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THE ROLE OF MAN IN FLIGHT EXPERIMENT PAYLOAD MISSIONS

Volume II: Appendices

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Under Contract NASW 2389

August 1973

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APPENDIX A

FLIGHT EXPERIMENT PAYLOAD MISSION REQUIREMENTS ANALYSIS

A significant amount of effort is currently being generated by payload scientists and engineers concerning the types and numbers of man, and the skills required of man in orbit. In this effort, some ambiguity exists concerning the requirements and constraints governing the specification of roles. The approach taken in this study was to develop a functional model of a generalized experiment system and to identify requirements which can logically be associated with each function in the model. This approach has the advantage of establishing a set of baseline activities which are common across a wide range of potential experiments. The conceptualization of activities was based on a review of the types of functional requirements usually encountered in an earth-based laboratory.

The requirements analysis was conducted to identify performance requirements (tasks), information requirements, and interface requirements associated with each function. The results of the analysis are presented in the following pages. The functional models for the pre-flight and in-flight mission phases are presented in Figures 1 and 2.

The significance of the requirements analysis was that it clearly established the functions and associated requirements involved in experimentation as opposed to more overt operational requirements such as setup, preparation, checkout, operation, etc. Earlier attempts to classify experiment system functions usually did not distil or abstract the more scientifically oriented requirements from the overt, and easily identifiable, support operations. Thus a function entitled "operate experiment" would include the decisions concerning data quality, effects of changing conditions, etc., along with the actual physical operation of experimental hardware. Such an approach would make it extremely difficult to

isolate requirements for scientists to fly experiments. On the other end of the spectrum, payload scientists usually report that scientists will be required to fly experiments, based on their general understanding of the types of experiments under consideration and the manner in which such experiments are conducted in earth-based laboratories.

The requirements analysis, therefore, forms the framework for classification and identification of roles, responsibilities, and requirements of Man in the Shuttle experiment missions. At present the analysis exists only in a broad, general level. The analysis will be updated for more specific groups of experiments as the payloads themselves become better defined.

The information used in performing the requirements analysis was derived from several sources, which included:

The MSFC Shuttle Payload Planning activity

The report on the Shuttle Payload Workshop, held at Goddard in the summer of 1972

The reports of each working group, published in May of 1973

The Life Science Payload Planning Panel output. (The author attended the panel meetings as an invited guest.)

Minutes of JSC Payload Coordination Office meetings and interaction with Mr. J. Heberlig of that office

Sortie Lab status reports, from MSFC-PD/SL

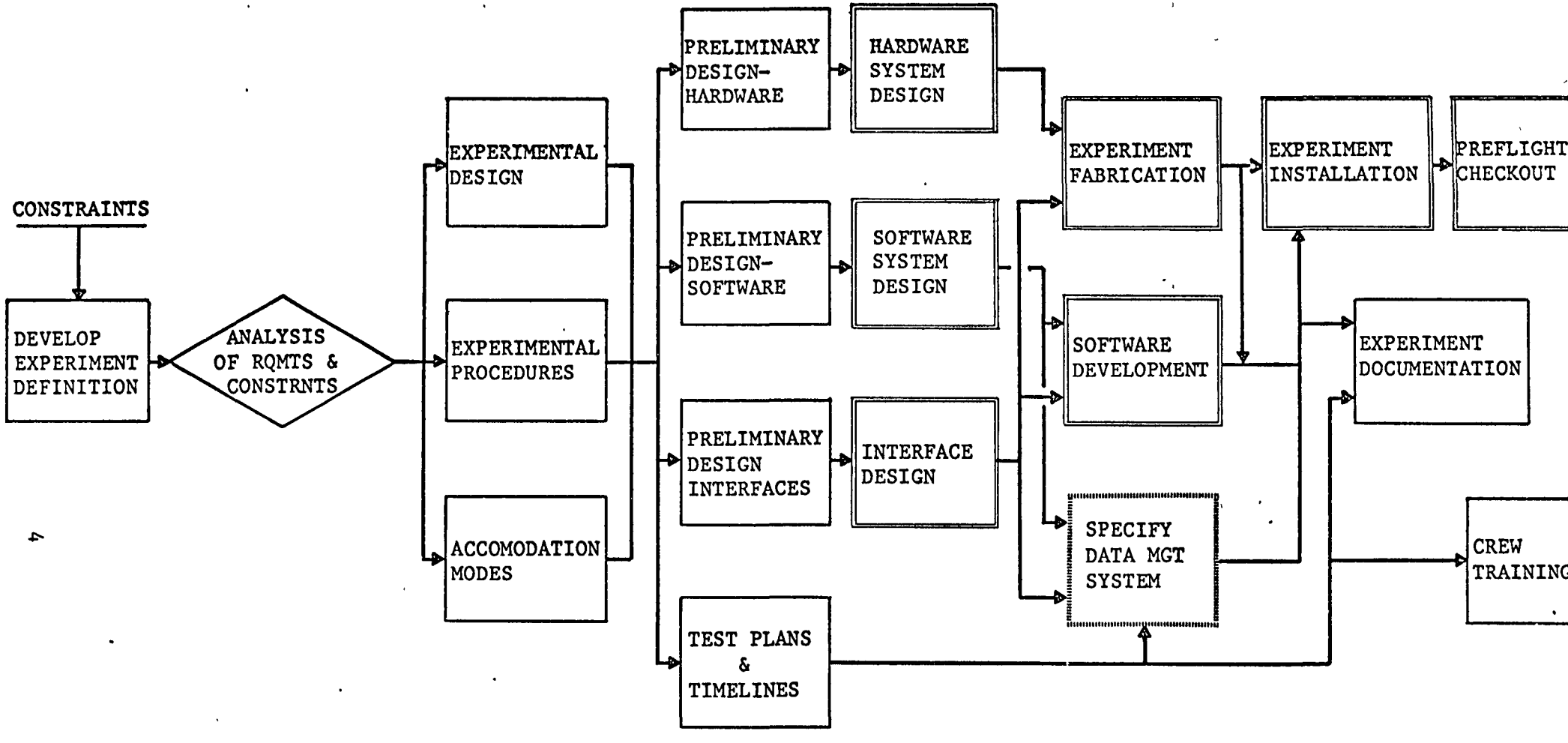
Discussions with several payload working group chairmen and members

Outputs of the SOAR, Low Cost Payload, and Tug efforts

The 1972 NASA mission model and the Payload data book prepared by Aerospace Corp.

The URS/Matrix 1972 report on Flight Experiment Task Requirements

Reports on NASA/U. Houston Seminars on Manned Functions in Space Observations; Astronomy; and Plasma, Particles, and Fields



KEY:

- EXPERIMENTER FUNCTION
- ENGINEERING/ MAINTENANCE
- DATA MGT FUNCTION
- OPERATION
- INFORMATION RECEPTION
- COGNITIVE-MENTAL OPERATION

Figure 1
FUNCTIONAL FLOW
EXPERIMENT FUNCTIONS
PREFLIGHT

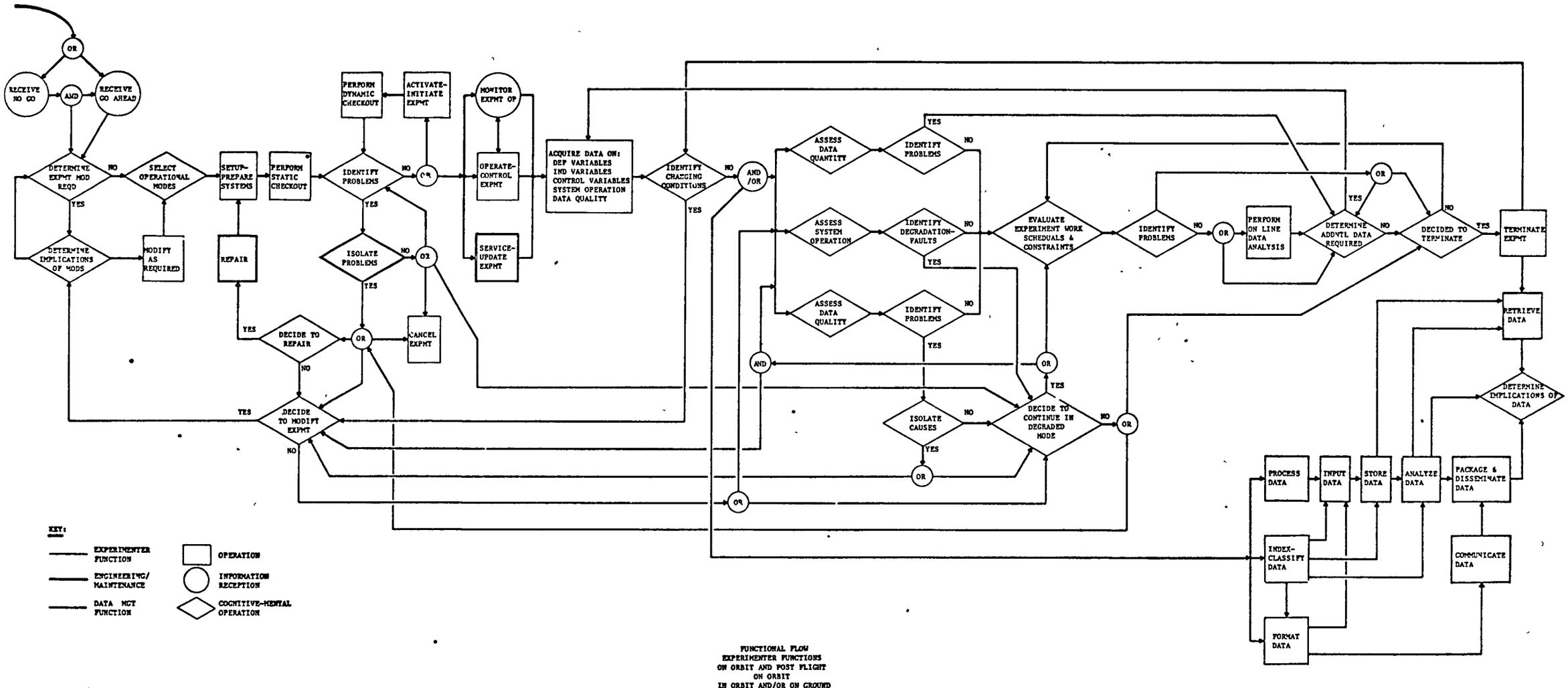


Figure 2 - Experiment Functional Flow - In flight and post flight

Function 1. Receive Go - No Go Decision

Performance Rqmts	Information Rqmts	Interface Rqmts
Receive Command	Schedule Data Indication of:	Mission Manager
Understand command	Go command as scheduled and requested	Commo. link
Acknowledge command	Go command as scheduled but not requested	Schedules
Request command modification	Go command not scheduled but requested	
	Go command not scheduled nor requested	
	No Go command when scheduled as requested	
	No Go command when scheduled but not requested	
	Verification of command	

Function 2. Determine Required Modification to Experiment

Performance Rqmts	Information Rqmts	Interface Rqmts
Acquire information on present conditions, trends, etc.	Existing environmental conditions	Environment
Compare actual with required conditions	Required conditions	Schedules
Identify if experiment must be modified	Availability of special event data	Support Systems
Identify specific modifications in:	Availability of interest data	Mission Manager
Test Plans:	Experiment priorities	
Priorities	Existing test plans	
Schedules and time lines	Time to set up and operate	
Variables and levels	Time in which interest-event data will be available	
Experimental conditions	Experiment system readiness	
Experiment objectives and scope	Support system readiness	
Test Procedures:	Personnel readiness	
Sampling techniques	Experiment data requirements	
Test methodology	Data management system status	
Experiment Systems:		
Operating modes		
Subsystem capability-response		
Experiment configuration		
Systems performance		
Systems status		
Hardware modules-components		
Software modules		
Interfaces		
Experiment Personnel:		
Experimenter		
Support personnel		
Test subjects		
Support Systems:		
Status and performance of		
Life support system		
Communications system		
Structures		
Materials		
Power supplies and distribution		
Lighting systems		
EVA systems		
Servicing systems		
Data		
Data source		
Data to be acquired		
Data quantity		
Data analysis - on line		
Uses of data		

Function 2. (con't)

Performance Rqmts	Information Rqmts	Interface Rqmts
Data Management System		
Data Collection		
Data Verification		
Data indexing-classification		
Data Reduction		
Data Processing		
Data Integration		
Data Input		
Data Format		
Data Communications		
Data Retrieval		
Data Display		
Data Analysis		
Data Packaging		
Data Dissemination		
Data Interpretation		
Data Diagnosis		
Data Storage		
Identify modification constraints		
Identify modification options		
Tradeoff options		
Make Modification decision		

Function 3. Determine Implications of Modifications

Performance Rqmts	Information Rqmts	Interface Rqmts
Develop data for modification Tradeoff decision - including: . Benefit - each option . Cost - each option . Impact on mission rqmts . Risk associated - Personnel safety - Loss of data - Degradation of experiment . Impact on data - Reliability - Validity . Impact on experiment - Coverage of Phenomena - Control - Fidelity of conditions - Flexibility - Operation - Performance - Status . Impact on environment - Physical/mechanical - Operational . Impact on personnel - Workloads - Duty cycles - Motivation . As Impacted by Personnel - Workloads - Capabilities - Availability . As Impacted by Experiment - Capability - Configuration - Status . As Impacted by Constraints - Geophysical - Operational - Mission - System	Modification options Relationship of tradeoff Criteria with each option Data for option evaluation Data for priority assessments Data for decision option Impact assessments	Function 2. Mission mgr. Ground control

Function 4. Modify Experiment as Required

Performance Requirements	Information Requirements	Interface Requirements
Make modifications resulting from:	Decision to modify	Mission Manager
Command decisions	Approval to modify	Support personnel
Experiment equipment failures and degradations	Specific modification requirements	Systems to be modified
Experiment data degradations	Specific modification procedures	
Identified changes in prevailing conditions	Indication that modification cannot be made	
Modify:	Indication that modification is complete	
Experiment Plans - Modify Requirements and Detailed Plans		
Reschedule		
Reorder priorities		
Change variables		
Change experimental conditions		
Change objective and scope		
Experiment Procedures - Modify Techniques, Protocol, Methods, and Tasks		
Revise sampling procedures		
Revise set-up procedures		
Revise operational procedures		
Revise analysis procedures		
Revise test checkup procedures		
Revise communication procedures		
Revise data management procedures		
Revise data verification procedures		
Experiment Systems - Modify configuration, operation, performance or location		
Modify experimental control system		
Modify experiment monitoring system		
Modify data processing system		
Modify data verification system		
Modify data recording system		
Modify data analysis system		
Modify data interpretation system		
Modify experiment planning system		
Modify system interfaces		
Modify system structures		
Modify operational modes		
Experiment personnel - Modify selection and location		
Support Systems - Modify configuration, operation, performance or location		
Modify ECLS		
Modify EVA systems		

(continued)

Function 4. (con't.)

Performance Requirements (con't.)

Modify materials and structures
Modify communication systems
Modify power generation and distribution systems
Modify maintenance and servicing systems

Data - Modify data requirements
Change data source
Change data to be acquired
Change baseline data for comparison
Modify quantity of data
Modify quality standards
Modify formats
Modify on line analysis
Modify uses to be made of data

Modify Data Management System - See Function 2 for items to be Modified

Function 5. Select Operational Modes

Performance Requirements	Information Requirements	Interface Requirements
Identify system capability required	Alternate configurations	Support systems
Identify available alternate system configurations	Information on capability in alternate configurations	
Identify capabilities and limitations - each configuration	Verification of selection	
Select one configuration	Alternate modes	
Identify alternate modes of operation - system and sub-systems	Information on capability in alternate modes	
Identify capabilities and limitations - each mode	Verification of mode selection	
Identify implications of each mode		
Select operational modes		
Configure experiment system for selected mode		
Configure data mgt. system for selected mode		
Configure support systems for selected mode		

Function 6. Set up-Prepare Systems

Performance Requirements	Information Requirements	Interface Requirements
Prepare Records	Time to begin preparation	Experiment personnel
Prepare checklists	Time to complete preparation	Support systems
Prepare Data forms	Set up procedures and sequences	
Prepare instructional media	Responsibilities - each set up operator	
Prepare worksite	Verification Procedures	
Configure worksite	Verification Data	
Translocate equipment	Criteria for conditions selection	
Prepare tools-test sets	Data to be obtained	
Prepare Experiment Systems	Data recording procedures	
Configure experiment		
Select modes		
Inspect apparatus		
Unstow		
Unpackage		
Uncover		
Remove restraints		
Open doors, etc.		
Deploy		
Assemble		
Erect		
Emplace		
Translocate		
Set up		
Calibrate		
Adjust		
Align		
Ready Software		
Load film		
Fill containers		
Establish interfaces		
Electrical		
Mechanical		
Structural		
Functional		
Prepare Support Systems		
Prepare Power		
Prepare Propulsion		
Prepare Structures		
Prepare Lighting		
Prepare communications		
Prepare for experiment		
Select experimental conditions		
Schedule experiment		
Alert personnel		
Prepare base line data		
Verify preparation		

Function 7. Perform static checkout

Performance Requirements	Information Requirements	Interface Requirements
Verify Records	Checkout procedures	Support systems
Verify worksite configuration	Levels of readiness criteria	
Inspect apparatus	Checkout tolerances	
Visually	Visual inspection data	
Tactually	Tactile inspection data	
Inspect connections		
Assemblies		
Emplacements		
Check interfaces		
Check components		
Check modules		
Check system configuration		
Check support systems		

Function 8. Activate-Initiate Experiment

Performance Requirements	Information Requirements	Interface Requirements
Decide to begin experiment	Time of initiation	Physical environemnt
Power experiment systems	Experiment schedule	Support systems
Activate support systems	Decision criteria	Ground personnel
Activate experiment systems	Environmental conditions	Mission manager
Activate data acquisition systems	Orbital data	
	Geophysical data	
Activate data recording systems	Mission data	
Activate experiment monitoring systems	Verification of activations	
Activate experiment control systems		
Deploy free flying experiments		
Deploy boom mounted experiments		

Function 9. Perform Dynamic Checkout

Performance Requirements	Information Requirements	Interface Requirements
Free Flying Experiment	Check out procedures	Support systems
Check attitude control-pointing	Check lists	
Check propulsion	Decision criteria	
Check sensors		
Check comm. link		
Check responses-handling qualities		
Check special systems		
Check data acquisition systems		
Change operational modes		
Attached Experiment		
Check structural interfaces		
Check data acquisition systems		
Check sensors		
Check comm. links		
Check special systems		
All Experiments		
• Check sensors		
Check sensor location		
Check sensor response		
Check sensor range		
Check sensor accuracy		
• Check data acquisition systems		
Check sample rates		
Check data selection		
Check time to acquire		
• Check data recording systems		
Verify operation		
Verify data indexing		
• Check data validation systems		
Verify operation		
Verify accuracy		
• Check experiment operation		
Change modes		
Change configurations		
Conduct test sequence		
Receive feedback		
• Verify systems operation		
• Verify systems readiness		
• Calibrate systems		
• Align systems		
• Adjust systems		
• Reconfigure systems		

Function 10. Detect-Isolate Problems

Performance Requirements	Information Requirements	Interface Requirements
Detect problems - Static Checkout	Checkout data	Ground personnel
Detect problems - Dynamic checkout	Performance criteria	Mission Manager
Detect problems - operation	Data-criteria comparison	Support Systems
	Decision rules-detection	
Problem areas	Troubleshooting procedures	
Data quantity	Support data	
Data quality	Test readouts	
Hardware operation	Test criteria	
Hardware performance	Decision rules-isolation	
Software performance	Knowledge of system responses	
Systems Status	Knowledge of data characteristics	
Isolate Problems		
Identify diagnostics		
Identify symptoms		
Identify potential causes		
Determine criticality of Problem isolation		
Schedule isolation		
Prepare test sets-tools-Checklists		
Prepare systems for isolation		
Perform troubleshooting		
Consult supporting publications and records		
Perform special tests		
Identify causal factor		
Record Isolation sequence		
Consult with ground		

Function 11. Repair-Reconfiguration Decision

Performance Requirements	Information Requirements	Interface Requirements
Determine effects of degradation on: Data quantity Data quality Experiment schedules Experiment objectives Experiment operation Experiment status Other systems	Projected effects Decision criteria	Other systems Support systems Mission Manager Ground personnel
Determine effects of repair-reconfiguration.		
Determine time to complete		
Determine techniques of accomplishing		
Determine benefits of repair-reconfiguration.		
Determine costs-time lost, data lost, etc.		
Determine when to perform		
Determine support requirements		
Decide to repair-reconfigure		
Decide to not repair-reconfigure		
Consult with ground personnel		

Function 12. Operate-Control Experiment

Performance Requirements	Information Requirements	Interface Requirements
Perform operational sequence	Feedback information from Function 13	Support systems
Control sensor systems	Information on System Current Configuration	
location	Information on required or desired configuration	
orientation	Information on data to be acquired	
response	Knowledge of procedures, techniques, methodologies	
sensitivity		
range		
mode		
Control data processing systems		
configuration		
response		
alignment		
Control data acquisition systems		
photographic		
electromagnetic		
sampling		
optic		
electronic		
Control support systems		
lighting		
thermal control		
Control specific experiment systems		
Control event-sequence scheduling		
Control sequencing of events		

Function 13. Monitor Experiment Operation

Performance Requirements	Information Requirements	Interface Requirements
Acquire information on styles of experiment systems	Subsystems status data	
Acquire information on experiment system performance	Systems status data	
Acquire information on experimenter procedures	Systems performance data	
Acquire time-line information	Timelines and schedules	
Continue to monitor:	Information on Procedures	
. Periodically		
. At special events		
. Continuously		
Acquire feedback on control inputs		

Function 14. Acquire Data

Performance Requirements	Information Requirements	Interface Requirements
Locate or position data acquisition systems	Data required	Other missions
Configure acquisition systems	Data acquisition/ recording procedures	Support systems
Select sample rates	Sample rate and durations	
Select sample duration	Experiment test plan	
Select number of samples	Experiment schedules	
Acquire data on:	Constraints on other mission activities	
Experimental conditions	Constraints imposed by other mission activities	
Independent variables		
Control variables		
Dependent variables or Performance measures		
Experiment systems operation		
Hardware		
Software		
Procedures		
Timelines		
Experiment systems Performance		
Experiment systems Status		
Acquire data via		
Sensors		
Samplers		
Measurements		
Observations		
Record data		
- Photographic Film		
- Video Tape		
- Mag Tape		
- Analog charts		
- Recording forms		
- Computer input		

Function 15. Identify Changing Conditions

Performance Requirements	Information Requirements	Interface Requirements
Identify targets of opportunity	Real time information on existing conditions	
Identify changes in experimental conditions	Tolerances-envelopes for acceptable conditions	
Determine effects of changes - on data validity - on data reliability - on data quantity - on systems status - on systems performance	Criteria for identifying novel conditions	

Functions 16-18. Assess System Operation, Data Quantity, Data Quality

Performance Requirements	Information Requirements	Interface Requirements
Compare system performance levels with required levels	Data from functions 14 and 15	
Compare system status data with tolerances	Required or criterion levels of system performance	
Compare quantity of data acquired with quantity required	Acceptable max./min. values os system operation	
Perform tests of data validity	Data quantity requirements	
Perform tests of data reliability	Data quality testing procedures	
Identify level of data fidelity		
Identify level of data reliability		
Compare levels of fidelity and reliability with required levels		

Functions 19-22. Identify-Isolate faults or problems

Performance Requirements	Information Requirements	Interface Requirements
Identify out-of-tolerance conditions	Decision rules	
Detect failures-degradations	Test procedures	
Detect off nominal performance envelopes for experiment systems	Check point data	
Identify problems for data quantity		
Identify problems for data validity		
Identify problems for data reliability		
Isolate causes for problems		
- Perform troubleshooting		
- Perform data checks		
- Perform test sequences		
- Identify failures		
- Identify degradation		
- Identify procedural errors		
- Identify data acquisition problems		
- Identify data recording problems		

Function 23. Decide to continue in degraded mode

Performance Requirements	Information Requirements	Interface Requirements
Determine implications for continuation in degraded mode: on future system performance on system operability on other on-board systems on data quantity on data quality Determine options available . Interrupt experiment and modify . Interrupt experiment and repair . Modify on the fly . Reschedule experiment . Terminate experiment Determine advantages vs. costs - each option Decide to continue - or Decide to repair and continue - or Decide to modify and continue - or Decide to terminate the experiment Confer with mission manager	Available decision options Implications - each option Advantages - costs - each option	Mission manager Other on-board systems

Function 24. Perform on-line data analysis

Performance Requirements	Information Requirements	Interface Requirements
Determine requirement for scheduled analysis	Availability of computation aids	Computer
Determine method of analysis	Time availability for analysis	Ground
Acquire data for analysis	Importance of analysis	
Perform analysis		
Interpret finding		

Function 25. Determine if additional data are required

Performance Requirements	Information Requirements	Interface Requirements
Determine that additional data are needed:	Need for additional data	Ground
on dependent variables	Availability of conditions	
on expmtl conditions	Importance of acquisition	
on expmtl systems performance	Impact on schedules	
on expmtl systems status	Impact on mission	
for experiment objectives	Impact on data return	
for diagnostics	Additional cost	
for correlation		
for historical purposes		
for baseline		
for verification purposes		
Identify conditions of acquisition		
Identify Quantity of addtl data		
Identify source		
Schedule addtl data acquisition		
Update records - indexing		
Conduct addtl data acquisition		

Function 26-27 Decide to terminate and terminate

Performance Requirements	Information Requirements	Interface Requirements
Identify need for unscheduled termination	Requirement to terminate Verification of termination	Shuttle crew Ground
assess impact on experiment		
assess impact on mission		
assess impact on schedules		
Identify need for scheduled termination		
determine readiness		
Identify options		
experiment hold-delay		
experiment abort		
experiment completed		
Terminate data acquisition		
Alert personnel		
Shut down systems		
Verify shutdown		
Store data		
Secure equipment		

Function 28 - Index-classify data

Performance Requirements	Information Requirements	Interface Requirements
Identify experimental conditions under which data were collected	Constrants on coding	Shuttle data mgt.
Code data by conditions	Classification scheme	Ground
Code data by measure	Code system employed	
Code data by run number	Methods for coding	
Code data by experiment time	Verification of coding	
Code data by sample number		
Code data by repetition number		
Code data by subject number		
Identify location of data in classification scheme		
Code data by classification		
• dependent measure		
• correlation data		
• baseline data		
• diagnostic data		
• historical data		
• prediction data		
Verify - data indexed		

Function 29. Process data

Performance Requirements	Information Requirements	Interface Requirements
Determine reduction requirements	Processing requirements	
Determine enhancement requirements	Verification	
Determine modification requirements		
Compile data		
Perform processing		
Process films-emulsions		
Process digital data		
Process analog data		
Process voice data		
Process video data		
Verify processing		

Function 30. Format Data

Performance Requirements	Information Requirements	Interface Requirements
Format data for analysis alternate format for alternate analysis common format for all analyses	Formats	

Function 31. Input Data

Performance Requirements	Information Requirements	Interface Requirements
Enter data Verify entry	Verification	

Function 32. Store Data

Performance Requirements	Information Requirements	Interface Requirements
Prepare data for storage	Storage requirements	
Prepare storage area	Storage procedures	
Store		
Hard copy data		
Samples - specimens		
film		
magnetic tape		
analog records		
manual records		
video tape		
voice tape		
Verify storage		

Function 33. Communicate Data

Performance Requirements	Information Requirements	Interface Requirements
Select data for communication	Need to communicate	Comm link
Select method of communication	Communication procedures	
Select communication mode	Verification	
Identify need to compress data		
Identify constraints on comm. availability		
Identify available time - next pass		
Identify when to communicate		
Establish link		
Perform communication:		
on demand		
as scheduled		
for classification		
for diagnostics		
for contingency acquisition		
Verify communication		

Function 34. Analyze Data

Performance Requirements	Information Requirements	Interface Requirements
Perform data checks	Techniques required in experiment plan	
reliability		
validity		
usability		
Identify data quality		
identify "good" data		
identify "bad" data		
identify marginal data		
Fill gaps in data		
Analyze data		
Statistically		
inferential statistics		
trend analysis		
significance tests		
correlation		
covariance		
relationships		
predictive tests		
descriptive statistics		
control tendency		
variability		
graphically		
illustration of interaction		
identification of trends		
Identify causal factors		
Identify dependencies-relationships		
Identify levels of performance		
Terminate analysis		

Function 35. Package-Disseminate Data

Performance Requirements	Information Requirements	Interface Requirements
Identify use requirements Package for user Disseminate		

Function 36. Determine implication of data

Performance Requirements	Information Requirements	Interface Requirements
Interpret analyzed data		
Interpret baseline data		
Integrate data		
Develop insights		

Function 37. Retrieve Data

Performance Requirements	Information Requirements	Interface Requirements
Access data	Procedures	
Select data for retrieval	Verification	
Retrieve data		
Verify retrieval		

APPENDIX B

TASK ALLOCATION TO ROLES

Allocation Code

3 - Primary Responsibility

2 - Secondary - Support Responsibility

1 - Backup - Needs Supervision

- No Responsibility

RESPONSIBILITIES BY ROLE Functions/Tasks Page 1	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Planning									
Establish priorities							3	2	1
Identify variables							3	2	1
Id. data requirements							3	2	1
Schedule expmt.							3	2	1
Allocate resources							3	2	1
Establish procedures							3	2	1
Determine analysis rqmts.							3	2	1
Integration with other mission activities			3				2	2	1
Contingency planning							3	2	1
Expmt. Management									
Go decision			3				3	2	
Terminate decision			3				3	2	
Modify decision							3	2	
Modify Experiment									
Modify plans							3	2	
Modify procedures									
Sampling							3	2	
Set-up	3						3	2	
Operational							3	3	
Analysis							3	3	
Checkout	3						3	3	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 2	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Modify Experiment (cont.)									
Modify procedures (cont.)									
Commun.						3	3	3	
Data mgt.						3	3	3	
Modify Exmpt. Systems									
Control	1			3	2		3	2	
Monitoring	1			3	2		3	2	
Data process.	1			3	2	2	3	2	
Data record.	1			3	2	2	3	2	
Data analysis	1			3	2	2	3	2	
Interfaces	1			3	2		3	2	
Oper. modes				3	2		3	2	
Modify Support System									
Life support	1	3							
EVA	1	3							
Materials	1	3							
Commun.	1	3							
Power	1	3							
Maintenance	1	3							
Modify Data Rqmts.									
Source						2	3	3	
Measures						2	3	3	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 3	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Modify Experiment (cont.)									
Modify Data Rqmts. (cont.)									
Baseline						2	3	3	
Quantity						2	3	3	
Qual. standards						2	3	2	
Formats						2	3	2	
Analysis						2	3	2	
Uses							3	2	2
Modify Personnel									
Selection							3	2	
Location			3				3	2	
Select Oper. Modes									
Id capability reqd.							3	3	
Id available configuration							3	3	
Select configuration							3	3	
Id alternate modes							3	3	
Select modes							3	3	
Configure expmt. system							3	3	
Configure data system						1	3	3	
Configure support system		3							
Set up - Prepare Expmt.									
Prepare records				3	3		3	3	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 4	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Set up - Prepare Expmt.(cont)									
Prepare worksite	3	3	1	2	2	2	2	2	
Prepare expmt. systems									
Inspect	3	3	1	2	2	2	2	2	
Unstow - unpack	3	3	1	2	2	2	2	2	
Open doors, etc.	3	3	1	2	2	2	2	2	
Deploy - assemble	3	3	1	2	2	2	2	2	
Emplace	3	3	1	2	2	2	2	2	
Transport	3	3	1	2	2	2	2	2	
Setup	3	3	1	2	2	2	2	2	
Calibrate	3	3	1	2	2	2	2	2	
Adjust	3	3	1	2	2	2	2	2	
Ready software	3	3	1	2	2	2	2	2	
Load film	3	3	1	2	2	2	2	2	
Fill containers	3	3	1	2	2	2	2	2	
Estab. interfaces	3	3	1	2	2	2	2	2	
Arrange apparatus	3	3	1	2	2	2	2	2	
Prepare support systems									
Power	3	3	1	2	2	2	2	2	
Computation	3	3	1	2	2	2	2	2	
Structures	3	3	1	2	2	2	2	2	
Lighting	3	3	1	2	2	2	2	2	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 5	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Set up - Prepare Expmt.(cont)									
Prepare support systems (cont.)									
Commun.	2	2	1	2	2	3	2	2	
Prepare experiment									
Select conditions				2	2	1	3	3	
Schedule runs				2	2	1	3	3	
Alert personnel				3	3	1	3	3	
Prepare baseline data				2	2	1	3	3	
Perform Static Check									
Inspect	3	3	2	3	3	2	3	3	
Check interfaces	3	3	2	3	3	2	3	3	
Check components	3	3	2	3	3	2	3	3	
Check config.	3	3	2	3	3	2	3	3	
Check support sys.	3	3	2	3	3	2	3	3	
Activate - Initiate Expmt.									
Decide to begin							3	3	
Activate power	2	2	1	3	3	2	3	3	
Activate support systems	2	2	1	3	3	2	3	3	
Activate expmt. systems	2	2	1	3	3	2	3	2	
Activate data systems	2	2	1	3	3	3	3	3	
Activate monitoring				3	3	2	3	3	
Activate control				3	3	2	3	3	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 6	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Activate - Initiate Expmt. (cont.)									
Deploy free flyers				3	3	2	3	3	
Deploy booms				3	3	2	3	3	
Perform Dynamic Check									
Check sensors	2	2	1	3	3	2	2	2	
Check data acquis.	2	2	1	3	3	3	2	2	
Check data record.	2	2	1	3	3	3	2	2	
Check data valid.	2	2	1	3	3	3	2	2	
Check expmt. oper.	2	2	1	3	3	2	2	2	
Verify sys. readings	2	2	1	3	3	2	3	3	
Calibrate systems	3	3	2	3	3	2	2	2	
Align - adjust	3	3	2	3	3	2	2	2	
Reconfigure				3	3				
Detect - Isolate Probs.									
Detect problems									
Data quantity					3		2	2	
Data quality					3		2	2	
Hardware oper.	3	3	1	3	3	2	2	2	
Software				3	3	3	2		
Systems status				3	3	2	2		
Isolate problems									
Id diagnostics	3	3	1	2	2	2	2	2	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 7	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Detect - Isolate Probs.(cont)									
Isolate problems (cont.)									
Id symptoms	2	2	1	3	3	1	3	2	
Id potential cause	2	2	1	3	3	1	3	2	
Schedule troubleshoot.	1	1		1	1		3	3	
Prepare tests - tools	3	3	2	2	2	2			
Prepare systems	3	3	2	2	2	2			
Perform troubleshoot.	3	3	2	2	2	2			
Perform special tests	3	3	2	2	2	2			
Id causal factors	3	3	2	2	2	2			
Repair - Reconfig. Decision									
Determine effects of degradation on:									
Data qty.							3	2	
Data quality							3	2	
Schedules							3	2	
Objectives							3	2	
Operation							3	2	
Status							3	2	
Other systems							2	2	
Determine effects of repair				3	3	2	3	2	
Estimate time to complete				3	3	2	3	2	
Determine techniques				3	3	2	3	2	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 8	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Repair - Reconfig. Decision (cont.)									
Determine benefits				3	3	2	3	2	
Determine costs				3	3	2	3	2	
Determine schedule				3	3	2	3	2	
Decide - Repair or not				2	2	1	3	2	
Consult				3	2	1	3	3	
Operate - Control Expmt.									
Perform sequence				3	3	2	2	2	1
Control sensors				3	3	2	2	2	
Control data process.				3	3	3	2	2	1
Control data acquis.				3	3	3	2	2	1
Photographic									
Electromag.									
Sampling									
Optic									
Electronic									
Observation									
Control data record.				3	3	3	2	2	1
Photographic									
Readings									
Mag. Tape									
Voice tape									

RESPONSIBILITIES BY ROLE Functions/Tasks Page 9	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Operate - Control Expmt. (cont.)									
Control data record. (cont.)									
Analog record									
Control support sys.				3	3	2	2	2	1
Control expmt. sys.				3	3	2	2	2	1
Control sequencing				3	3	2	2	2	1
Handle apparatus				3	3	2	2	2	1
Handle samples				3	3	2	2	2	1
Use lab apparatus				3	3	2	2	2	1
Clean - stow apparatus	3	3	1	3	3	2	2	2	1
Communicate				3	3	3	2	2	1
Monitor Expmt. Operation									
Monitor sys. status				3	3	2	3	3	1
Monitor sys. performance				3	3	2	3	3	1
Monitor procedures				3	3	2	3	3	1
Acquire timeline info				3	3	2	3	3	1
Monitor control inputs				3	3	2	3	3	1
Assess expmt. status with respect to mission				2	2	1	3	2	1
Acquire Data									
Locate-position acq.sys.				3	3	2	2	2	
Configure acq. sys.				3	3	2	2	2	
Select sample rates				3	3	2	2	2	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 10	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Acquire Data (cont.)									
Select sample duration				3	3	2	2	2	
Select number - samples				3	3	2	2	2	
Acquire data on:									
Expmtl. conditions	1	1		3	3	2	2	2	
Measures	1	1		3	3	2	2	2	
Sys. operation	2	2		3	3	2	2	2	
Sys. performance	2	2		3	3	2	2	2	
Sys. status	2	2		3	3	2	2	2	
Acquire data via:									
Sensors	1	1		3	3	2	2	2	
Samplers	1	1		3	3	2	2	2	
Measurements	1	1		3	3	2	2	2	
Observations	1	1		3	3	2	2	2	
Record data:									
Film	1	1		3	3	2	2	2	1
Video tape	1	1		3	3	2	2	2	1
Mag. tape	1	1		3	3	2	2	2	1
Voice tape	1	1		3	3	2	2	2	1
Analog charts	1	1		3	3	2	2	2	1
Record forms	1	1		3	3	2	2	2	1
Computer input	1	1		3	3	2	2	2	1

RESPONSIBILITIES BY ROLE Functions/Tasks Page 11	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Identify Changing Conditions									
Id targets of opportunity				2	2	1	3	3	
Id changes in conditions	1	1		2	2	1	3	3	
Determine effects of change				1	1	1	3	3	
Assess Expmt. Operation									
Assess expmt. performance				2	2	1	3	3	
Compare status with tolerances				2	2	1	3	3	
Assess data quantity				2	2	1	3	3	
Test data validity				2	2	1	3	3	
Test data reliability				2	2	1	3	3	
Test data usability				2	2	1	3	3	
Id level of fidelity				2	2	1	3	3	
Id - Isolate Faults - Probs.									
Id out-of-tolerances	3	3	1	2	2	2	2	2	
Detect failures	3	3	1	3	3	2	2	2	
Detect off nominal cases	3	3	1	3	3	2	2	2	
Id data qty. probs.	2	2	1	3	3	2	3	3	
Id data quality probs.	1	1	1	3	3	2	3	3	
Isolate causes									
Troubleshoot	3	3	2	2	2	1			
Data checks	3	3	2	2	2	1			
Test sequences	3	3	2	2	2	1			

RESPONSIBILITIES BY ROLE Functions/Tasks Page 12	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Id - Isolate Faults - Probs. (cont.)									
Isolate causes (cont.)									
Id failures	3	3	2	2	2	1			
Id errors	2	2	1	3	3	2	3	3	
Id acq. probs.	2	2	1	3	3	2	2	2	
Id record. probs.	3	3	2	2	2	1	2	2	
Decide - Continue in *Degraded Mode*									
Determine implications									
On performance							3	2	
On operability							3	2	
On other systems							3	2	
On data qty.							3	2	
On data quality							3	2	
Determine options									
Interrupt - modify							3	2	
Interrupt - repair							3	2	
Mod on the fly							3	2	
Reschedule							3	2	
Terminate									
Tradeoff options							3	2	
Perform on-line Analysis									
Determine degree reqd.							3	2	

RESPONSIBILITIES BY ROLE Functions/Tasks Page 13	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Perform On-line Analysis (cont.)									
Make calculations				2	2	1	3	3	
Use programs				2	2	1	3	3	
Integrate data				2	2	1	3	3	
Determine implications							3	2	
Determine - Addtl. Data Rqd.									
Id source				2	2	1	3	3	
Id quantity				2	2	1	3	3	
Id conditions				2	2	1	3	3	
Index - Classify Data				2	2	2	3	3	
Code data				3	3	2	2	2	
Id classification				3	3	2	2	2	
Format Data				3	3	2	2	2	
For analysis				3	3	2	2	2	2
For storage				3	3	2	2	2	
Process Data				3	3	2	2	2	
Reduce data				3	3	2	2	2	2
Correlate data				3	3	2	3	3	2
Check data				3	3	2	3	3	2
Input Data				3	3	3	3	3	3
Store Data				3	3	3	3	3	3
Computer memory				3	3	3	2	2	2
Hard copy				3	3	2	3	3	2

RESPONSIBILITIES BY ROLE

Functions/Tasks Page 14	Prin. Tech.	Tech.	Tech. Aide	Prin. Expmtr.	Expmtr.	Expmtr. Aide	Prin. Scientist	Scientist	Scientist Aide
Analyze Data				2	2	1	3	3	3
Communicate Data				2	2	1	3	3	3
Package - Disseminate Data				3	3	1	3	3	3
Retrieve Data				3	3	1	3	3	3
Decide to Terminate				2	2	1	3	3	
Scheduled				3	3	2	3	3	
Unscheduled				2	2	1	3	3	
Terminate Experiment				3	3	1	3	3	
Perform Repair - Maint.									
Remove - replace	3	3	1	2	2	2	2	2	
Clean - modify	3	3	1	2	2	2	2	2	

APPENDIX C

ROLE PROFILES

Skill Requirements Category
0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: +3 Principal Scientist

Description: Planner, Designer, Manager of the Experiment

Responsibilities:

Decisions Experimental Design, Objectives, Schedules, Modifications, Go-No, termination, additional data, continue degraded, data quality

Operations Operate, set up, calibrate, checkout, monitor, control apparatus, data management, analysis and interpretation

Sys. Responsibility Overall

Skill Requirements Categories:

Knowledges - General	3 - In Area of Specialization and for experiment
Science	3 - In Area of Specialization
Experiment	3 - Systems, design, procedures, techniques
Expmt Systems	3 - Capability, readiness, status
Engineering	2 - To extent required above
Support Sys.	2 - To extent required
Skills	
Experimentation	3 - Full knowledge of plans and procedures
Data Interpretation	3 - Objectives of experiment
Data Analysis	3 - Defined in plan
Data Management	2 - Mechanics 3 - Acquisition and recording
Expmt System Control	3 - Inherent in experiment procedures
System Maint.	2 - Checkout 1 - Actual repair
Mission Integration	2 - With shuttle crew
Expmt Setup-Preparation	3 - Inherent in procedures
Expmt Operation-Monitoring	3 - Inherent in procedures
Assess Changing Conditions	3 - Experimental design
Support Sys. Control	2 - To the degree required to support experiment

Skill Requirements Category
0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: 3 Scientist

Description: Scientist in Experiment Discipline other than PI

Responsibilities:

Decisions Primary - Mode select, setup and prep., readiness, operation. Secondary - Planning, modif., isolate probs., repair, terminate.

Operations Primary - Activation, control, monitor, data acq., analysis, data mgt; Secondary - Planning, modify, maint. and repair

Sys. Responsibility Supervision in place of PI - report to PI.

Skill Requirements Categories:

Knowledges - General	3 - In specific area of specialization
Science	3 - In experiment area
Experiment	3 - Procedures and techniques
Expmt Systems	2 - To level required to support operations
Engineering	1 - No intimate knowledge of experiment design
Support Sys.	1 - Minimum
Skills	
Experimentation	3 - Experimental method/experimental design
Data Interpretation	3 - Objective of experiment
Data Analysis	3 - Defined in plan
Data Management	2 - Mechanics
Expmt System Control	3 - Established by training
System Maint.	0 or 1
Mission Integration	0 or 1 - Established by PI - Mission Specialist
Expmt Setup-Preparation	2 - Inherent in procedures
Expmt Operation-Monitoring	2 - Inherent in procedures
Assess Changing Conditions	3 - Experimental design
Support Sys. Control	1 - Minimum facility

Skill Requirements Category
0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: -3 Scientist Aide

Description: Scientists other than experimental - interested in results of experiment.

Responsibilities:

Decisions Uses of data obtained

Operations Data management, backup planning

Sys. Responsibility Deliver requirements to PI

Skill Requirements Categories:

Knowledges - General	
Science	3 - Areas of specialization
Experiment	2 - Objectives, experiment design
Expmt Systems	1 - Apparatus
Engineering	0
Support Sys.	0
Skills	
Experimentation	3 - Experimental method
Data Interpretation	3 - Integration of results with body of knowledge
Data Analysis	3 - Experience
Data Management	2 - General 0 - Specific
Expmt System Control	2 - Procedures only
System Maint.	0 - No capability required
Mission Integration	0 - No capability required
Expmt Setup-Preparation	1 - Minimum capability required
Expmt Operation-Monitoring	2 - Procedures only
Assess Changing Conditions	2 - Experimental design
Support Sys. Control	0 - No capability required

Skill Requirements Category

0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: +2 Principal Experimenter

Description: Capabilities in setup, maintenance, checkout, and operation where decisions concerning data quality and expmt. modifications are not required.

Responsibilities:

Decisions Effects of repair decision, repair dec.

Operations Modify expmt. sys., setup/prepare, static check, activation, maintenance, dynamic check, fault isolation, operate/control monitor, data management

Sys. Responsibility Operation, control, maintenance, checkout

Skill Requirements Categories:

Knowledges - General EE - ME - Experiment hardware/software, data mgt.
Science 1 - No real capability required
Experiment 2 - Familiarity with experimental design
Expmt Systems 3 - Full knowledge of hardware/software & interfaces
Engineering 3 - Strong engineering background
Support Sys. 2

Skills

Experimentation 1 or 2
Data Interpretation 1 or 2 for Expmt. data 3 - Diagnostic data
Data Analysis Same as above
Data Management 3 - Mechanics and/or computer programming
Expmt System Control 3 - Training
System Maint. 2 - Based on knowledge of design and eng. skills
Mission Integration 1
Expmt Setup-Preparation 2 - For command/control and For laboratory apparatus
Expmt Operation-Monitoring 3 - Most important skill
Assess Changing Conditions 2 - Little scientific orientation
Support Sys. Control 2 - To degree needed to control/maintain

Skill Requirements Category
0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: 2 Experimenter

Description: Experiment setup and data acquisition for lab type experiments - Support of scientist or Principal Experimenter

Responsibilities:

Decisions Problem Identification

Operations Setup/preparation, static checks, activation, operation/control monitor, expmtl. data acq. and recording, fault isolation, data mgt.

Sys. Responsibility Perform standard lab techniques - routine procedures

Skill Requirements Categories:

Knowledges - General	Laboratory apparatus, measures, procedures
Science	2 - Methodology 1 - Scientific discipline information
Experiment	2 - Procedures
Expmt Systems	2 - Apparatus
Engineering	2 - Moderate familiarity with system design
Support Sys.	2
Skills	
Experimentation	2 - For specific experiment
Data Interpretation	2 - Data checks
Data Analysis	2 - Preliminary analysis
Data Management	3 - Acquisition and recording
Expmt System Control	3 - Inherent in procedures
System Maint.	1 - Engineering 3 - Lab apparatus cleaning
Mission Integration	1
Expmt Setup-Preparation	2 - Apparatus preparation
Expmt Operation-Monitoring	3 - Use of lab techniques
Assess Changing Conditions	2 - Experiment specific
Support Sys. Control	2 To extent that experiment is affected

Skill Requirements Category
0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: -2 Experimenter Aide

Description: Manage, operate data systems, little facility with the experiment hardware and procedures

Responsibilities:

Decisions Data management - not content

Operations Store, retrieve, input, communicate, format, disseminate data.

Operate, maintain, checkout data systems

Sys. Responsibility Data management and communication systems

Skill Requirements Categories:

Knowledges - General	Facility in data mgt. of the type required
Science	0
Experiment	0
Expmt Systems	2 - Data systems 0 - All other
Engineering	2 - Engineering aspects of data systems
Support Sys.	2 - Data interface
Skills	
Experimentation	1
Data Interpretation	1 - Diagnostics
Data Analysis	1
Data Management	2 - Operate; update; maintain data systems
Expmt System Control	1 - To extent that data mgt. is involved
System Maint.	1 - Same as above
Mission Integration	0
Expmt Setup-Preparation	2 - Prepare data systems
Expmt Operation-Monitoring	2 - Operate data systems
Assess Changing Conditions	0
Support Sys. Control	1 - Data interface

Skill Requirements Category

0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: +1 Principal Technician

Description: Objective - Assurance of expmt. system availability - Support in operation/control

Responsibilities:

Decisions Maintenance and repairs completed, checkout accomplished, operational readiness

Operations Modify systems, prepare, static check, dynamic check, problem isolation, maintenance and repair, and setup

Sys. Responsibility Setup, checkout, maintenance and repair

Skill Requirements Categories:

Knowledges - General	Experiment System design, operation and maintenance
Science	0
Experiment	0
Expmt Systems	3 - To level required
Engineering	3 - To level required
Support Sys.	3
Skills	
Experimentation	0
Data Interpretation	2 - Diagnostic data 0 - Expmt. data
Data Analysis	0
Data Management	0
Expmt System Control	1 - Backup
System Maint.	3 - Test, use of tools, removal/replacement
Mission Integration	1
Expmt Setup-Preparation	3 - Following established procedures
Expmt Operation-Monitoring	1
Assess Changing Conditions	0
Support Sys. Control	3 - As required

Skill Requirements Category

0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: 1 Technician

Description: Technician responsible for sortie-expmt. interfaces and sortie system operation and control

Responsibilities:

Decisions Operational readiness of support systems - lighting, power, life support, caution/warning, controls/display, communication

Operations Setup and maintain experiment systems

Sys. Responsibility Maintenance and setup

Skill Requirements Categories:

Knowledges - General	Sortie engineering
Science	0
Experiment	0
Expmt Systems	1 - Experiment 3 - Support
Engineering	2 - As regards support systems design and operation
Support Sys.	2
Skills	
Experimentation	0
Data Interpretation	0
Data Analysis	0
Data Management	0
Expmt System Control	0
System Maint.	3 - Experiment support equipment
Mission Integration	1 - Sortie integration
Expmt Setup-Preparation	3
Expmt Operation-Monitoring	1
Assess Changing Conditions	0
Support Sys. Control	2

Skill Requirements Category

0 - No Reqmt
1 - Backup - need supervision
2 - Familiarity - competence
3 - Full knowledge capacity

ROLE PROFILE

Position: -1 Technician Aide

Description: Assist technician - under supervision

Responsibilities:

Decisions Minimal

Operations Backup operations, maintenance and setup

Sys. Responsibility None

Skill Requirements Categories:

Knowledges - General	Mission objectives, schedules, requirements
Science	0
Experiment	0
Expmt Systems	1
Engineering	2 - Shuttle/sortie - experiment interfaces
Support Sys.	1
Skills	
Experimentation	0
Data Interpretation	0
Data Analysis	0
Data Management	0
Expmt System Control	0
System Maint.	0
Mission Integration	2
Expmt Setup-Preparation	0
Expmt Operation-Monitoring	2
Assess Changing Conditions	0
Support Sys. Control	1 - Shuttle/sortie - experiment interface

APPENDIX D

CURRENT STATUS OF THE ROLE OF MAN DETERMINATION

The crew skill allocations as developed by Sortie Lab personnel for the Sortie experiments are presented in Table 1. In a complementary program, the MSFC Shuttle Payload Planning Activity (SPPA) identified 45 experiments as candidates for the Sortie Lab, in seven disciplines. For each experiment the report of the activity identifies personnel types by three general classifications: scientist (by type), engineer, and technician (by type, electromechanical, optics, etc.). A summary of personnel requirements by experiment, as reported in the SPPA status report (1972) is presented in Table 2. A technician (usually electromechanical) is required for 34 of the 45 experiments. At least one scientist is required also for 34 experiments. An electrical engineer is required for six experiments while two others require a pilot/navigator for subsatellite control.

An attempt to classify payload personnel skill requirements based on an analysis of task requirements was made by the URS/Matrix Company in June, 1972. This study used the General Dynamics Blue Book as the source of information on experiment requirements.

The URS/Matrix report initially identified 32 functions for an experimenter. This list is presented in Table 3. The general functions in this list can be classified into three groups: data acquisition functions; cognitive functions; and operational functions. The first three items in the list comprised the data acquisition functions. A total of four functions were classified as cognitive type of functions. These included decision making, pattern recognizer, evaluator, and data processor. The remaining 25 functions were classified as operational functions.

The URS/Matrix list of 2000 task skills was then analyzed to determine the types of functions evolving from the list. The 2000 task-skills were accommodated by 52 different functional designators. This list is presented in Table 4 with a tally of the number of times each function was cited in the list of 2000

(actually 1994). The percentage of times each function was cited is also presented in this table.

A comparison of the function lists in Tables 3 and 4 led to the following conclusions:

- Three of the functions listed in Table 3 did not occur in the task skill list of Table 4. These include pattern recognizer, experimental subject, and decision maker.
- 23 additional functions were identified in the task skill analysis which were not included in the original list (Table 4).

The distribution of the task skill functions (Table 4) was as follows:

- Information Acquisition Functions - 11%
- Operational Functions, including preparation, servicing, actuation, and configuration - 80%
- Cognitive, Executive and Communicative Functions - 9%

The functions developed in the functional model (Appendix A) numbered 36. The distribution of these functions was as follows:

- Information Acquisition Function 8.3%
- Operational Functions 25%
- Cognitive, Executive, Communications 61%
- Engineering Function 5.6%

It can be concluded that the functional model of the experimenter/scientist developed in this study places greater emphasis on the cognitive and executive aspects of the role than did the URS/Matrix task skill analysis. The correspondence of the three lists of experimenter/scientist functions is described in Table 5.

For Skylab seven specific functions had been identified for the experimenter. These include:

- Sensor operator
- Discriminator
- Data selection and evaluation
- Manual control
- Maintenance and repair
- Assembly and setup
- Mobility

TABLE 1. SORTIE EXPERIMENT SUMMARY

Discipline Astronomy

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
AS-1 UV Astronaut	1 m. diff. limit. telescope	0	Astronomer	12		100%	100%	10%	Some
			Optical Technician	12					
	Deep sky survey	0	"	24	Monitor-target selector for 2 dark side sessions	100%	100%	-	Some
	ALT. UV Telescope	0	"	24		100%	100%	50%	Some
AS-2 IR	1-5M telescope	Emerg Only	"	12 each		100%	90%	10%	Some
	Large aperture	"	"	"		100%	90%	10%	Some
AS-3 Comet Sim.	-	0	2 Electromech. technicians	12 hrs each	Time-control release oper. data rec. voice record	100%	80-100	-	20%
AS-4 Met. Sim.	-	0	E/M Technician	12	Point-adjust projectile guns-seq. instrum. monitor	100%	80-100	-	20%
Discipline High Energy Astrophysics									
HE-1 Cosmic Ray Survey	Spectrometer	0	E/M Technician	.2 hr/ miss.	Auto control	0	100%	6%	0
	Heavy NVC detect	0	"	"	"	0	100%	6%	0
	Mag. spectrometer	0	"	10.5 hrs/ miss.	Periodic monitor.	1%	100%	6%	0

TABLE 1 Continued

Discipline High Energy Astrophysics

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
E-1 Cosmic Ray Survey	Spectrometer	0	E/M Technician	.2 hr/ miss.	Auto control	0	100%	6%	0
	Heavy NVC detect.	0	"	"	"	0	100%	6%	0
	Mag. spectrometer	0	"	10.5hr miss.	Periodic monitor.	1%	100%	6%	0
HE-2 X & Gamma Ray	Detector-gamma	0	"	.2hrs/ miss.	Turn on/off only	0	100%	6%	0
	G-ray Spectrometer	0	"	"	"	0	100%	6%	0
	X-ray Spectrometer	0	"	"	"	0	100%	6%	0
	X-ray Polarim.	0	"	"	"	0	100%	6%	0
	X-ray Detectors	0	"	.7hrs/ miss.	Turn on/off-refill prop. counter	0	100%	6%	0
Discipline Atmosphere- Space Physics									
AP-PPEPL	Plasma Physics & environ. perturb. laboratory	emerg. only	Physicist	30	Crew of three	10-20	75-100	25	10-30
			E/M Technician	10	One only				

TABLE 1 Continued

Discipline High Energy Astrophysics

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
E-1 Cosmic Ray Survey	Spectrometer	0	E/M Technician	.2 hr/ miss.	Auto control	0	100%	6%	0
	Heavy NVC detect.	0	"	"	"	0	100%	6%	0
	Mag. spectrometer	0	"	10.5hr/ miss.	Periodic monitor.	1%	100%	6%	0
HE-2 X & Gamma Ray	Detector-gamma	0	"	.2hrs/ miss.	Turn on/off only	0	100%	6%	0
	G-ray Spectrometer	0	"	"	"	0	100%	6%	0
	X-ray Spectrometer	0	"	"	"	0	100%	6%	0
	X-ray Polarim.	0	"	"	"	0	100%	6%	0
	X-ray Detectors	0	"	.7hrs/ miss.	Turn on/off-refill prop. counter	0	100%	6%	0
Discipline Atmosphere- Space Physics									
AP-PPEPL	Plasma Physics & environ. perturb. laboratory	emerg. only	Physicist	30	Crew of three	10-20	75-100	25	10-30
			E/M Technician	10	One only				

TABLE 1 Continued

Discipline Earth Observation

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
EO-1 Earth Observ.		0	Geologist	22					
			Optical Technician	11					
			Elec. Engineer	11					
			Optical Scientist	9					
EO-2 Zero-G	Lab Operations	0	Meteorologist	4-8					
Cloud Physics Laboratory			Physicist	4-8					
			E/M Technician	2-4					
Discipline Earth and Ocean Physics Applications									
Test bed P/L	-	0	Technician	18		25%	100%	0	10%

TABLE 1 Continued

Discipline Space Processing Applications

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
SPA-1 Biological Sub-element	B-10 read. check	0	E/M Technician	.5 hr/ miss.	Over all experiments			-	-
	B-20 sample prep	0	"	.1	Start-stop				
	B-30 Operation	0	"	.2					
	B-40 Store sample	0	"	.1					
	B-50 Equip. Refurb.	0	"	.1					
	B-60 Shutdown	0	"	.5 hr/ miss.					
SPA-2 Gen. Purpose	G-10	0	"	"					
	G-20	0	"	.2					
	G-30	0	"	1.5	initiate, operate, terminate				
	G-40	0	"	.1					
	G-50	0	"	.1					
	G-60	0	"	.5 hr/ miss					
SPA-3 Furnace Sub-element	F-10	0	"	.5hr/ miss.					

TABLE 1 Continued

Discipline Space Processing Applications Continued

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
	F-20	0	E/M Technician	.2					
	F-30	0	"	.2					
	F-40	0	"	.2					
	F-50	0	"	.2					
Discipline Communications - Navigation									
CNRL-1 Early lab		0	Electronics eng.	10	Console oper., re-				
			Optical Tech.	10	config. data analysis, target selection	0	100	0	1%

TABLE 1 Continued

Discipline Life Sciences

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
LS-1 7-day ded. laboratory		TBD	M.D.	12					
			Biologist	12					
			E/M engin./L.S. Technician	12					
LS-2 30-day ded. laboratory		TBD	Same as above						
LS-3 Carry on mini laboratory	Medical Res.	-	M.D.	1.75					
	Verteb. Res.	-	Biol. Technician	1.75					
	Cell-tissue res.	-	Med. Technician	1.75					
	Life Support res.	-	Eng. Technician	1.75					
	MSI Res.	-	Med. Technician	1.75					
	Plant Res.	-	Biol. Technician	1.75					
	Invertab. Res.	-	Biol. Technician	1.75					
LS-4 BRM		-	C/o-launch-retriev	6/ launch retr.					

TABLE 1 Continued

Discipline Space Technology

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
ST-1 ATL-1	CN1, 2, 4 Micro-wave	0	E/M Technician	3					
	EO3 Scanner	0	"	1					
	Ph1, 3, 4, 5, 6	0	Physicist/Chemist	5					
			E/M Technician	2					
	MB1-5	0	Scientist	5					
			E/M Technician	2					
	CS1-2	0	"	6					
	EN1-4	0	Mech. Technician	5					
			E/M Technician	1					
ST-2 ATL-2	CN3	0	E/M Technician	.5					
	CN5	0	"	.5					
	CN7	0	"	.5					
	CN9	0	"	.5					

TABLE 1 Continued

Discipline Space Technology Continued

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
	E01	0	E/M Technician	2					
			Physicist	2					
	E02	0	E/M Technician	.5					
	E04	0	Physicist	4					
	Ph1	0	E/M Technician	.25					
	Ph2	0	"	.5					
	Ph4	0	"	.5					
	Ph5	0	Anyone	.25					
	MB-1	0	Anyone	.25					
	MB-2	0	2 crewmen	.5					
	MB-3	0	Photograph Tech.	1.5					
	MB-4	0	Biol. Technician	2					
	5 experiments	0	E/M Technician	5					

TABLE 1 Continued

Discipline Space Technology Continued

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
ST-3 ATL-3	CN-6	-	E/M Technician	2					
			Anyone	2					
	CN-8		E/M Technician	2					
			Anyone	2					
	CN-9		EE						
	EO1-4		E/M Technician	4					
	Ph1 - MB1		F/M Technician	.33					
			Physicist						
			Meteorologist						
			Anyone						
	MB2-5		Crewman	.25					
			Photo Technician						
	EN1-3		Biol. Technician						

TABLE 1 Continued

Discipline Space Technology Continued

Payload	Experiment	EVA	Skills	Crew Hrs./ Day	Remarks	On Orbit Display	Data Store for Return	On Orbit Dump	Real Time Transit
ST-4 Phys./Chemist	Wall-less chemical	-	Physicist/Chemist	2					
			E/M Technician	4					
	Sup. He		"	4					
	Fluid Ph		"	4					
	Neutral Beam		"	4					

TABLE 2

SPPA EXPERIMENT MANNING REQUIREMENTS

Experiment	Scientist	Engineer	Technician
Astronomy			
1 M Photoheliograph	Astronomer/Astrophys.		
Solar Spar - ASMDS	"		
Stratoscope III	"		
Wide Angle UV	"		
IR Telescope	"		
Small UV	"		
1.5 M Photoheliograph	"		
Communications/Navigation			
Early Lab		Electrical	Optical
C/N Research Lab		Electrical	Electronic
Earth Observations			
Met. and Atmos. Science	Oceanographer	Electrical	Electromech.
	Meteorologist		Optical
Land Use	Agronomist		Electromech.
	Geologist		Optical
Pollution	Meteorologist		Photo
	Oceanographer		Electromech.
	Hydrologist		Optical
Resources	Phys. Geologist		Photo
	Photo Geologist		Electromech.
	Agronomist		Optical
	Hydrologist		
Disaster	Same as above		Same as above
Ocean Resources	Meteorologist		Electromech.
	Oceanographer		Optical
Atmos. Cloud Physics	Atmos. Physics		
Freezing Droplet	Cloud Physics		
Drop Change	General Science		
Material Scie. - Manufacturing			
Biological			Biotech.
			Electromech.
Levitation	Material Scientist	EE	Electromech.
	Metallurgist		Optical
Furnace	Metallurgist	EE	Electromech.
Small/Low Temp.	Material Scientist	EE	Electromech.

TABLE 2
Continued

Experiment	Scientist	Engineer	Technician
Planetary			
Intermediate Telescope			Technician
Space Physics			
Atmos. and Magnetic Sci.	Physicist		Electromech.
Commentary Physics	Physicist		Electromech.
Meteroid Science	Physicist		Electromech.
Small Astr. Telescopes	Physicist		Electromech.
Plasma Physics Lab	Physicist		Electromech.
Wake Measurement	Physicist	Pilot/Navigator	Electromech.
Plasma Resources	Physicist		Electromech.
Wave Particle Interaction	Physicist	Pilot/Navigator	Electromech.
Electron-Iron Beam	Physicist		Electromech.
Cosmic Ray Mag. Spectrum	Physicist Scientist-Astronaut		
Plastic - Nuclear Emulsion			Electromech.
Physics - Chem. Lab	Physicist Physical Chemist		Electromech.
Flame and Laser	Physicist Physical Chemist Thermodynamist		Electromech.
Test Chamber	Physicist Thermodynamist		Electromech.
Technology			
Certanin. Measurement	Physicist		Electrical
Monitor	Physicist		Electrical
Short Term Cryo			Electrical
Slush Propellant			Electrical
Noncryo			Electrical
Noncryo			Electrical
AMU			3 Electrical
MWP			3 Electrical

TABLE 3

URS/MATRIX INITIAL LIST OF FUNCTIONS

Status Monitor
Observer
Inspector
Pattern Recognizer
Communicator
Data Processor
Fault Isolator
Calibrator
Aligner
Controller
Evaluator
Analyzer
Decision Maker
Tester-Checkout
Actuator
Stower
Cleaver-decontaminator
Assembler
Translocater
Deployer
Retriever
Locomotion
Remover
Repairer
Experimental Subject
Occupier
Wearer
Receiver/Donor
Deactivator
Unstower
Disassembler
Replacer

TABLE 4

URS/MATRIX TASK SKILL LIST

Task Skill	No. of Citations	%	Task Skill	No. of Citations	%
Inspector	53	2.5	*Filler	1	.05
Remover	220	11.0	Cleaner	56	2.8
Installer	244	12.2	Analyzer	8	.4
Stower-unstower	229	11.5	*Recorder	17	.85
Translocater	99	4.9	*Data Interpreter	1	.05
Monitor	108	5.4	*Record Organizer	1	.05
*Opener-closer	6	.3	Observer	51	2.5
Repairer	112	5.6	Evaluator	46	2.3
Selecter	21	1.0	*Developer	1	.05
Router	3	.15	*Classifier	1	.05
Connector-Disconnector	18	.9	*Measurer	1	.05
Actuator	117	5.8	*Determiner	28	1.4
Identifier	4	.2	*Director	1	.05
Tester	46	2.3	*Donner	1	.05
Assembler	86	4.3	*Preparer	2	.1
Disassembler	79	3.9	*Formulator	1	.05
Fault identifier	121	6.0	*Applier	1	.05
Translater	3	.15	*Mixer	1	.05
Calibrator	38	1.9	Occupier	1	.05
Deployer	7	.35	Wearer	5	.25
Aligner	15	.75	Processor	1	.05
Retractor-Retriever	1	.05	Donor	1	.05
*Adjuster	14	.7	Receiver	1	.05
*Coverer	1	.05			
Planner	20	1.0			
Communicator	51	2.5			
Controller	12	.6			
Deactivator	61	3.1			

*Not on original function list.

TABLE 5

SUMMARY OF FUNCTIONS

Essex Model Functions	Matrix Functional List	Matrix Task-Skill List
Experiment Definer		
Experiment Analyzer		
Experiment Planner		X
Experiment Designer		
Experiment Fabricator		
Experiment Installer		
Experiment Documentor		
Crew Trainer		
Communicator	X	X
Experiment Modifier		
Experiment Preparer		X
Experiment Checkout-Tester	X	X
Fault Identifier		
Fault Isolator	X	
Repairer	X	X
Actuator	X	X
Monitor-Observer	X	X
Operator-Controller	X	X
Data Acquirer-Measurer		X
Data Verifier		
System Monitor	X	
Decision Maker	X	
Evaluator	X	X
Problem Identifier		
On Line Data Analyzer	X	X
Experiment Terminator		X
Data Indexer		X
Data Processor	X	X
Data Formatter		
Data Inputter		
Data Communicator		
Data Retriever		
Data Analyzer		
Data Interpreter		X
Data Storer		
Data Disseminator		
	Inspector	X
	Pattern Recognizer	
	Calibrator	X
	Aligner	X
	Stower-Unstower	X
	Cleaner-Decontaminator	X
	Assembler-Disassembler	X
	Translocator	X
	Deployer	X
	Retriever	X
	Locomotion	X
	Remover/Replacer	X

TABLE 5
Continued

Essex Model Functions	Matrix Functional List	Matrix Task-Skill List
	Experimental Subject	
	Occupier	X
	Wearer	X
	Receiver/Donor	X
		Opener-Closer
		Selector
		Router
		Connector
		Identifier
		Adjuster
		Coverer
		Filler
		Recorder
		Record Organizer
		Developer
		Determiner
		Director
		Donner
		Formulator
		Applier
		Mixer