar)
2.A.12-22 X-Band Transmitter Antenna (Radar)
2.A.12-23 L-Band Antennas (Radar)

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.A Observation Equipment (Continued)
2.A.13 Molecular Beam Scattering Devices

2.A.14 Optical Gratings
2.A.14-1 Fine Optical Gratings
2.A.14-2 Coarse Optical Gratings

2.A.15 Band Filters
2.A.15-1 Narrow Band Filters
2.A.15-2 Broad Band Filters

2.A.16 Gas-Surface Interaction Device
2.A.16-1 Test Surfaces
2.A.16-2 Test Surface Blocks
2.A.16-3 Plating Materials Boats

2.A.17 Film Cameras
2.A.17-1 Field Cameras
2.A.17-2 Spectrograph Cameras
2.A.17-3 Metric Camera
2.A.17-4 Multispectral Camera
2.A.17-5 16 mm Time-Lapse Movie Camera
2.A.17-6 Stellar Camera
2.A.17-7 16 mm Movie Camera

2.A.18 Microscopes

2.A.19 Scanners
2.A.19-1 Multispectral Scanner
2.A.19-2 Passive Microwave Scanner

2.A.20 Plethysmographs
2.A.20-1 Leg Volume Plethysmograph

2.A.21 Radiometers
2.A.21-1 Microwave Mapping Radiometers
2.A.21-2 Multispectral Radiometer

2.A.22 Scatterometers
2.A.22-1 Scatterometer/Radiometer

2.A.23 Polarimeters

2.A.24 Sferics Detector

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.A Observation Equipment (Continued)
2.A.25 Refractometers
2.A.25-1 Goldberg Refractometer (AO)

2.A.26 Body Temperature Measurement Devices
2.A.26-1 Thermometers
2.A.26-2 Thermocouples
2.A.26-3 Ear Canal Temperature Probe

2.A.27 Film

2.A.28 Spectrographs

2.A.29 Gas Chromatograph

2.A.30 Calorimeter

2.A.31 Contamination Coupons

2.A.32 Body Mass Measurement Device

2.A.33 Blood Test/Measurement Device and Equipment

2.A.34 Food Moisture Measurement Device

2.A.35 Body Waste Measurement Devices and Equipment

2.A.36 X-Ray Analysis Equipment
2.A.36-1 Radionuclide Bone-Scanner
2.A.36-2 Isotope Tracer-Counter

2.A.37 Ergometers
2.A.37-1 Bicycle Ergometer (Skylab M171 Model)

2.A.38 Biological Contamination Sampling Equipment
2.A.38-1 Reynier Plates
2.A.38-2 Reynier Sampler
2.A.38-3 Agar Plates
2.A.38-4 Rodac Plates
2.A.38-5 Gram Staining Equipment
2.A.38-6 Nutrient Broth
2.A.38-7 Differential/Selective Media

2.A.39 Interferometers
2.A.39-1 Holographic Interferometer

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.A Observation Equipment (Continued)
2.A.39 Interferometers (Continued)
2.A.39-2 Schlieren Optical Interferometer

2.A.40 Densitometers
2.A.40-1 Photometric Densitometer
2.A.40-2 Ultraviolet (UV) Densitometer

2.A.41 Biomedical Measurements Instruments
2.A.41-1 EVA/Biomedical Measurements Sensors

2.A.42 Sphygmomanometers

2.A.43 Holographic Devices

2.A.44 High Temperature Viewing Device

2.A.45 Magnetostatic Devices

2.A.46 Optical Monitoring Probes (Type Unspecified)

2.A.47 Pressure Monitoring Probes
2.A.47-1 Thermocouple Gauge

2.A.48 Temperature Monitoring Probes

2.A.49 Spacecraft Plasma Monitoring Probes (Type Unspecified)

2.A.50 Power Monitoring Devices
2.A.50-1 Transmitted Microwave Power Monitor
2.A.50-2 Reflected Microwave Power Monitor

2.A.51 VSWR Measuring Equipment

2.A.52 Attitude Measuring Equipment

2.A.53 Accelerometers

2.A.54 Head Proximity Device

2.A.55 Electrocardiographs
2.A.55-1 Vectorcardiographs

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.B Control/Display Equipment
2.B.01 Control/Display Equipment - Astronomy
2.B.01-1 C/D Console, 0.9 M. Narrow Field UV Telescope
2.B.01-2 C/D Console, Wide Field UV Telescope
2.B.01-3 Instrument Power Distribution Controls and Displays
2.B.01-4 Spectrometer Operating Controls and Displays
2.B.01-5 Telescope Operation Controls and Displays
2.B.01-6 Telescope Deployment Controls and Displays
2.B.01-7 Automatic Film Changing System Controls and Displays

2.B.02 Control/Display Equipment - Physics
2.B.02-1 Single Sweep Oscilloscope Controls and Displays
2.B.02-2 Instrument Power Distribution Controls and Displays
2.B.02-3 Spectrometer Operating Controls and Displays
2.B.02-4 Gas-Surface Interaction Controls and Displays
2.B.02-5 Telescope Operation Controls and Displays
2.B.02-6 Telescope Deployment Controls and Displays
2.B.02-7 SITOS Operation Controls and Displays
2.B.02-8 Zero-G Combustion Controls and Displays
2.B.02-9 Chemical Laser Controls and Displays
2.B.02-10 Physics Subsatellite Controls and Displays
2.B.02-11 Electron Probe Controls and Displays
2.B.02-12 Photometer Controls and Displays
2.B.02-13 Gas Reaction Data Acquisition Displays
2.B.02-14 Canister Release Controls

2.B.03 Control/Display Equipment - Comm/Nav
2.B.03-1 Laser Communication Control/Display Equipment
2.B.03-2 Subsatellite Control/Display Equipment
2.B.03-3 Millimeter Wave R/T Control/Display Equipment
2.B.03-4 ELT Transponder Control/Display Equipment
2.B.03-5 Satellite Navigation Control/Display Equipment
2.B.03-6 Laser Radar Control/Display Equipment
2.B.03-7 Autonomous Navigation Control/Display Equipment
2.B.03-8 Plasma Propagation Control/Display Equipment
2.B.03-9 Transmitter Breakdown Test Control/Display Equipment
2.B.03-10 Multipath Measurements Control/Display Equipment

2.B.04 Control/Display Equipment - Earth Observations
2.B.04-1 Cloud Chamber Controls and Displays

2.B.05 Control/Display Equipment - Life Sciences
2.B.05-1 Readouts and Gauges (Undefined)
2.B.05-2 Heart Rate Monitor
2.B.05-3 Medical Research Control/Display Console

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.B Control/Display Equipment (Continued)
2.B.05 Control/Display Equipment - Life Sciences (Continued)
2.B.05-4 Life Support Subsystem Test Unit (LSSTU)
2.B.05-5 Life Sciences Experiment Support Unit

2.B.06 Control/Display Equipment - Materials Science
2.B.06-1 Process Control Computer
2.B.06-2 Instrumentation and Control Center

2.B.07 Control/Display Equipment - Technology
2.B.07-1 Teleoperator Control Station

2.C Experiment Materials
2.C.01 Maps
2.C.01-1 Topographic Maps of Earth Surface

2.C.02 Rotational Testing Devices and Associated Equipment
2.C.02-1 Rotating Litter Chair
2.C.02-2 Otolith Test Goggles
2.C.02-3 Magnetic Pointer ("Rod and Sphere Apparatus")
2.C.02-4 Reference Sphere ("Rod and Sphere Apparatus")

2.C.03 Physiological Test Devices
2.C.03-1 Lower Body Negative Pressure (LBNP) Device

2.C.04 Chemicals and Biologicals
2.C.04-1 PAH (Para-Aminohippuric Acid)
2.C.04-2 ADH
2.C.04-3 Agar Nutrient Culture
2.C.04-4 Bacterial Colonies (Species Not Defined)
2.C.04-5 Solvents
2.C.04-6 Buffer Solutions
2.C.04-7 Biological Materials (For Electrophoretic Separation and Lyophilization)
2.C.04-8 Biological Reagents
2.C.04-9 Enzymes

2.C.05 Body Fluids and Wastes
2.C.05-1 Urine
2.C.05-2 Feces
2.C.05-3 Blood
2.C.05-4 Saliva

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.C Experiment Materials (Continued)
2.C.06 Laser Fuels and Oxidizer

2.C.07 Chemical Lasers

2.C.08 Food and Drink for Consumption

2.C.09 *Fecal Dye Markers*

2.C.10 Teleoperator Spacecraft
2.C.10-1 Video/Illumination System
2.C.10-2 Communication System

2.C.11 Airlock Task Board
2.C.11-1 Thermal Insulation
2.C.11-2 Film Pack
2.C.11-3 Thruster Assembly
2.C.11-4 Satellite Skin Panel
2.C.11-5 Electrical Connector
2.C.11-6 Fuel Transfer Lines
2.C.11-7 Adjustment/Alignment Stops
2.C.11-8 Structural Fasteners
2.C.11-9 Jury Structure
2.C.11-10 Electronic Modules
2.C.11-11 Fluid Valves

2.C.12 Docking Adapter

2.C.13 Spare Parts and Tools

2.C.14 Metal Matrix Composite Materials
2.C.14-1 Fiber-Reinforced Composites
2.C.14-2 Particle-Dispersed Composites
2.C.14-3 Cemented Compacts
2.C.14-4 Controlled Eutectic Structures
2.C.14-5 Controlled Monotectic Structures
2.C.14-6 Metal Foams
2.C.14-7 Controlled Density Metals

2.C.15 Maintainable Attitude Control System

2.C.16 Flame Chemistry Fuels (Gases) and Oxidizers

2.C.17 Navigation Code Generator

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.C Experiment Materials (Continued)
2.C.18 Precision Clock

2.C.19 Inertial Navigation Sensor

2.C.20 Microwave Breakdown Test Structures
2.C.20-1 Microwave Antenna
2.C.20-2 Microwave Antenna Feed

2.C.21 Microwave Radiation Energy

2.C.22 Reentry Vehicle Probes

2.C.23 Basic Metals

2.C.24 Immiscible Liquid Systems

2.C.25 Crystal Growth Materials and Samples

2.C.26 Glass Preparation Materials and Samples

2.C.27 Fluid Materials and Samples

2.C.28 Human Subjects

2.C.29 Atmosphere Supply and Control Systems
2.C.29-1 Two Gas Control Unit Test Specimen (Type Unspecified)
2.C.29-2 Multigas Mass Spectrometer Sensor and Control

2.C.30 EVA Suits

2.C.31 Biopacks

2.C.32 Manikins

2.C.33 EVA Test Assembly (Contents Unspecified)

2.D Materials Control Equipment
2.D.01 Gas Release Devices
2.D.01-1 NH_3 Gas Canister
2.D.01-2 ICN^{16} Gas Canister

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.D Materials Control Equipment (Continued)
2.D.02 Cloud Chamber

2.D.03 Gas Storage Devices

2.D.04 Gas Mixing Devices

2.D.05 Injection and Withdrawal Instruments
2.D.05-1 Hypodermic Syringes
2.D.05-2 Ampoule
2.D.05-3 Sample Syringe

2.D.06 Zero-G Combustion Device
2.D.06-1 Various Size Gas Tubes

2.D.07 Laser Fuel and Oxidizer Containers

2.D.08 Food and Beverage Measuring Equipment

2.D.09 Canister Deployment Mechanisms

2.D.10 Biological Samples Containers
2.D.10-1 Sample Storage Containers
2.D.10-2 Centrifuge Tubes

2.D.11 Teleoperator Deployment/Retrieval Mechanism

2.D.12 Incubators

2.D.13 Environmental Chambers
2.D.13-1 Environmental Chamber "A" - Passive Cooling
2.D.13-2 Environmental Chamber "B" - Passive Cooling
2.D.13-3 Environmental Chamber "C" - Active Cooling
2.D.13-4 Controlled Atmosphere Chamber

2.D.14 Liquid Metal Supply System

2.D.15 Atmosphere Supply and Control System (For Environmental Chambers)

2.D.16 Subsatellite Storage Point/Container

2.D.17 Mold Injection System

2.D.18 Dispersion Control System

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.D Materials Control Equipment (Continued)
2.D.19 Materials Forming Equipment
2.D.19-1 Molds
2.D.19-2 Cavities
2.D.19-3 Crucibles
2.D.19-4 Crystal Growth Tubes

2.D.20 Miscellaneous Internal Attachments (Materials Science)

2.D.21 Mixing Units
2.D.21-1 Liquid/Solid Mixing Unit
2.D.21-2 Liquid/Liquid Mixing Unit
2.D.21-3 Liquid/Gas Mixing Unit

2.D.22 Vibrator

2.D.23 Freezers

2.D.24 Furnaces
2.D.24-1 Resistance Heated Furnace (1600°C)
2.D.24-2 Inert/Vacuum Furnace (2600°C)
2.D.24-3 Oxygen Furnace (3200°C)

2.D.25 Open Materials and Fluid Storage Containers

2.D.26 Water Recovery System/Components
2.D.26-1 Specimen Unit
2.D.26-2 Chemical/Microbial Analysis Equipment

2.D.27 Materials Analysis Equipment

2.D.28 Biomedical Fluid Transfer Equipment

2.D.29 Zone Melter

2.D.30 Chemical Storage and Release Devices

2.D.31 Clinical Centrifuges

2.D.32 Heating and Positioning Coil Sets

2.D.33 Plasma Electron Beam Unit

2.D.34 Continuous Atmosphere Analysis Apparatus

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.D Materials Control Equipment (Continued)
2.D.35 Controlled Atmosphere Fluids Storage Equipment

2.D.36 Biological Enclosure

2.D.37 Electrophoretic Columns
2.D.37-1 Stationary Electrophoretic Column
2.D.37-2 Continuous Electrophoretic Column

2.D.38 Lower Body Negative Pressure (LBNP) Device

2.D.39 Buffer Recovery/Waste Disposal System

2.D.40 Gas Elimination/Cooling System

2.D.41 Food Preparation/Storage/Feeding Equipment

2.D.42 (Not Assigned)

2.D.43 Lyophilization Apparatus
2.D.43-1 Basic Lyophilization Unit
2.D.43-2 Rack for Sample Vials
2.D.43-3 Sample Vials
2.D.43-4 Heat Pumps
2.D.43-5 Sample Vial Stoppers (Mechanically Actuated)

2.D.44 Biologicals Measuring Device

2.D.45 Susceptor for Silicate Melts

2.D.46 Liquid Sphere Deployment System

2.D.47 Hollow Bodies Deployment System

2.D.48 Membrane Drawing Tool

2.D.49 Czochralski Crystal Puller

2.D.50 Slip Cast Injection System

2.D.51 Model Zone Refiner

2.D.52 VHF Power Unit

2.D.53 Chill System

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.D Materials Control Equipment (Continued)
2.D.54 Microwave Transmitter, 10 kw

2.D.55 Waveform Modulators

2.D.56 Microscope Stage Heating/Cooling Device

2.D.57 Floating Zone Test Cell

2.E Accessories
2.E.01 Cables and Connectors

2.E.02 Star Trackers
2.E.02-1 Guide Star Tracker
2.E.02-2 Star Tracker/Inertial Reference Assembly
2.E.02-3 Star Field Lock on Unit

2.E.03 Microscopes

2.E.04 Electrodes, Biological Data

2.E.05 Experiment Equipment Drives
2.E.05-1 Roll Drive
2.E.05-2 Pitch Drive
2.E.05-3 Yaw Drive
2.E.05-4 Camera Mirror Cell and Focus Drive
2.E.05-5 Secondary Mirror Cell and Focus Drive
2.E.05-6 Collating Mirror Cell and Focus Drive
2.E.05-7 Fine Grating Drive
2.E.05-8 Coarse Grating Drive
2.E.05-9 Light Shade Drive
2.E.05-10 Filter Slide Drive

2.E.06 Automatic Film Cassette Replacement System

2.E.07 Battery Charger System

2.E.08 Refueling System

2.E.09 X-Ray Shielded Holding Unit

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

2. EXPERIMENT EQUIPMENT AND MATERIALS (Continued)
2.E Accessories (Continued)
2.E.10 Timing Devices
2.E.10-1 Stop Watches
2.E.10-2 Electric/Electronic Timer

2.F Experiment Records and Data
2.F.01 Film Records

2.F.02 Hard Copy Records
2.F.02-1 Questionnaires (Record Keeping Materials)
2.F.02-2 Response Matrix Forms (Record Keeping Materials)

2.F.03 Tape Recordings

2.F.04 Specimen and Samples

2.G Integral Spacecraft Systems
2.G.01 RAM Mobility Unit
2.G.01-1 Portable Metabolic Rate Analyzer (PMA)
2.G.01-2 Portable Acceleration Sensors
2.G.01-3 Elapsed Time Timer
2.G.01-4 Selected Locomotion and Restraint Devices
2.G.01-5 Impact Force Recorder

2.G.02 RAM Airlock/EVA Capability Unit
2.G.02-1 Airlocks
2.G.02-2 Pressure Suits
2.G.02-3 EVA Viewing Ports
2.G.02-4 Tether Control Units
2.G.02-5 Unspecified Communications Systems

2.G.03 RAM Visual Records Unit
2.G.03-1 Motion Picture Equipment
2.G.03-2 Video Tape Equipment

2.G.04 Reaction Control System
2.G.04-1 Control Valve

2.G.05 Waste Management System

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

3. OBJECT OR AREA UNDER INVESTIGATION
3.A Solar Phenomena

3.B Stellar Phenomena
3.B.01 Ultraviolet (UV) Emissions
3.B.01-1 Galaxies
3.B.01-2 Stellar Nebulae
3.B.01-3 Planetary Nebulae
3.B.01-4 Star Clusters
3.B.01-5 Quasars
3.B.01-6 Novae

3.C Earth Surface
3.C.01 Topography
3.C.02 Near-Earth Atmosphere
3.C.03 Inland Waterways
3.C.04 Oceans
3.C.05 Potential Disasters
3.C.06 Actual Disasters
3.C.07 Land Use and Resources

3.D Man - Biological and Physiological Aspects
3.D.01 Mineral Balance
3.D.02 Rotational Gravity Effects
3.D.02-1 Semicircular Canals Stimulation Threshold
3.D.02-2 Semicircular Canals Stimulation Susceptibility Symptoms
3.D.02-3 Spatial Localization
3.D.03 Cardioangiology
3.D.03-1 Cardiovascular Deconditioning

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

3. OBJECT OR AREA UNDER INVESTIGATION (Continued)
3.D Man - Biological and Physiological Aspects (Continued)
3.D.04 Urology
3.D.04-1 Renal Blood Flow

3.D.05 Vestibular Function

3.D.06 Bone Densitometry

3.D.07 Metabolic Activity

3.D.08 Endocrine Function

3.D.09 Exercise Conditioning

3.D.10 Airborne and Surface Contamination

3.D.11 Man's Immunity, in Vitro Aspects

3.D.12 Bacteriology

3.E Spacecraft (Physical and Structural Factors)

3.F Extravehicular Space Environment
3.F.01 Molecular Beam Scattering

3.F.02 Gas-Surface Interaction

3.F.03 Gas Reactions

3.G Planetary Studies

3.H Lunar Studies

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

3. OBJECT OR AREA UNDER INVESTIGATION (Continued)
3.I Processes in Zero Gravity
3.I.01 Cloud Formation

3.I.02 Combustion Phenomena
3.I.02-1 Temperature
3.I.02-2 Pressure
3.I.02-3 Chemical Composition of Flame
3.I.02-4 Flame Visible Structure

3.I.03 Chemical Laser Operation

3.I.04 Metal Structure
3.I.04-1 Fiber Orientation
3.I.04-2 Particle Distribution
3.I.04-3 Grain Structure
3.I.04-4 Liquid-Phase Sintering
3.I.04-5 Directional Freezing
3.I.04-6 Monotectic Alloy Mixtures
3.I.04-7 Gas Bubble Distribution (Metal Foams and Controlled Density)
3.I.04-8 Free-Casting
3.I.04-9 Liquid Dispersions; Slip Casting
3.I.04-10 Liquid Dispersions; Immiscible Liquids

3.I.05 Crystal Structure
3.I.05-1 Growth from Solution
3.I.05-2 Growth from Melts
3.I.05-3 Growth from Vapor
3.I.05-4 Homogeneous Nucleation

3.I.06 Preparation of Glasses
3.I.06-1 Optical Glasses
3.I.06-2 Oxide Composition Glasses

3.I.07 Biological Processing
3.I.07-1 Electrophoretic Separation of Organic Molecules

3.I.08 Convection of Fluids

3.J Lyophilization

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

3. OBJECT OR AREA UNDER INVESTIGATION (Continued)

3.K Communication Processes and Equipment

3.K.01 Laser Communication

3.K.01-1 Intervehicular Space Communication

3.K.01-2 Space to Ground Communication

3.K.02 Millimeter Wave Sources

3.K.02-1 Intervehicular Space Communication

3.K.02-2 Space to Ground Communication

3.K.03 Surveillance and Search and Rescue

3.K.04 Laser Radar

3.K.05 Microwave Energy Transmitter Breakdown

3.L Navigational Processes and Equipment

3.L.01 Navigation Data

3.N Life Support and Habitability Systems and Equipment

3.N.01 Water Recovery Methods and Components

3.N.02 Waste Management Methods and Components

3.N.03 Advanced Cooling System Methods and Components

3.N.04 Zero-Gravity Whole-Body Shower

3.N.05 Advanced Two-Gas Atmosphere Supply and Control Systems

3.N.06 Carbon Dioxide Collection Methods and Components

3.N.07 Protective Clothing and Advanced Space Suit Assemblies

3.N.08 EVA Suit and Biopack

3.N.09 Food Storage, Preparation and Feeding Methods

3.N.10 Biopack Technology

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

3.	OBJECT OR AREA UNDER INVESTIGATION (Continued)
3.0	Man - Performance Capability Aspects
3.0.01	(Not Assigned)
3.0.02	Cargo Handling Capabilities
3.0.03	Assembly, Deployment, Maintenance and Repair Capabilities
3.0.04	Locomotion and Restraint Capabilities

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

4. SUPPORT EQUIPMENT
4.A Communications Equipment
4.A.01 Telemetry

4.A.02 Voice Radio

4.A.03 Vehicle Intercomm

4.A.04 Data Compression (Dump) Equipment

4.A.05 Data Storage Equipment

4.A.06 EVA-Vehicle Intercom Equipment

4.B Data Processing Equipment
4.B.01 Computers
4.B.01-1 Special Purpose Computer, 0.9 M. Narrow Field UV Telescope Experiment
4.B.01-2 General Purpose Computer
4.B.01-3 Telescope Computer (Earth Observations)

4.B.02 Amplifiers
4.B.02-1 Preamplifiers
4.B.02-2 Narrow Pass Band Amplifiers

4.B.03 Phase Shifter

4.B.04 Phase Sensitive Detector

4.B.05 A/D Converter

4.B.06 Null Signal System

4.B.07 Data Encoding Keyboards

4.B.08 Film Developing Processing Equipment

4.B.09 Data Management Unit, Life Sciences FPEs

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

4. SUPPORT EQUIPMENT (Continued)
4.C Test and Checkout Equipment
4.C.01 Calibration Equipment and Materials
4.C.01-1 Optical Spectrometer Calibration Lamps
4.C.01-2 Mass Spectrometer Calibration Gases
4.C.01-3 Gas Chromatograph Calibration Gases

4.C.02 Electrical/Electronic Equipment Test Equipment
4.C.02-1 Oscilloscopes
4.C.02-2 Digital Multimeters
4.C.02-3 Function Generators

4.C.03 Laser Transmitter/Receiver Test Equipment

4.C.04 Radar Transmitter/Receiver Test Equipment

4.C.05 Radio Transmitter/Receiver Test Equipment

4.C.06 Millimeter Wave Transmitter/Receiver Test Equipment

4.C.07 Optical Equipment Test Equipment

4.D Miscellaneous Equipment and Materials
4.D.01 Equipment Covers and Caps
4.D.01-1 Protective Cover, 0.9 M. Narrow Field UV Telescope
4.D.01-2 Protective Cap, 0.9 M. Narrow Field UV Telescope Optics
4.D.01-3 Protective Cover, 16 Inch Cassegrain Telescope
4.D.01-4 Protective Cap, 16 Inch Cassegrain Telescope Optics
4.D.01-5 Protective Cap, Star Tracker
4.D.01-6 Protective Cap, Field TV Camera
4.D.01-7 Protective Cap, Combined Electronic/Backup Film Camera

4.D.02 Equipment Launch Restraints and Securing Devices
4.D.02-1 Launch Restraints, 0.9 M. Narrow Field UV Telescope
4.D.02-2 Launch Restraints, 16 Inch Cassegrain Telescope

4.D.03 Undefined Support Equipment
4.D.03-1 Workspace Equipment and Materials, 0.9 M. Narrow Field UV Telescope Experiments
4.D.03-2 Workspace Equipment and Materials, Wide Field UV Telescope Experiments

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

4. SUPPORT EQUIPMENT (Continued)
4.D Miscellaneous Equipment and Materials (Continued)
4.D.04 Cameras, Photographic and Film/Accessories
4.D.04-1 Film Cartridge
4.D.04-2 Trace Recording Camera
4.D.04-3 Photographic Camera
4.D.04-4 Visible Cine-Photographic Camera
4.D.04-5 Camera Timer, Programmable
4.D.04-6 Photograph Prints
4.D.04-7 Polaroid Camera
4.D.04-8 Roll Film Camera, 35 mm
4.D.04-9 Movie Camera, 35 mm
4.D.04-10 Plate Film Camera

4.D.05 Recorders, Tape
4.D.05-1 Voice Recorder, Tape
4.D.05-2 Tape Cartridges and Reels

4.D.06 Cleaning/Decontamination Equipment/Materials
4.D.06-1 Disinfectant

4.D.07 Cameras, Electronic
4.D.07-1 S.E.C. Vidicon
4.D.07-2 Combined Electronic/Backup Film Camera
4.D.07-3 Television Camera
4.D.07-4 Video Camera, Commercial Color
4.D.07-5 Video Camera, Standard Black and White

4.D.08 Manual Recording Equipment and Supplies
4.D.08-1 Writing Instruments (Pens, Pencils, etc.)
4.D.08-2 Writing Materials (Paper, Log Books, etc.)

4.D.09 Inspection Aids
4.D.09-1 Microscopes

4.D.10 Data Recorders, Type Unspecified

4.D.11 Freeze/Vacuum Drying Equipment

4.D.12 Vacuum Pumps

4.D.13 Power Conditioning and Distribution System

4.D.14 Heat Rejection System

4.D.15 Materials Analysis Equipment

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

4. SUPPORT EQUIPMENT (Continued)
4.D Miscellaneous Equipment and Materials (Continued)
4.D.16 Open Materials

4.D.17 Photographic/Film Processing Equipment (See also 4.B.08)

4.D.18 Tools, General Purpose

4.D.19 Freezing/Refrigeration Equipment

4.D.20 Stowage Containers (for Experiment Equipment and Materials)

4.D.21 Portable Lamps

4.E Life Support and Protective Equipment
4.E.01 Toxic Materials Protection Equipment

4.E.02 Pressure Suits and Associated Life Support Equipment
4.E.02-1 EVA Space Suit
4.E.02-2 (Not Assigned)
4.E.02-3 Biopack

4.E.03 Eye Protection Equipment
4.E.03-1 Laser Protection Eyeglasses

4.E.04 Fire Detection and Control Equipment

4.E.05 Integrated Spacecraft Water Supply System

4.E.06 Integrated Spacecraft Oxygen Supply System

4.E.07 Integrated Spacecraft Waste Management System

4.E.08 Integrated Spacecraft Advanced Cooling System

4.E.09 (Not Assigned)

4.E.10 Personnel Clothing, Garments and Accessories
4.E.10-1 Constant Wear Garment

4.E.11 Tether and Control Unit (for EVA)

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

4. SUPPORT EQUIPMENT (Continued)
4.F Subsatellites
4.F.01 Comm/Nav Subsatellites
4.F.01-1 Satellite Navigation Subsatellite
4.F.01-2 Laser Communication Subsatellite
4.F.01-3 Surveillance/Search and Rescue Subsatellite
4.F.01-4 Laser Ranging Subsatellite
4.F.01-5 Plasma Propagation Subsatellite
4.F.01-6 Multipath Measurements Subsatellite

4.F.02 Physics Subsatellites

4.F.03 Teleoperator Task Board Subsatellite

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

5. ENVIRONMENT

5.A Acceleration and Gravity

5.A.01 Zero-G

5.A.01-1 $\leq 10^{-4}$ G

5.B *Illumination*

5.B.01 Artificial Illumination

5.B.02 Solar Illumination

5.B.03 Stellar Illumination

5.C Pressure

5.D Temperature

5.E Noise

5.F Radiation (Ionizing)

5.G Radiation (Radio Frequency)

5.H Extravehicular Environment
(Includes 5.B + 5.C + 5.D; may include 5.F and/or 5.G

TASK DEPENDENCY REFERENCE LIST

- NUMERICAL LISTING -

5. ENVIRONMENT (Continued)
5.I Earth Atmosphere
5.I.01 Meteorological Conditions

5.J Fire and/or Explosion Hazard
5.J.01 Combustible Gas Mixtures

5.K Intravehicular Environment (5.B + 5.C + 5.D)

5.L Object/Vehicle Relationship
5.L.01 Relative Velocity

DEVELOPMENT OF FLIGHT EXPERIMENT TASK REQUIREMENTS

NASW-2192

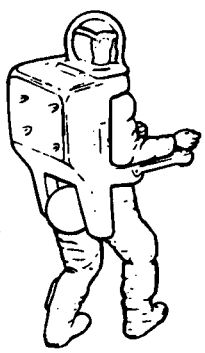
FINAL REPORT

VOLUME II - TECHNICAL REPORT

PART I - PROGRAM REPORT AND APPENDICES A-G

APPENDIX E

FLIGHT EXPERIMENT
TASK-SKILLS -
NUMERICAL LISTING



MATRIX
MAN SYSTEMS

APPENDIX E

FLIGHT EXPERIMENT TASK-SKILLS - NUMERICAL LISTING

EXPLANATION OF TASK-SKILLS

The approach developed to accomplish skill determination was to convert the brief task statement, or applicable portion thereof, into a task-skill title. A task-skill title is a brief phrase which denotes a specific equipment or procedure-oriented crew function. The task-skill is derived from the primary task dependency and the primary crew function, within the context of the experiment and the task. Some task statements have but one associated task-skill; others, because of the level of complexity or generality of the task statement have generated two or more task-skill titles. Each task-skill was given a 4-digit code number to avoid duplication in the task-skill processing. 2,044 task-skills were identified across the forty-eight (48) experiments subjected to detailed analysis. A complete listing, in numerical order, of the identified task-skill titles is included on the following pages of this appendix. The data sheets for each of the forty-eight (48) experiments, identifying basic functions, task statements, crew functions, operating environments, dependencies, and the associated task-skills, are compiled into a separate volume of the report, Appendix H. A more thorough explanation of the task-skill concept may be found in Sections 2.0 and 3.0.

0001 Telescope Inspector
0002 Telescope Cover Remover
0003 Launch Restraint Remover
0004 Telescope Optics Cleaner
0005 SITOS Optics Cleaner
0006 Spectrometer Installer
0007 Spectrometer Unstower
0008 Spectrometer Translocator
0009 Airlock Status Monitor
0010 Airlock Inside Hatch Opener
0011 Magnetometer Remover
0012 VLF Sensor Remover
0013 Probe Remover
0014 Ion Trap Remover
0015 Probe Gas Distribution Monitor
0016 Particle Sensor Repairer
0017 Particle Sensor Remover
0018 VLF Sensor Repairer
0019 Gas Temperature Chamber Remover
0020 Particle Sensor Translocator
0021 VLF Sensor Translocator
0022 Magnetometer Translocator
0023 Probe Translocator
0024 Ion Trap Translocator
0025 Gas Temperature Chamber Translocator
0026 TV Camera Translocator
0027 Photometer Translocator
0028 Spectrometer Cable Selector
0029 Spectrometer Cable Router
0030 Spectrometer Cable Connector
0031 Airlock Inside Hatch Closer
0032 Airlock Depressurization Actuator
0033 Airlock Outside Hatch Opener
0034 Rail/Boom Extension Actuator
0035 Instrument Power Actuator
0036 Spectrometer Control Actuator
0037 Spectrometer Operating Status Monitor
0038 Spectrometer Fault Identifier
0039 Camera Installer
0040 Spectrometer Tester
0041 Gas Temperature Chamber Assembler
0042 Gas Temperature Chamber Installer
0043 Spectrometer Grating Remover
0044 Spectrometer Grating Installer
0045 Film Cartridge Remover
0046 Film Cartridge Installer
0047 Oscilloscope Repairer
0048 Oscilloscope Fault Identifier
0049 Ion Trap Installer
0050 Probe Installer

0051 Magnetometer Installer
0052 VLF Sensor Installer
0053 Photometer Unstower
0054 TV Camera Unstower
0055 Gas Temperature Chamber Unstower
0056 Ion Trap Unstower
0057 Probe Unstower
0058 Magnetometer Unstower
0059 VLF Sensor Unstower
0060 Particle Sensor Unstower
0061 Spacecraft Exterior Translationer
0062 Photometer Stower
0063 Spectrometer Stower
0064 TV Camera Stower
0065 Gas Temperature Chamber Stower
0066 Ion Trap Stower
0067 Probe Stower
0068 Magnetometer Stower
0069 VLF Sensor Stower
0070 Particle Sensor Stower
0071 Calibration Equipment Installer
0072 Spectrometer Calibrator
0073 Spectrometer Optics Inspector
0074 Camera Lens Inspector
0075 Photometer Optics Inspector
0076 TV Camera Optics Inspector
0077 Photometer Assembly Inspector
0078 Spectrometer Assembly Inspector
0079 TV Camera Inspector
0080 Gas Temperature Chamber Inspector
0081 Ion Trap Assembly Inspector
0082 Probe Assembly Inspector
0083 Magnetometer Assembly Inspector
0084 VLF Sensor Assembly Inspector
0085 Particle Sensor Assembly Inspector
0086 Photometer Calibrator
0087 Gas Temperature Chamber Calibrator
0088 Ion Trap Calibrator
0089 Probe Calibrator
0090 Magnetometer Calibrator
0091 VLF Sensor Calibrator
0092 Particle Sensor Calibrator
0093 Optical Equipment Cleaner
0094 Photometer Optics Cleaner
0095 Spectrometer Optics Cleaner
0096 TV Camera Optics Cleaner
0097 Camera Lens Cleaner
0098 Magnetometer Repairer
0099 Probe Repairer
0100 Gas Temperature Chamber Repairer

0101 Gas Temperature Chamber Fault Identifier
0102 Ion Trap Fault Identifier
0103 Probe Fault Identifier
0104 Magnetometer Fault Identifier
0105 VLF Sensor Fault Identifier
0106 Electronic Instruments Tester
0107 Photometer Module Remover
0108 Photometer Module Installer
0109 Spectrometer Module Remover
0110 Spectrometer Module Installer
0111 TV Camera Module Remover
0112 TV Camera Module Installer
0113 Gas Temperature Chamber Module Remover
0114 Gas Temperature Chamber Module Installer
0115 Ion Trap Module Remover
0116 Ion Trap Module Installer
0117 Probe Module Remover
0118 Probe Module Installer
0119 Magnetometer Module Remover
0120 Magnetometer Module Installer
0121 VLF Sensor Module Remover
0122 VLF Sensor Module Installer
0123 Particle Sensor Module Remover
0124 Particle Sensor Module Installer
0125 Gas Canister Unstower
0126 Gas Canister Translocator
0127 Gas Canister Cable Selector
0128 Gas Canister Cable Router
0129 Gas Canister Cable Connector
0130 Gas Canister Installer
0131 Rail/Boom Retraction Actuator
0132 Airlock Outside Hatch Closer
0133 Airlock Pressurization Actuator
0134 Spectrometer Cable Disconnector
0135 Gas Canister Cable Disconnector
0136 Gas Canister Remover
0137 Gas Canister Stower
0138 Rail/Boom Position Monitor
0139 Instrument Power Monitor
0140 Particle Sensor Installer
0141 Particle Sensor Deployer
0142 Spacecraft Airlock Translationer
0143 Particle Sensor Cable Selector
0144 Particle Sensor Cable Router
0145 Particle Sensor Cable Connector
0146 Particle Sensor Aligner
0147 Particle Sensor Optics Calibrator
0148 Oscilloscope Unstower
0149 Oscilloscope Installer
0150 Particle Sensor Retractor

0151 Film Cartridge Stower
0152 Cable Stower
0153 Oscilloscope Stower
0154 Camera Stower
0155 Particle Sensor Optics Inspector
0156 Particle Sensor Optics Cleaner
0157 Particle Sensor Fault Identifier
0158 Camera Module Remover
0159 Oscilloscope Module Remover
0160 Camera Module Installer
0161 Oscilloscope Module Installer
0162 Telescope Baffle Deployment Actuator
0163 Telescope Baffle Status Monitor
0164 SITOS Unstower
0165 SITOS Translocator
0166 SITOS Installer
0167 SITOS Tester
0168 SITOS Calibrator
0169 SITOS Grating Remover
0170 SITOS Grating Installer
0171 Telescope Baffle Retraction Actuator
0172 Launch Restraint Installer
0173 SITOS Remover
0174 SITOS Stower
0175 Telescope Coverer
0176 Spectrometer Grating Inspector
0177 SITOS Grating Inspector
0178 Telescope Optics Inspector
0179 SITOS Optics Inspector
0180 SITOS Assembly Inspector
0181 Camera Assembly Inspector
0182 SITOS Module Inspector
0183 SITOS Module Remover
0184 SITOS Module Installer
0185 Ion Trap Repairer
0186 Combustible Gas Distribution Monitor
0187 Telescope Module Remover
0188 Telescope Module Installer
0189 Spectrometer Adjuster
0190 Oscilloscope Adjuster
0191 Amplifier Adjuster
0192 Phase Shifter Adjuster
0193 Phase Sensitive Detector Adjuster
0194 Null Signal System Adjuster
0195 A/D Converter Adjuster
0196 Molecular Beam Scattering Device Assembler
0197 Molecular Beam Scattering Device Disassembler
0198 Molecular Beam Scattering Device Installer
0199 Mounting Platform Installer
0200 Instrument Pointing Direction Monitor

0201 Instrument Pointing Direction Controller
0202 Tape Recorder Actuator
0203 Tape Cartridge Stower
0204 (Not Assigned)
0205 Molecular Beam Scattering Data Analyst
0206 Radio Communicator
0207 Molecular Beam Scattering Data Communicator
0208 Molecular Beam Scattering Research Planner
0209 (Not Assigned)
0210 Molecular Beam Scattering Device Inspector
0211 Molecular Beam Scattering Device Fault Identifier
0212 (Not Assigned)
0213 Amplifier Fault Identifier
0214 Phase Shifter Fault Identifier
0215 Phase Sensitive Detector Fault Identifier
0216 Null Signal System Fault Identifier
0217 A/D Converter Fault Identifier
0218 Molecular Beam Scattering Device Module Remover
0219 Molecular Beam Scattering Device Module Installer
0220 Amplifier Module Remover
0221 Amplifier Module Installer
0222 Phase Shifter Module Remover
0223 Phase Shifter Module Installer
0224 Phase Sensitive Detector Module Remover
0225 Phase Sensitive Detector Module Installer
0226 A/D Converter Module Remover
0227 A/D Converter Module Installer
0228 Null Signal System Module Remover
0229 Null Signal System Module Installer
0230 Gas-Surface Interaction Device Unstower
0231 Gas-Surface Interaction Device Assembler
0232 Gas-Surface Interaction Device Installer
0233 Test Surface Remover
0234 Test Surface Installer
0235 Gas-Surface Interaction Device Plating Monitor
0236 Gas-Surface Interaction Device Plating Control Actuator
0237 Gas-Surface Interaction Device Disassembler
0238 Test Surface Block Remover
0239 Test Surface Block Installer
0240 Plating Material Boat Remover
0241 Plating Material Boat Installer
0242 Gas-Surface Interaction Operations Monitor
0243 Gas-Surface Interaction Control Actuator
0244 Gas-Surface Interaction Control Deactuator
0245 Camera Control Actuator
0246 Gas-Surface Interaction Data Recorder
0247 Gas-Surface Interaction Observer
0248 Gas-Surface Interaction Data Interpreter
0249 Gas-Surface Interaction Records Organizer
0250 Hard Copy Records Stower

0251 Data Recording Stower
0252 Astronomy C/D Console Self-Test Control Actuator
0253 Astronomy C/D Console Self-Test Display Monitor
0254 Telescope Drive Inspector
0255 Telescope Drive Tester
0256 Telescope Drive Control Actuator
0257 Telescope Drive Control Deactuator
0258 Camera Focusing Tester
0259 Spectrograph Focusing Tester
0260 Telescope Chamber Inspector
0261 Telescope Chamber Hatch Closer
0262 Telescope Chamber Status Monitor
0263 Telescope Chamber Depressurization Actuator
0264 Telescope Status Monitor
0265 Telescope Mode Selector
0266 Telescope Mode Control Actuator
0267 Spectrometer Mode Selector
0268 TV Mode Selector
0269 Grating Mode Selector
0270 Band Filter Mode Selector
0271 Camera Mode Selector
0272 Star Tracker Mode Selector
0273 Stellar Ultraviolet Observation Mode Selector
0274 Computer Mode Selector
0275 Amplifier Mode Selector
0276 Phase Shifter Mode Selector
0277 Spectrometer Mode Control Actuator
0278 TV Mode Control Actuator
0279 Grating Mode Control Actuator
0280 Band Filter Mode Control Actuator
0281 Camera Mode Control Actuator
0282 Star Tracker Mode Control Actuator
0283 Stellar Ultraviolet Observation Mode Control Actuator
0284 Computer Mode Control Actuator
0285 Amplifier Mode Control Actuator
0286 Phase Shifter Mode Control Actuator
0287 Film Cartridge Inspector
0288 Film Cartridge Unstower
0289 Film Changing System Actuator
0290 Film Changing System Monitor
0291 Star Tracker Unstower
0292 Camera Unstower
0293 Star Tracker Inspector
0294 Camera Inspector
0295 Grating Inspector
0296 Band Filter Inspector
0297 Telescope Aligner
0298 Star Tracker Aligner
0299 Camera Aligner
0300 Spectrometer Aligner

0301 Grating Aligner
0302 Band Filter Aligner
0303 Telescope Unstower
0304 Star Tracker Cap Remover
0305 Star Tracker Installer
0306 TV Camera Installer
0307 Camera Cap Remover
0308 Telescope Cap Remover
0309 TV Camera Cap Remover
0310 Grating Remover
0311 Grating Installer
0312 Band Filter Remover
0313 Band Filter Installer
0314 Camera Remover
0315 Spectrometer Remover
0316 Telescope Chamber Outside Hatch Control Actuator
0317 Telescope Deployment Status Monitor
0318 Telescope Deployment Control Actuator
0319 Computer Control Deactuator
0320 Telescope Control Deactuator
0321 Star Tracker Stower
0322 Telescope Position Monitor
0323 Telescope Retraction Actuator
0324 Telescope Pointing Status Monitor
0325 Telescope Pointing Control Actuator
0326 Stellar Ultraviolet Observer
0327 Stellar Ultraviolet Evaluator
0328 Film Developer
0329 Film Evaluator
0330 Stellar Ultraviolet Emission Classifier
0331 Stellar Ultraviolet Research Planner
0332 Stellar Ultraviolet Data Analyst
0333 Star Tracker Controller
0334 TV Camera Controller
0335 Camera Controller
0336 Spectrometer Controller
0337 Telescope Controller
0338 Telescope System Controller
0339 Camera Focusing Monitor
0340 Spectrograph Focusing Monitor
0341 Camera Focusing Aligner
0342 Spectrograph Focusing Aligner
0343 Star Tracker Module Remover
0344 Star Tracker Module Installer
0345 TV System Module Remover
0346 TV System Module Installer
0347 Band Filter Module Remover
0348 Band Filter Module Installer
0349 Combustible Gas Mixing Controller
0350 Combustible Gas Mixture Stower

0351 Zero-G Combustion Research Planner
0352 Spectrograph Calibrator
0353 Gas Chromatograph Calibrator
0354 Combustible Gas Tube Filler
0355 Fire Detection Equipment Monitor
0356 Fire Control Equipment Controller
0357 Zero-G Combustion Control Actuator
0358 Zero-G Combustion Display Monitor
0359 Combustible Gas Distribution Control Actuator
0360 Temperature Measurement Observer
0361 Temperature Measurement Recorder
0362 Pressure Measurement Observer
0363 Pressure Measurement Recorder
0364 Flame Composition Measurement Observer
0365 Flame Composition Measurement Recorder
0366 Flame Visible Structure Observer
0367 Probe Gas Distribution Control Actuator
0368 Zero-G Combustion Data Analyst
0369 Zero-G Combustion Observer
0370 Zero-G Combustion Device Fault Identifier
0371 Zero-G Combustion Device Adjustor
0372 Spectrograph Fault Identifier
0373 Spectrograph Adjustor
0374 Gas Chromatograph Fault Identifier
0375 Gas Chromatograph Adjuster
0376 Calorimeter Fault Identifier
0377 Calorimeter Adjustor
0378 Zero-G Combustion C/D Equipment Fault Identifier
0379 Zero-G Combustion C/D Equipment Adjuster
0380 Calorimeter Calibrator
0381 Laser Fuel and Oxidizer Installer
0382 Contamination Coupon Translocator
0383 Contamination Coupon Installer
0384 Chemical Laser Installer
0385 Contamination Coupon Remover
0386 Chemical Laser Operation Monitor
0387 Contamination Coupon Sample Measurer
0388 Chemical Laser Control Actuator
0389 Chemical Laser Control Deactuator
0390 Zero-G Laser Operation Observer
0391 Calorimeter Operation Monitor
0392 Calorimeter Control Actuator
0393 Calorimeter Control Deactuator
0394 Chemical Laser Temperature Monitor
0395 Gas Canister Deployment Control Actuator
0396 Gas Canister Deployment Monitor
0397 Physics Subsatellite Flight Controller
0398 Physics Subsatellite Flight Monitor
0399 Space Gas Reactions Research Planner
0400 Space Gas Reactions Observer

0401 Chemical Canister Deployment Control Actuator
0402 Chemical Canister Deployment Monitor
0403 Chemical Canister Unstower
0404 Chemical Canister Translocator
0405 Photometer Installer
0406 Physics Subsatellite Instrumentation Monitor
0407 Physics Subsatellite Instrumentation Controller
0408 Instrument Power Deactuator
0409 Spectrometer Control Deactuator
0410 Probe Operating Status Monitor
0411 Probe Control Actuator
0412 Probe Control Deactuator
0413 Photometer Operating Status Monitor
0414 Photometer Control Actuator
0415 Photometer Control Deactuator
0416 Rail/Boom-Cloud Observer
0417 Rail/Boom-Cloud Position Determiner
0418 Physics Subsatellite-Cloud Observer
0419 Physics Subsatellite-Cloud Position Determiner
0420 Space Gas Reactions Data Monitor
0421 Space Gas Reactions Observation Director
0422 Chemical Canister Chemical Release Actuator
0423 Space Gas Reactions Data Recorder
0424 Refueling System Control Actuator
0425 Refueling System Control Deactuator
0426 Refueling System Monitor
0427 Teleoperator Refueling Control Actuator
0428 Teleoperator Refueling Control Deactuator
0429 Teleoperator Fuel Status Monitor
0430 Battery Charging System Control Actuator
0431 Battery Charging System Control Deactuator
0432 Battery Charging System Monitor
0433 Teleoperator Battery Charging Control Actuator
0434 Teleoperator Battery Charging Control Deactuator
0435 Teleoperator Battery Charge Status Monitor
0436 Teleoperator Subsystem Inspector
0437 Teleoperator Subsystem Tester
0438 Teleoperator Deployment Mechanism Monitor
0439 Teleoperator Deployment Control Actuator
0440 Docking Adapter Status Monitor
0441 Docking Adapter Release Control Actuator
0442 Teleoperator Systems Monitor
0443 Teleoperator Retrieval Mechanism Monitor
0444 Teleoperator Retrieval Control Actuator
0445 Teleoperator Flight Observer
0446 Teleoperator Flight Controller
0447 Teleoperator Performance Evaluator
0448 Teleoperator Deficiency Determiner
0449 Teleoperator Design Evaluator
0450 Teleoperator Design Planner

0451 Teleoperator/Man Interface Deficiency Determiner
0452 Teleoperator/Man Interface Design Evaluator
0453 Teleoperator/Man Interface Design Planner
0454 Spacecraft External Surface Inspector
0455 Teleoperator Docking Observer
0456 Teleoperator Communication System Controller
0457 Teleoperator Communication System Evaluator
0458 Teleoperator Communication Deadzone Determiner
0459 Teleoperator Multipath Effects Determiner
0460 Teleoperator Subsystem Adjuster
0461 Teleoperator System Inspector
0462 Teleoperator System Fault Identifier
0463 Teleoperator Manipulations Observer
0464 Teleoperator Manipulations Controller
0465 Lighting Adaptation Evaluator
0466 Teleoperator Video Systems Evaluator
0467 Teleoperator Video Control Actuator
0468 Teleoperator Video Presentation Observer
0469 Teleoperator Video Acquisition Controller
0470 Task Board Docking Point Identifier
0471 Teleoperator Video Control Deactuator
0472 Task Board Observer
0473 Task Board Subsatellite Observer
0474 Task Board Subsatellite Release Control Actuator
0475 Spacecraft Relative Velocities Determiner
0476 Task Board Subsatellite Inspector
0477 Teleoperator Camera Controller
0478 Teleoperator Stability Status Monitor
0479 Teleoperator Attitude Status Monitor
0480 Teleoperator Undocking Observer
0481 Teleoperator Docking Release Actuator
0482 Teleoperator Manipulations Evaluator
0483 Laser Optics Aligner
0484 Laser Optics Installer
0485 Laser Optics Remover
0486 Laser Electronics Installer
0487 Laser Electronics Adjuster
0488 Laser Electronics Remover
0489 Comm/Nav Subsatellite Launch Controller
0490 Laser Control Deactuator
0491 Protective Eyeglasses Donner
0492 Laser Operating Status Monitor
0493 Laser Communication Data Evaluator
0494 Laser Tracking Signal Monitor
0495 Laser Tracking System Controller
0496 Radio Transmitter Assembler
0497 Radio Transmitter Disassembler
0498 Radio Transmitter Module Remover
0499 Radio Transmitter Module Installer
0500 Radio Receiver Assembler

0501 Radio Receiver Disassembler
0502 Radio Receiver Module Remover
0503 Radio Receiver Module Installer
0504 Radio Antenna Assembler
0505 Radio Antenna Disassembler
0506 Radio Antenna Module Remover
0507 Radio Antenna Module Installer
0508 Radio Antenna Deployment Control Actuator
0509 Radio Antenna Translocator
0510 Radio Antenna Installer
0511 Radio Receiver Calibrator
0512 Radio Frequency Control Actuator
0513 MW Communications Research Planner
0514 Radio Transceiver Control Deactuator
0515 Meteorological Condition Determiner
0516 Meteorological Condition Observer
0517 Radio Antenna Pointing Controller
0518 MW Communications Data Evaluator
0519 Computer Module Remover
0520 Computer Module Installer
0521 Radio Transmitter Fault Identifier
0522 Radio Receiver Fault Identifier
0523 Computer Fault Identifier
0524 Radio Antenna Fault Identifier
0525 Radio Transponder Assembler
0526 Interferometer Antenna Array Assembler
0527 Radio Transponder Installer
0528 Radio Transponder Calibrator
0529 Radio Transponder Disassembler
0530 Interferometer Antenna Array Installer
0531 Interferometer Antenna Array Disassembler
0532 Radio Transponder Control Deactuator
0533 Radio Transponder Operating Status Monitor
0534 Surveillance/S&R Data Processing Monitor
0535 Surveillance/S&R Data Evaluator
0536 Radio Transponder Repairer
0537 Comm/Nav C/D Equipment Repairer
0538 Comm/Nav Subsatellite Repairer
0539 Comm/Nav Subsatellite C/D Equipment Repairer
0540 Computer Repairer
0541 Interferometer Antenna Array Repairer
0542 Radio Transmitter Repairer
0543 Radio Receiver Repairer
0544 Radio Antenna Repairer
0545 Satellite Navigation Equipment Module Remover
0546 Satellite Navigation Equipment Module Installer
0547 Radio Transmitter Remover
0548 Radio Transmitter Installer
0549 Radio Antenna Remover
0550 Radio Receiver Remover

0551 Radio Receiver Installer
0552 Code Generator Remover
0553 Code Generator Installer
0554 Frequency Synthesizer Remover
0555 Frequency Synthesizer Installer
0556 Precision Clock Remover
0557 Precision Clock Installer
0558 Comm/Nav Subsatellite Module Remover
0559 Comm/Nav Subsatellite Module Installer
0560 Comm/Nav Subsatellite Module Aligner
0561 Radio Antenna-Transmitter Calibrator
0562 Radio Transmitter Power Control Actuator
0563 Radio Receiver Power Control Actuator
0564 Radio Transmitter Stower
0565 Radio Receiver Stower
0566 Radio Antenna Stower
0567 Frequency Synthesizer Stower
0568 Code Generator Stower
0569 Precision Clock Stower
0570 Comm/Nav Subsatellite Stower
0571 Radio Transmitter Power Control Deactuator
0572 Radio Receiver Power Control Deactuator
0573 Comm/Nav Subsatellite Flight Controller
0574 Radio Transmitter Operation Monitor
0575 Comm/Nav C/D Equipment Fault Identifier
0576 Frequency Synthesizer Fault Identifier
0577 Frequency Synthesizer Repairer
0578 Code Generator Fault Identifier
0579 Code Generator Repairer
0580 Precision Clock Fault Identifier
0581 Precision Clock Repairer
0582 Comm/Nav Subsatellite Fault Identifier
0583 Laser Transmitter Assembler
0584 Laser Transmitter Disassembler
0585 Laser Transmitter Module Remover
0586 Laser Transmitter Module Installer
0587 Laser Transmitter Remover
0588 Laser Transmitter Installer
0589 Laser Receiver Assembler
0590 Laser Receiver Disassembler
0591 Laser Receiver Module Remover
0592 Laser Receiver Module Installer
0593 Laser Receiver Remover
0594 Laser Receiver Installer
0595 Comm/Nav C/D Equipment Module Remover
0596 Comm/Nav C/D Equipment Module Installer
0597 Laser Transmitter Control Deactuator
0598 Laser Receiver Control Deactuator
0599 Laser Transmitter Controller
0600 Laser Radar Target Observer

0601 Laser Radar Data Evaluator
0602 Laser Radar Display Observer
0603 Map Observer
0604 Topographic Map-Match Determiner
0605 Laser Transmitter Calibrator
0606 Laser Transmitter Optics Cleaner
0607 Laser Transmitter Fault Identifier
0608 Laser Receiver Fault Identifier
0609 Computer Program Determiner
0610 Computer Program Controller
0611 Radar Transmitter Unstower
0612 Radar Transmitter Assembler
0613 Radar Transmitter Tester
0614 Radar Transmitter Installer
0615 Radar Transmitter Module Remover
0616 Radar Transmitter Module Installer
0617 Radar Transmitter Remover
0618 Radar Transmitter Disassembler
0619 Radar Transmitter Stower
0620 Radar Receiver Assembler
0621 Radar Receiver Disassembler
0622 Radar Receiver Installer
0623 Radar Receiver Module Installer
0624 Radar Receiver Module Remover
0625 Radar Receiver Remover
0626 Radar Transmitter Stower
0627 Radar Receiver Tester
0628 Radar Transmitter Unstower
0629 Laser Transmitter Unstower
0630 Laser Transmitter Tester
0631 Laser Receiver Unstower
0632 Laser Receiver Tester
0633 TV Camera Tester
0634 Radiometer Assembler
0635 Radiometer Disassembler
0636 Radiometer Installer
0637 Radiometer Module Installer
0638 Radiometer Module Remover
0639 Radiometer Remover
0640 Radiometer Stower
0641 Radiometer Tester
0642 Radiometer Unstower
0643 Star Tracker Assembler
0644 (Not Assigned)
0645 Star Tracker Remover
0646 Star Tracker Tester
0647 Inertial Navigation Sensor Installer
0648 Inertial Navigation Sensor Remover
0649 Inertial Navigation Sensor Stower
0650 Inertial Navigation Sensor Tester

0651 Inertial Navigation Sensor Unstower
0652 Magnetostatic Device Assembler
0653 (Not Assigned)
0654 Magnetostatic Device Installer
0655 Magnetostatic Device Module Installer
0656 Magnetostatic Device Module Remover
0657 Magnetostatic Device Remover
0658 Magnetostatic Device Stower
0659 Magnetostatic Device Tester
0660 Magnetostatic Device Unstower
0661 TV Camera Remover
0662 Telemetry Equipment Control Actuator
0663 Telemetry Equipment Control Deactuator
0664 Radar Transmitter Control Deactuator
0665 Radar Transmitter Translocator
0666 Radar Receiver Control Deactuator
0667 Radar Receiver Translocator
0668 Laser Transmitter Translocator
0669 Laser Receiver Translocator
0670 Laser Receiver Stower
0671 Laser Transmitter Stower
0672 TV Camera Control Deactuator
0673 Radiometer Control Deactuator
0674 Radiometer Translocator
0675 Star Tracker Control Deactuator
0676 Star Tracker Translocator
0677 Inertial Navigation Sensor Control Deactuator
0678 Inertial Navigation Sensor Translocator
0679 Magnetostatic Device Control Deactuator
0680 Magnetostatic Device Translocator
0681 Comm/Nav C/D Equipment Control Deactuator
0682 Navigation Signal Comparison Evaluator
0683 Radar Transmitter Fault Identifier
0684 Radar Transmitter Repairer
0685 Radar Receiver Fault Identifier
0686 Radar Receiver Repairer
0687 Laser Transmitter Repairer
0688 Laser Receiver Repairer
0689 TV Camera Fault Identifier
0690 TV Camera Repairer
0691 Radiometer Fault Identifier
0692 Radiometer Repairer
0693 Star Tracker Fault Identifier
0694 Star Tracker Repairer
0695 Inertial Navigation Sensor Fault Identifier
0696 Inertial Navigation Sensor Repairer
0697 Magnetostatic Device Fault Identifier
0698 Magnetostatic Device Repairer
0699 Telemetry Equipment Fault Identifier
0700 Telemetry Equipment Repairer

0701 Microscope Fault Identifier
0702 Microscope Unstower
0703 Microscope Stower
0704 Microscope Translocator
0705 Microscope Repairer
0706 Power Monitoring Device Control Deactuator
0707 Power Monitoring Device Installer
0708 Power Monitoring Device Remover
0709 Power Monitoring Device Fault Identifier
0710 Power Monitoring Device Unstower
0711 Power Monitoring Device Stower
0712 Power Monitoring Device Translocator
0713 Power Monitoring Device Repairer
0714 Waveform Modulator Control Deactuator
0715 Waveform Modulator Module Installer
0716 Waveform Modulator Module Remover
0717 Waveform Modulator Installer
0718 Waveform Modulator Remover
0719 Waveform Modulator Fault Identifier
0720 Waveform Modulator Unstower
0721 Waveform Modulator Stower
0722 Waveform Modulator Translocator
0723 Waveform Modulator Repairer
0724 Spacecraft Plasma Probe Control Deactuator
0725 Spacecraft Plasma Probe Installer
0726 Spacecraft Plasma Probe Remover
0727 Spacecraft Plasma Probe Fault Identifier
0728 Spacecraft Plasma Probe Unstower
0729 Spacecraft Plasma Probe Stower
0730 Spacecraft Plasma Probe Translocator
0731 Spacecraft Plasma Probe Repairer
0732 Temperature Monitoring Device Control Deactuator
0733 Temperature Monitoring Device Installer
0734 Temperature Monitoring Device Fault Identifier
0735 Temperature Monitoring Device Remover
0736 Temperature Monitoring Device Unstower
0737 Temperature Monitoring Device Stower
0738 Temperature Monitoring Device Translocator
0739 Temperature Monitoring Device Repairer
0740 Pressure Monitoring Device Control Deactuator
0741 Pressure Monitoring Device Installer
0742 Pressure Monitoring Device Remover
0743 Pressure Monitoring Device Fault Identifier
0744 Pressure Monitoring Device Unstower
0745 Pressure Monitoring Device Stower
0746 Pressure Monitoring Device Translocator
0747 Pressure Monitoring Device Repairer
0748 Optical Monitoring Device Control Deactuator
0749 Optical Monitoring Device Installer
0750 Optical Monitoring Device Remover

0751 Optical Monitoring Device Fault Identifier
0752 Optical Monitoring Device Unstower
0753 Optical Monitoring Device Stower
0754 Optical Monitoring Device Translocator
0755 Optical Monitoring Device Repairer
0756 Microwave Transmitter Control Deactuator
0757 Microwave Transmitter Condition Determiner
0758 Microwave Transmitter Inspector
0759 Microwave Transmitter Module Installer
0760 Microwave Transmitter Module Remover
0761 Microwave Transmitter Installer
0762 Microwave Transmitter Remover
0763 Microwave Transmitter Fault Identifier
0764 Microwave Transmitter Unstower
0765 Microwave Transmitter Stower
0766 Microwave Transmitter Translocator
0767 Microwave Transmitter Repairer
0768 Microwave Test Structure Condition Determiner
0769 Microwave Test Structure Inspector
0770 Microwave Test Structure Module Installer
0771 Microwave Test Structure Module Remover
0772 Microwave Test Structure Installer
0773 Microwave Test Structure Remover
0774 Microwave Test Structure Unstower
0775 Microwave Test Structure Stower
0776 Microwave Test Structure Disassembler
0777 Microwave Test Structure Assembler
0778 Microwave Test Structure Translocator
0779 Spectrometer Repairer
0780 Radio Receiver Cable Connector
0781 RV Launch Cable Connector
0782 Radio Transmitter Cable Connector
0783 VSWR Measuring Equipment Cable Connector
0784 Attitude Measuring Equipment Cable Connector
0785 Data Recorder Cable Connector
0786 Telemetry Cable Connector
0787 (Not Assigned)
0788 Comm/Nav Subsatellite Launch Cable Connector
0789 RV Fault Identifier
0790 RV Repairer
0791 VSWR Measuring Equipment Fault Identifier
0792 Attitude Measuring Equipment Fault Identifier
0793 Data Recorder Fault Identifier
0794 Cable Fault Identifier
0795 Electronic Equipment Fault Identifier
0796 VSWR Measuring Equipment Repairer
0797 Attitude Measuring Equipment Repairer
0798 Data Recorder Repairer
0799 Cable Repairer
0800 Radar Receiver Cable Connector

0801 Radar Antenna Remover
0802 Radar Antenna Installer
0803 Radar Transmitter Cable Connector
0804 Radar Antenna Cable Connector
0805 Radar Antenna Fault Identifier
0806 Radar Antenna Repairer
0807 Radar Antenna-Transmitter Calibrator
0808 Radar Transmitter Power Control Actuator
0809 Radar Receiver Power Control Actuator
0810 Radar Transmitter Power Control Deactuator
0811 Radar Receiver Power Control Deactuator
0812 Radar Transmitter Operation Monitor
0813 Comm/Nav System Tester
0814 Comm/Nav System Test Monitor
0815 Radio Antenna Unstower
0816 Radar Antenna Unstower
0817 Radar Antenna Translocator
0818 Radar Antenna Assembler
0819 Radar Antenna Disassembler
0820 Telemetry Equipment Module Remover
0821 Telemetry Equipment Module Installer
0822 Cloud Chamber Unstower
0823 Scanner Unstower
0824 Polarimeter Unstower
0825 Sferics Detector Unstower
0826 Scatterometer Unstower
0827 Microscope Inspector
0828 Scanner Inspector
0829 Radiometer Inspector
0830 Scatterometer Inspector
0831 Polarimeter Inspector
0832 Sferics Detector Inspector
0833 Spectrometer Inspector
0834 Cloud Chamber Inspector
0835 Microscope Calibrator
0836 Scanner Calibrator
0837 Radiometer Calibrator
0838 Scatterometer Calibrator
0839 Polarimeter Calibrator
0840 Sferics Detector Calibrator
0841 Cloud Chamber Calibrator
0842 Scanner Control Actuator
0843 Radiometer Control Actuator
0844 Polarimeter Control Actuator
0845 Sferics Detector Control Actuator
0846 Telescope Control Actuator
0847 Computer Control Actuator
0848 Camera Control Deactuator
0849 Scanner Control Deactuator
0850 Scatterometer Control Actuator

0851 Scatterometer Control Deactuator
0852 Film Stower
0853 Sferics Detector Control Deactuator
0854 Cloud Chamber Control Deactuator
0855 Cloud Chamber Control Actuator
0856 Scanner Stower
0857 Scatterometer Stower
0858 Sferics Detector Stower
0859 Telescope Stower
0860 Cloud Chamber Stower
0861 Cloud Physics Process Observer
0862 Tape Recorder Controller
0863 Cloud Physics Observation Communicator
0864 Topographic Feature Observer
0865 Atmospheric Feature Observer
0866 Topographic Feature Determiner
0867 Atmospheric Feature Determiner
0868 Observation Condition Observer
0869 Scanner Data Quality Monitor
0870 Radiometer Data Quality Monitor
0871 Scatterometer Data Quality Monitor
0872 Spectrometer Data Quality Monitor
0873 Polarimeter Data Quality Monitor
0874 Telescope Operation Evaluator
0875 Camera Operation Evaluator
0876 Scanner Operation Evaluator
0877 Radiometer Operation Evaluator
0878 Scatterometer Operation Evaluator
0879 Spectrometer Operation Evaluator
0880 Polarimeter Operation Evaluator
0881 Sferics Detector Operation Evaluator
0882 Sferics Detector Data Quality Monitor
0883 Microscope Optics Cleaner
0884 Scanner Optics Cleaner
0885 Telescope Fault Identifier
0886 Camera Fault Identifier
0887 Scanner Fault Identifier
0888 Scatterometer Fault Identifier
0889 Polarimeter Fault Identifier
0890 Sferics Detector Fault Identifier
0891 Optical Equipment Fault Identifier
0892 TV Camera Calibrator
0893 Camera Disassembler
0894 Camera Assembler
0895 Telescope Presentation Observer
0896 TV Presentation Observer
0897 Scanner Presentation Observer
0898 Radiometer Presentation Observer
0899 TV Camera Control Actuator
0900 TV Camera Disassembler

0901 TV Camera Assembler
0902 Scanner Disassembler
0903 Scanner Assembler
0904 Scanner Module Remover
0905 Scanner Module Installer
0906 Polarimeter Disassembler
0907 Polarimeter Assembler
0908 Polarimeter Module Remover
0909 Polarimeter Module Installer
0910 Spectrometer Disassembler
0911 Spectrometer Assembler
0912 Telescope Disassembler
0913 Telescope Assembler
0914 Polarimeter Presentation Observer
0915 Spectrometer Presentation Observer
0916 Scanner Mode Selector
0917 Radiometer Mode Selector
0918 Polarimeter Mode Selector
0919 Polarimeter Control Deactuator
0920 Data Photographic Quality Evaluator
0921 Telescope Pointing Controller
0922 TV Data Quality Monitor
0923 TV Camera Operation Evaluator
0924 Radiometer Optics Cleaner
0925 Polarimeter Optics Cleaner
0926 Earth Survey C/D Equipment Module Remover
0927 Earth Survey C/D Equipment Module Installer
0928 Earth Survey C/D Equipment Fault Identifier
0929 TV Camera Aligner
0930 Radar Transmitter Aligner
0931 Radar Receiver Aligner
0932 Radar Transmitter Inspector
0933 Radar Receiver Inspector
0934 Radar Presentation Observer
0935 Radar Transmitter Control Actuator
0936 Radar Receiver Control Actuator
0937 Sferics Detector Presentation Observer
0938 Radar Transmitter Mode Selector
0939 Radar Receiver Mode Selector
0940 Sferics Detector Mode Selector
0941 Forest Fire Disaster Identifier
0942 (Not Assigned)
0943 (Not Assigned)
0944 Radar Data Quality Monitor
0945 Sferics Detector Optics Cleaner
0946 Sferics Detector Module Remover
0947 Sferics Detector Module Installer
0948 Scatterometer Presentation Observer
0949 Scatterometer Mode Selector
0950 TV Camera Cap Installer

0951 Camera Cap Installer
0952 Scanner Cap Installer
0953 Film Data Usefulness Determiner
0954 TV Data Usefulness Determiner
0955 Scanner Data Usefulness Determiner
0956 Scatterometer Usefulness Determiner
0957 Scanner Data Evaluator
0958 TV Data Evaluator
0959 Scatterometer Data Evaluator
0960 Scatterometer Optics Cleaner
0961 Scatterometer Module Remover
0962 Scatterometer Module Installer
0963 Telescope Cap Installer
0964 Spectrometer Cap Installer
0965 Radiometer Cap Installer
0966 Scatterometer Cap Installer
0967 Polarimeter Cap Installer
0968 Composite Materials Research Planner
0969 Composite Materials Data Recorder
0970 Composite Materials Structure Determiner
0971 Composite Materials Structure Analyzer
0972 Composite Materials Processing Observer
0973 Composite Materials Research Evaluator
0974 Composite Materials Sample Installer
0975 Composite Materials Sample Unstower
0976 Composite Materials Sample Translocator
0977 Composite Materials Sample Remover
0978 Composite Materials Sample Stower
0979 Furnace Deployer
0980 Furnace Unstower
0981 Furnace Module Remover
0982 Furnace Module Installer
0983 Furnace Stower
0984 Furnace Cleaner
0985 Furnace Operation Monitor
0986 Furnace Disassembler
0987 Furnace Assembler
0988 Furnace Repairer
0989 Furnace Fault Identifier
0990 Mixing Unit Deployer
0991 Mixing Unit Installer
0992 Mixing Unit Unstower
0993 Mixing Unit Translocator
0994 Mixing Unit Remover
0995 Mixing Unit Module Remover
0996 Mixing Unit Module Installer
0997 Mixing Unit Stower
0998 Mixing Unit Cleaner
0999 Mixing Unit Operation Monitor
1000 Mixing Unit Disassembler

1001 Mixing Unit Assembler
1002 Mixing Unit Repairer
1003 Mixing Unit Fault Identifier
1004 Mold Injection System Deployer
1005 Mold Injection System Unstower
1006 Mold Injection System Module Remover
1007 Mold Injection System Module Installer
1008 Mold Injection System Stower
1009 Mold Injection System Cleaner
1010 Mold Injection System Operation Monitor
1011 Mold Injection System Disassembler
1012 Mold Injection System Assembler
1013 Mold Injection System Repairer
1014 Mold Injection System Fault Identifier
1015 Materials Forming Equipment Deployer
1016 Materials Forming Equipment Installer
1017 Materials Forming Equipment Unstower
1018 Materials Forming Equipment Translocator
1019 Materials Forming Equipment Remover
1020 Materials Forming Equipment Stower
1021 Materials Forming Equipment Cleaner
1022 Liquid Metal Supply System Deployer
1023 Liquid Metal Supply System Unstower
1024 Liquid Metal Supply System Module Remover
1025 Liquid Metal Supply System Module Installer
1026 Liquid Metal Supply System Stower
1027 Liquid Metal Supply System Cleaner
1028 Liquid Metal Supply System Operation Monitor
1029 Liquid Metal Supply System Disassembler
1030 Liquid Metal Supply System Assembler
1031 Liquid Metal Supply System Repairer
1032 Liquid Metal Supply System Fault Identifier
1033 Materials Science C/D Equipment Deployer
1034 Materials Science C/D Equipment Module Remover
1035 Materials Science C/D Equipment Module Installer
1036 Materials Science C/D Equipment Disassembler
1037 Materials Science C/D Equipment Assembler
1038 Materials Science C/D Equipment Repairer
1039 Materials Science C/D Equipment Fault Identifier
1040 Materials Analysis Equipment Installer
1041 Materials Analysis Equipment Unstower
1042 Materials Analysis Equipment Translocator
1043 Materials Analysis Equipment Remover
1044 Materials Analysis Equipment Module Remover
1045 Materials Analysis Equipment Module Installer
1046 Materials Analysis Equipment Calibrator
1047 Materials Analysis Equipment Stower
1048 Materials Analysis Equipment Cleaner
1049 Materials Analysis Equipment Controller
1050 Materials Analysis Equipment Disassembler

1051 Materials Analysis Equipment Assembler
1052 Materials Analysis Equipment Repairer
1053 Materials Analysis Equipment Fault Identifier
1054 Computer Unstower
1055 Computer Operation Monitor
1056 Computer Disassembler
1057 Computer Assembler
1058 Environmental Chamber Unstower
1059 Environmental Chamber Module Remover
1060 Environmental Chamber Module Installer
1061 Environmental Chamber Stower
1062 Environmental Chamber Cleaner
1063 Environmental Chamber Disassembler
1064 Environmental Chamber Assembler
1065 Environmental Chamber Repairer
1066 Environmental Chamber Fault Identifier
1067 Chill System Installer
1068 Chill System Unstower
1069 Chill System Translocator
1070 Chill System Remover
1071 Chill System Module Remover
1072 Chill System Module Installer
1073 Chill System Stower
1074 Chill System Operation Monitor
1075 Chill System Disassembler
1076 Chill System Assembler
1077 Chill System Repairer
1078 Chill System Fault Identifier
1079 Vibrator Installer
1080 Vibrator Unstower
1081 Vibrator Translocator
1082 Vibrator Remover
1083 Vibrator Module Remover
1084 Vibrator Module Installer
1085 Vibrator Stower
1086 Vibrator Operation Monitor
1087 Vibrator Disassembler
1088 Vibrator Assembler
1089 Vibrator Repairer
1090 Vibrator Fault Identifier
1091 VHF Power Unit Installer
1092 VHF Power Unit Unstower
1093 VHF Power Unit Translocator
1094 VHF Power Unit Remover
1095 VHF Power Unit Module Remover
1096 VHF Power Unit Module Installer
1097 VHF Power Unit Calibrator
1098 VHF Power Unit Stower
1099 VHF Power Unit Operation Monitor
1100 VHF Power Unit Disassembler

1101 VHF Power Unit Assembler
1102 VHF Power Unit Repairer
1103 VHF Power Unit Fault Identifier
1104 Telemetry Equipment Controller
1105 Dispersion Control System Unstower
1106 Dispersion Control System Module Remover
1107 Dispersion Control System Stower
1108 Dispersion Control System Module Installer
1109 Dispersion Control System Cleaner
1110 Dispersion Control System Operation Monitor
1111 Dispersion Control System Disassembler
1112 Dispersion Control System Assembler
1113 Dispersion Control System Repairer
1114 Dispersion Control System Fault Identifier
1115 Slip Cast Injection System Installer
1116 Slip Cast Injection System Unstower
1117 Slip Cast Injection System Translocator
1118 Slip Cast Injection System Remover
1119 Slip Cast Injection System Module Remover
1120 Slip Cast Injection System Module Installer
1121 Slip Cast Injection System Stower
1122 Slip Cast Injection System Operation Monitor
1123 Slip Cast Injection System Disassembler
1124 Slip Cast Injection System Assembler
1125 Slip Cast Injection System Repairer
1126 Slip Cast Injection System Fault Identifier
1127 Atmosphere Supply/Control System Module Remover
1128 Atmosphere Supply/Control System Module Installer
1129 Atmosphere Supply/Control System Operation Monitor
1130 Atmosphere Supply/Control System Disassembler
1131 Atmosphere Supply/Control System Assembler
1132 Atmosphere Supply/Control System Repairer
1133 Atmosphere Supply/Control System Fault Identifier
1134 Power Conditioning/Distribution System Module Remover
1135 Power Conditioning/Distribution System Module Installer
1136 Power Conditioning/Distribution System Operation Monitor
1137 Power Conditioning/Distribution System Disassembler
1138 Power Conditioning/Distribution System Assembler
1139 Power Conditioning/Distribution System Repairer
1140 Power Conditioning/Distribution System Fault Identifier
1141 Environmental Chamber Operation Monitor
1142 Heat Rejection System Unstower
1143 Heat Rejection System Module Remover
1144 Heat Rejection System Module Installer
1145 Heat Rejection System Stower
1146 Heat Rejection System Operation Monitor
1147 Heat Rejection System Disassembler
1148 Heat Rejection System Assembler
1149 Heat Rejection System Repairer
1150 Heat Rejection System Fault Identifier

1151 Internal Attachments Installer
1152 Internal Attachments Unstower
1153 Internal Attachments Translocator
1154 Internal Attachments Remover
1155 Internal Attachments Stower
1156 Data Recorder Installer
1157 Data Recorder Controller
1158 Photograph Enlarger Controller
1159 Photograph Printer Controller
1160 Computer Stower
1161 Materials Science C/D Equipment Unstower
1162 Atmosphere Supply/Control System Unstower
1163 Power Conditioning/Distribution System Unstower
1164 Metal Foam Sample Unstower
1165 Metal Foam Sample Translocator
1166 Metal Foam Sample Installer
1167 Metal Foam Sample Remover
1168 Materials Science C/D Equipment Stower
1169 Atmosphere Supply/Control System Stower
1170 Power Conditioning/Distribution System Stower
1171 Metal Foam Sample Stower
1172 Materials Science C/D Equipment Control Actuator
1173 Environmental Chamber Control Actuator
1174 Atmosphere Supply/Control System Control Actuator
1175 Furnace Control Actuator
1176 Dispersion Control System Control Actuator
1177 Mixing Unit Control Actuator
1178 Liquid Metal Supply System Control Actuator
1179 Power Conditioning/Distribution System Control Actuator
1180 Mold Injection System Control Actuator
1181 Chill System Control Actuator
1182 Vibrator Control Actuator
1183 VHF Power Unit Control Actuator
1184 Heat Rejection System Control Actuator
1185 Metal Foam Structure Determiner
1186 Metal Foam Structure Analyzer
1187 Metal Foam Structure Evaluator
1188 Metal Foam Structure Test Report Preparer
1189 Metal Foam Research Planner
1190 Metal Foam Research Evaluator
1191 Workspace Equipment Unstower
1192 Workspace Equipment Stower
1193 Telescope Repairer
1194 TV System Repairer
1195 Camera Repairer
1196 Grating Repairer
1197 Band Filter Repairer
1198 Metal Free Casting Research Planner
1199 Metal Free Casting Test Report Preparer
1200 Metal Free Casting Structure Determiner

1201 Metal Free Casting Structure Analyzer
1202 Metal Free Casting Research Evaluator
1203 Atmosphere Analysis Unit Unstower
1204 Atmosphere Analysis Unit Translocator
1205 Atmosphere Analysis Unit Installer
1206 Atmosphere Analysis Unit Remover
1207 Atmosphere Analysis Unit Stower
1208 Atmosphere Analysis Unit Module Remover
1209 Atmosphere Analysis Unit Module Installer
1210 Atmosphere Analysis Unit Fault Identifier
1211 Atmosphere Analysis Unit Repairer
1212 Atmosphere Analysis Unit Disassembler
1213 Atmosphere Analysis Unit Assembler
1214 Atmosphere Analysis Unit Control Actuator
1215 Viewing Device Unstower
1216 Viewing Device Translocator
1217 Viewing Device Installer
1218 Viewing Device Remover
1219 Viewing Device Stower
1220 Viewing Device Module Remover
1221 Viewing Device Module Installer
1222 Viewing Device Fault Identifier
1223 Viewing Device Repairer
1224 Viewing Device Disassembler
1225 Viewing Device Assembler
1226 Camera Translocator
1227 Holographic Device Calibrator
1228 Holographic Device Operation Monitor
1229 Holographic Device Control Actuator
1230 Holographic Device Assembler
1231 Holographic Device Disassembler
1232 Holographic Device Repairer
1233 Holographic Device Fault Identifier
1234 Holographic Device Module Installer
1235 Holographic Device Module Remover
1236 Holographic Device Stower
1237 Holographic Device Remover
1238 Holographic Device Installer
1239 Holographic Device Translocator
1240 Holographic Device Unstower
1241 Heating/Cooling Device Operation Monitor
1242 Heating/Cooling Device Control Actuator
1243 Heating/Cooling Device Assembler
1244 Heating/Cooling Device Disassembler
1245 Heating/Cooling Device Repairer
1246 Heating/Cooling Device Fault Identifier
1247 Heating/Cooling Device Module Installer
1248 Heating/Cooling Device Module Remover
1249 Heating/Cooling Device Stower
1250 Heating/Cooling Device Remover

1251 Heating/Cooling Device Installer
1252 Heating/Cooling Device Translocator
1253 Heating/Cooling Device Unstower
1254 Metal Sample Installer
1255 Metal Sample Remover
1256 Metal Sample Translocator
1257 Metal Sample Unstower
1258 Heating/Positioning Coil Controller
1259 Heating/Positioning Coil Operation Monitor
1260 Heating/Positioning Coil Control Actuator
1261 Heating/Positioning Coil Assembler
1262 Heating/Positioning Coil Disassembler
1263 Heating/Positioning Coil Repairer
1264 Heating/Positioning Coil Fault Identifier
1265 Heating/Positioning Coil Module Installer
1266 Heating/Positioning Coil Module Remover
1267 Heating/Positioning Coil Stower
1268 Heating/Positioning Coil Remover
1269 Heating/Positioning Coil Installer
1270 Heating/Positioning Coil Translocator
1271 Heating/Positioning Coil Unstower
1272 Plasma Beam Unit Operation Monitor
1273 Plasma Beam Unit Control Actuator
1274 Plasma Beam Unit Assembler
1275 Plasma Beam Unit Disassembler
1276 Plasma Beam Unit Repairer
1277 Plasma Beam Unit Fault Identifier
1278 Plasma Beam Unit Module Installer
1279 Plasma Beam Unit Module Remover
1280 Plasma Beam Unit Stower
1281 Plasma Beam Unit Remover
1282 Plasma Beam Unit Installer
1283 Plasma Beam Unit Translocator
1284 Plasma Beam Unit Unstower
1285 Liquid Sphere Deployment System Operation Observer
1286 Liquid Sphere Deployment System Controller
1287 Liquid Sphere Deployment System Operation Monitor
1288 Liquid Sphere Deployment System Control Actuator
1289 Liquid Sphere Deployment System Assembler
1290 Liquid Sphere Deployment System Disassembler
1291 Liquid Sphere Deployment System Repairer
1292 Liquid Sphere Deployment System Fault Identifier
1293 Liquid Sphere Deployment System Module Installer
1294 Liquid Sphere Deployment System Module Remover
1295 Liquid Sphere Deployment System Stower
1296 Liquid Sphere Deployment System Remover
1297 Liquid Sphere Deployment System Installer
1298 Liquid Sphere Deployment System Translocator
1299 Liquid Sphere Deployment System Unstower
1300 Hollow Bodies Deployment System Controller

1301 Hollow Bodies Deployment System Operation Observer
1302 Hollow Bodies Deployment System Operation Monitor
1303 Hollow Bodies Deployment System Control Actuator
1304 Hollow Bodies Deployment System Assembler
1305 Hollow Bodies Deployment System Disassembler
1306 Hollow Bodies Deployment System Repairer
1307 Hollow Bodies Deployment System Fault Identifier
1308 Hollow Bodies Deployment System Module Installer
1309 Hollow Bodies Deployment System Module Remover
1310 Hollow Bodies Deployment System Stower
1311 Hollow Bodies Deployment System Remover
1312 Hollow Bodies Deployment System Installer
1313 Hollow Bodies Deployment System Translocator
1314 Hollow Bodies Deployment System Unstower
1315 Membrane Drawing Tool Controller
1316 Membrane Drawing Tool Operation Observer
1317 Membrane Drawing Tool Operation Monitor
1318 Membrane Drawing Tool Control Actuator
1319 Membrane Drawing Tool Assembler
1320 Membrane Drawing Tool Disassembler
1321 Membrane Drawing Tool Repairer
1322 Membrane Drawing Tool Fault Identifier
1323 Membrane Drawing Tool Module Installer
1324 Membrane Drawing Tool Module Remover
1325 Membrane Drawing Tool Stower
1326 Membrane Drawing Tool Remover
1327 Membrane Drawing Tool Installer
1328 Membrane Drawing Tool Translocator
1329 Membrane Drawing Tool Unstower
1330 Materials Science C/D Equipment Control Deactuator
1331 Heat Rejection System Remover
1332 Heat Rejection System Installer
1333 Heating/Positioning Coil Calibrator
1334 Plasma Beam Unit Calibrator
1335 Membrane Drawing Tool Calibrator
1336 Heating/Positioning Coil Cleaner
1337 Plasma Beam Unit Cleaner
1338 Liquid Sphere Deployment System Cleaner
1339 Hollow Bodies Deployment System Cleaner
1340 Membrane Drawing Tool Cleaner
1341 Metal Sample Stower
1342 Heating/Positioning Coil Operation Observer
1343 Atmosphere Analysis Unit Operation Monitor
1344 Camera Operation Monitor
1345 TV Camera Operation Monitor
1346 Liquid Dispersion Research Planner
1347 Materials Slip Formulator
1348 Materials Slip Stower
1349 Materials Slip Mixing Controller
1350 Materials Slip Mold Opener

1351 Materials Slip Excess Remover
1352 Materials Slip Drying Observer
1353 Liquid Dispersion Research Evaluator
1354 Materials Sample Unstower
1355 Materials Sample Translocator
1356 Materials Sample Installer
1357 Materials Sample Remover
1358 Metal Slip Casting Remover
1359 Metal Slip Casting Stower
1360 Immiscible System Casting Stower
1361 Slip Cast Injection System Cleaner
1362 Immiscible System Casting Remover
1363 Slip Cast Injection System Controller
1364 Mold Injection System Controller
1365 Immiscible System Dispersion Determiner
1366 Sample Holder Installer
1367 Crystal Growth Research Planner
1368 Crystal Growth Observer
1369 Crystal Growth Process Evaluator
1370 Materials Dopant Installer
1371 Materials Sample Stower
1372 Silicate Melt Susceptor Control Actuator
1373 Silicate Melt Susceptor Unstower
1374 Silicate Melt Susceptor Translocator
1375 Silicate Melt Susceptor Installer
1376 Silicate Melt Susceptor Remover
1377 Silicate Melt Susceptor Module Remover
1378 Silicate Melt Susceptor Module Installer
1379 Silicate Melt Susceptor Cleaner
1380 Seed Injector Control Actuator
1381 Seed Injector Unstower
1382 Seed Injector Translocator
1383 Seed Injector Installer
1384 Seed Injector Remover
1385 Seed Injector Module Remover
1386 Seed Injector Module Installer
1387 Seed Injector Cleaner
1388 Seed Injector Operation Monitor
1389 Seed Injector Disassembler
1390 Seed Injector Assembler
1391 Seed Injector Fault Identifier
1392 Seed Injector Repairer
1393 Teleoperator System Repairer
1394 Crystal Growth Research Evaluator
1395 Silicate Melt Susceptor Fault Identifier
1396 Silicate Melt Susceptor Repairer
1397 SITOS Fault Identifier
1398 Silicate Solvent Applier
1399 Data Recorder Control Actuator
1400 Furnace Control Deactuator

1401 Silicate Melt Susceptor Operation Monitor
1402 Silicate Melt Susceptor Disassembler
1403 Silicate Melt Susceptor Assembler
1404 SITOS Repairer
1405 Zone Melter Control Actuator
1406 Zone Melter Unstower
1407 Zone Melter Translocator
1408 Zone Melter Installer
1409 Zone Melter Remover
1410 Zone Melter Module Remover
1411 Zone Melter Module Installer
1412 Zone Melter Cleaner
1413 Zone Melter Operation Monitor
1414 Zone Melter Disassembler
1415 Crystal Puller Control Actuator
1416 Crystal Puller Unstower
1417 Crystal Puller Translocator
1418 Crystal Puller Installer
1419 Crystal Puller Remover
1420 Crystal Puller Module Remover
1421 Crystal Puller Module Installer
1422 Crystal Puller Cleaner
1423 Crystal Puller Operation Monitor
1424 Crystal Puller Disassembler
1425 Zone Refiner Control Actuator
1426 Zone Refiner Unstower
1427 Zone Refiner Translocator
1428 Zone Refiner Installer
1429 Zone Refiner Remover
1430 Zone Refiner Module Remover
1431 Zone Refiner Module Installer
1432 Zone Refiner Cleaner
1433 Zone Refiner Operation Monitor
1434 Zone Refiner Disassembler
1435 Zone Refiner Assembler
1436 Zone Refiner Fault Identifier
1437 Zone Refiner Repairer
1438 Zone Melter Assembler
1439 Zone Melter Fault Identifier
1440 Zone Melter Repairer
1441 Crystal Puller Assembler
1412 Crystal Puller Fault Identifier
1443 Crystal Puller Repairer
1444 Crystal Growth Characteristics Determiner
1445 Crystal Growth Structure Analyzer
1446 Test Cell Installer
1447 Materials Analysis Equipment Tester
1448 Camera Tester
1449 Holographic Device Tester
1450 Holographic Device Controller

1451 Camera Timer Control Actuator
1452 Camera Timer Disassembler
1453 Crystal Growth Structure Evaluator
1454 Crystal Growth Data Recorder
1455 Densitometer Unstower
1456 Densitometer Translocator
1457 Densitometer Installer
1458 Densitometer Remover
1459 Densitometer Module Remover
1460 Densitometer Module Installer
1461 Densitometer Calibrator
1462 Densitometer Operation Monitor
1463 Densitometer Disassembler
1464 Densitometer Assembler
1465 Densitometer Fault Identifier
1466 Densitometer Repairer
1467 Growth Tube Remover
1468 Growth Tube Controller
1469 Camera Timer Assembler
1470 Camera Timer Module Remover
1471 Camera Timer Module Installer
1472 Camera Timer Fault Identifier
1473 Camera Timer Repairer
1474 Calorimeter Repairer
1475 Calorimeter Assembler
1476 Calorimeter Disassembler
1477 Calorimeter Module Installer
1478 Calorimeter Module Remover
1479 Calorimeter Remover
1480 Calorimeter Installer
1481 Calorimeter Translocator
1482 Calorimeter Unstower
1483 Friction Measuring Device Repairer
1484 Friction Measuring Device Fault Identifier
1485 Friction Measuring Device Assembler
1486 Friction Measuring Device Disassembler
1487 Friction Measuring Device Operation Monitor
1488 Friction Measuring Device Calibrator
1489 Friction Measuring Device Module Installer
1490 Friction Measuring Device Module Remover
1491 Friction Measuring Device Remover
1492 Friction Measuring Device Installer
1493 Friction Measuring Device Translocator
1494 Friction Measuring Device Unstower
1495 Friction Measuring Device Control Deactuator
1496 Friction Measuring Device Control Actuator
1497 Friction Measuring Device Stower
1498 Friction Measuring Device Cleaner
1499 Calorimeter Stower
1500 Calorimeter Cleaner

1501 Materials Science C/D Equipment Operation Monitor
1502 Atmosphere Supply/Control System Control Deactuator
1503 Environmental Chamber Control Deactuator
1504 Power Conditioning/Distribution System Control Deactuator
1505 Heating/Positioning Coil Control Deactuator
1506 Zone Melter Control Deactuator
1507 Atmosphere Analysis Unit Control Deactuator
1508 Holographic Device Control Deactuator
1509 VHF Power Unit Control Deactuator
1510 Heat Rejection System Control Deactuator
1511 Zone Melter Stower
1512 Crystal Growth Process Monitor
1513 Glass Samples Unstower
1514 Glass Samples Translocator
1515 Glass Samples Installer
1516 Glass Samples Remover
1517 Glass Samples Stower
1518 Glass Structure Analyzer
1519 Data Recorder Unstower
1520 Data Recorder Translocator
1521 Glass Processing Research Planner
1522 Glass Processing Research Evaluator
1523 Glass Samples Observer
1524 Gas Elimination/Cooling System Installer
1525 Gas Elimination/Cooling System Unstower
1526 Gas Elimination/Cooling System Translocator
1527 Gas Elimination/Cooling System Cleaner
1528 Gas Elimination/Cooling System Stower
1529 Gas Elimination/Cooling System Operation Monitor
1530 Gas Elimination/Cooling System Disassembler
1531 Gas Elimination/Cooling System Assembler
1532 Gas Elimination/Cooling System Module Remover
1533 Gas Elimination/Cooling System Module Installer
1534 Gas Elimination/Cooling System Fault Identifier
1535 Gas Elimination/Cooling System Repairer
1536 Cleanup/Refurbishment Equipment Installer
1537 Cleanup/Refurbishment Equipment Unstower
1538 Cleanup/Refurbishment Equipment Translocator
1539 Cleanup/Refurbishment Equipment Stower
1540 Buffer/Waste Separator Installer
1541 Buffer/Waste Separator Unstower
1542 Buffer/Waste Separator Translocator
1543 Buffer/Waste Separator Cleaner
1544 Buffer/Waste Separator Stower
1545 Buffer/Waste Separator Operation Monitor
1546 Buffer/Waste Separator Disassembler
1547 Buffer/Waste Separator Assembler
1548 Buffer/Waste Separator Fault Identifier
1549 TV System Control Actuator
1550 Data Compression Equipment Control Actuator

1551 Buffer Solution Installer
1552 Buffer Solution Unstower
1553 Buffer Solution Translocator
1554 Buffer Solution Remover
1555 Buffer Solution Mixer
1556 Biological Materials Installer
1557 Biological Materials Unstower
1558 Biological Materials Translocator
1559 Biological Materials Remover
1560 Biological Enclosure Unstower
1561 Biological Enclosure Cleaner
1562 Biological Enclosure Stower
1563 Biological Enclosure Operation Monitor
1564 Biological Enclosure Disassembler
1565 Biological Enclosure Assembler
1566 Biological Enclosure Module Remover
1567 Biological Enclosure Module Installer
1568 Biological Enclosure Fault Identifier
1569 Biological Enclosure Repairer
1570 Buffer/Waste Separator Module Remover
1571 Buffer/Waste Separator Module Installer
1572 Buffer/Waste Separator Repairer
1573 Electrophoretic Column Installer
1574 Electrophoretic Column Unstower
1575 Electrophoretic Column Translocator
1576 Electrophoretic Column Remover
1577 Electrophoretic Column Cleaner
1578 Electrophoretic Column Stower
1579 Electrophoretic Column Operation Monitor
1580 Electrophoretic Column Disassembler
1581 Electrophoretic Column Assembler
1582 Electrophoretic Column Module Remover
1583 Electrophoretic Column Module Installer
1584 Electrophoretic Column Fault Identifier
1585 Electrophoretic Column Repairer
1586 Electrophoretic Separation Research Planner
1587 Electrophoretic Separation Process Evaluator
1588 Electrophoretic Separation Data Recorder
1589 Lyophilization Apparatus Control Actuator
1590 Lyophilization Apparatus Operation Monitor
1591 Lyophilization Apparatus Disassembler
1592 Lyophilization Apparatus Assembler
1593 Lyophilization Apparatus Module Remover
1594 Lyophilization Apparatus Module Installer
1595 Lyophilization Apparatus Fault Identifier
1596 Lyophilization Apparatus Repairer
1597 Syringe Controller
1598 Ampoule Installer
1599 Data Recorder Remover
1600 Data Recorder Stower

1601 Interferometer Installer
1602 Interferometer Unstower
1603 Interferometer Translocator
1604 Interferometer Remover
1605 Interferometer Calibrator
1606 Interferometer Tester
1607 Interferometer Stower
1608 Interferometer Controller
1609 Interferometer Operation Monitor
1610 Interferometer Disassembler
1611 Interferometer Assembler
1612 Interferometer Module Remover
1613 Interferometer Module Installer
1614 Interferometer Fault Identifier
1615 Interferometer Repairer
1616 Interferometer Control Actuator
1617 Densitometer Control Actuator
1618 Densitometer Tester
1619 Densitometer Stower
1620 Densitometer Controller
1621 Buffer/Waste Separator Remover
1622 Gas Elimination/Cooling System Remover
1623 Buffer Solution Flow Rate Determiner
1624 Biological Materials Test Observer
1625 Electrophoretic Separation Research Evaluator
1626 Biological Materials Mixing Controller
1627 Lyophilization Apparatus Unstower
1628 Lyophilization Apparatus Translocator
1629 Lyophilization Apparatus Installer
1630 Lyophilization Apparatus Remover
1631 Lyophilization Data Recorder
1632 Lyophilization Research Planner
1633 Biological Materials Culturing Controller
1634 Isotope Tracer-Counter Unstower
1635 Isotope Tracer-Counter Translocator
1636 Isotope Tracer-Counter Installer
1637 Isotope Tracer-Counter Remover
1638 Isotope Tracer-Counter Module Remover
1639 Isotope Tracer-Counter Module Installer
1640 Isotope Tracer-Counter Calibrator
1641 Isotope Tracer-Counter Operation Monitor
1642 Isotope Tracer-Counter Controller
1643 Isotope Tracer-Counter Disassembler
1644 Isotope Tracer-Counter Assembler
1645 Isotope Tracer-Counter Fault Identifier
1646 Isotope Tracer-Counter Repairer
1647 Fluid Sample Mixing Controller
1648 Fluid Convection Research Planner
1649 Fluid Convection Research Evaluator
1650 Fluid Samples Installer

1651 Fluid Samples Translocator
1652 Fluid Samples Unstower
1653 Fluid Samples Remover
1654 Rotational Testing Device Unstower
1655 Rotational Testing Device Translocator
1656 Rotational Testing Device Assembler
1657 Rotational Testing Device Installer
1658 Rotational Testing Device Tester
1659 Rotational Testing Device Remover
1660 Rotational Testing Device Module Remover
1661 Rotational Testing Device Module Installer
1662 Rotational Testing Device Cleaner
1663 Rotational Testing Device Stower
1664 Rotational Testing Device Control Actuator
1665 Rotational Testing Device Occupant
1666 Rotational Testing Device Controller
1667 Rotational Testing Device Calibrator
1668 Rotational Testing Device Disassembler
1669 Rotational Testing Device Fault Identifier
1670 Rotational Testing Device Repairer
1671 Protective Cover Remover
1672 Protective Cover Translocator
1673 Protective Cover Stower
1674 Protective Cover Unstower
1675 Protective Cover Installer
1676 Biteboard Unstower
1677 Biteboard Translocator
1678 Biteboard Installer
1679 Biteboard Remover
1680 Biteboard Cleaner
1681 Biteboard Stower
1682 Cable Unstower
1683 Cable Translocator
1684 Cable Installer
1685 Cable Remover
1686 Accelerometer Unstower
1687 Accelerometer Translocator
1688 Accelerometer Installer
1689 Accelerometer Tester
1690 Accelerometer Remover
1691 Accelerometer Cleaner
1692 Accelerometer Stower
1693 Accelerometer Fault Identifier
1694 Accelerometer Repairer
1695 Cable Tester
1696 Data Recorder Tester
1697 Data Recorder Disassembler
1698 Data Recorder Assembler
1699 Data Recorder Module Remover
1700 Data Recorder Module Installer

1701 Life Sciences C/D Equipment Unstower
1702 Life Sciences C/D Equipment Tester
1703 Life Sciences C/D Equipment Module Remover
1704 Life Sciences C/D Equipment Module Installer
1705 Life Sciences C/D Equipment Cleaner
1706 Life Sciences C/D Equipment Stower
1707 Life Sciences C/D Equipment Fault Identifier
1708 Life Sciences C/D Equipment Repairer
1709 Record Keeping Materials Unstower
1710 Record Keeping Materials Translocator
1711 Record Keeping Materials Stower
1712 Head Proximity Device Unstower
1713 Head Proximity Device Translocator
1714 Head Proximity Device Installer
1715 Head Proximity Device Tester
1716 Head Proximity Device Remover
1717 Head Proximity Device Module Remover
1718 Head Proximity Device Module Installer
1719 Head Proximity Device Cleaner
1720 Head Proximity Device Stower
1721 Head Proximity Device Disassembler
1722 Head Proximity Device Assembler
1723 Head Proximity Device Fault Identifier
1724 Head Proximity Device Repairer
1725 Vestibular Research Configuration Observer
1726 Vestibular Research Configuration Recorder
1727 Vestibular Research Data Recorder
1728 Vestibular Research Evaluator
1729 Vestibular Research Results Determiner
1730 Vestibular Research Planner
1731 Vestibular Research Observer
1732 Vestibular Research Results Communicator
1733 Data Management Unit Tester
1734 Data Management Unit Disassembler
1735 Data Management Unit Assembler
1736 Data Management Unit Module Remover
1737 Data Management Unit Module Installer
1738 Data Management Unit Fault Identifier
1739 Data Management Unit Repairer
1740 Human Subject Status Observer
1741 Human Subject Status Monitor
1742 RAM Surfaces Cleaner
1743 RAM Facility Equipment Cleaner
1744 Visual Target Observer
1745 Visual Target Evaluator
1746 Visual Target Status Communicator
1747 Canal Stimulation Symptoms Evaluator
1748 Canal Stimulation Symptoms Communicator
1749 Spatial Localization Success Evaluator
1750 Plethysmograph Installer

1751 Plethysmograph Wearer
1752 Plethysmograph Unstower
1753 Plethysmograph Tester
1754 Plethysmograph Remover
1755 Plethysmograph Translocator
1756 Plethysmograph Stower
1757 Plethysmograph Operation Monitor
1758 Plethysmograph Disassembler
1759 Plethysmograph Assembler
1760 Plethysmograph Module Remover
1761 Plethysmograph Module Installer
1762 Plethysmograph Fault Identifier
1763 Plethysmograph Repairer
1764 Sphygmomanometer Installer
1765 Sphygmomanometer Wearer
1766 Sphygmomanometer Unstower
1767 Sphygmomanometer Translocator
1768 Sphygmomanometer Tester
1769 Sphygmomanometer Remover
1770 Sphygmomanometer Stower
1771 Sphygmomanometer Operation Monitor
1772 Sphygmomanometer Disassembler
1773 Sphygmomanometer Assembler
1774 Sphygmomanometer Module Remover
1775 Sphygmomanometer Module Installer
1776 Sphygmomanometer Fault Identifier
1777 Sphygmomanometer Repairer
1778 Electrocardiograph Installer
1779 Electrocardiograph Wearer
1780 Electrocardiograph Unstower
1781 Electrocardiograph Translocator
1782 Electrocardiograph Tester
1783 Electrocardiograph Remover
1784 Electrocardiograph Stower
1785 Electrocardiograph Operation Monitor
1786 Electrocardiograph Disassembler
1787 Electrocardiograph Assembler
1788 Electrocardiograph Module Remover
1789 Electrocardiograph Module Installer
1790 Electrocardiograph Fault Identifier
1791 Electrocardiograph Repairer
1792 LBNP Device Installer
1793 LBNP Device Wearer
1794 LBNP Device Unstower
1795 LBNP Device Translocator
1796 LBNP Device Tester
1797 LBNP Device Remover
1798 LBNP Device Stower
1799 LBNP Device Control Actuator
1800 LBNP Device Operation Monitor

1801 LBNP Device Disassembler
1802 LBNP Device Assembler
1803 LBNP Device Module Remover
1804 LBNP Device Module Installer
1805 LBNP Device Fault Identifier
1806 LBNP Device Repairer
1807 Body Temperature Measuring Device Installer
1808 Body Temperature Measuring Device Wearer
1809 Body Temperature Measuring Device Unstower
1810 Body Temperature Measuring Device Translocator
1811 Body Temperature Measuring Device Tester
1812 Body Temperature Measuring Device Remover
1813 Body Temperature Measuring Device Stower
1814 Body Temperature Measuring Device Operation Monitor
1815 Body Temperature Measuring Device Disassembler
1816 Body Temperature Measuring Device Assembler
1817 Body Temperature Measuring Device Module Remover
1818 Body Temperature Measuring Device Module Installer
1819 Body Temperature Measuring Device Fault Identifier
1820 Body Temperature Measuring Device Repairer
1821 Stowage Container Unstower
1822 Stowage Container Translocator
1823 Stowage Container Installer
1824 Stowage Container Remover
1825 Stowage Container Stower
1826 Life Sciences C/D Equipment Operation Monitor
1827 Cardioangiology Research Data Recorder
1828 Cardioangiology Research Planner
1829 Data Management Unit Control Actuator
1830 Cleaning/Decontamination Equipment Remover
1831 Electroanalytical System Cleaner
1832 Electroanalytical System Unstower
1833 Electroanalytical System Translocator
1834 Electroanalytical System Installer
1835 Electroanalytical System Tester
1836 Electroanalytical System Remover
1837 Electroanalytical System Module Remover
1838 Electroanalytical System Module Installer
1839 Electroanalytical System Stower
1840 Electroanalytical System Control Actuator
1841 Electroanalytical System Disassembler
1842 Electroanalytical System Assembler
1843 Electroanalytical System Fault Identifier
1844 Electroanalytical System Repairer
1845 Biomedical Fluid Transfer Equipment Cleaner
1846 Biomedical Fluid Transfer Equipment Unstower
1847 Biomedical Fluid Transfer Equipment Translocator
1848 Biomedical Fluid Transfer Equipment Installer
1849 Biomedical Fluid Transfer Equipment Remover
1850 Biomedical Fluid Transfer Equipment Stower

1851 Photometer Cleaner
1852 Photometer Tester
1853 Photometer Remover
1854 Photometer Disassembler
1855 Photometer Assembler
1856 Photometer Fault Identifier
1857 Photometer Repairer
1858 Refractometer Cleaner
1859 Refractometer Unstower
1860 Refractometer Translocator
1861 Refractometer Installer
1862 Refractometer Tester
1863 Refractometer Remover
1864 Refractometer Module Remover
1865 Refractometer Module Installer
1866 Refractometer Stower
1867 Refractometer Control Actuator
1868 Refractometer Disassembler
1869 Refractometer Assembler
1870 Refractometer Fault Identifier
1871 Refractometer Repairer
1872 Centrifuge Cleaner
1873 Centrifuge Unstower
1874 Centrifuge Translocator
1875 Centrifuge Installer
1876 Centrifuge Tester
1877 Centrifuge Remover
1878 Centrifuge Module Remover
1879 Centrifuge Module Installer
1880 Centrifuge Stower
1881 Centrifuge Disassembler
1882 Centrifuge Assembler
1883 Centrifuge Fault Identifier
1884 Centrifuge Repairer
1885 Waste Management System Cleaner
1886 Waste Management System Unstower
1887 Waste Management System Tester
1888 Waste Management System Module Remover
1889 Waste Management System Module Installer
1890 Waste Management System Stower
1891 Waste Management System Disassembler
1892 Waste Management System Assembler
1893 Waste Management System Fault Identifier
1894 Waste Management System Repairer
1895 Syringe Unstower
1896 Syringe Translocator
1897 Syringe Installer
1898 Syringe Stower
1899 Biological Sample Container Unstower
1900 Biological Sample Container Translocator

1901 Biological Sample Container Installer
1902 Biological Sample Container Stower
1903 Freezer Unstower
1904 Freezer Tester
1905 Freezer Stower
1906 Freezer Disassembler
1907 Freezer Assembler
1908 Freezer Module Remover
1909 Freezer Module Installer
1910 Freezer Fault Identifier
1911 Freezer Repairer
1912 Timing Device Remover
1913 Timing Device Installer
1914 Timing Device Module Remover
1915 Timing Device Module Installer
1916 Timing Device Translocator
1917 Timing Device Stower
1918 Timing Device Unstower
1919 Timing Device Observer
1920 Timing Device Disassembler
1921 Timing Device Assembler
1922 Timing Device Fault Identifier
1923 Timing Device Repairer
1924 Timing Device Tester
1925 Body Waste Stower
1926 Body Waste Sample Remover
1927 Body Waste Sample Translocator
1928 Body Waste Sample Stower
1929 Body Waste Controller
1930 Body Waste Measurement Observer
1931 Body Waste Measurement Recorder
1932 Body Waste Sample Installer
1933 Gauze Sponge Stower
1934 Urology Research Data Recorder
1935 Urology Research Data Processor
1936 Urology Research Planner
1937 Record Keeping Materials Remover
1938 Blood Sample Remover
1939 Blood Sample Translocator
1940 Blood Sample Stower
1941 Blood Sample Donor
1942 Blood Sample Installer
1943 Blood Sample Measurement Observer
1944 Blood Sample Measurement Recorder
1945 Waste Management System Control Actuator
1946 Human Subject Injection Site Determiner
1947 Human Subject Withdrawal Site Determiner
1948 PAH Injection Receiver
1949 Urology Research Schedule Communicator
1950 Electrocardiograph Control Actuator

1951 Ergometer Control Actuator
1952 Ergometer Unstower
1953 Ergometer Translocator
1954 Ergometer Installer
1955 Ergometer Tester
1956 Ergometer Control Deactuator
1957 Ergometer Remover
1958 Ergometer Stower
1959 Ergometer Controller
1960 Ergometer Disassembler
1961 Ergometer Assembler
1962 Ergometer Module Remover
1963 Ergometer Module Installer
1964 Ergometer Fault Identifier
1965 Ergometer Repairer
1966 Life Sciences C/D Equipment Control Deactuator
1967 Life Sciences C/D Equipment Control Actuator
1968 Cardiotachometer Unstower
1969 Cardiotachometer Translocator
1970 Cardiotachometer Installer
1971 Cardiotachometer Tester
1972 Cardiotachometer Remover
1973 Cardiotachometer Stower
1974 Cardiotachometer Control Actuator
1975 Cardiotachometer Disassembler
1976 Cardiotachometer Assembler
1977 Cardiotachometer Module Remover
1978 Cardiotachometer Module Installer
1979 Cardiotachometer Fault Identifier
1980 Cardiotachometer Repairer
1981 Timing Device Control Actuator
1982 Exercise Conditioning Research Planner
1983 Exercise Conditioning Research Instruction Communicator
1984 Exercise Conditioning Research Data Recorder
1985 Human Subject Heart Rate Monitor
1986 Atmosphere Supply/Control System Inspector
1987 Atmosphere Supply/Control System Tester
1988 Atmosphere Supply/Control System Installer
1989 Atmosphere Supply/Control Research Data Communicator
1990 Atmosphere Supply/Control System Remover
1991 Atmosphere Supply/Control System Translocator
1992 Atmosphere Supply/Control Sample Stower
1993 Atmosphere Supply/Control Research Data Recorder
1994 Atmosphere Supply/Control System Problem Determiner
1995 Data Management Unit Operation Monitor
1996 EVA Suit Unstower
1997 EVA Suit Inspector
1998 EVA Suit Installer
1999 EVA Suit Umbilical Connector
2000 EVA Suit Cable Connector

2001 EVA Suit Tester
2002 EVA Suit Remover
2003 EVA-Vehicle Intercom Communicator
2004 EVA Test Assembly Calibrator
2005 EVA Test Assembly Controller
2006 EVA Test Assembly Control Actuator
2007 EVA Test Assembly Control Deactuator
2008 EVA Test Assembly Cleaner
2009 EVA Test Assembly Assembler
2010 EVA Test Assembly Disassembler
2011 EVA Test Assembly Translocator
2012 EVA Test Assembly Module Remover
2013 EVA Test Assembly Module Installer
2014 EVA Test Assembly Remover
2015 EVA Test Assembly Installer
2016 EVA Suit Operating Status Monitor
2017 EVA Suit Research Debriefing Communicator
2018 EVA Suit Research Data Evaluator
2019 EVA Suit Cleaner
2020 EVA Suit Module Remover
2021 EVA Suit Module Installer
2022 EVA Suit Fault Identifier
2023 EVA Suit Repairer
2024 Biomedical Measurements Sensor Installer
2025 Biopack Unstower
2026 Biopack Installer
2027 Biopack Tester
2028 Biopack Remover
2029 Biopack Operating Status Monitor
2030 Biopack Research Debriefing Communicator
2031 Biopack Research Data Evaluator
2032 Biopack Cleaner
2033 Biopack Disassembler
2034 Biopack Assembler
2035 Biopack Module Remover
2036 Biopack Module Installer
2037 Biopack Fault Identifier
2038 Biopack Repairer
2039 Tether/Control Unit Control Actuator
2040 Spectrograph Remover
2041 Spectrograph Installer
2042 Comm/Nav C/D Equipment Self-Test Control Actuator
2043 Comm/Nav C/D Equipment Self-Test Display Monitor
2044 Lyophilization Research Evaluator

- END OF LISTING -

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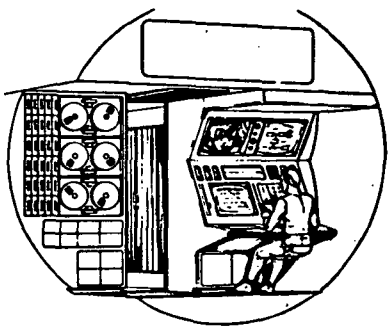
APPENDIX F

TASK-SKILL LOCATION
BY EXPERIMENT



MATRIX
MAN SYSTEMS

APPENDIX F

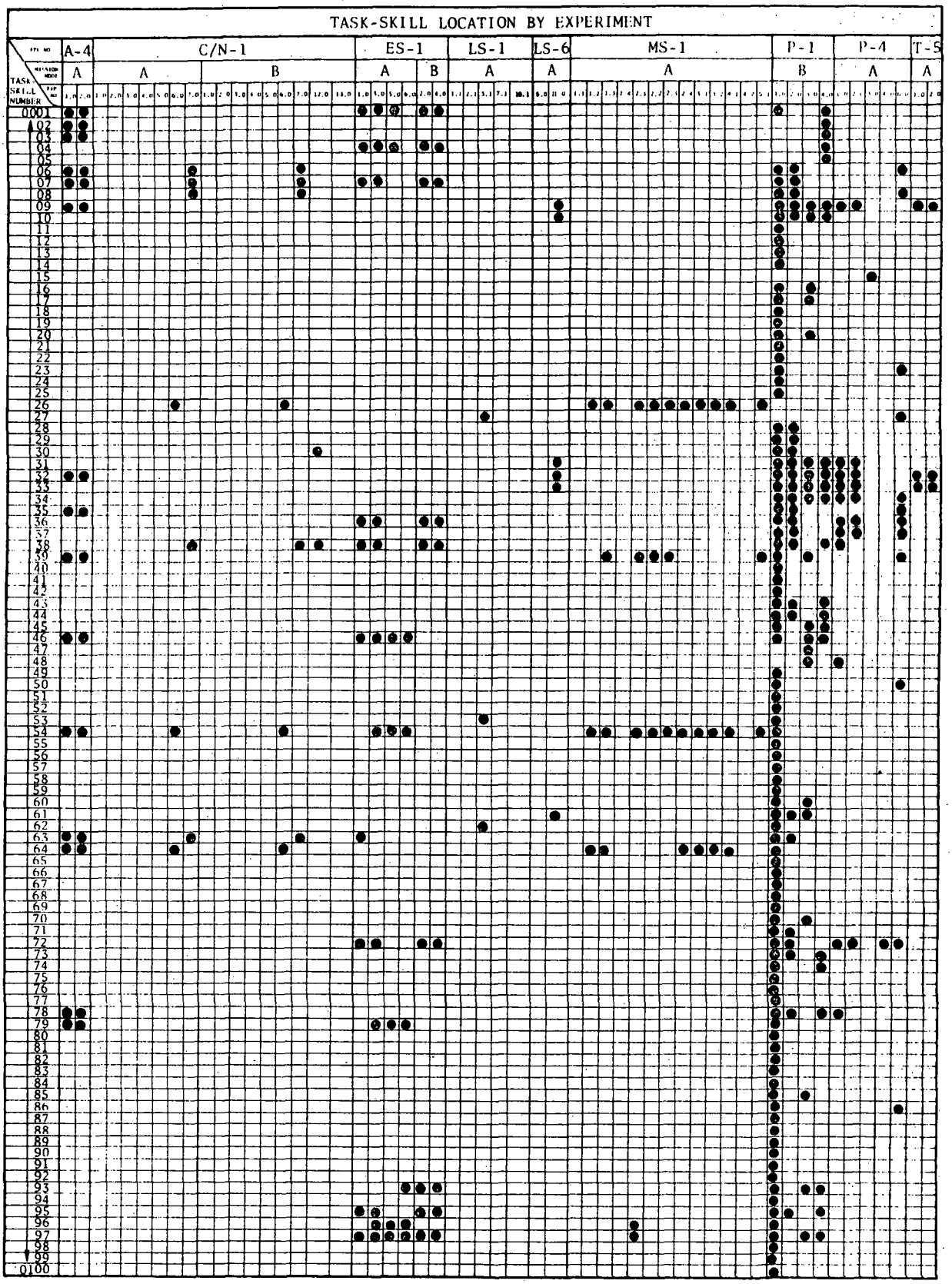
TASK-SKILL LOCATION BY EXPERIMENT

EXPLANATION OF TASK-SKILL LOCATION CHARTS

The charts on the following pages of this appendix show the incidence of identification of task-skills in each of the experiments encompassed by the study. Task-skill code numbers are listed in the left hand column, 100 to a page (e.g., #0001 to #0100). Functional Program Element (FPE) designators, mission mode identification, and experiment numbers are listed as column headings.

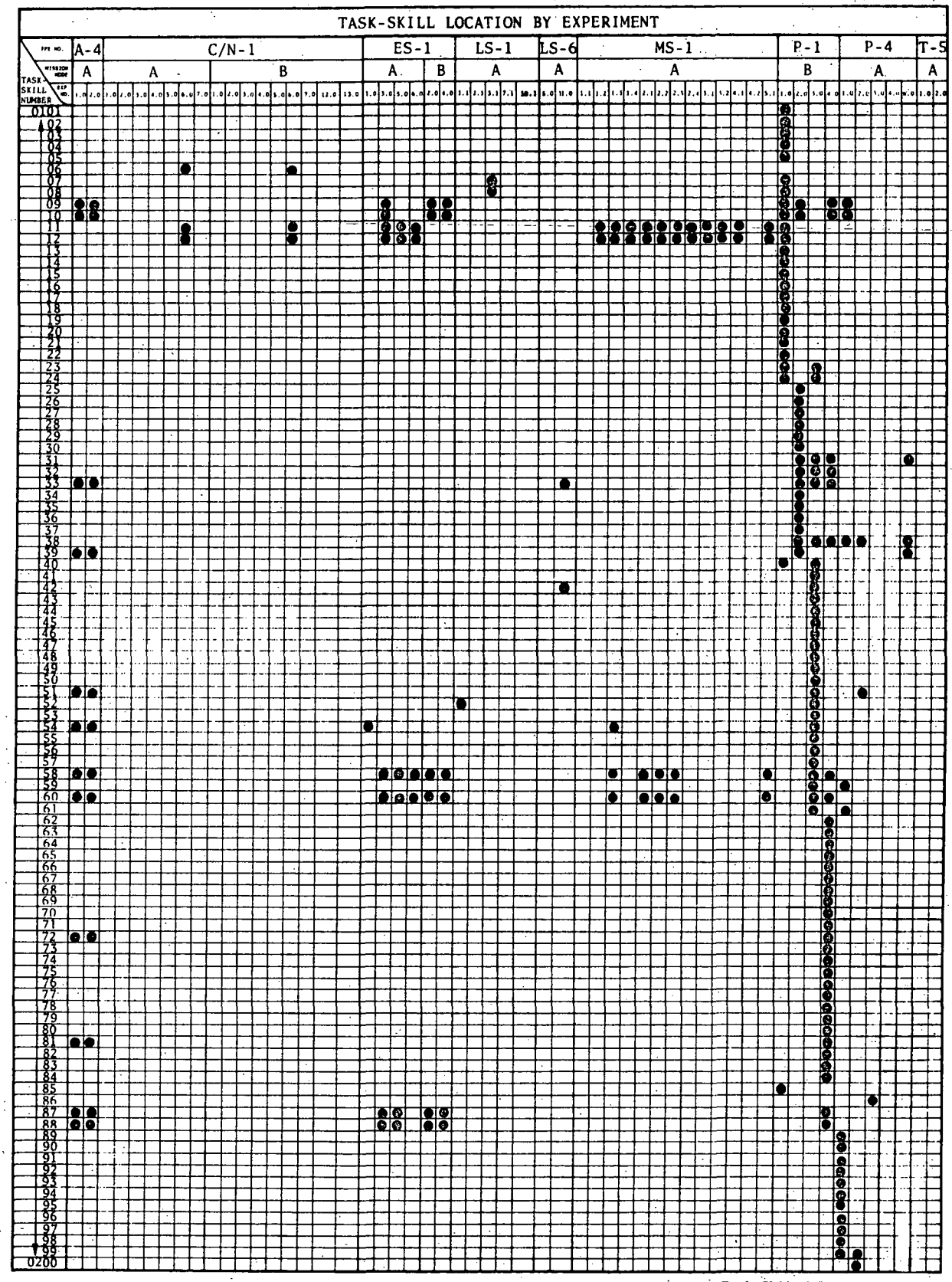
To find the incidence of a particular task-skill across experiments, locate the task-skill number in the left hand column. Read horizontally until reaching a marked column, then vertically to identify the FPE, mission mode, and experiment number. Additional detail, such as the specific conditions requiring the task-skill, can be located by turning to the task-skill data sheets in Appendix H for the experiment identified.

To find the task-skills identified as being required in each experiment, reverse the procedure, starting with the appropriate experiment column and reading down. Repeat for each page. Task-skill titles for each task-skill number are provided in Appendix E.

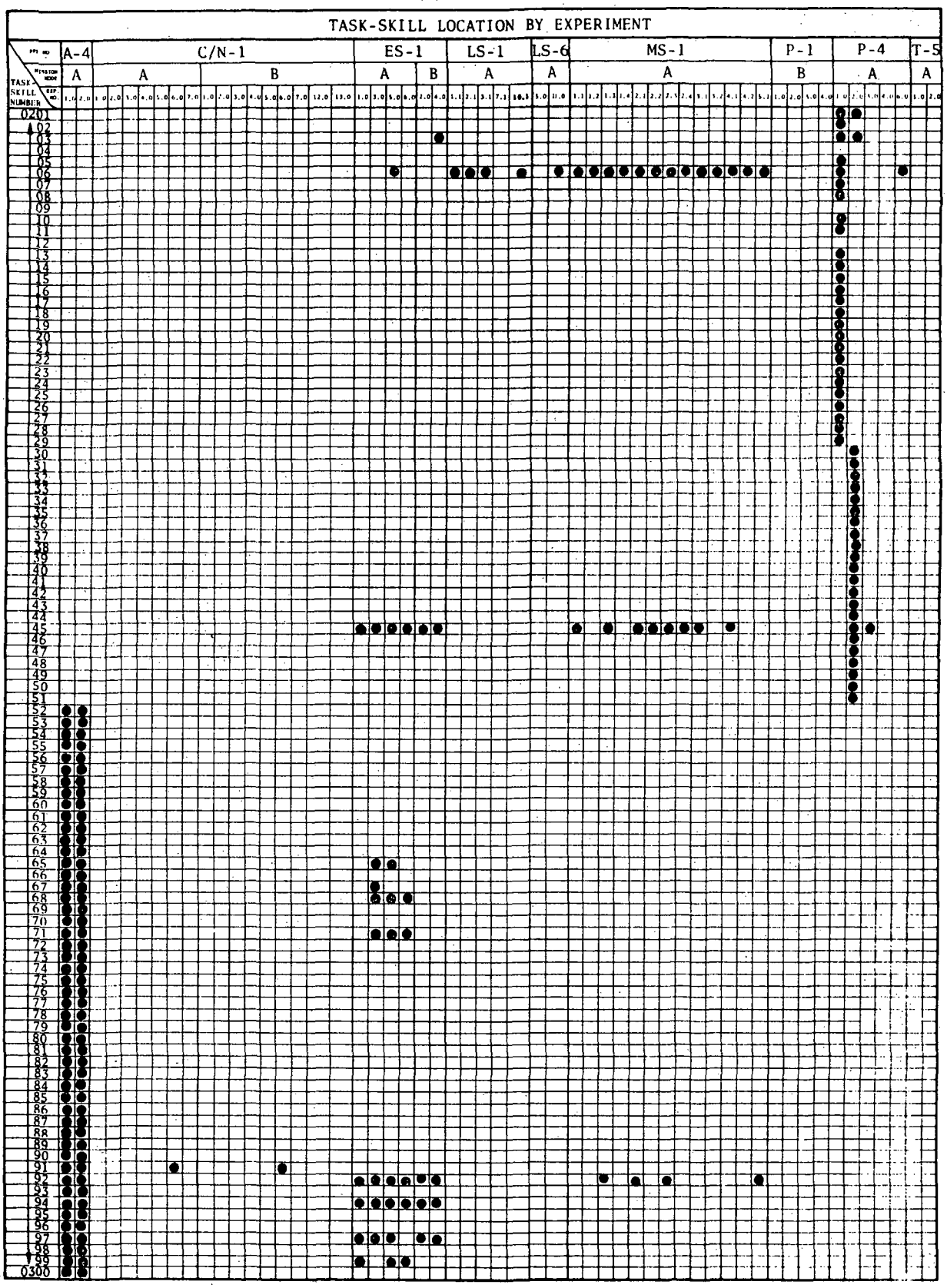


Task-Skill #0001 - 0100

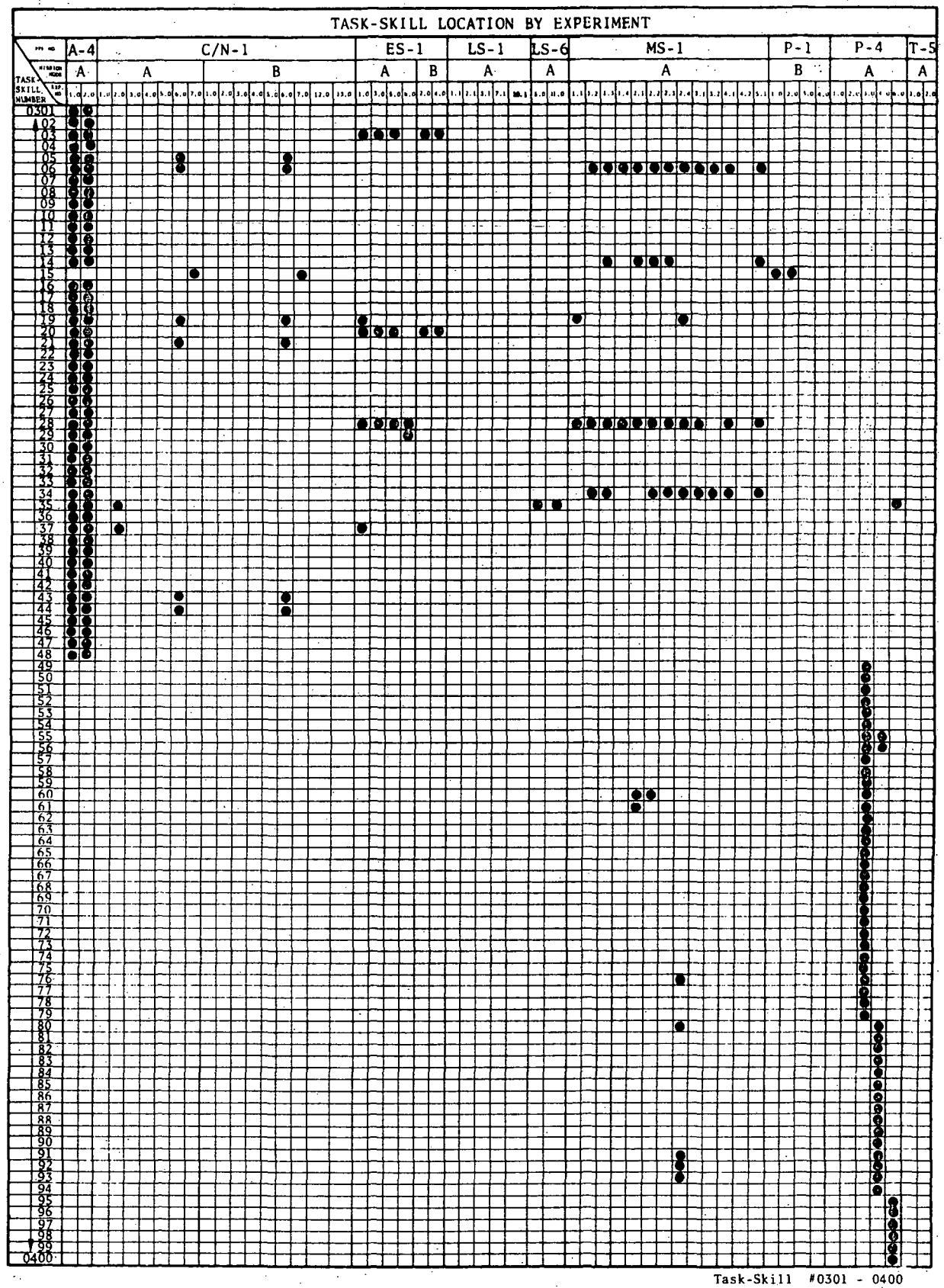
TASK-SKILL LOCATION BY EXPERIMENT



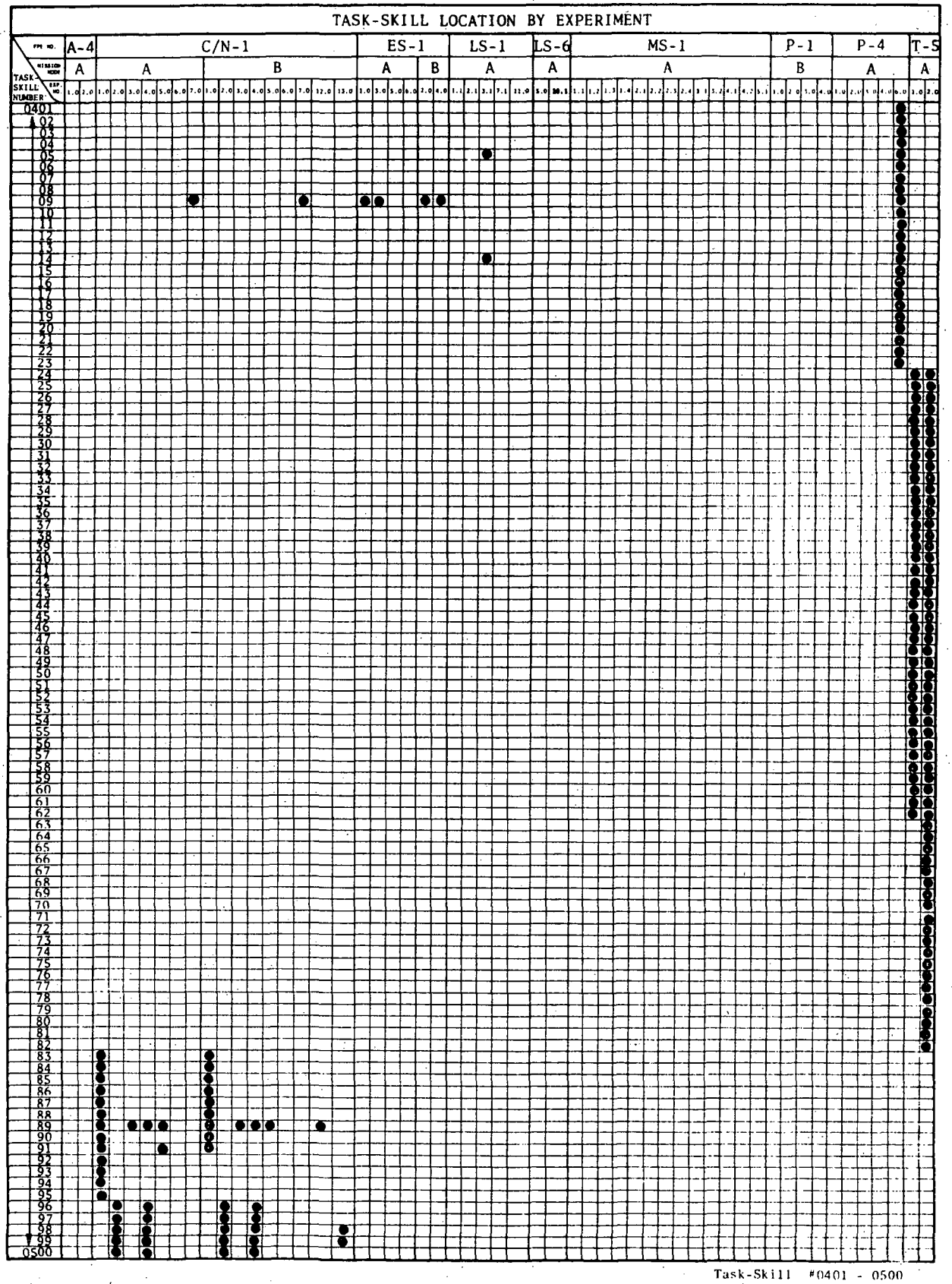
Task-Skill #0101 - 0200



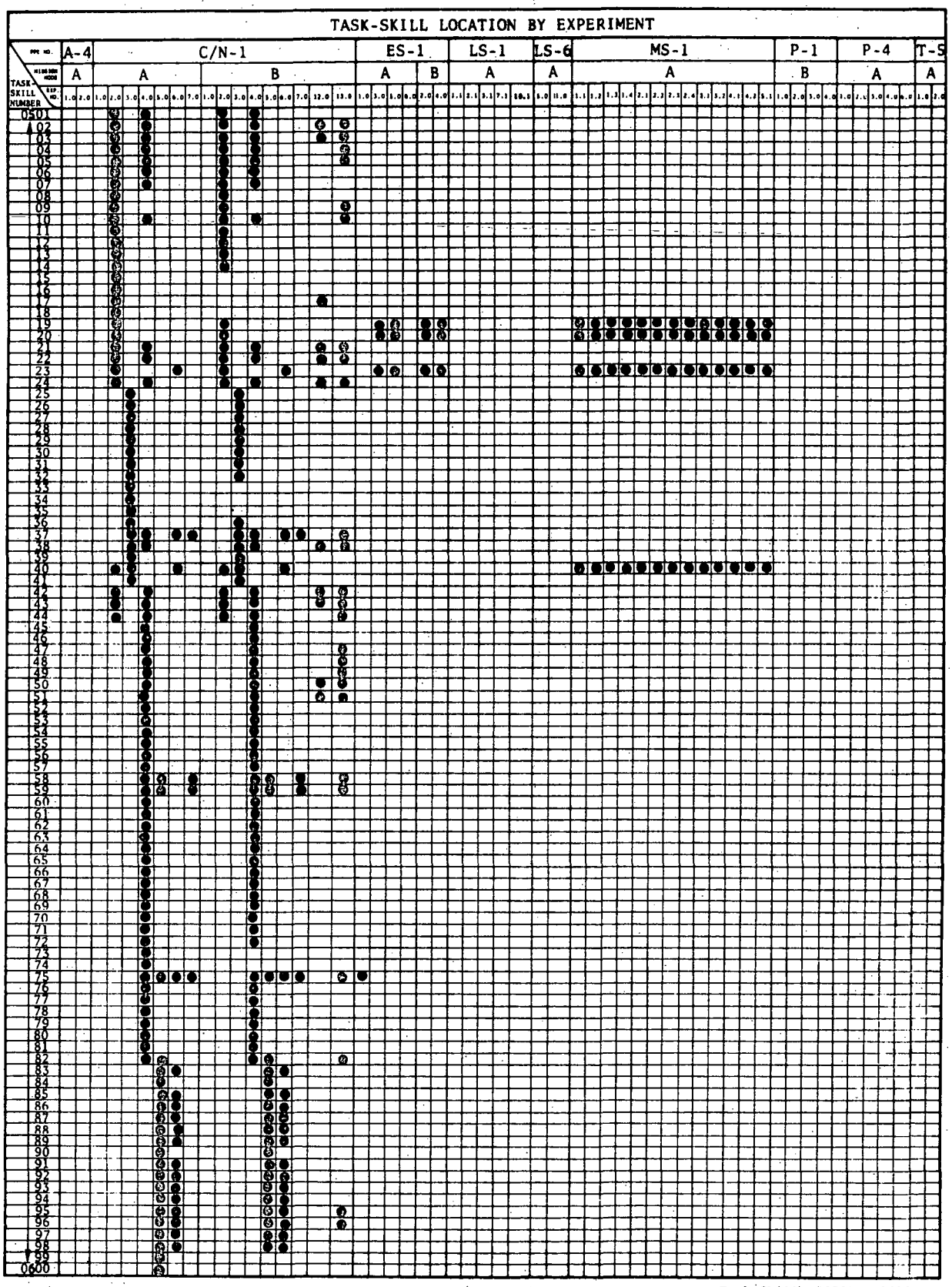
Task-Skill #0201 - 0300



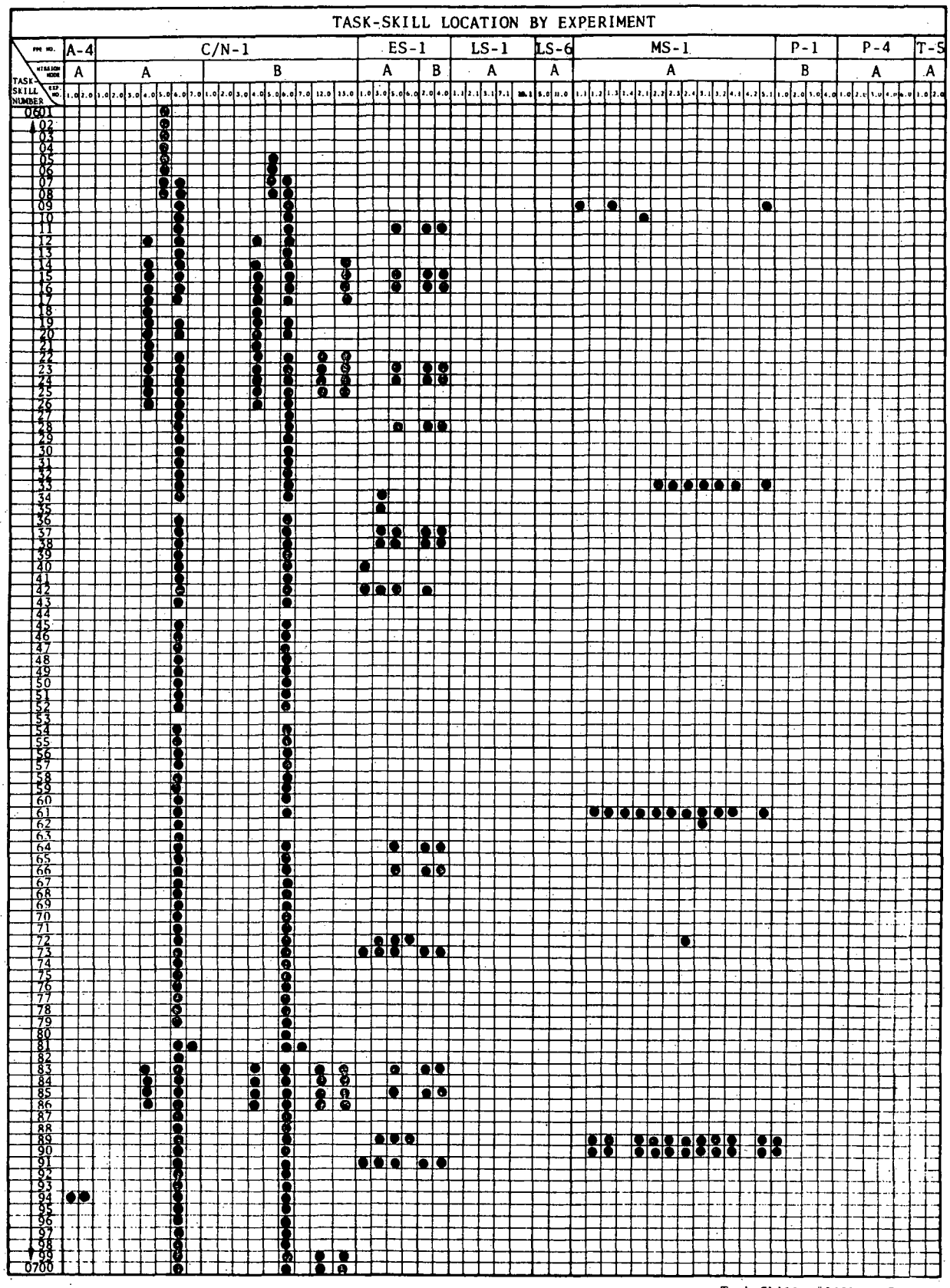
Task-Skill #0301 - 0400



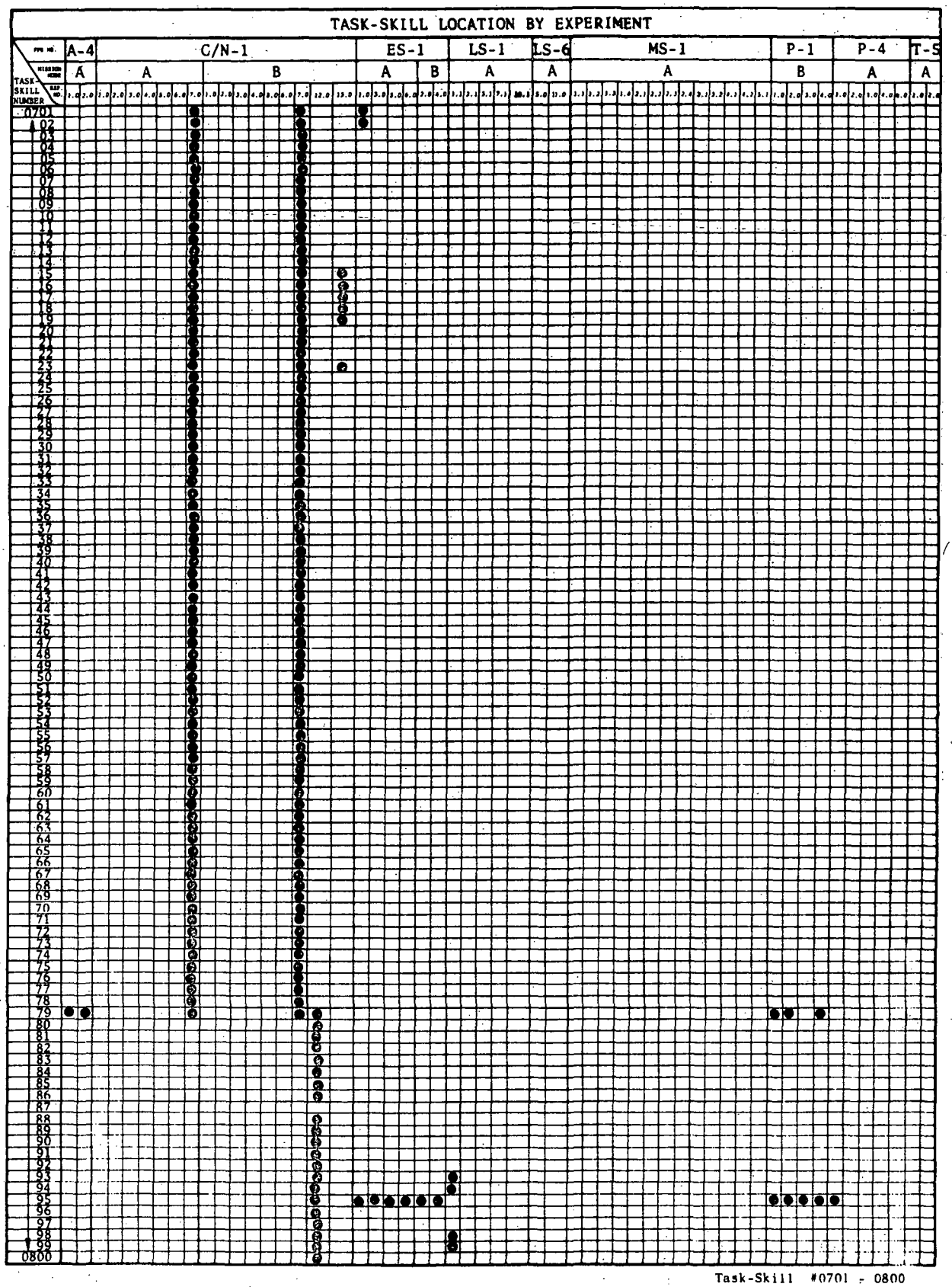
Task-Skill #0401 - 0500



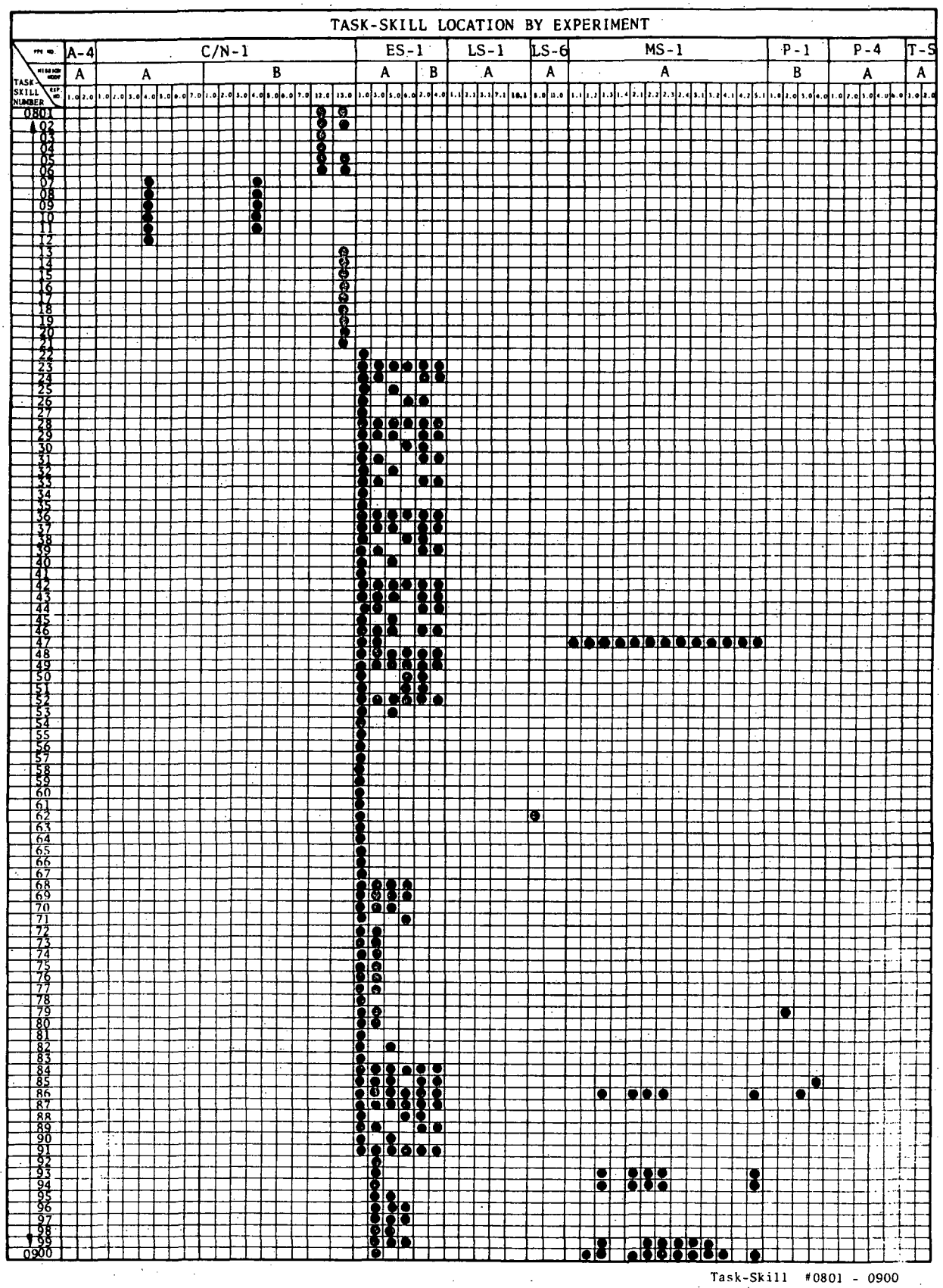
Task-Skill #0501 - 0600



Task-Skill #0601 - 0700



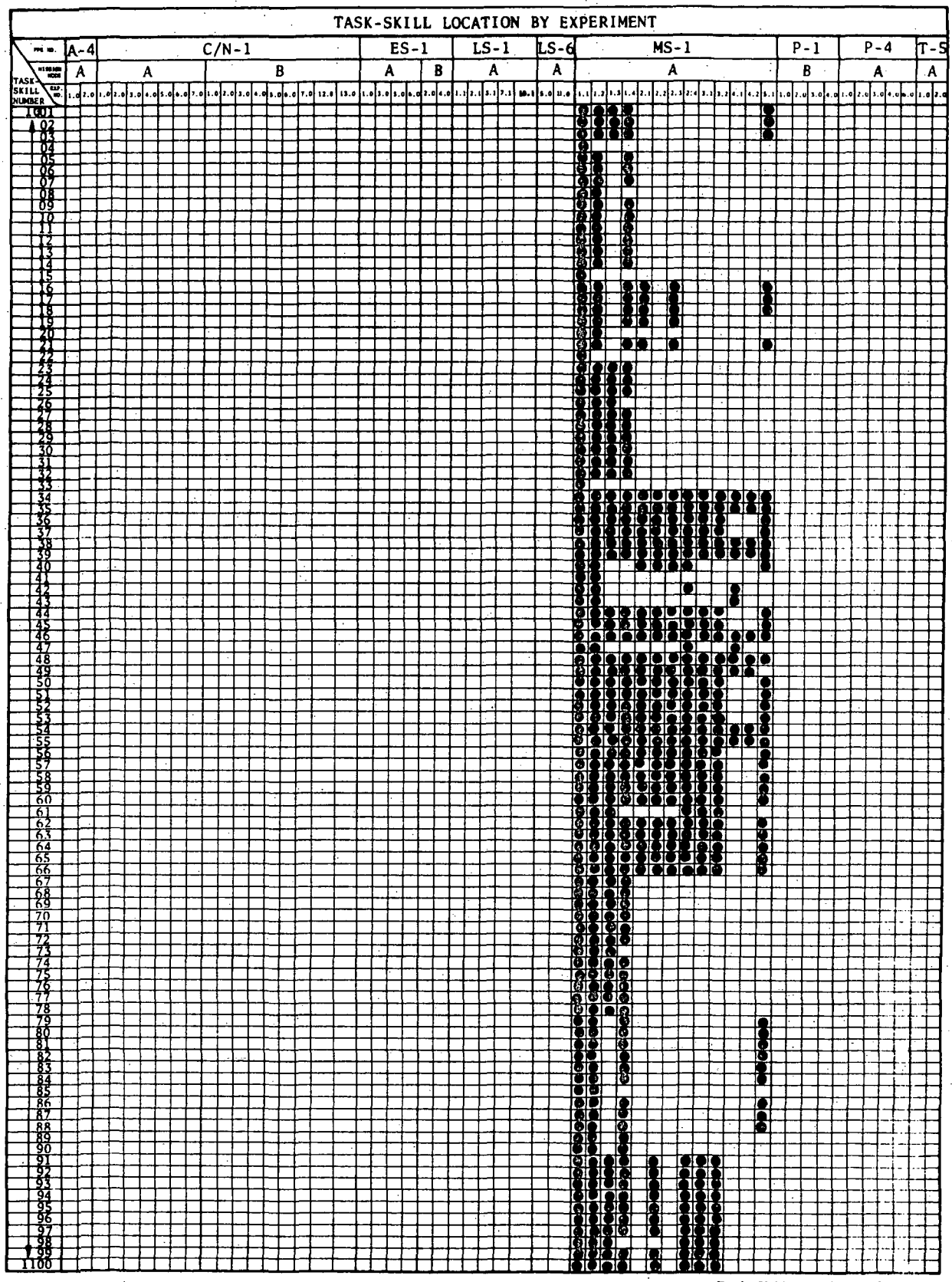
Task-Skill #0701 - 0800



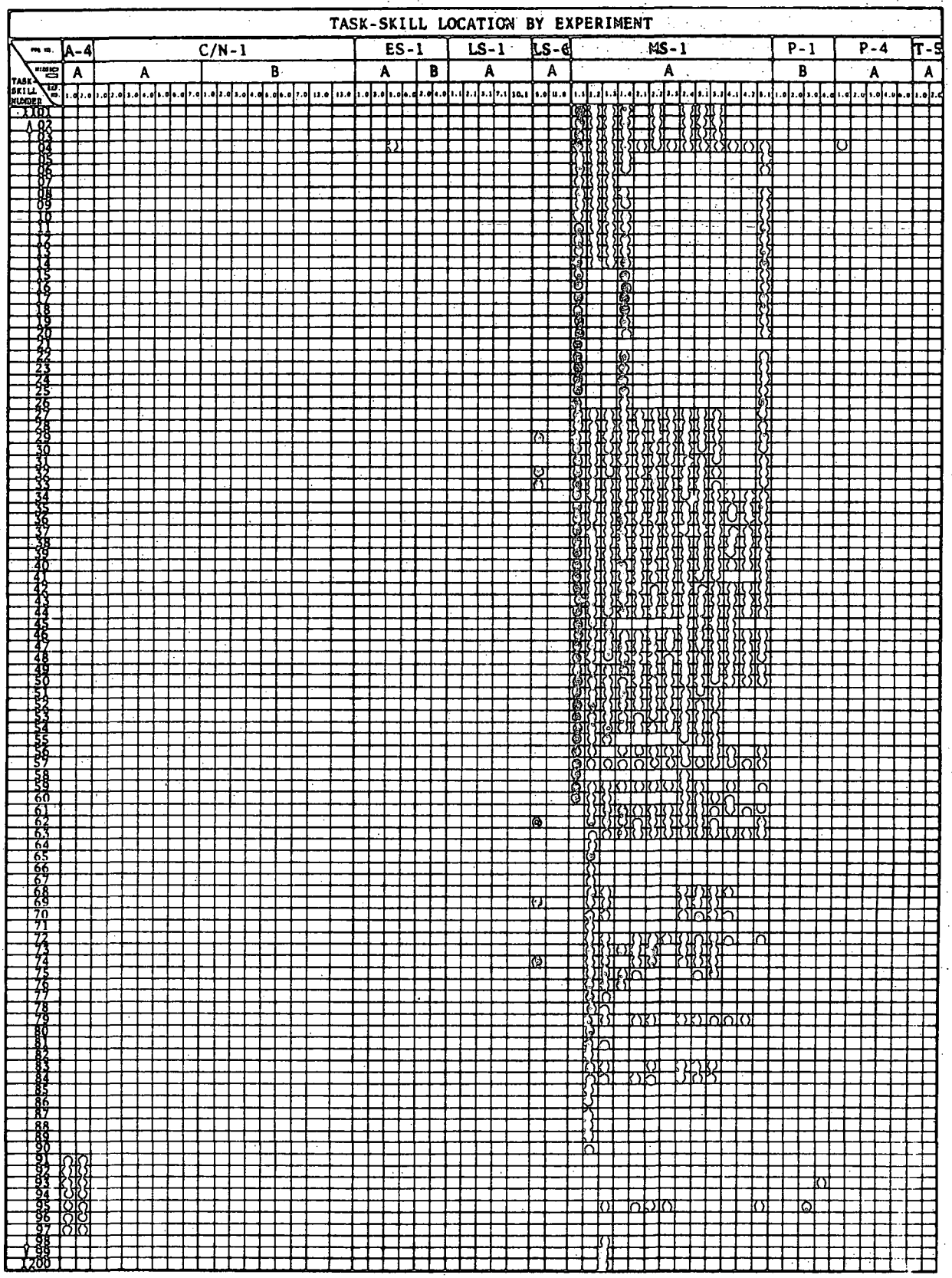
Task-Skill #0801 - 0900

Task-Skill #0901 - 1000

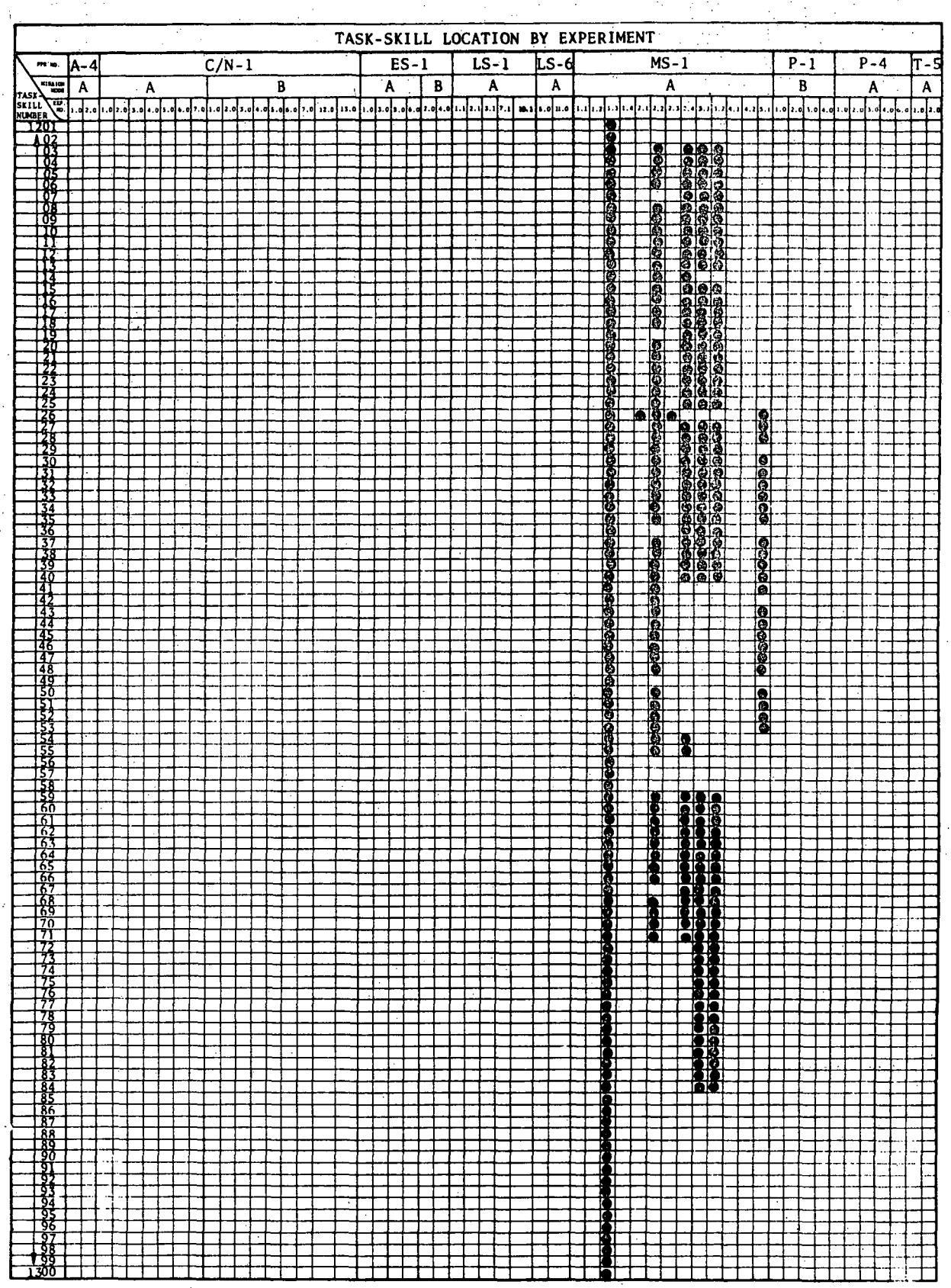
TASK-SKILL LOCATION BY EXPERIMENT



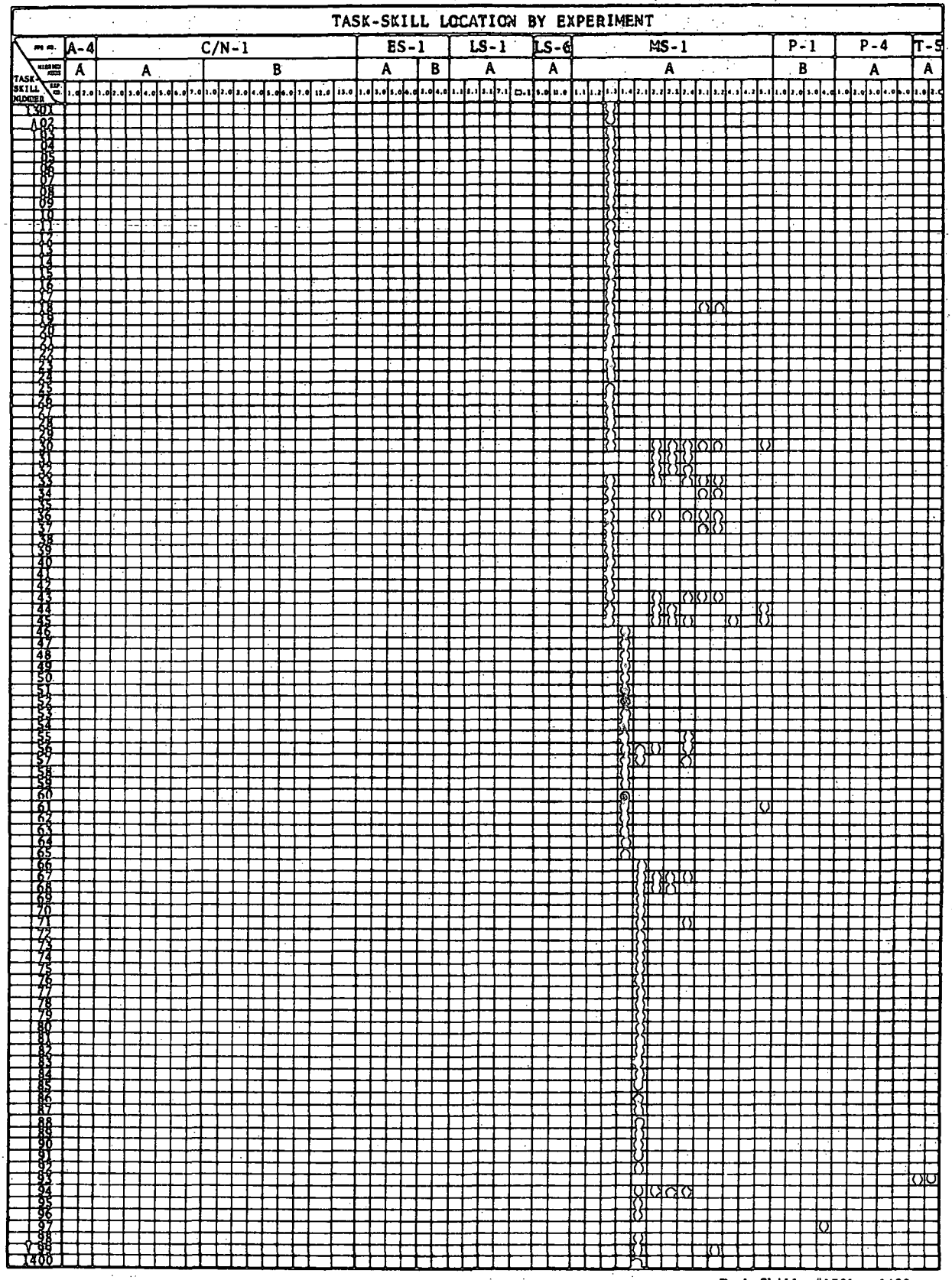
Task-Skill #1001 - 1100



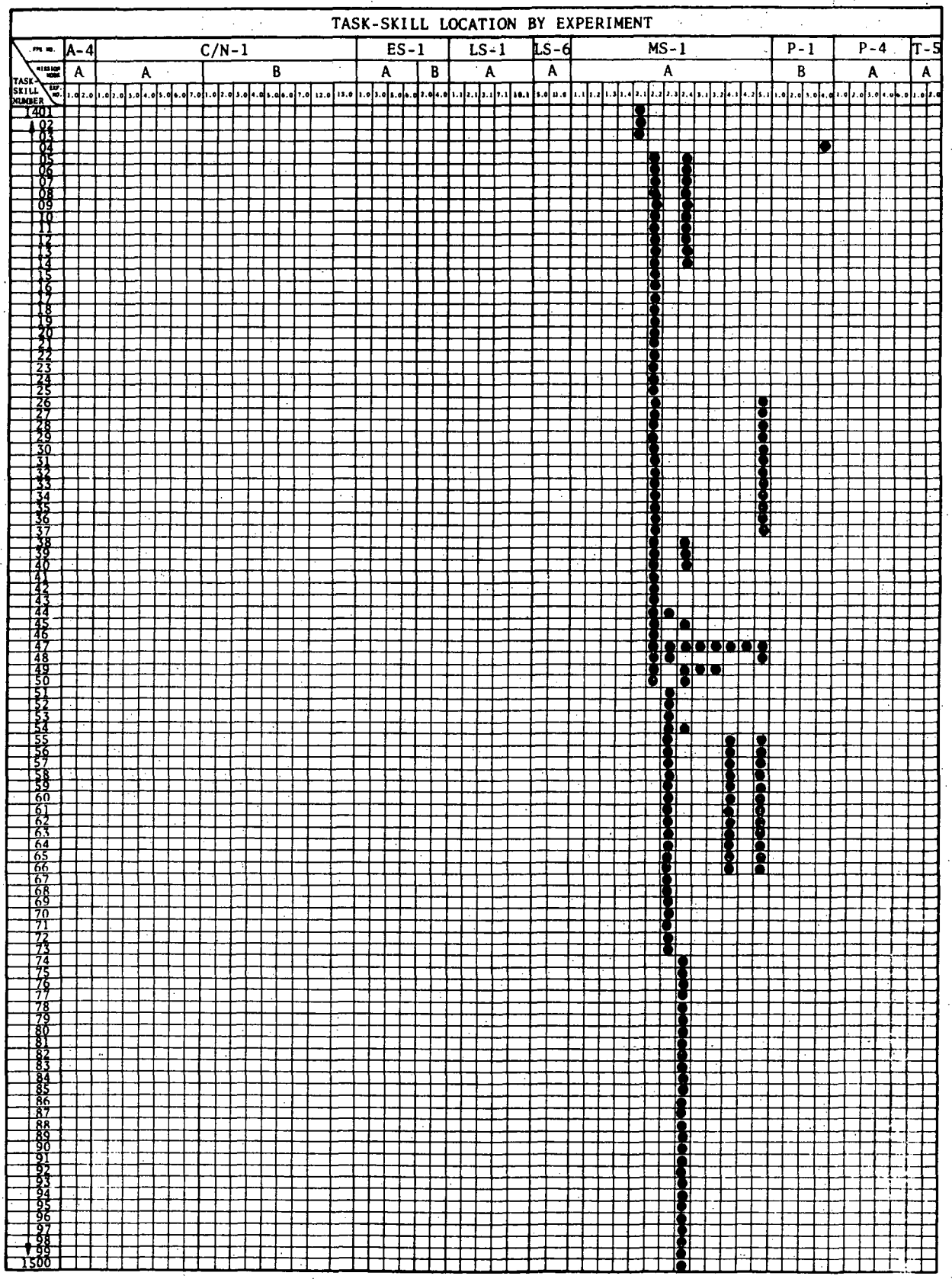
Task Skill #1101 - 1200



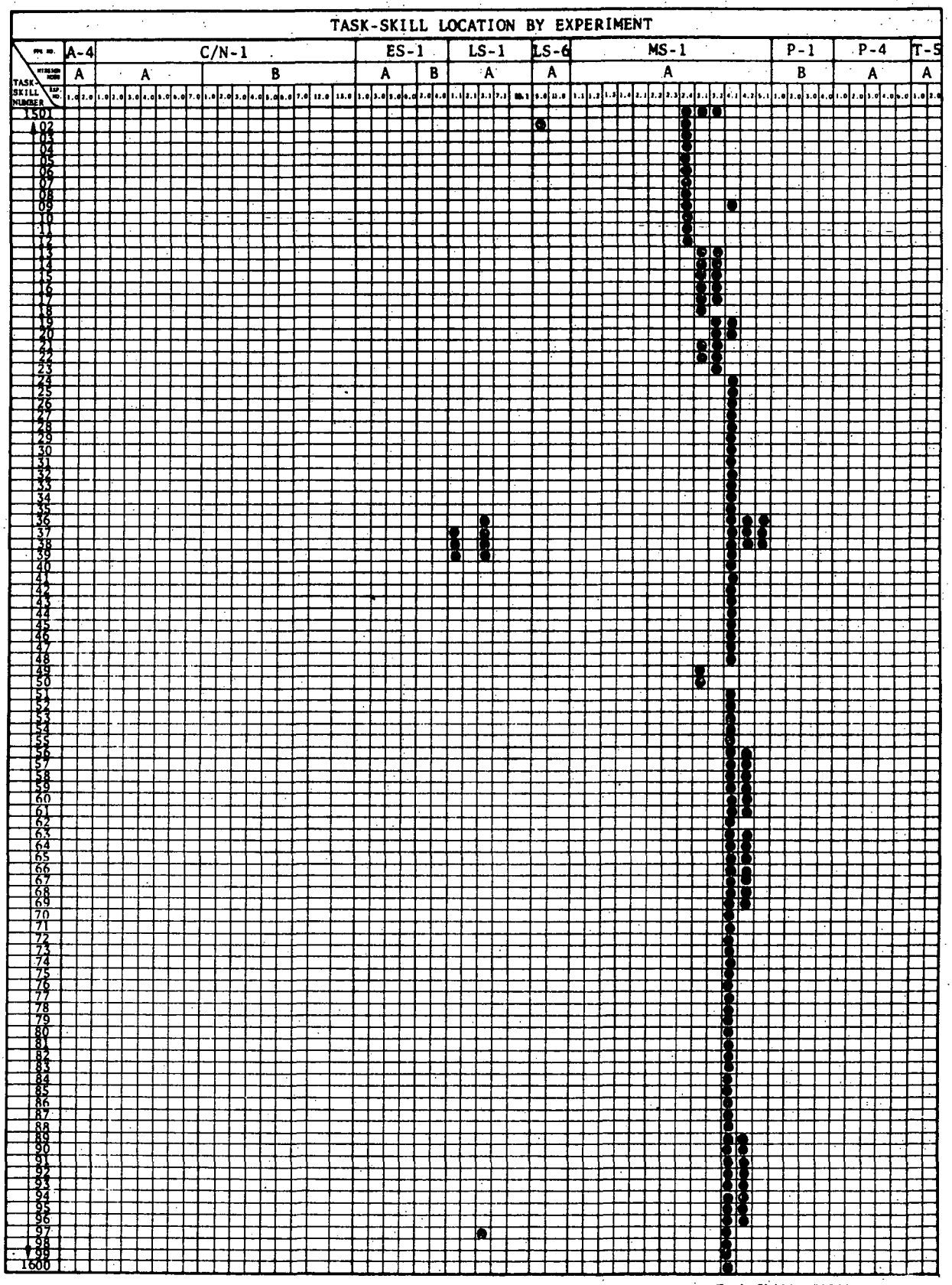
Task-Skill #1201 - 1300



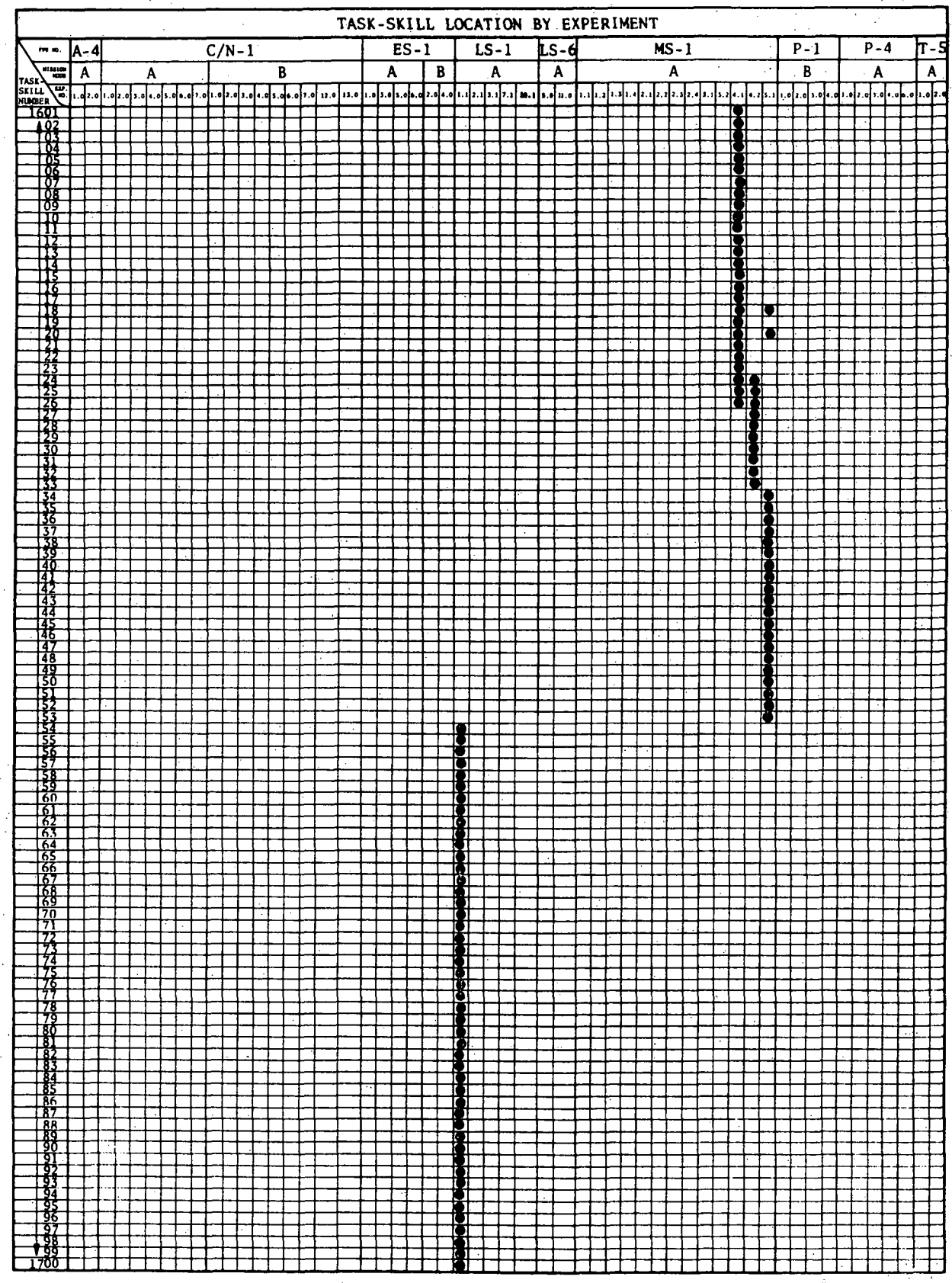
Task-Skill #1301 - 1400



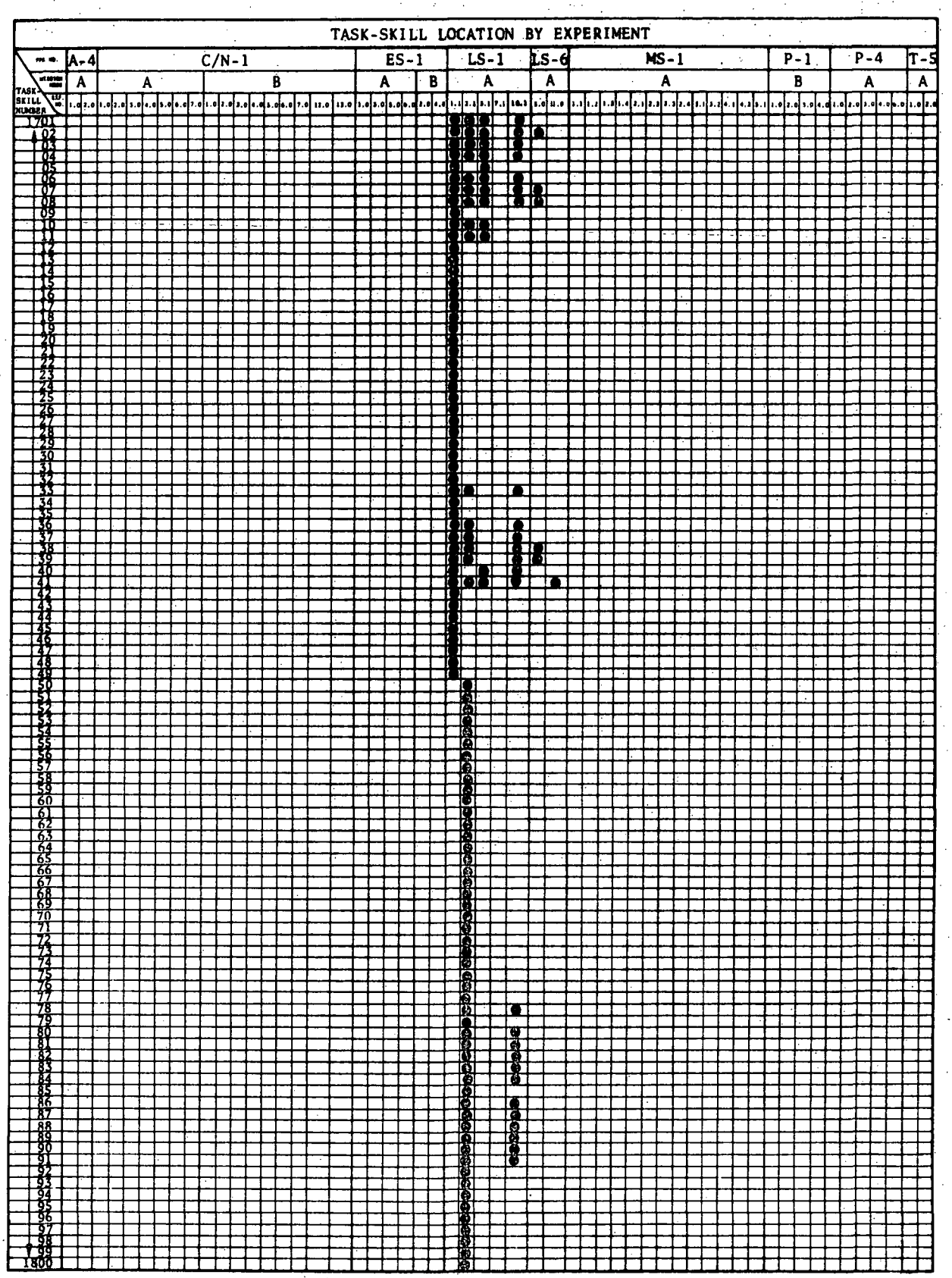
Task-Skill #1401 - 1500



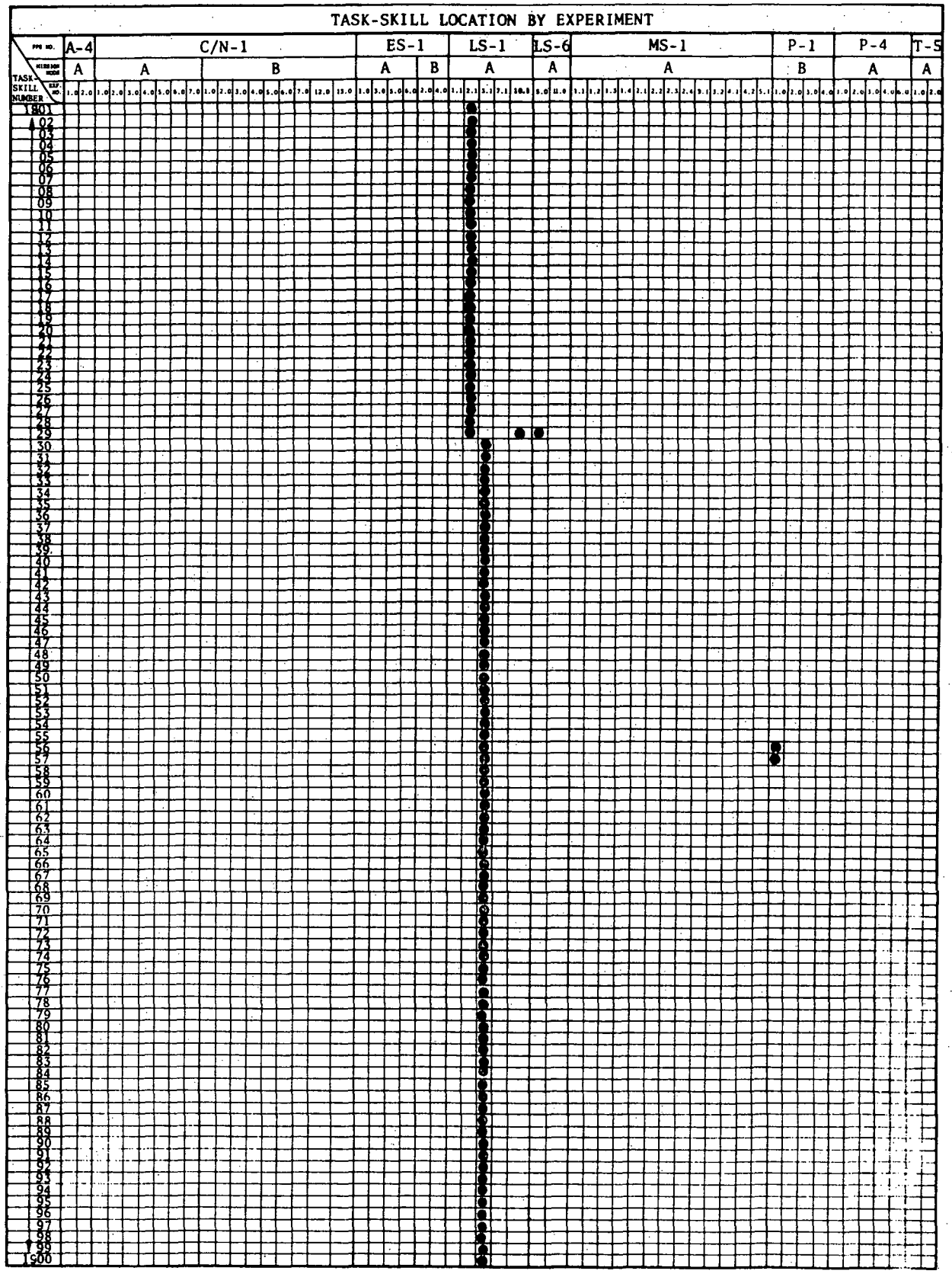
Task-Skill #1501 - 1600

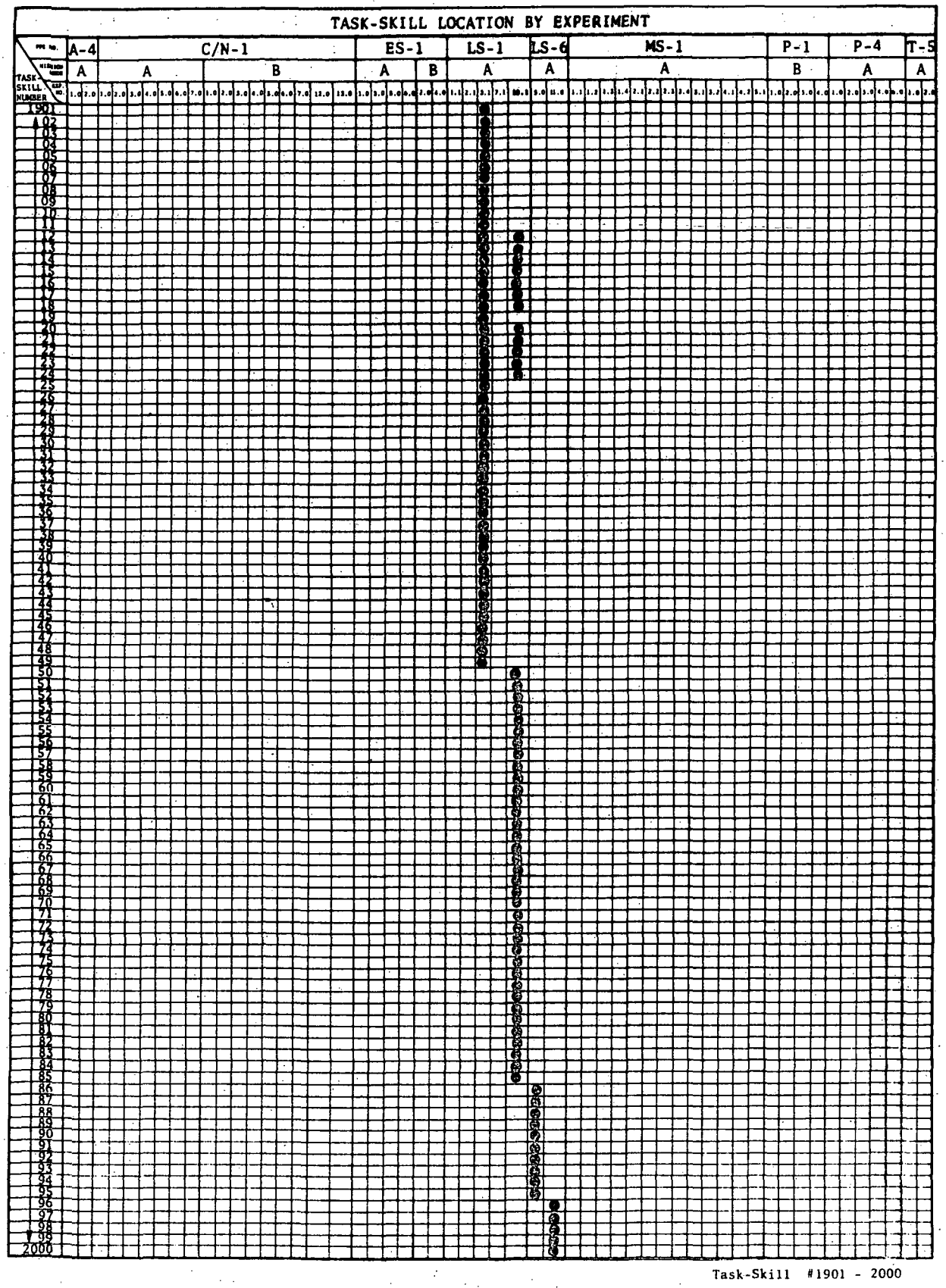


Task-Skill #1601 - 1700

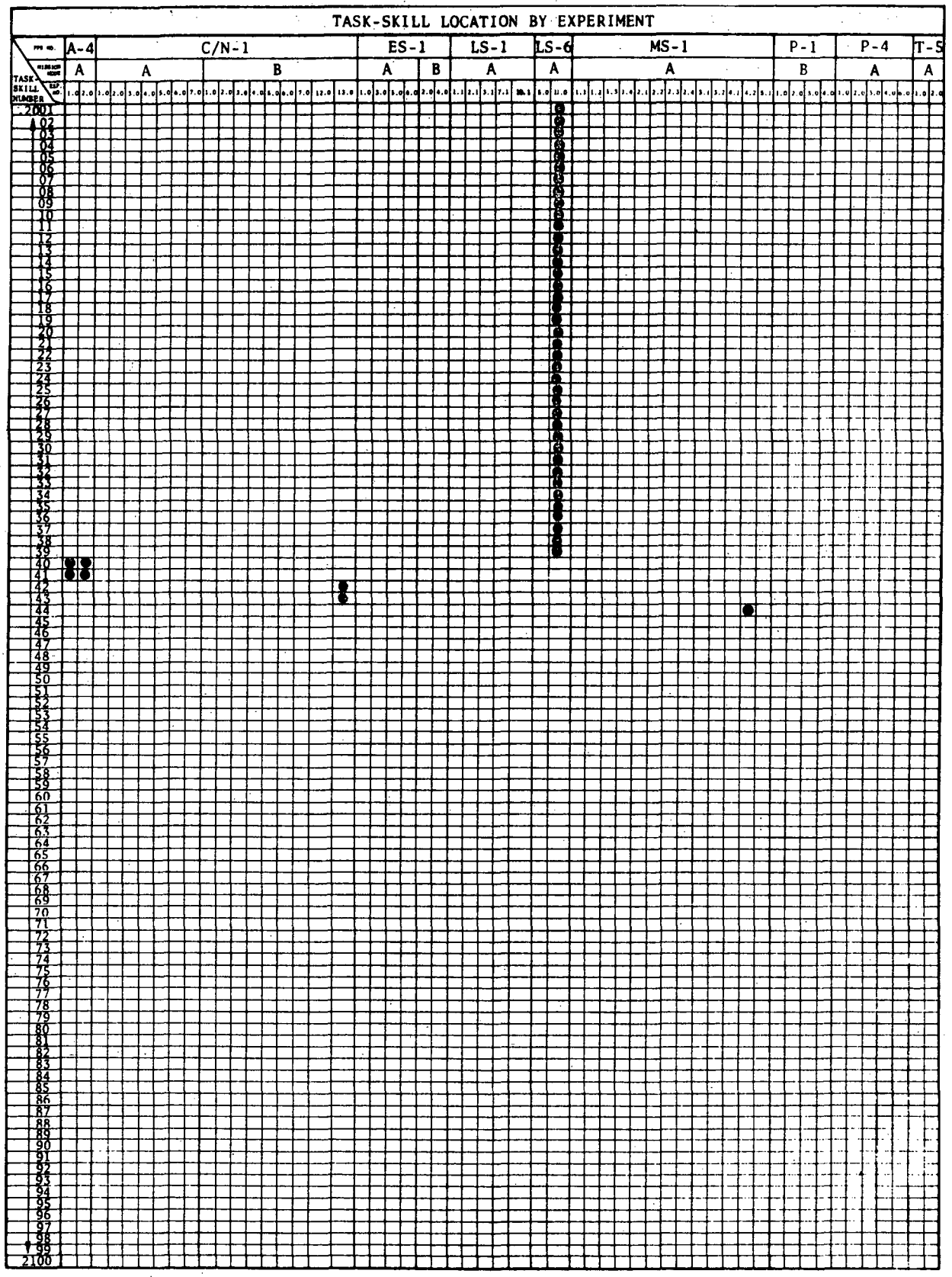


Task-Skill #1701 - 1800


TASK-SKILL LOCATION BY EXPERIMENT
PPS NO.
A-4
C/N-1
ES-1
LS-1
LS-6
MS-1
P-1
P-4
T-S
MISSION MODE
A
A
B
A
B
A
A
A
B
A
A
TASK-SKILL NUMBER
EXP. NO.
1.0 2.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 12.0 13.0 1.0 3.0 5.0 6.0 2.0 4.0 1.1 2.1 3.1 7.1 10.1 5.0 11.0 1.1 1.2 1.3 1.4 2.1 2.2 2.3 2.4 3.1 3.2 4.1 4.2 5.1 1.0 2.0 3.0 4.0 1.0 2.0 3.0 4.0 6.0 1.0 2.0
1801
1900
Task-Skill #1801 - 1900



Task-Skill #1901 - 2000



Task-Skill #2001 - 2100

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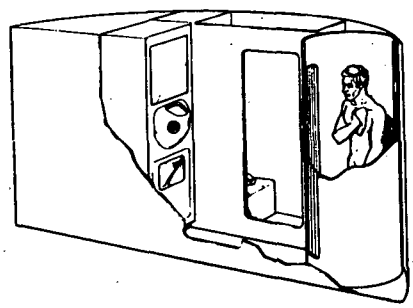
APPENDIX G

IDENTIFICATION OF
OFF-DUTY/NON-OPERATIONAL
FUNCTIONS



MATRIX
MAN SYSTEMS

APPENDIX G

OFF DUTY/NONOPERATIONAL FUNCTIONS

SOURCE: HABITABILITY GUIDELINES & CRITERIA

AIRESEARCH REPORT #70-6651

1.0 Provide for Privacy

1.1 Provide for Sleeping

1.1.1 Restrain Body for Sleep*

a. Prepare sleep restraint unit
b. Enter sleep restraint unit
c. Fasten sleep restraint unit
d. Exit from sleep restraint unit
e. Close sleep restraint unit

1.1.2 Provide Variable Lighting

a. Adjust lights for intensity

1.1.3 Provide Audio Control

a. Isolate external noise
b. Adjust normal audio communication system
c. Activate emergency communication system

1.1.4 Provide Temperature Control

a. Adjust temperature

1.2 Provide for Relaxation

1.3.1 Provide for Individual Aesthetic Pursuits

a. Draw and sketch pictures
b. Compose music
c. Creative writing
d. Play musical instrument

*Special skill or training may be required.

OFF DUTY/NONOPERATIONAL FUNCTIONS (cont.)

1.3.2 Provide for One-man Games (Example: cards)

a. Open storage compartment
b. Select game cards
c. Remove from storage
d. Set up playing surface
e. Restrain torso*
f. Adjust lighting
g. Proceed with games

1.3.3 Provide for Games Requiring More Than One Person (e.g., chess)

a. Open storage compartment
b. Select game set
c. Remove from storage
d. Set up game
e. Restrain torso*
f. Proceed with game

1.4 Provide for Study

1.4.1 Provide for Reading

a. Procure study material
b. Turn on audio-visual device
c. Study subject matter
d. Restrain body for reading*

1.4.2 Provide for Writing

a. Open storage compartment
b. Select writing material
c. Remove material from storage
d. Restrain torso*
e. Adjust lighting

1.4.3 Provide Study Restraint

a. Restrain body for study*

*Special skill or training may be required.

OFF DUTY/NONOPERATIONAL FUNCTIONS (cont.)

1.4.4 Provide Local Illumination

a. Turn on light
b. Adjust light direction
c. Adjust light intensity

1.4.5 Facilitate Rapid Recall of Information*

a. Activate audio-visual system
b. Select study item
c. Load tape
d. Start tape
e. Adjust audio and video

1.5 Provide for Grooming

1.5.1 Restrain Personal Effects

a. Prepare garment for storage
b. Place in storage compartment

1.5.2 Dress and Undress*

a. Dress: put on underwear
b. Don outer garments
c. Don space suit
d. Doff space suit
e. Remove outer garments
f. Remove underwear

1.5.3 Provide for Dry Hygiene*

a. Superficial bathing
b. Shaving
c. Brush or comb hair

1.6 Eliminate Habituation

1.6.1 Change (personal) Space

a. Rearrange furnishings
b. Enlarge living space

*Special skill or training may be required.

OFF DUTY/NONOPERATIONAL FUNCTIONS (cont.)

1.6.2 Change Color of Lighting

a. Change color of ambient lighting
b. Change intensity of lighting

1.6.3 Change Color Appearance

a. Change interior colors
b. Change interior texture
c. Change interior appearance

2.0 Provide Sustenance

2.1 Store Food and Liquids*

a. Open food storage compartment door
b. Select food
c. Remove food from storage
d. Close food compartment door
e. Open beverage compartment door
f. Select beverage
g. Remove beverage from storage
h. Close beverage compartment door

2.2 Prepare Food and Beverage (?)

(See note, #7.2.1; probably use different approach [e.g., pre-prepared foods] for 5-30 day missions).

2.3 Restrain Individuals for Eating*

a. Restrain food package
b. Restrain beverage
c. Restrain body
d. Ingest food and beverage

2.4 Dispose of Food Waste*

a. Remove used food packet from restraint
b. Seal food packet
c. Deposit waste packet in system container

*Special skill or training may be required.

OFF DUTY/NONOPERATIONAL FUNCTIONS (cont.)

3.0 Facilitate Recreation

3.1 Provide for Group Active Games (?)
(See note, #7.2.1)

3.2 Provide for Group Passive Games
(Same as #1.3.2 and #1.3.3)

3.3 Provide Projection Capability (Note: may use different approach, e.g., ground transmission).

a. Open projector storage compartment
b. Remove projector from storage (?)
c. Open film storage compartment
d. Select film
e. Remove film from storage
f. Close film storage compartment door
g. Thread film in projectors
h. Set up movie screen
i. Adjust lighting
j. Project movie

4.0 Maintain Physical Condition

4.1 Provide for Group Calisthenics
(See note, #7.2.1)

4.2 Provide for Individual Exercise

a. Prepare exercise area
b. Prepare equipment for storage*
c. Store equipment*
d. Set up ergometer*
e. Exercise*

4.3 Provide for Group Motor Sports (?)
(See note, #7.2.1)

5.0 Provide Medical Care

5.1 Provide Medical Personnel*

a. Medical examination
b. Medical treatment

} Tasks to be determined

*Special skill or training may be required.

OFF DUTY/NONOPERATIONAL FUNCTIONS (cont.)

6.0 Assemble Crew (?)

(This is facility-limited; may be no requirement for crew assembly on Shuttle-sortie mission).

7.0 Provide for Hygiene

7.1 Eliminate Body Wastes

7.1.1 Remove urine

a. Prepare for urine elimination
b. Restrain body*
c. Proceed with elimination
d. Purge urinal system*

7.1.2 Dispose of Feces

a. Prepare for fecal elimination
b. Restrain body*
c. Proceed with elimination
d. Purge latrine system*

7.1.3 Remove Vomitus

a. Prepare for oral elimination*
b. Position body*
c. Eliminate wastes orally
d. Purge waste disposal system*

7.2 Ensure Body Cleanliness

7.2.1 Wash Entire Body (?)

(Tasks omitted; probably not required/available on short missions)

7.2.2 Wash Hands*

a. Prepare for washing hands
b. Start water flow
c. Complete washing of hands
d. Dry hands

*Special skill or training may be required.

OFF DUTY/NONOPERATIONAL FUNCTIONS (cont.)

7.2.3 Wash Face*

a. Obtain wash cloth
b. Prepare to wash face
c. Start water flow
d. Prepare cloth for washing
e. Wash face

7.2.4 Remove whiskers*

7.2.5 Oral Hygiene*

7.2.6 Cutting Hair (?)

7.2.7 Trimming Nails*

7.3 Provide Clean Garments (?)

(See note, #7.2.1) re: wash and dry garments

7.3.3 Maintain Garments

a. Inspect for wear and damage
b. Repair garments*
c. Stow garments for use*

*Special skill or training may be required.