POSITION REQUIREMENTS FOR SPACE STATION PERSONNEL AND LINKAGES TO PORTABLE MICROCOMPUTER PERFORMANCE ASSESSMENT

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FOREWARD

While it would seem that the most rational way to assess the effects of agents or treatments on operational performance is to measure it on the job, such an approach has difficulties. Aside from safety and otherwise interfering with a controller's primary duties, most operational performance metrics are formed of composite elements and the reliability of such composites is the geometric mean of the reliability of all of the elements in the composite score. As a result, operational scores have low reliability and tests with low reliability are insensitive to treatment effects.

To address this problem, and to enable study of various agents and treatments, a surrogate approach to human performance testing has been proposed. This approach suggests that if tests of the same mental faculties (as are in operational performance) can be shown to change with treatments, one might infer that the operational performance might also be degraded.

As part of the development, we sought a technique that would permit comparison of abilities tested by APTS tests and the requirements for those abilities in various NASA mission specialist tasks was sought. To follow this strategy, two goals needed to be accomplished: (1) a metrically sound battery of tests needed to be developed, and (2) the tests in the battery needed to be compared to the elements of jobs performed by mission specialists.

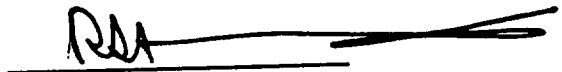
The Automated Performance Test System (APTS) is now a menu of cognitive and motor tasks which have been reported in a series of NASA-sponsored studies and are reviewed in a final report. A User's Manual is also available to aid in evaluating the effects of motion sickness drugs and other factors on human performance. The second question, "Could the relevance of the tasks in the APTS battery be shown in connection with jobs of interest to NASA?" is the subject of this report.

For this purpose, Dr. P. R. Jeanneret, a well-known analyst of jobs, was enlisted to conduct a task analysis of 14 NASA mission specialist jobs and then compare those abilities to abilities tested by the various APTS tests.

A generic position was selected for study. This position, the job of Aerospace Payload Specialist, covered the range of anticipated duties of astronauts and others assigned to a space station. For this effort, the task was decomposed following the approach of the Position Analysis Questionnaire (PAQ). The PAQ is perhaps the most widely used example of such an analysis instrument which has the capability to describe jobs in mental attributes and the development of the PAQ was originally sponsored by ONR. The PAQ is a structured job analysis questionnaire that can be used for analyzing jobs of many different types. It consists of six major divisions: (1) information input, (2) mental processes, (3) work output, (4) relationships with other persons, (5) job context, and (6) other job characteristics.

The preliminary results of the PAQ analysis yielded a set of behavioral job dimensions which characterized the content of these positions and permitted estimation of requirements for effective job performance. These elements are shown to converge with APTS test factors in matrix form (pp. 38, 39) and tabular form (pp. 41, 42).

This document, and the two comparison works, may be employed to plan experimental work regarding human performance changes of relevance to National Aeronautics and Space Administration.



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INTRODUCTION

This report describes the research conducted to complete Phase 4 - Task Analysis and Task Taxonomy in accord with the provisions of NASA Contract No. NAS9-17326 that provides for the development and use of a menu of performance tests that can be self-administered on a portable microcomputer. It is anticipated that such a test battery would be valuable in the assessment of change in performance associated with the Space Adaptation Syndrome, and thus would have direct implications for job accomplishment expected of space mission personnel and astronauts. In order to identify, develop, or otherwise select the relevant human capabilities/attributes to measure and hence include in the performance battery, it is essential that an analysis be conducted of the jobs or functions that will be performed throughout a space shuttle mission. An analysis of the duties and tasks performed during a mission also will identify the important behaviors and requirements associated with successful job accomplishment. These behaviors and requirements will specify the domain of skills, abilities, and other characteristics that should be incorporated in a performance assessment battery.

As a means of accomplishing Phase 4 of the research contract, the Position Analysis Questionnaire (PAQ) developed by McCormick, Jeanneret and Mecham (1972) was used to analyze the various space mission specialist functions. The results obtained from the PAQ provide for the identification of the core of attributes that underlie the performance of critical mission functions. In turn, these attributes, and especially those of a cognitive nature, have been matched with the components of the Automated Performance

Test System (APTS) (Kennedy, Jones, Dunlap, Wilkes, and Bittner, 1985) a portable microcomputer test battery developed under NASA, U.S. Army, and NSF sponsorship. The results provide for a clear understanding of what skills and abilities are required for job accomplishment, and how these skills and abilities are measured with components of the APTS.

This report is structured as follows: (1) The primary job analysis instrument, the PAQ, is discussed in detail so the reader will have sufficient background for understanding (a) the application of the instrument to the various work activities included within the scope of the study, and (b) the derivation of the human requirements (abilities/ attributes) from the PAQ analyses. (2) The research methodology is described and includes the procedures used for gathering the PAQ data. (3) The results are presented in detail with specific emphasis on identifying critical requirements that can be measured with a portable computerized assessment battery. (4) A discussion of the results is given with implications for future research.

JOB ANALYSIS WITH THE PAQ

Historically, several different methods/procedures have been used to analyze job content and determine job requirements (McCormick, 1976). Depending on the method, the job information might be couched in terms of tasks or outputs, or in terms of behavioral processes (e.g., sensing, estimating, etc.). The former type of job analysis data may be referred to as "job-oriented," while the latter can be considered "worker-oriented" (McCormick, 1976).

Background

The PAQ and associated computer-based analytical systems are the result of over 20 years of research and experience carried out principally by the authors of the PAQ (and secondly by industrial/organizational psychologists throughout the world). The research efforts of Drs. McCormick, Jeanneret, and Mecham during the late 1960's were focused on designing a generic, worker-oriented, structured job analysis questionnaire that could be used in the analysis of most, if not all, jobs in the work force. Further, the questionnaire design provided for the quantification of each worker-oriented element (PAQ item) so that systematic and objective analysis could be completed of the job data.

Three initial objectives guided the PAQ-related research activities once development of the PAQ was completed. First, it was hypothesized that there was an underlying structure to the world of work, and that this structure could be identified and subsequently form the foundation for a research data base. Second, it was expected that a statistical method

could be derived for determining the aptitude requirements for jobs in a manner that would reduce the need for conventional validation procedures. Third, it was anticipated that a statistical procedure could be developed for estimating the values of jobs (in a compensation sense), thus reducing the need for using more traditional and highly subjective job evaluation methods (McCormick, Jeanneret, and Mecham, 1972).

Following the development of the PAQ and continued research and applications by the authors as well as many other professionals, it was found that the data obtained with the PAQ had many other valuable uses. Specifically, jobs could be compared with one another in order to identify job progressions, job families, or career pathways; performance dimensions could be derived for personnel appraisal purposes; and matches could be made between a person's work interests (recorded on an interest questionnaire that is a derivative of the PAQ) and the vast data base of job information. Further, many other applications have been developed from the PAQ data base for specific human resource management or personnel research purposes. Recent reviews of the PAQ itself as well as its application can be found in McCormick and Jeanneret (1988) and Jeanneret (1988).

To summarize, the PAQ data can readily serve as the basis for an organization's integrated human resource system. Dunnette and Borman (1979) in their annual review article cited the PAQ and research related to its application as one of 15 major milestones in personnel and classification research during the last 60 years. This conclusion has been confirmed by several research studies that have documented the value of the

"worker-oriented" approach, and particularly the PAQ, relative to other conventional job analysis procedures, especially for such purposes as establishing job requirements, classification, job evaluation, and job design. [Brumbach, Romashko, Hahn, and Fleishman (1974); Center for Evaluation Research (1980); Levine, Ash, Hall, and Sistrunk (1983)]. These same studies also cite the value of the PAQ in terms of its strong psychometric characteristics and ease of use. Jeanneret (1988) has summarized most of the applications of the PAQ as applied to a series of jobs within the computer manufacturing industry with the intent of providing an integrated human resource system approach to incumbent management.

Structure and Content of the PAQ

The current version of the PAQ is the result of several "generations" of questionnaires that were prepared and used from the early 1960's through 1980, which is the year of the latest published version. The PAQ itself is comprised of 187 items (job elements) of a worker-oriented nature that relate to work functions and work situations. The job elements are organized into the following six major divisions:

1. Information Input (Where and how does the worker get the information that is used in performing the job?)
2. Mental Processes (What reasoning, decision-making, planning, and information processing activities are involved in performing the job?)
3. Work Output (What physical activities does the worker perform and what tools or devices are used?)

4. Relationships With Other Persons (What relationships with other people are required in performing the job?)
5. Job Context (In what physical and social contexts is the work performed?)
6. Other Job Characteristics (What activities, conditions, or characteristics other than those described above are relevant to the job?)

The job elements (items) themselves describe general work behaviors, activities, situations, or characteristics. The work functions and requirements reflected in the PAQ items are presented in Appendix A.

Rating scales are used by job analysts to rate the relevance of each PAQ element to the job being analyzed. There are several different types of rating scales, but only one scale is used with any specific element. The principal rating scales that are used include the following:

- Extent of Use (Scale range 0-5)
- Importance to This Job (Scale range 0-5)
- Amount of Time (Scale range 0-5)
- Possibility of Occurrence (Scale range 0-5)
- Applicability (Scale range 0-1)

Additionally, there are "one-of-a-kind" rating scales designed specifically for individual PAQ items (e.g., Years of Job-Related Experience) and the scale values range from either 0 to 5 or 1 to 5. Further, most of the PAQ rating scales provide for a mid-rating (e.g., .5) between the whole-number scale values, so there are usually 11 rating categories.

Job Dimensions

Research by Jeanneret (1970) and subsequently replicated by Marquardt and McCormick (1974) and by Mecham, McCormick, and Jeanneret (1977) indicated that there is structure to work that spans a broad spectrum of occupations. This structure can be defined in terms of what are called job dimensions. These job dimensions were derived through the principal components analyses of the intercorrelations of PAQ element ratings across large numbers of jobs (in one study, 3,700 different jobs). The results are expressed as 45 job dimensions (see Appendix B) which characterize the organization of human job behaviors as they occur throughout the world of work. These dimensions reflect the results of the most recent principal components analysis carried out with a sample of 2,200 jobs that characterize the structure of the U.S. labor force (see Mecham, McCormick, and Jeanneret, 1977). Actually, separate principal components analyses have been completed, with the elements in each of the six divisions of the PAQ analyzed separately, followed by an overall analysis with virtually all PAQ items pooled together. These various principal components analyses resulted in the identification of 32 "divisional" job dimensions (labelled 1 to 32 in Appendix B) and 13 "overall" dimensions (labelled 33 to 45 in Appendix B). The name of a dimension is based on the content of the PAQ elements that correlated significantly with the dimension.

Job dimension scores can be derived for any job analyzed with the PAQ. These dimension scores are based on the PAQ element ratings on a job in combination with the loadings of these elements with respect to each specific dimension. Thus, a job with high ratings on certain PAQ elements

that in turn have high loadings with respect to a specific dimension will receive a high score for that job dimension.

Expanding upon the derivation of job dimensions, several researchers have demonstrated that profiles based on the job dimension scores can be statistically compared to examine job interrelationships. The work of Arvey and his colleagues (Arvey et. al. 1977, 1979, 1981) as well as Taylor (Taylor, 1978; Taylor and Colbert, 1978) is representative. Further, Pearlman (1980), in an American Psychological Association award-winning dissertation, has described the value of the linkage between the PAQ job dimensions and necessary job requirements, and cites the linkage as an important ingredient to establishing meaningful job interrelationships.

Reliability of PAQ Data

The reliability of any job analysis data should be established, since without information on reliability it is difficult to establish the validity or utility of any results based on the job analysis data.

Reliability has been determined for the ratings of each PAQ element across all 187 elements by having two analysts study the same job and independently complete a PAQ (McCormick, Jeanneret, and Mecham, 1972). These ratings are then correlated, and the average correlations (converted to Z-scores) for "pairs" of analysts are accumulated across a wide range of job analyses to obtain an average reliability coefficient. The average reliability coefficients have typically been in the .80's (McCormick, et. al., 1972), and even as high as .90 across 303 different positions analyzed with the PAQ (Jeanneret, 1980). Additionally, studies have been made of

the rate-rerate reliability of the PAQ, and the results reveal reliabilities in the high .70's and .80's. These reliability results tend to be consistent when the analysts are incumbents, supervisors, or independent job analysts (McCormick, et. al., 1972; Taylor and Colbert, 1978), although job incumbents and their supervisors do give higher ratings on the elements than do independent job analysts (Smith, 1975; Smith and Hakel, 1979).

Research during the last 10 years has studied the confounding effects of the number of PAQ elements that are rated "0" (Does Not Apply) by a job analyst and analyst reliability. Initially the issue was raised by Smith and Hakel (1979) who reported high correlations between expert analyst and naive raters completing PAQs for the same jobs using only job titles or brief job descriptions as a source of job content information. The preliminary conclusion was that the PAQ may only reflect job stereotypes or knowledge about jobs. However, Cornelius, DeNisi and Blencoe (1984) using more appropriate statistical measures found that the PAQ was clearly able to provide more than common knowledge or stereotypic information about jobs. Nevertheless Harvey and Hayes (1986) in a Monte Carlo study did show that the number of "0" rated elements had a confounding influence on analyst reliability. In effect, increasing numbers of "0" rated elements artificially inflates reliability. Further DeNisi, Cornelius and Blencoe (1987) suggested that when there are large numbers of "0" rated elements in the analysis of a job, the PAQ may be limited in effectively characterizing that job. Both the Harvey and Hayes (1986) and DeNisi, Cornelius and Blencoe (1987) studies indicated that the validity or utility of the PAQ as a job analysis tool is only called into question when there is a large

number of elements rated "0." The baseline number in the Monte Carlo study was 56 percent of "0" rated items which yielded an artificial reliability coefficient of .78 (i.e. a reliability of .78 when the data were actually random). On the other hand, if only 21 percent of the PAQ elements are rated "0" then the reliability would not artificially exceed .50 (i.e. if all element ratings were random).

While the above research is useful in understanding the measurement properties of the PAQ, it does not recognize the importance of an element not being a part of a job. In other words, the fact that a job element is not reflected by the PAQ in a job is potentially as valuable a piece of job information as the element being a part of the job and therefore rated other than "0." Further, the above cited researchers fully recognize that analyst training is an extremely important consideration and might well mitigate the findings of their research.

The reliabilities of the job dimension scores also have been computed by comparing the dimension scores which result from independent analyses of the same job across job analysts. These reliability coefficients average in the .60's, depending on the statistical method used to calculate the coefficients (McCormick, et. al., 1977; Jones, Main, Butler, and Johnson, 1982).

Estimation of Job Requirements

The PAQ can serve as the basis for a generalized method of estimating aptitude requirements of jobs directly, thus foregoing the need to conduct the research typically required by conventional test validation procedures.

This is the central basis for job component validity, which assumes that the requirements for any given job activity or component would be comparable in the case of any job in which that same activity or component occurred, regardless of the specific technology of the job (McCormick, et. al., 1972).

Requirements based on the General Aptitude Test Battery (GATB). A primary analysis of PAQ data based on the job component validity concept defines requirements in terms of the nine tests of the General Aptitude Test Battery (GATB) of the United States Employment Service (USES). The underlying research was based on a sample of 163 jobs for which both PAQ analyses and GATB job incumbent mean test-score data were available.

The mean test scores for job incumbents working on the 163 jobs were used as a criterion of the "importance" of the various GATB tests for selecting personnel for the different jobs, predicated on the assumption that people tend to "gravitate" into those jobs that are commensurate with their own aptitudes. Thus, for a given test high mean test scores of people on certain jobs would imply that those jobs require high levels of the attribute measured, and vice versa.

All the job dimension scores derived from the PAQ analyses of the 163 jobs were used as potential predictors of the mean test scores of incumbents on the jobs. For each of the nine GATB tests a multiple correlation was computed for the combination of job dimensions that best predicted the mean test scores of incumbents. The results indicated that the prediction of mean test scores is very high for the cognitive tests (G, V, and O), and is also quite satisfactory for the perceptual tests (S, P, and Q) and the

motor coordination test (K). The correlations for the finger and manual dexterity tests (F and M) were the only ones that were rather low. More recently it has been demonstrated that the validity of at least certain cognitive ability predictions is moderated by behavioral job characteristics measured with the PAQ (Gutenberg, Arvey, Osburn, and Jeanneret, 1983).

Since the GATB tests are not available for use by private organizations, another study was carried out for incumbents on 202 jobs with data on a number of commercially available tests that were considered to "match" certain of the GATB tests. "Matching" was completed with commercially available tests for five of the GATB aptitudes, namely, G, V, N, S, and Q. The combination of job dimensions and their statistically determined weights for each of the five GATB aptitudes was used to derive "predicted" mean test scores for the jobs in the sample, which were correlated with actual mean test scores obtained for incumbents on the jobs. The correlations for four aptitudes (G, V, N, and S) ranged between .67 and .74, while the correlation for the Clerical test (Q) was .53 (McCormick, DeNisi, and Shaw, 1979).

The validity and utility of the GATB is well established across the domain of work. Validity generalization research by John Hunter in cooperation with the U.S. Employment Service found that in 515 validity studies the GATB far exceeded any other techniques for assessing job performance (Hunter, 1980; 1981). The average predictive validity coefficient for the cognitive and psychomotor ability components of the GATB is .55.

Requirements based on ratings of human attributes. A second procedure developed for the derivation of job requirements from PAQ data is based on the relationships between PAQ items and a set of 76 human attributes. These attributes and their respective definitions are reported in Appendix C. The attributes may be categorized into four groups: mental aptitudes; perceptual aptitudes; physical and psychomotor aptitudes; and interest and temperament aptitudes. Studies by both Mecham and McCormick (1969) and Marquardt and McCormick (1972; 1973) established the degree of relevance between each of the 76 attributes and each of the 187 PAQ elements. For example, the attribute "verbal comprehension" has a very high degree of relevance for the PAQ element, "written materials," but would have little if any relevance to the PAQ element, "mechanical devices" when these elements are sources of information to a worker. Statistical procedures have been developed to create an attribute profile across the 76 attributes based on the PAQ element ratings for a job (Mecham, et. al., 1977). The value and validity of these attribute ratings has been established by McCormick, DeNisi, and Shaw (1979) for a broad sample of jobs, and by Carter and Biersner (1982, 1987) who determined that for a sample of military jobs, the cognitive attributes scores were equivalent to mental abilities measured by the Armed Forces Vocational Aptitude Battery and that the physically-oriented attribute scores were related to direct estimates of various strength requirements. Further, Carter and Biersner in their 1982 study showed the value of the attribute profiles for selecting abilities that should be evaluated in research on the job performance effects of unusual environments (e.g., heat, cold, motion, and deep-sea diving).

In summary, the research results clearly suggest that aptitude and attribute indices that reflect job requirements can be derived directly from PAQ data. Further, these analyses can document which aptitudes are related to specific types of job performance or specific categories of work content.

METHOD

The primary data collection needs of Phase 4 - Task Analysis and Task Taxonomy - was the development of information about the jobs performed by space shuttle mission personnel. Since it was not feasible to collect this information as the jobs were actually being carried out, the PAQ became an especially valuable instrument; it does not require direct observation of the tasks or completion by incumbents who perform the jobs. Rather the PAQ can be completed by a trained job analyst using information about the jobs that is documented directly or inferred through published materials. This approach became the preferred method of data collection for this project.

Source Material Review and Selection of Specialty Functions

Two initial components of the research plan were undertaken somewhat simultaneously. One component provided for (1) the collection and review of source materials that documented space shuttle mission job functions, and (2) the determination of specific mission specialty functions. The resource materials used for this process are listed in Appendix D. The mission specialty functions derived from the source materials and selected for job analysis are listed in Figure 1, and each specialty function is assigned an alpha identification that is used in reporting the results of the analysis of that function. These specialty functions were developed on the basis of information provided in the source materials, as well as the expectation that they were stand-alone functions that could be performed by one or more mission personnel. That is to say, performing one specialty

FIGURE 1

SPACE MISSION SPECIALTY FUNCTIONS
IDENTIFIED FOR JOB ANALYSIS

Alpha Identification	Specialty Function Description
A	Activate, Calibrate, Deactivate, and Stow Equipment
B	Operate and Monitor Experiments, and Check Performance of Specific Systems
C	Make and Record Detailed Measurements and Visual Observations
D	Communicate Effectively with Principal Investigators
E	Make Independent Scientific Inferences, Judgments, and Decisions
F	Make Required Changes in Experimental Protocol and Accommodate Unscheduled Adjustments
G	Evaluate and Interpret Experimental Data
H	Troubleshoot Instrumentation
I	Photograph Experimental Phenomena
J	Change Photographic Film and Data Tapes
K	Participate in All Aspects of Life Science Investigations
L	Adapt to Unforeseen, Anomalous Laboratory Situations
M	Fluid Experimental System and Vapor Crystal Growth System
N	Fluid Experimental System

function did not require an individual to perform other specialty functions, although that could be the actual scenario during a space mission.

Job Analyst Training

A second component of the research plan that occurred during the same time frame as the identification and specification of mission functions was that of training an Essex Corporation Researcher in the application of the PAQ. This training focused on the interpretation of the PAQ elements as they related to the various mission functions known to the researchers. Opportunities were provided for practice and interchange during the training, and a variety of examples and scenarios were discussed so that the researcher receiving training had the opportunity to understand the scope and relevance of each PAQ element.

Job Analysis of Mission Specialty Functions

Two activities were accomplished during the job analysis components of the research. One activity involved the completion of a PAQ for each of the fourteen (14) specialty functions by the Essex researcher trained in the use of the PAQ. Once completed and submitted, the PAQ ratings for each specialty function were then reviewed and edited as necessary by two members of Jeanneret & Associates experienced in the use of the PAQ. Thus for each specialty function a final PAQ was completed that had input from three job analysts.

Statistical Analyses of PAQ Data

The fourteen (14) sets of PAQ ratings were subjected to the full array of statistical analyses offered for the PAQ. These analyses included the computation of intercorrelations between all possible pairs of ratings, the calculation of job dimension scores and predicted General Aptitude Test Battery (GATB) test scores, and the derivation of profiles for seventy-six (76) human attributes.

Review of Microcomputer Performance Tests

Three researchers (the Principal Investigator and two other psychologists, one Ph.D., and one completing a Ph.D. dissertation) independently reviewed the microcomputer performance tests and indicated what human attributes (particularly of a mental aptitude, perceptual, or psychomotor ability nature) were being measured. In turn, a consensus from the three judgments was developed by the Principal Investigator. The review of the performance tests included reading descriptive material as well as two of the researchers actually responding to the tests as presented on a microcomputer.

Documentation of Relationship Between Mission Specialty Function Requirements and Attributes Measured by the Microcomputer Performance Tests

The final activity involved matching the mission specialty function requirements (developed from analyses of the PAQ data) with the attributes measured by the microcomputer performance test battery. This matching was completed by the Principal Investigator.

RESULTS

The PAQ item responses were scored for each of the mission specialty functions, and the standard statistical analyses were carried out by PAQ Services, Inc.[1] These analyses provided the following information for each specialty function:

- Job Dimension Profiles (expressed as percentile scores across 45 dimensions)
- Predicted Aptitude Requirements (expressed as three different indices for the nine aptitude scores derived from the GATB)
- Predicted Attribute Requirements (expressed as percentile scores across 76 attributes)

Subsequently, judgments were made as to which job requirements (defined as an aptitude or attribute) were measured by the microcomputer performance test battery. Then a comparison could be made between the job requirements on the one hand and the availability of performance measures on the other hand.

These various results are described in the sections that follow and then are summarized in the last section of this part of the report.

Interrelationships Among Mission Specialty Functions

Before analyzing the various requirements underlying the accomplishment of the mission functions, a review was made of the extent to which the

[1]PAQ Services, Inc. is the provider of statistical scoring of PAQ data and retains all of the algorithms developed from the 20 years of research conducted by Drs. McCormick, Jeanneret, and Mecham.

functions were inter-related. The upper half of an intercorrelation matrix is presented in Table 1 which indicates the relationships between all possible paired combinations of mission specialty functions. These relationships, expressed as correlation coefficients, describe the degree to which the profile of PAQ element ratings for one function is consistent with the profile of element ratings for "paired" functions. The lower half of the matrix in Table 1 is the percent overlap in PAQ item ratings. The percentage is calculated as the extent to which item ratings are equal or within 1 rating scale value across all 187 PAQ elements for "paired" functions.

As indicated by the data in Table 1, 13 of the 14 functions are highly intercorrelated; Function D is the exception. The average coefficient is .84 even when Function D is included in the average. The range of overlap in the similarity of PAQ item ratings is from 67 to 96 percent and the average percent of similar pairs of PAQ items across all 14 functions is 85 percent. Again, Function D has the lowest percent overlap with the other mission functions. If the basic behavioral elements of the functions are highly correlated, then it is reasonable to expect that the underlying dimensions and requirements will have a strong degree of similarity as well. Results for the job dimensions and requirements are presented in the sections that follow.

Job Dimension Scores

Table 2 sets forth the job dimension percentile scores for each mission specialty function. The functions are labelled A through N as described in the Method section of this report. Past experience of the Principal

TABLE 1

INTERCORRELATION MATRIX AND PERCENT PAIRS OF SIMILARLY RATED PAQ ITEMS FOR MISSION SPECIALTY FUNCTIONS

	A	B	C	D	E	G	H	K	F	L	I	J	M	N
A	**	.86	.86	.58	.78	.73	.87	.85	.85	.85	.85	.81	.87	.85
B	87	**	.91	.64	.83	.79	.90	.91	.90	.92	.84	.74	.90	.88
C	89	94	**	.71	.89	.84	.89	.91	.90	.93	.85	.77	.91	.92
D	75	73	75	**	.69	.73	.59	.67	.71	.66	.59	.54	.63	.69
E	83	88	88	75	**	.90	.84	.82	.86	.88	.84	.76	.89	.92
G	79	86	83	82	95	**	.79	.79	.85	.80	.81	.78	.81	.87
H	85	90	91	67	86	84	**	.91	.91	.92	.85	.79	.91	.91
K	82	91	92	73	81	79	91	**	.90	.93	.85	.74	.90	.89
F	89	92	91	77	87	87	92	92	**	.94	.84	.76	.91	.91
L	83	92	93	74	89	81	93	93	96	**	.85	.74	.93	.91
I	88	86	87	75	86	85	86	83	87	87	**	.85	.85	.88
J	84	80	78	77	85	86	77	74	78	77	87	**	.79	.82
M	84	90	93	69	89	80	90	90	92	93	85	77	**	.94
N	88	89	95	69	95	85	91	85	95	91	88	82	94	**

Upper half of matrix are product moment correlation coefficients.

Lower half of matrix are percentages.

Note: Functions A through N are identified in the Method section of this report. (See Figure 1, page 16.)

TABLE 2

JOB DIMENSION PROFILES FOR MISSION SPECIALTY FUNCTIONS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Division 1: Information Input														
1. Interpreting What is Sensed	87	97	91	84	94	92	92	98	68	48	95	98	86	78
2. Using Various Sources of Information	36	51	39	47	31	42	51	39	21	12	41	26	29	54
3. Watching Devices and/or Materials for Information	86	73	71	39	50	45	35	78	62	86	57	37	68	70
4. Evaluating and/or Judging What is Sensed	89	73	89	63	99	95	92	99	99	91	95	98	99	99
5. Being Aware of Environmental Conditions	40	51	91	42	54	38	36	35	81	45	76	48	61	56
6. Using Various Senses	19	27	27	38	44	24	18	13	12	27	35	42	11	13
Division 2: Mental Processes														
7. Making Decisions	88	99	98	94	99	99	99	96	90	49	98	98	99	99
8. Processing Information	53	66	54	61	70	74	57	72	58	41	75	75	61	54
Division 3: Work Output														
9. Using Machines and/or Tools and/or Equipment	96	99	99	87	78	99	54	99	93	68	99	99	99	97
10. Performing Activities Requiring General Body Movement	35	17	28	7	21	16	4	13	51	8	32	22	10	18
11. Controlling Machines and/or Processes	23	45	33	16	30	26	39	32	17	19	36	43	18	26
12. Performing Skilled and/or Technical Activities	98	90	88	39	92	93	80	97	99	97	84	92	95	98
13. Performing Controlled Manual and/or Related Activities	83	30	51	48	71	76	71	84	58	88	49	47	73	80
14. Using Miscellaneous Equipment and/or Devices	65	94	80	96	73	75	56	78	49	28	85	80	90	63
15. Performing Handling and/or Related Manual Activities	46	50	42	21	55	68	64	38	21	60	38	67	94	65
16. General Physical Coordination	49	36	49	30	21	51	22	56	76	43	64	58	20	26
Division 4: Relationships with Other Persons														
17. Communicating Judgments and/or Related Information	55	68	67	92	51	70	54	44	45	35	76	69	68	71
18. Engaging in General Personal Contact	56	52	46	21	58	52	55	59	65	69	65	57	56	51
19. Performing Supervisory and/or Coordination and/or Related Activities	40	39	30	29	41	35	36	38	40	45	28	35	31	32
20. Exchanging Job-Related Information	7	9	15	41	3	14	5	7	5	3	16	9	9	10
21. Public and/or Related Personal Contacts	17	12	15	7	22	11	21	20	20	23	9	11	13	12

Note: Functions A through N are identified in the Method section of this report. (See Figure 1, page 16.)

TABLE 2 - Continued

JOB DIMENSION PROFILES FOR MISSION SPECIALTY FUNCTIONS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Division 5: Job Context														
22. Being in a Stressful and/or Unpleasant Environment	93	89	84	74	87	84	82	87	87	87	84	87	87	87
23. Engaging in Personally Demanding Situations	55	53	56	79	54	55	53	59	54	54	82	54	54	54
24. Being in Hazardous Job Situations	9	10	16	15	12	12	13	12	12	12	13	12	12	12
Division 6: Other Job Characteristics														
25. Working Non-Typical vs. Day Schedule	8	8	8	8	8	8	8	8	8	8	8	8	8	8
26. Working in a Businesslike Situation	38	38	38	38	38	38	38	38	38	38	38	38	38	38
27. Wearing Specified vs. Optional Apparel	19	19	19	19	19	19	19	19	19	19	19	19	19	19
28. Being Paid on a Salary vs. Variable Basis	53	53	53	53	53	53	53	53	53	53	53	53	53	53
29. Working on an Irregular vs. Regular Schedule	2	2	2	2	2	2	2	2	2	2	2	2	2	2
30. Working Under Job-Demanding Circumstances	44	38	55	88	56	60	62	61	59	55	57	70	64	57
31. Performing Unstructured vs. Structured Work	54	72	68	35	23	39	51	44	41	46	47	33	61	68
32. Being Alert to Changing Conditions	84	99	98	56	97	98	95	97	97	90	99	95	97	96
Overall Dimensions														
33. Having Decision, Communication, and General Responsibilities	41	53	50	69	50	60	52	44	44	30	62	54	53	54
34. Operating Machines and/or Equipment	97	98	96	58	90	99	70	99	92	85	99	99	99	98
35. Performing Clerical and/or Related Activities	45	54	54	47	31	52	39	59	40	25	56	52	54	50
36. Performing Technical and/or Related Activities	97	92	99	87	99	88	99	97	99	96	93	90	97	99
37. Performing Service and/or Related Activities	40	32	51	19	51	25	35	29	44	53	45	45	41	39
38. Other Work Schedules vs. Working Regular Day Schedules	2	2	2	2	2	2	2	2	2	3	2	2	3	3
39. Performing Routine and/or Repetitive Activities	13	19	31	40	39	17	48	20	50	37	29	21	35	45
40. Being Aware of Work Environment	25	51	56	21	39	31	38	44	38	22	55	49	32	35
41. Engaging in Physical Activities	6	2	3	4	2	3	2	2	3	4	2	2	2	3
42. Supervising/Directing/Estimating	52	87	86	80	97	73	90	82	54	28	81	90	92	87
43. Public and/or Customer and/or Related Contacts	52	30	49	51	69	50	44	56	53	74	43	61	74	68
44. Working in an Unpleasant/Hazardous/Demanding Environment	77	53	56	86	77	59	68	52	63	77	52	50	57	56
45. Having a Non-Typical Schedule/Optional Apparel Style	99	99	93	87	91	99	93	98	97	98	94	94	96	96

Note: Functions A through N are identified in the Method section of this report. (See Figure 1, page 16.)

Investigator has indicated that both the magnitude and pattern of the dimension percentile scores are important. Furthermore, while it is useful to examine the higher percentile scores (numerically speaking), it is also important to consider lower scores as well, since the absence of a dimension in a job can reveal important information.

A review of the data in Table 2 indicates that several dimensions are particularly dominant across the various mission specialty functions. These dimensions and their identification numbers are listed below. (More detailed definitions of the PAQ job dimensions are presented in Appendix B.)

Dominant PAQ Dimensions (Relatively High Percentile Scores)

Divisional Dimensions

1 - Interpreting What is Sensed
3 - Watching Devices and/or Materials for Information
4 - Evaluating and/or Judging What is Sensed
5 - Being Aware of Environmental Conditions
7 - Making Decisions
8 - Processing Information
9 - Using Machines and/or Tools and/or Equipment
12 - Performing Skilled and/or Technical Activities
13 - Performing Controlled Manual and/or Related Activities
14 - Using Miscellaneous Equipment and/or Devices
17 - Communicating Judgments and/or Related Information
18 - Engaging in General Personal Contact
22 - Being in a Stressful and/or Unpleasant Environment
23 - Engaging in Personally Demanding Situations
30 - Working Under Job Demanding Circumstances
31 - Being Alert to Changing Conditions

Overall Dimensions

33 - Having Decision, Communication, and General Responsibility
34 - Operating Machines and/or Equipment
36 - Performing Technical and/or Related Activities
42 - Supervising/Directing/Estimating
44 - Working in an Unpleasant/Hazardous/Demanding Environment
45 - Having a Non-Typical Schedule

The above job dimensions characterize the mission specialty functions as ones that (a) have high perceptual demands (dimensions 1, 3, 4 and 5); (b) require considerable decision making, information processing, and communications (dimensions 7, 8, 17, 18, 33, and 42); (c) depend on technical skills and equipment operation (dimensions 9, 12, 13, 14, 34, and 36); and (d) must be performed under demanding circumstances requiring alertness and tolerance for stress (dimensions 22, 23, 30, 32, 44, and 45). It is noted that the job demands are of a mental rather than physical nature since dimensions 10, 15, 16, and 41 (which reflect physical exertion) have relatively low percentile scores across most of the functions. Further, the job dimension data indicate that the specialty functions are performed in a singular fashion for the most part and do not require interactive processes or coordination with others. Thus, the mission specialty functions are performed more on an individual than team basis.

Predicted Results for Nine Aptitude Scores

The PAQ predictions for the nine aptitude scores that comprise the GATB were derived for each of the mission specialty functions labelled "A" through "N." These results are presented in Table 3. For each aptitude, three indices are presented: A predicted mean score, a predicted validity coefficient, and a predicted use in selection index. For all three predicted values, the higher the numerical value the more important the attribute. The following information will assist the reader in further evaluating the aptitude indices.

TABLE 3

PREDICTED MEAN SCORES, VALIDITY COEFFICIENTS, AND USE IN SELECTION INDICES FOR EACH GATB APTITUDE FOR MISSION SPECIALTY FUNCTIONS

Test Predictions / GATB Tests	A			B			C			D			E			F			G		
	MS*	PVC*	UISS*	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS
G: Intelligence	120.6	.34	.44	131.9	.39	.32	124.0	.36	.24	129.0	.34	.66	128.4	.45	.15	129.0	.46	.26	131.0	.43	.37
V: Verbal Aptitude	116.4	.12	.15	126.7	.13	.30	116.7	.10	.25	125.1	.13	.12	121.5	.14	.47	127.0	.15	.39	128.0	.11	.65
N: Numerical Aptitude	112.5	.36	.97	125.5	.44	1.17	114.3	.38	1.03	117.6	.29	.85	117.0	.49	1.41	122.8	.46	1.23	119.2	.46	1.48
S: Spatial Aptitude	116.6	.23	.85	123.0	.33	1.07	118.7	.30	.94	118.4	.29	.66	119.3	.22	.89	122.4	.25	.97	117.7	.21	.63
P: Form Perception	117.6	.07	.73	120.6	.10	.32	115.1	.05	.51	109.9	.04	.07	114.6	.06	.79	117.6	.11	.68	111.5	.07	.60
Q: Clerical Perception	115.8	-.02	.34	123.9	-.06	.51	113.7	-.09	.34	115.7	.02	.11	110.2	-.01	.29	122.0	.00	.32	115.3	-.01	.19
K: Motor Coordination	114.7	-.04	-.43	122.4	-.02	-.40	114.9	.00	-.38	113.8	.04	-.37	108.6	.00	-.42	119.3	.00	-.38	112.4	.00	-.35
F: Finger Dexterity	109.0	.00	.40	108.9	-.03	.20	106.8	-.04	.22	107.1	.00	.41	104.6	-.01	.34	108.4	-.01	.43	106.4	.01	.11
M: Manual Dexterity	114.8	.00	-.42	118.2	.05	-.49	118.4	.09	-.34	111.3	.16	-.01	111.5	.09	-.99	113.8	.08	-.77	108.7	.13	-.78

Test Predictions / GATB Tests	H			I			J			K			L			M			N		
	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS	MS	PVC	UISS
G: Intelligence	120.1	.42	.11	121.4	.39	.11	112.6	.31	.22	124.6	.40	.29	126.0	.47	.19	119.6	.38	.18	123.1	.34	.27
V: Verbal Aptitude	115.9	.15	.23	114.8	.13	.32	109.5	.07	.18	120.5	.14	.33	122.4	.16	.31	118.3	.05	.31	119.8	.04	.51
N: Numerical Aptitude	113.3	.49	.99	113.1	.46	1.13	102.5	.29	.69	118.2	.45	.92	119.5	.50	1.07	112.4	.41	1.06	114.2	.37	1.14
S: Spatial Aptitude	116.2	.30	.84	114.5	.19	.61	108.4	.16	.48	119.0	.31	.93	120.5	.27	.97	114.7	.29	.91	113.8	.23	.70
P: Form Perception	119.2	.17	1.18	122.3	.11	1.36	118.4	.15	1.85	117.8	.13	.62	120.2	.14	.73	112.3	.10	.72	113.0	.03	.64
Q: Clerical Perception	114.5	.00	.41	119.1	.02	.58	116.1	.00	.35	118.6	-.03	.44	118.7	.05	.34	113.9	-.06	.36	115.8	-.05	.27
K: Motor Coordination	113.8	-.03	-.47	118.3	.00	-.40	117.5	-.01	-.33	118.3	-.01	-.50	114.7	.05	-.37	114.1	.00	-.48	113.8	-.01	-.47
F: Finger Dexterity	110.7	-.02	.53	109.6	-.03	.29	111.7	.00	.40	110.6	-.06	.40	106.3	.00	.61	105.8	.00	.56	103.5	-.03	.36
M: Manual Dexterity	119.9	.04	-.83	118.0	.06	-.79	113.6	.11	-.40	119.2	.14	-.55	116.6	.09	-.81	117.2	.07	-.65	113.2	.03	-.58

*Mean Score, Predicted Validity Coefficient, Use in Selection Score

The mean score for each GATB aptitude score is 100 and the standard deviation is 15. Hence, scores that exceed 115 indicate that individuals performing the job in question should have capabilities equivalent to approximately the upper one-third of the population. Of the 126 predicted aptitude mean scores, 82 are equal to or exceed one standard deviation above the mean (i.e., a score of 115 when predictions are rounded to the nearest whole number). Aptitudes G (intelligence) and V (verbal) had values exceeding one standard deviation for 13 of the 14 mission specialty functions. Furthermore, S (spatial) exceeded one standard deviation for 12 functions, Q (clerical perception) for 11 functions, and P (form perception) for 10 functions. Only F (finger dexterity) did not exceed one standard deviation for any function. The majority of specialty functions have five to eight predicted aptitude scores that exceed one standard deviation, indicating that individuals performing the functions require both depth and breadth in their abilities.

The predicted validity coefficients as reported in Table 3 range from 0 to .49. Typically, a validity coefficient exceeding .20 can be meaningful, and a coefficient above .30 is often considered substantial, depending of course on the sample size and reliability of the criterion used in the validation research. The pattern of the predicted validity coefficients across the 14 mission specialty functions is very consistent. Aptitudes G and N are predicted to be valid for every specialty function, and S is predicted to be valid for 12 of the 14 functions.

The third index, predicted use in selection, presented in Table 3 also is very restricted in terms of which aptitudes receive high indices.

Typically a value equal to or exceeding .80 is considered sufficient to indicate the likely use of a test in a selection battery. Numerical (N) aptitude was predicted to be used in a selection battery for 13 of the 14 functions; spatial (S) for nine; and form perception (P) for three functions.

When examining the predicted GATB information across all indices it is clear that the cognitive and perceptual aptitudes are identified as being more critical requirements than those of a psychomotor nature. Furthermore, it must be remembered that V and N are combined to form G. Therefore a test of G and/or tests of V and N would be highly indicative of mission specialty function performance. In the perceptual domain, spatial is likely to be related to performance more so than form perception; and clerical perception, while having 11 of 14 predicted mean scores one standard deviation above the mean, may be the least critical of the three perceptual aptitudes. Finally, it appears from these data that the psychomotor aptitudes will have the least impact on job performance, although eight of the mission specialty functions have predicted mean scores exceeding one standard deviation for both motor coordination and manual dexterity.

Predicted Results for Seventy-Six Attributes

A matrix of the predicted attribute requirements (expressed as percentile scores) by the various mission specialty functions is presented in Table 4. It is the experience of the Principal Investigator that a percentile score equal to or exceeding the 75th percentile is indicative of an attribute's particular importance as a job requirement. As is evident

by the data in Table 4, there are several attributes having percentile scores meeting or exceeding the 75th percentile for many if not all of the mission specialty functions. Several of these attributes are of an interest or temperament nature, and are listed below. (Note: The definitions of the attributes are presented in Appendix C.)

Important Interest/Temperament Attributes
Repetitive/Short-Cycle Operations
Dealing with Things/Objects
Processes/Machines/Techniques
Scientific/Technical Activities
Pressure of Time
Sensory Alertness
Attainment of Set Standards
Working Under Specific Instructions
Tangible/Physical-End Products
Sensory/Judgmental Criteria
Measurable/Verifiable Criteria

The above attribute requirements describe the types of situations to which an individual must adapt and several basic personality characteristics an individual should have to be satisfied and effective in a position. The attribute data provide clear indications that the individuals performing the various mission functions will work more with data/things than people; must complete their jobs under time constraints, closely following exact procedures and within well-defined tolerances; and must be alert and accurate realizing their efforts will be the subject of close scrutiny.

The data in Table 4 also indicate that many of the psychomotor attributes are important, although there is considerable variation as to the number of mission specialty functions for which each attribute is important. A list of the psychomotor attributes considered most relevant is given below in the order in which they appear in Table 4.

TABLE 4

PREDICTED ATTRIBUTE SCORES FOR MISSION SPECIALTY FUNCTIONS

Attribute	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Verbal Comprehension	20	26	24	69	27	28	43	17	20	17	27	21	21	26
Word Fluency	19	24	22	71	25	27	38	14	17	12	26	20	19	23
Oral Communication	14	18	16	64	16	21	27	10	12	10	22	15	13	--
Numerical Computation	53	54	54	56	60	52	60	51	54	52	49	52	54	56
Arithmetic Reasoning	59	66	68	77	81	68	80	64	59	47	56	69	70	75
Convergent Thinking	31	43	40	87	54	43	69	32	40	29	42	37	36	44
Divergent Thinking	30	38	36	80	53	42	67	30	41	34	38	34	33	41
Intelligence	40	50	46	80	56	54	68	45	45	32	51	47	44	51
Long-Term Memory	38	54	48	86	61	53	72	43	49	34	53	48	44	52
Short-Term Memory	35	50	45	77	54	48	61	42	39	26	52	48	44	49
Mechanical Ability	97	97	96	47	98	93	92	99	98	96	93	97	98	98
Ideational Fluency	23	31	29	77	32	37	48	18	22	17	37	29	26	30
Originality	27	32	31	77	35	43	50	23	26	25	37	33	30	32
Problem Sensitivity	39	51	50	81	61	55	62	46	41	28	54	50	46	53
Selective Attention	67	84	77	75	82	83	82	85	82	61	83	79	75	82
Time Sharing	39	59	56	87	67	62	73	52	52	33	64	57	49	59
Aesthetic Judgment	94	79	89	39	89	82	89	94	95	91	84	82	87	87
Visual Form Perception	98	98	98	33	99	98	96	99	99	99	98	98	99	99
Perceptual Speed	93	99	97	25	99	98	94	99	99	97	97	98	99	99
Closure	67	90	89	89	98	90	99	91	88	66	92	89	88	92
Movement Detection	81	91	86	27	82	85	74	92	89	79	86	90	90	85
Spatial Visualization	96	96	96	30	95	94	89	99	98	97	94	96	98	97
Near Visual Acuity	98	97	96	23	97	97	93	99	99	99	94	97	99	99
Far Visual Acuity	71	82	82	22	80	78	63	87	87	94	83	84	89	84
Depth Perception	81	81	83	24	81	80	72	91	92	87	81	83	91	88
Color Discrimination	81	79	88	36	91	80	92	91	96	96	84	77	91	93
Auditory Acuity	12	30	21	75	18	29	25	18	9	3	27	25	17	20
Olfactory Acuity	44	48	48	44	50	47	48	47	47	47	48	47	46	47
Gustatory Acuity	50	51	52	50	56	52	52	52	51	52	54	55	51	52
Tactual Acuity	87	81	77	20	62	83	46	92	79	87	80	87	86	78
Kinesthesis	80	71	64	12	41	71	26	79	64	71	71	75	73	61
Spatial Orientation	89	87	88	25	85	85	71	94	93	90	87	88	90	88
Body Orientation	64	59	54	11	25	55	18	63	52	62	58	60	60	45
Finger Dexterity	90	77	68	16	46	80	39	91	76	90	74	80	82	75
Manual Dexterity	85	78	64	11	42	73	29	87	68	80	73	78	80	69
Arm/Hand Positioning	84	77	63	12	33	70	21	85	61	78	72	76	78	64
Arm/Hand Steadiness	84	75	65	15	44	73	32	85	73	83	71	75	77	69
Continuous Muscular Control	73	67	57	10	35	64	25	75	60	72	62	66	67	56

Note: Functions A through N are identified in the Method Section of this report. (See Figure 1, page 16.)

TABLE 4 - Continued

PREDICTED ATTRIBUTE SCORES FOR MISSION SPECIALTY FUNCTIONS

Attribute	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Rate of Arm Movement	76	70	61	12	35	67	24	76	57	71	67	72	73	57
Stamina	66	49	45	16	26	59	21	50	41	62	48	52	55	44
Speed of Limb Movement	71	67	58	12	37	67	23	72	47	51	66	72	70	56
Eye-Hand Coordination	82	78	63	12	41	70	30	83	67	78	70	73	77	65
Eye-Hand-Foot Coordination	62	69	56	17	32	59	23	68	45	46	61	63	67	49
Simple Reaction Time	70	93	84	33	77	84	69	91	78	62	85	91	86	79
Response Integration	76	76	61	8	34	70	26	82	62	73	67	72	75	62
Dynamic Strength	69	61	55	10	33	61	22	66	49	59	59	64	66	53
Static Strength	71	61	58	16	38	64	28	68	50	61	59	64	67	57
Explosive Strength	69	65	59	16	44	65	31	67	48	59	64	65	68	57
Rate Control	81	90	85	32	77	85	68	93	86	81	89	90	91	85
Variety of Duties	32	39	37	82	47	40	56	27	38	32	41	34	33	41
Repetitive/Short-Cycle Operations	79	79	73	27	62	70	59	85	76	85	68	77	83	75
Dealing with Things/Objects	86	84	82	22	72	78	57	92	81	86	79	84	88	82
Processes/Machines/Techniques	98	98	96	33	95	95	89	99	96	97	95	98	99	98
Scientific/Technical Activities	90	96	93	92	98	94	98	94	87	69	89	93	94	95
Dealing with People	9	12	12	61	11	15	18	5	9	6	17	11	9	13
Social Welfare	14	21	18	77	22	26	37	10	18	14	24	17	15	18
Influencing People	10	11	12	61	9	14	15	5	7	8	17	10	9	12
Directing/Controlling/Planning	16	24	20	70	27	26	38	13	20	15	24	19	18	25
Empathy	11	17	16	61	14	19	24	8	11	8	21	13	11	16
Personal Risk	58	53	49	33	44	58	38	58	51	61	54	56	59	48
Conflicting/Ambiguous Information	29	45	45	83	56	44	66	35	41	27	50	42	36	47
Pressure of Time	94	99	97	34	94	96	90	99	98	93	98	99	99	98
Sensory Alertness	83	97	94	49	86	94	82	98	97	85	96	96	90	93
Attainment of Set Standards	98	98	98	55	99	98	99	99	99	99	98	99	99	99
Working Under Specific Instructions	88	92	77	20	64	82	61	95	74	87	77	85	93	86
Working Alone	34	35	38	48	40	36	52	35	40	43	35	32	36	37
Separation from Family/Home	50	55	52	92	18	59	83	44	65	78	57	46	44	50
Stage Presence	8	9	9	59	5	13	9	3	5	3	16	10	7	11
Prestige/Esteem from Others	28	35	30	76	37	39	47	24	29	23	36	30	28	34
Tangible/Physical End-Products	87	72	68	11	60	73	51	89	80	91	63	75	85	79
Sensory/Judgmental Criteria	64	82	84	73	94	78	91	85	84	65	85	83	78	86
Measurable/Verifiable Criteria	87	91	86	81	97	86	95	91	85	70	82	86	89	90
Interpretation from Personal Viewpoint	16	19	20	69	23	23	37	11	21	19	23	17	15	21
Susceptibility to Fatigue	64	62	54	18	35	62	35	65	69	75	56	57	54	55
Dealing with Concepts/Information	31	35	34	75	43	37	56	26	32	26	36	30	31	39
Creative Activities	44	47	48	79	56	54	76	44	55	51	51	45	46	56

Note: Functions A through N are identified in the Method Section of this report. (See Figure 1, page 16.)

Important Psychomotor Attributes
Finger Dexterity
Manual Dexterity
Arm/Hand Positioning
Arm/Hand Steadiness
Eye-Hand Coordination
Simple Reaction Time
Rate Control

While the above attributes can be important criteria for selection, some are not easily measured with portable computer assessment techniques (e.g., manual dexterity, arm/hand positioning). The primary focus of this research segment is on the attributes of a mental or perceptual nature. Fourteen of these types of attributes seem particularly important across the group of mission specialty functions and are listed below in an order that reflects descending importance in terms of the magnitude of their average percentile score across the 14 functions.

Important Mental/Perceptual Attributes - Most Mission Functions
Visual Form Perception
Perceptual Speed
Near Visual Acuity
Mechanical Ability
Spatial Visualization
Closure
Spatial Orientation
Aesthetic Judgment
Color Discrimination
Movement Detection
Depth Perception
Far Visual Acuity
Tactual Acuity
Selective Attention

In order to be included in the above list, the attribute percentile score had to equal or exceed the 75th percentile for more than seven of the mission functions. Consequently, there are some additional mental and perceptual attributes that are important, but only for a limited number of

the functions. These attributes are listed below in their order of appearance in Table 4.

Important Mental/Perceptual Attributes - Limited Mission Functions
Arithmetic Reasoning
Convergent Thinking
Divergent Thinking
Intelligence (G)
Long-Term Memory
Short-Term Memory
Kinesthesis

An alternative approach to inspecting the data in Table 4 is to examine the extent to which a particular mission function has a composite amount of those requirements specifically within either the mental or perceptual attribute domains. Such analyses were accomplished by calculating the mean percentile score for those attributes of a mental nature and rank ordering the mission functions in accord with the mean scores. These data are presented in Table 5. Certain functions have considerably greater amounts of mental attribute requirements than do other functions and the range of percentile score differences is approximately 40 percentile points. From these data it is concluded that communications with scientists, evaluation of data, and making scientific judgments have greater mental demands than functions associated with record keeping and operating/maintaining equipment related to scientific investigations.

Examination of the perceptual attributes in a similar fashion results in different rank ordering of the 14 mission functions. These results are reported in Table 6. With regard to perceptual requirements, the maintenance and operation of experiments and associated equipment are often the more demanding functions, while communications and decision making require less perceptual aptitudes.

TABLE 5

RANK ORDER OF MISSION SPECIALTY FUNCTIONS
BY MEAN PERCENTILE SCORE
ACROSS ALL MENTAL APTITUDES PREDICTED FROM PAQ DATA

Mission Specialty Function	Mean Percentile Score
D - Communicate Effectively with Principal Investigators	74.44
G - Evaluate and Interpret Experimental Data	62.00
E - Make Independent Scientific Inferences, Judgments, and Decisions	53.88
N - Fluid Experiment System	51.40
F - Make Required Changes in Experimental Protocol and Accommodate Unscheduled Adjustments	50.56
K - Participate in All Aspects of Life Science Investigations	49.00
B - Operate and Monitor Experiments and Check Performance of Specific Systems	48.56
C - Make and Record Detailed Measurements and Visual Observations	46.13
L - Adapt to Unforeseen, Anomalous Laboratory Situations	46.00
M - Fluid Experimental System and Vapor Crystal Growth System	43.88
I - Photograph Experimental Phenomena	43.56
H - Troubleshoot Instrumentation	41.94
A - Activate, Calibrate, Deactivate, and Stow Equipment	39.44
J - Change Photographic Film and Data Tapes	34.56

TABLE 6

RANK ORDER OF MISSION SPECIALTY FUNCTIONS
BY MEAN PERCENTILE SCORE
ACROSS ALL PERCEPTUAL APTITUDES PREDICTED FROM PAQ DATA

Mission Specialty Function	Mean Percentile Score
H - Troubleshoot Instrumentation	82.75
M - Fluid Experimental System and Vapor Crystal Growth System	80.88
I - Photograph Experimental Phenomena	80.31
L - Adapt to Unforeseen, Anomalous Laboratory Situations	79.49
N - Fluid Experiment System	79.31
B - Operate and Monitor Experiments and Check Performance of Specific Systems	78.75
K - Participate in All Aspects of Life Science Investigations	78.75
J - Change Photographic Film and Data Tapes	78.44
C - Make and Record Detailed Measurements and Visual Observations	78.38
F - Make Required Changes in Experimental Protocol and Accommodate Unscheduled Adjustments	78.06
E - Make Independent Scientific Inferences, Judgments, and Decisions	76.44
A - Activate, Calibrate, Deactivate, and Stow Equipment	76.38
G - Evaluate and Interpret Experimental Data	70.56
D - Communicate Effectively with Principal Investigators	35.87

The data represented in Tables 5 and 6 are quite consistent and otherwise correspond with expected outcomes with respect to the attribute requirements underlying job functions throughout the world of work and performed in virtually any environment.

Attributes Measured by Microcomputer Performance Tests

The 20 performance tests available via the microcomputer battery measure one or more of the attributes considered to be important job requirements according to the PAQ system. A list of the attributes measured by the test battery is presented in Table 7. The determination of the linkages are judgmental, and initially 69 percent of the ratings of the attributes measured by the performance test were consistent across the three psychologists. Subsequent discussions lead to 100 percent agreement. The emphasis of all three psychologists was to focus on the mental, perceptual, and psychomotor attributes linked to the PAQ, and to not give much consideration to the interest/temperament attributes. Also, no attempt was made to identify other attributes measured by the performance battery that are not within the realm of the PAQ system.

The data from Table 7 have been set forth in matrix form and are presented in Table 8. It is readily obvious that the performance test battery is measuring attributes such as short-term memory and perceptual speed with considerable frequency, while other attributes are only measured by one or two of the tests in the battery.

The final analysis compared the attributes measured by the performance test battery with the attributes predicted from the PAQ data to be important to

TABLE 7

ATTRIBUTES PREDICTED FROM PAQ DATA
THAT ARE MEASURED BY MICROCOMPUTER PERFORMANCE TESTS

Performance Test	Attributes Measured
Tapping	Finger Dexterity; Response Integration
Pattern Comparison	Visual Form Perception; Perceptual Speed; Spatial Visualization(?); Short-Term Memory (sequential stimulus presentation)
Alien Space Shoot	Eye-Hand Coordination; Simple Reaction Time; Response Integration; Rate Control
Reason	Verbal Comprehension; Intelligence (G); Short-Term Memory
Reaction Time	Simple Reaction Time; Perceptual Speed
Code Substitution	Perceptual Speed; Short-Term Memory
Alphanumeric Visual Vigilance	Selective Attention; Sensory Alertness; Perceptual Speed
Complex Counting	Numerical Computation; Sensory Alertness; Time Sharing; Short-Term Memory
Fitts Histogram	Visual Form Perception; Spatial Visualization; Perceptual Speed; Short-Term Memory
Flying Landolt C	Near Visual Acuity; Perceptual Speed
Mathematical Processing	Numerical Computation; Arithmetic Reasoning
Continuous Recall	Short-Term Memory
Item Recognition	Short-Term Memory
Matrix Rotation	Spatial Visualization; Short-Term Memory; Visual Form Perception
Manikin	Spatial Visualization; Visual Form Perception
Item Order	Short-Term Memory; Perceptual Speed
Visual Scanning	Perceptual Speed
Associative Memory	Short-Term Memory
Tower of Hanoi	Convergent Thinking; Intelligence (G); Ideational Fluency
Short-Term Memory	Short-Term Memory; Perceptual Speed

TABLE 8

ATTRIBUTE BY MICROCOMPUTER PERFORMANCE TEST MATRIX

Attributes / Performance Test Battery Components	Tapping	Pattern Comparison	Alien Space Shoot	Reason	Reaction Time	Code Substitution	Alphanumeric Visual Vigilance	Complex Counting	Fitts Histogram	Flying Landbolt C	Mathematical Processing	Continuous Recall	Item Recognition	Matrix Rotation	Manikin	Item Order	Visual Scanning	Associative Memory	Tower of Hanoi	Short-Term Memory
Intelligence (G)				x															x	
Verbal Comprehension				x																
Numerical Computation								x			x									
Arithmetic Reasoning											x									
Convergent Thinking																			x	
Short-Term Memory		x		x		x		x	x			x	x	x		x		x		x
Ideational Fluency																			x	
Selective Attention							x													
Time Sharing								x												
Visual Form Perception		x							x					x	x					
Perceptual Speed		x			x	x	x		x	x						x	x			x
Spatial Visualization		x							x					x	x					
Near Visual Acuity										x										
Eye-Hand Coordination			x																	
Simple Reaction Time			x		x															
Response Integration	x		x																	
Rate Control			x																	
Sensory Alertness							x	x												
Finger Dexterity	x																			

mission function performance. This comparison is presented in Table 9. There is considerable overlap in the attributes measured by the performance battery and those attributes predicted to be important requirements for the performance of mission specialty functions. Only three of the 19 attributes that are measured by the test battery are not predicted to be important mission function requirements. However, there are 24 attributes predicted to be important job requirements on the basis of the PAQ analyses that are not measured by the performance test battery. Nine of these 24 attributes are of an interest/temperament nature; three are psychomotor skills; and nine are perceptual abilities. Thus, only three cognitive abilities, namely long-term memory, divergent thinking, and mechanical ability are important job requirements not measured by the performance test battery.

The above results lead to the following conclusions:

- There are 10 cognitive attributes identified by the PAQ analyses that are required for successful performance of the various mission functions; the performance test battery measures 7 (70 percent) of these mental abilities.
- There are 7 psychomotor attributes identified by the PAQ analyses that are required for successful performance of the various mission functions; the performance test battery measures 4 (57 percent) of these psychomotor abilities.
- There are 13 perceptual attributes identified by the PAQ analyses that are required for successful performance of the various mission functions; the performance test battery measures 4 (31 percent) of these perceptual skills.

TABLE 9

COMPARISON OF ATTRIBUTES MEASURED BY MICROCOMPUTER TEST BATTERY WITH PREDICTED ATTRIBUTES FROM PAQ DATA FOR SPECIALTY FUNCTIONS

Attributes Measured by Microcomputer Performance Tests	Attributes Predicted from PAQ Data to be Important to Function Performance
Verbal Comprehension	Verbal Comprehension
Numerical Computation	Numerical Computation
Arithmetic Reasoning	Arithmetic Reasoning
Convergent Thinking	Convergent Thinking
Intelligence (G)	Intelligence (G)
Short-Term Memory	Short-Term Memory
Ideational Fluency	--
Selective Attention	Selective Attention
Time Sharing	--
Visual Form Perception	Visual Form Perception
Perceptual Speed	Perceptual Speed
Spatial Visualization	Spatial Visualization
Near Visual Acuity	Near Visual Acuity
Eye-Hand Coordination	Eye-Hand Coordination
Simple Reaction Time	Simple Reaction Time
Response Integration	--
Rate Control	Rate Control
Sensory Alertness	Sensory Alertness
Finger Dexterity	Finger Dexterity
	Dealing with Things/Objects
	Processes/Machines/Techniques
	Scientific/Technical Activities
	Pressure of Time
	Attainment of Set Standards
	Working Under Specific Instructions
	Tangible/Physical-End Products
	Sensory/Judgmental Criteria
	Measurable/Verifiable Criteria
	Manual Dexterity
	Arm/Hand Positioning
	Arm/Hand Steadiness
	Closure
	Spatial Orientation
	Aesthetic Judgment
	Color Discrimination
	Movement Detection
	Depth Perception
	Far Visual Acuity
	Tactual Acuity
	Kinesthesis
	Long-Term Memory
	Divergent Thinking
	Mechanical Ability

The PAQ analyses also indicated that there are 10 interest and temperament attributes identified by the PAQ analyses that are required for successful performance of the various mission functions. While the performance battery was not designed to measure interest and temperament attributes, at least two of the subtests in the battery measures one of the temperaments.

If the interest and temperament attributes are excluded from consideration, the current performance test battery is measuring 50 percent of the aptitudes and abilities required to perform the various space shuttle functions as analyzed by the PAQ.

Summary of Results

The previous results are highly consistent across the various indices that can be derived from the PAQ analyses of the 14 mission specialty functions. The functions themselves require high levels of certain mental abilities, perceptual aptitudes, and psychomotor skills. The most important requirements considering all the analyses are the following:

Cognitive

Intelligence (G)
Verbal Comprehension
Numerical Computation
Arithmetic Reasoning
Convergent Thinking
Short-Term Memory

Perceptual

Spatial Visualization
Visual Form Perception
Perceptual Speed

Psychomotor

Eye-Hand Coordination
Simple Reaction Time

All of the above attributes are measured by one or more of the subtests in Automated Performance Test System (APTS). While other attributes from the cognitive, perceptual, and psychomotor domains are potentially important, the above listed skills and abilities are considered to be the most critical requirements. Further, while interest and temperament characteristics are also important, they were not the primary focus of this research project and were not influential in the development of the APTS.

DISCUSSION

The primary goals of this research have been to identify the requirements of space mission specialty functions and to determine if these requirements were measured by a microcomputer-based performance test battery (the APTS). Such results would be particularly useful in the assessment of changes in performance that might occur because of the influences of the Space Adaptation Syndrome on mission personnel and astronauts during actual space operations.

The goals have been met and the results are both consistent and reasonable. There are six key cognitive abilities that are required of individuals performing any of the 14 mission specialty functions analyzed as part of this research project. Individuals would be expected to have ability levels one standard deviation or higher above population means (averages), and the microcomputer test battery should clearly be able to detect differences in human performance during mission operations. The six cognitive abilities are:

Intelligence (G)
Verbal Comprehension
Numerical Computation
Arithmetic Reasoning
Convergent Thinking
Short-Term Memory

Three perceptual aptitudes are the most essential requirements across mission specialty functions:

Spatial Visualization
Visual Form Perception
Perceptual Speed

The microcomputer test battery has several component tests that measure these three aptitudes.

Finally, two psychomotor abilities were found to be especially important job requirements:

Eye-Hand Coordination
Simple Reaction Time

These two skills are important to most but not all of the mission specialty functions. (It is noted that no psychomotor skill was a key requirement for all 14 of the mission functions.) While eye-hand coordination could be considered to underlie each of the components of the microcomputer test battery because of the interaction between the individual and the computer screen/keyboard, only one test was judged to specifically measure this ability. Similarly, simple reaction time is potentially measured by most of the components of the test battery because of the emphasis on speed of response in test taking performance, but only two tests were considered to be directly measuring this ability.

To summarize, the mission specialty functions were found to have a number of important job requirements that are measured by the microcomputer test battery. In particular, the test battery measures short-term memory, perceptual speed, visual form perception, and spatial visualization with a number of component tests. On the other hand, several important abilities are only measured by one or two components. Thus, careful consideration should be given to which specific tests should be included in a battery that would be most suitable for evaluating performance during shuttle mission operations. The psychometric qualities of each test would be the

primary basis for determining which tests among those measuring the same attribute should be retained in a final battery.

In addition to identifying several important job requirements that are currently measured by the portable microcomputer test battery, there are also several measurement opportunities presently not included in the battery. For example, the battery could be expanded in the cognitive domain to include measures of mechanical ability, divergent thinking, and perhaps long-term memory; among perceptual ability tests, measures of closure, color discrimination, depth perception, and movement detection would be potentially valuable additions. Finally, it is noted that a number of motivation, interest, and temperament measures could be adapted or developed for microcomputer presentation (cf., e.g., McCombs, Doll, Baltzley and Kennedy, 1986). Several of these self-system and trait characteristics have been identified as important in this research including: a preference for working on a repetitive basis with data/things (versus people); being able to work under the demands of time pressures, exact standards/instructions/procedures, and within well-defined tolerances; and accepting close scrutiny of one's work efforts.

It is recognized that this research has focused on one methodology - the PAQ - for developing job analysis and job requirements data. Thus, apart from continuing research on revisions and additions to measures that might be included in the microcomputer test battery, it is also relevant to consider alternative approaches to analyzing the domain of space shuttle mission work and developing job requirements, since these are the data that should determine the contents of the computerized test battery. The

primary job analysis alternative to the PAQ is that of task analysis. Furthermore, once task analysis data is obtained and evaluated (e.g., rated in terms of time spent, importance, learning difficulty, criticality, etc.), it can serve as the basis for judgementally derived job requirements. Further, it is possible to link task analysis and PAQ data in a confirmatory research model. Such a research study would lend even greater support to developing a final set of critical requirements underlying shuttle mission job performance that could be measured by a portable microcomputer test battery.

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APPENDIX A

FUNCTIONS AND REQUIREMENTS

ANALYZED BY THE PAQ

FUNCTIONS AND REQUIREMENTS ANALYZED BY THE PAQ

- Information Input (including visual, verbal, and other data sources)
- Estimation Activities (time, size, etc.)
- Decision Making, Reasoning, Planning
- Information Processing (analyzing, compiling, coding, etc.)
- Use of Learned Information (educational development, experience, training, use of mathematics, etc.)
- Use of Tools, Instruments, Equipment
- Manual Activities (calibrating, controlling, assembling, etc.)
- Physical Exertion (sitting, standing, etc.)
- Physical Coordination (finger manipulation, hand steadiness, etc.)
- Communications (advising, negotiating, interviewing, etc.)
- Job-required Personal Contact
- Supervision and Coordination (includes staff functions)
- Physical Working Conditions and Hazards
- Personal and Social Aspects (frustrations, conflicts, etc.)
- Work Schedules
- Job Demands (procedures, details, routines, vigilance, time pressures, etc.)
- Responsibilities (safety, assets, job structure, etc.)

Consideration is given to the extent to which the above behaviors and requirements comprise a job and are important to the completion of a job.

APPENDIX B

PAQ JOB DIMENSIONS

DEFINITIONS OF PAQ JOB DIMENSIONS

1. Interpreting what is sensed

   This dimension deals with situations in which the worker typically interprets the information that is received by the various sensory mechanisms, such as hearing, vision, touch, etc.

2. Using various sources of information

   This dimension represents circumstances in which individuals use, or depend upon, sources of information in their work such as written materials, quantitative materials, verbal information from other people, etc.

3. Watching devices/materials for information

   The emphasis in this dimension is on observing, or being alert to, devices, materials, processes, and other features of, or events in, the environment as part of the individual's work activities.

4. Evaluating/judging what is sensed

   The emphasis of this dimension is in terms of judging, estimating, or otherwise making evaluative judgments about the information input to the individual, most typically visual input, including the evaluation of the individual's own work and/or that of others. Such evaluation can cover a variety of "inputs," including materials, processes, events, human behavior, etc.

5. Being aware of environmental conditions

   The dominant aspect of this dimension is that of continually being aware of various aspects of the individual's work environment, especially various types of events or circumstances. Such awareness might relate to the man-made features of the environment or the natural environment.

6. Using various senses

   This dimension is characterized primarily by the need to use one or a combination of the senses as sources of job-related information. In particular it emphasizes the need for sensory acuity and perception on the part of the individual.

7. Making decisions

This dimension is characterized by the extent to which various mental processes are required in the performance of the job, typically reflected by some type of decision making, or problem solving, or the application of experience or training.

8. Processing information

This dimension is characterized by job activities involving any of various forms of "processing" or "using" information, perhaps most typically applying relatively standardized procedures or guidelines, although some aspects of decision making usually are also involved. The processing of information, as represented by this dimension, would be involved in many different types of jobs, including typical office activities.

9. Using machines/tools/equipment

This dimension is dominated by activities involving the use of any of various types of machines, tools, equipment, devices, etc., many of which require the use of control mechanisms.

10. Performing activities requiring general body movements

This dimension relates to the degree to which workers perform activities requiring general body movements. The movements primarily include those activities in which the entire body is involved, such as climbing, balancing, standing, and walking, but also, to a lesser degree, those activities emphasizing the use of major parts of the body (i.e., arms, legs, etc.).

11. Controlling machines/processes

This dimension primarily involves activities relating to the control of machines, processes, and related operations. The control frequently is executed by the use of various control mechanisms, or by direct physical control of some mechanism or device.

12. Performing skilled/technical activities

This dimension is characterized primarily by job activities of a skilled or technical nature, some of which may involve the use of control mechanisms, devices, and related equipment.

13. Performing controlled manual/related activities

This dimension is dominated by the execution of controlled manual activities of various types. The activities may involve the use of tools, equipment, or other devices or direct use of the hands as in assembling or adjusting tasks.

14. Using miscellaneous equipment/devices

This dimension embraces the use of any of a variety of different types of equipment, devices, and facilities, including those involved in the operation of various types of vehicles. The activities embraced by this dimension frequently involve general body activities and manual functions.

15. Performing handling/related manual activities

This dimension is characterized primarily by job activities which involve the handling or movement of materials with the hands and arms, or which involve the manipulation of things with the hands. It includes handling, positioning, and moving functions in which the hands and arms are dominant.

16. General physical coordination

The primary activities involved in this dimension are those in which the body and body members are used in some coordinated fashion. This may involve the use of various types of mechanical devices or the execution of coordination activities in the absence of physical equipment or machines or tools.

17. Communicating judgments/related information

This dimension is related to various types of communicating activities including particularly the communication of judgments, opinions, decisions and information of a nonroutine nature, etc. The communications activities include writing, advising, negotiating and persuading, and the interpersonal relationships involved in generally responsible, often higher level job functions.

18. Engaging in general personal contacts

This dimension is characterized by various types of personal communications, the nature of the communications being quite

varied in terms of content. Hence, the dimension represents something of a general communication type of activity.

19. Performing supervisory/coordination/related activities

This dimension represents a variety of communication activities such as those involved in supervisory, coordination, and related functions. In some instances it may involve the instruction or advising of others.

20. Exchanging job-related information

This dimension involves activities or contacts with personnel, both within and outside the organization, in which the exchange of job-related information tends to be dominant.

21. Public/related personal contacts

This dimension involves personal contacts with the public or other persons typically outside the organization, such as in selling, dealing with special interest groups, clients, customers, patients, counselees, etc. Although this dimension is concerned primarily with personal contacts with individuals outside the organization, it also may involve communications with some individuals within the organization.

22. Being in a stressful/unpleasant environment

This dimension is characterized by circumstances in which the individual is subjected to potentially stressful or unpleasant situations, some of which may involve hazardous or otherwise undesirable conditions.

23. Engaging in personally demanding situations

This dimension is dominated by circumstances in which demands are made upon an individual of an emotional nature or which may involve some subordination of personal desires to organizational or client needs, and in some instances may involve personal conflict, emotional frustrations, or personal sacrifice.

24. Being in hazardous job situations

This dimension is characterized by conditions which are potentially hazardous to the individuals; involved is the

possibility of disability or death. The conditions may be indoors or outdoors.

25. Working nontypical versus day schedule

This dimension tends to be "bi-polar" in nature. One end of the dimension is characterized by work situations involving conventional day work schedules with regular hours, as contrasted with the other end of the dimension which is characterized by work schedules of an irregular nature or a variable shift nature, or that involve non-typical schedules.

26. Working in businesslike situations

This dimension is characterized by job circumstances that may be thought of as being "businesslike" environments, such as offices, stores, and so forth. Individuals in such situations usually are on a salary basis as contrasted with being on an hourly wage basis.

27. Wearing specified versus optional apparel

This dimension is characterized by jobs or work situations in which some type of apparel is either specified or "expected" as a matter of custom on the part of the employer and/or employees, as contrasted to jobs in work situations in which individuals usually may wear virtually any kind of apparel.

28. Being paid on a salary versus variable basis

This dimension tends to be characterized by differences in the basis of compensation, on the one hand being paid on a straight salary basis as contrasted with such compensation bases as commissions, tips, incentive pay, supplementary compensation, and hourly wages. It must be recognized that this is not a clear-cut distinction, since the same type of job under various circumstances can be paid on different bases, and some jobs have a compensation system that provides for both variable and salary remuneration.

29. Working on an irregular versus regular schedule

This dimension tends to differentiate between and among jobs and job situations in which there is a tendency for some "irregularity" in the work load, such as seasonal fluctuations, variations in hours worked because of production

quotas, work demands, etc., as contrasted with those job situations which by their nature tend to be regular in terms of employment and work load.

30. Working under job-demanding circumstances

This dimension is characterized by circumstances in which there is typically some "demand" on the individual created by the job, such as the need to update job knowledge, the need to give attention to detail, the need for precision, the need to work under distractions or under time pressures, etc.

31. Performing unstructured versus structured work

This dimension reflects the degree to which the job activities are predetermined for the worker rather than being at the discretion of the person performing the job. High scores on this dimension indicate considerable structure in which the incumbents have relatively little discretion in performing their work, while low scores reflect relatively low job structure with the incumbents having considerable latitude in performing their jobs.

32. Being alert to changing conditions

This dimension is characterized primarily by circumstances that require continual attention or alertness, primarily because of potentially changing job conditions through time, such as being continually responsible for the safety of others, having various other types of continuing responsibilities, carrying out vigilant activities, etc.

33. Having decision, communicating, and general responsibilities

This dimension is the most inclusive of all the dimensions, having significant correlations with many of the job elements in the PAQ. The dimension reflects activities involving considerable amounts of responsibility for decision making, communicating, and general responsibility.

34. Operating machines/equipment

This dimension characterizes activities in which individuals are responsible for the operation of machines, equipment, tools, and other types of mechanical and related devices.

35. Performing clerical/related activities

The dominant feature of this dimension is involvement in the performance of typical clerical, office, and related types of activities.

36. Performing technical/related activities

This dimension covers a variety of activities that, in general, can be characterized as involvement in the use of various types of technical and related devices, or performing technical types of work without such devices.

37. Performing service/related activities

The common theme of the job activities covered by this dimension is that associated with performing some type of service generally for others, although such services typically also are accompanied by various types of sensory and manual activities.

38. Other work schedules versus working regular day schedules

The primary distinction represented by this dimension is that of working nontypical day schedules (such as shift work) and irregular kinds of work schedules as opposed to a typical day schedule.

39. Performing routine/repetitive activities

This dimension is characterized by the performance of routine, repetitive work activities, in some instances at predetermined work paces.

40. Being aware of work environment

This dimension typically involves continual awareness of, or sensitiveness to, the environment within which the individual is involved, such awareness being based on the use of various senses, such as vision, hearing, etc. In addition, the dimension typically involves making some kind of response to changing environmental conditions, such as the use of various kinds of control mechanisms, the operation of vehicles, etc.

41. Engaging in physical activities

The dominant feature of this dimension is involvement in general body or physical activities such as walking,

stooping, standing, handling, etc. Implicit in such involvement in some instances is the possibility of physical hazards and associated physical impairment.

42. Supervising/directing/estimating

This dimension involves several often related coordinating, directing, and estimating functions, frequently but not always associated with supervisory or management positions. This dimension has, for example, a somewhat different and more diffuse nature than dimension 19, which deals more specifically with the supervision and direction of others.

43. Public/customer/related contacts

This dimension is characterized dominantly by the need for personal contacts with the public, customers, or other individuals such as clients, patients, etc.

44. Working in an unpleasant/hazardous/demanding environment

This dimension is characterized by a spectrum of job environments that usually would be considered as unpleasant, potentially hazardous, or personally demanding.

45. Nontypical work schedule/optional apparel

This dimension is not as clearly delineated as some of the others in that it is dominated by an admixture of job elements dealing with nontypical work schedules (such as irregular work and night schedules) and dealing with apparel (optimal and informal apparel). The "opposite" end of the dimension is characterized by more regular work schedules. Aside from being a rather unclear dimension, it also is very unimportant since it accounts for only 1% of the total variance.

APPENDIX C

HUMAN ATTRIBUTES

Mental Aptitudes

Verbal comprehension: ability to understand the meaning of words and the ideas associated with them.

Word fluency: ability to rapidly produce words associated with a given word.

Oral communication: ability to communicate ideas with gestures or with spoken or written words.

Numerical computation: ability to manipulate quantative symbols rapidly and accurately, as in various arithmetic operations.

Arithmetic reasoning: ability to reason abstractly using quantitative concepts and symbols.

Convergent thinking: ability to select from possible alternative methods, the method of processing information that leads to the potentially best answer or solution to a problem.

Divergent thinking: ability to generate or conceive of new or innovative ideas of solutions to a problem.

Intelligence: the level of abstraction or symbolic complexity with which one can ultimately deal.

Long-term memory: ability to learn and store pertinent information and selectively to retrieve or recall, much later in time, that which is relevant to a specific context.

Short-term memory: ability to learn and store pertinent information and selectively to retrieve or recall, within a brief period of time, that which is relevant to a specific context.

Mechanical ability: ability to determine the functional interrelationships of parts within a mechanical system.

Ideational fluency: the ability to produce a number of ideas concerning a given topic. This attribute is only concerned with the number of ideas produced and does not extend to the quality of those ideas.

Originality: the ability to produce unusual or clever responses related to a given topic or situation. This attribute is concerned with the degree of creativity of responses and does not deal with the number of responses made.

Problem sensitivity: the ability to recognize and identify the existence of problems. This attribute does not include any of the reasoning necessary for the solution of a problem.

Selective attention: the ability to perform a task in the presence of distracting stimulation or under monotonous conditions without significant loss in efficiency.

Time sharing: the ability to utilize information obtained by shifting between two or more channels of information. The information obtained from these sources is either integrated and used as a whole or retained and used separately.

Perceptual Aptitudes

Aesthetic judgement: ability to make sensitive evaluations of artistic quality in one or more of the following: music, style, painting, sculpture, photography, architecture, etc.

Visual form perception: ability to perceive pertinent detail or configuration in a complex visual stimulus.

Perceptual speed: ability to make rapid discriminations of visual detail.

Closure: ability to perceptually organize a chaotic or disorganized field into a single perception.

Movement detection: ability to detect physical movement of objects and to judge their direction.

Spatial visualization: ability to manipulate visual images in two or three dimensions mentally.

Near visual acuity: ability to perceive detail at normal reading distance.

Far visual acuity: ability to perceive detail at distances beyond normal reading distance.

Depth perception: ability to estimate depth of distances or objects (or to judge their physical relationships in space).

Color discrimination: ability to perceive similarities or differences in colors or in shades of the same color, or to identify certain colors.

Auditory acuity: ability to perceive relevant cues by sound.

Olfactory acuity: ability to perceive relevant cues by smell.

Gustatory acuity: ability to perceive relevant cues by taste.

Tactual acuity: ability to perceive relevant cues by touch.

Kinesthesis: ability to sense position and movement of body members.

Spatial orientation: the ability to maintain one's orientation with respect to objects in space or to comprehend the position of objects in space with respect to the observer's position.

Physical and Psychomotor Aptitudes

Body orientation: ability to maintain body orientation with respect to balance and motion.

Finger dexterity: ability to manipulate small objects (with the fingers) rapidly and accurately.

Manual dexterity: ability to manipulate things with the hands.

Arm/hand positioning: ability to make precise, accurate movements of the hands and arms.

Arm/hand steadiness: ability to keep the hands and arms immobilized in a set position with minimal tremor.

Continuous muscular control: ability to exert continuous control over external devices through continual use of body limbs.

Rate of arm movement: ability to make gross, rapid arm movements.

Stamina: this ability involves the capacity to maintain physical activity over prolonged periods of time. It is concerned with the resistance of the cardio-vascular system to breakdown.

Speed of limb movement: this ability involves the speed with which discrete movements of the arms or legs can be made. The ability deals with the speed with which the movement can be carried out after it has been initiated; it is not concerned with the speed of initiation of the movement.

Eye-hand coordination: ability to move the hand and foot coordinately with each other in accordance with visual stimuli.

Simple reaction time: the period of time elapsing between the appearance of any stimulus and the initiation of an appropriate response.

Response integration: ability to rapidly perform various appropriate psychomotor responses in proper sequence.

Dynamic strength: ability to make repeated, rapid, flexing movements in which the rapid recovery from muscle strain is critical.

Static strength: ability to maintain a high level of muscular exertion for some minimum period of time.

Explosive strength: ability to expend a maximum amount of energy in one or a series of explosive or ballistic acts (as in throwing, pounding, etc.).

Rate control: ability to make continuous anticipatory motor adjustments, relative to change in speed and direction of continuous moving objects.

Interest and Temperment Attributes

Variety of duties: duties often characterized by frequent change.

Repetitive/short-cycle operations: operations carried out according to set procedures or sequences.

Dealing with things/objects: preference for situations involving activities which deal with things and objects rather than activities concerned with people or the communication of ideas.

Processes/machines/techniques: situations which are nonsocial in nature, being primarily concerned with methods and procedures often of a mechanical or chemical nature.

Scientific/technical activities: using technical methods or investigating natural phenomenon using scientific procedures.

Dealing with people: i.e., personal contacts beyond giving and receiving instructions.

Social welfare: working with people for their presumed good.

Influencing people: influencing opinions, attitudes, or judgments about ideas or things.

Directing/controlling/planning: operations involving the activities of others, or processes with which others are involved.

Empathy: seeing things from another person's point of view.

Personal risk: risk of physical or mental illness or injury.

Conflicting/ambiquous information: ability to tolerate and critically evaluate information of an uncertain or opposing nature.

Pressure of time: working in situations where time is a critical factor for successful job performance.

Sensory alertness: alertness over extended periods of time.

Attainment of set standards: attainment of set limits, tolerances, or standards.

Working under specific instructions: i.e., those that allow little or no room for independent action or judgment in working out job problems.

Working alone: working in physical isolation from others, although the activity may be integrated with that of others.

Separation from family/home: separation for extended periods of time.

Stage presence: speaking to or performing for an audience.

Prestige/esteem from others: working in situations resulting in high regard from others.

Tangible/physical end-products: working with material elements or parts which ultimately result in a physical product.

Sensory/judgmental criteria: arriving at generalizations, judgments, or decisions which require sensory discrimination or cognitive appraisal.

Measurable/verifiable criteria: arriving at generalizations, judgments, or decisions based on known or obtainable standards, characteristics, or dimensions.

Interpretation from personal viewpoint: interpretation of feelings, ideas, or facts in terms of personal viewpoint or values.

Susceptibility to fatigue: diminished ability to do work, either physical or mental, as a consequence of previous and recent work done.

Dealing with concepts/information: preference for situations that involve conceptual or informative ideas and the possible communication of these ideas to others.

Creative activities: preference for situations involving the finding of new solutions to a problem or new modes of artistic expression.

APPENDIX D

RESOURCE MATERIALS USED TO DEFINE AND DESCRIBE SHUTTLE MISSION JOB FUNCTIONS

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Connors, M.M., Harrison, A.A. & Akins, F.R. (1985). Living Aloft. Human Requirements for Extended Space Flight. NASA, Washington, D.C.

1.0 SPACE STATION OPERATIONS

1.1 Buildup/Development (Preparing for Initial Operations)

1.1.1 Deploy structures and appendages

- 1.1.1.1 Predeployment checkout
- 1.1.1.2 Install radiator panels
- 1.1.1.3 Remove payload package, etc.
- 1.1.1.4 Deployable structure
- 1.1.1.5 Solar array blankets
- 1.1.1.6 Berthing structure
- 1.1.1.7 MRMS
- 1.1.1.8 Install ATV/manipulator

1.1.2 Assemble large space structures

- 1.1.2.1 Remove and deploy lower keel
- 1.1.2.2 Radiator arms and panels
- 1.1.2.3 Remove and deploy port keel
- 1.1.2.4 Remove and deploy standard keel
- 1.1.2.5 MRMS

1.1.3 Launch/attach Hab 1 and airlocks

- 1.1.3.1 Remove and install Hab 1
- 1.1.3.2 Remove and attach Airlock 2
- 1.1.3.3 Remove and attach Airlock 1
- 1.1.3.4 MRMS

1.1.4 Launch/attach Hab 2

- 1.1.4.1 Remove and install Hab 2
- 1.1.4.2 Attach to Airlock 2 and Hab 2
- 1.1.4.3 Keel/upper boom structure
- 1.1.4.4 MRMS

1.1.5 Launch/attach Log 1

- 1.1.5.1 Remove and attach
- 1.1.5.2 Solar array blankets

1.1.5.3 MRMS

1.1.6 Launch/attach Lab 2
- 1.1.6.1 Remove, install, and attach
- 1.1.6.2 Side panel utilities
- 1.1.6.3 MRMS

1.1.7 Launch/attach Lab 1
- 1.1.7.1 Remove
- 1.1.7.2 Install
- 1.1.7.3 Attach to Hab 1 and Airlock 2

1.1.8 Perform verification/validation of subsystems onboard
- 1.1.8.1 Predeployment checkout
- 1.1.8.2 Pressurize and enter module
- 1.1.8.3 Perform subsystem activation
- 1.1.8.4 Inspect all latches
- 1.1.8.5 Unstow and remove equipment and supplies
- 1.1.8.6 Construct and attach utilities, communication and tracking equipment
- 1.1.8.7 Construct, assemble, and deploy antenna
- 1.1.8.8 Verify operations and perform functional checkout
- 1.1.8.9 Obtain flight data file operations procedures

1.2 On-Orbit Nominal Operations

1.2.1 General
- 1.2.1.1 Obtain power status for system hardware elements
- 1.2.1.2 Obtain system elements' configuration
- 1.2.1.3 Obtain system elements' operating modes/submodes
- 1.2.1.4 Respond to system fault alerts and identification messages
- 1.2.1.5 Perform checkout and troubleshooting procedures
- 1.2.1.6 Perform hardware element replacement and repair procedures
- 1.2.1.7 Input data display commands

1.2.1.8 Obtain software program listings

1.2.1.9 Select display modes, reference frames, scale factors

1.2.1.10 Select manual control's modes, functions and authorities

1.2.1.11 Interact with AI/ES program requests, information, and responses

1.2.1.12 Interact with training program stimuli, responses, and coaching messages

1.2.1.13 Obtain and process external views (direct vision, CCTV, etc.)

1.2.1.14 Perform equipment calibration and recalibration

1.2.1.15 Perform equipment testing

1.2.1.16 Perform equipment reconfiguration

1.2.1.17 Select desired power states for system hardware elements

1.2.1.18 Position Space Station elements

1.2.1.19 Detect and isolate system faults and restore system operations

1.2.1.20 Modify and update system software

1.2.2 Guidance, Navigation, and Control (GN&C)

1.2.2.1 Guidance

1.2.2.1.1 Select guidance subsystem modes and submodes of operation

1.2.2.1.2 Input guidance commands and data

1.2.2.1.3 Initiate and terminate guidance functions

1.2.2.1.3.1 Reboost/reentry targetting

1.2.2.1.3.2 Maneuver coordination

1.2.2.1.3.3 Collision check

1.2.2.1.3.4 Reboost maneuver

1.2.2.1.3.5 Tether control

1.2.2.1.3.6 Determine point mount control

1.2.2.1.3.7 Device management

1.2.2.1.4 Monitor guidance functions

1.2.2.1.5 Process guidance output data

1.2.2.2 Navigation

1.2.2.2.1 Select navigation subsystem modes and submodes of operation

1.2.2.2.2 Input navigation commands and data

1.2.2.2.3 Interact with star catalog

1.2.2.2.3.1 Constellation state/orbit determination

1.2.2.2.3.2 Determine ephemerides (Sun, Moon, etc.)

1.2.2.2.4 Monitor navigation subsystem operations

1.2.2.2.4.1 Monitor sensor/coupler operations and output data

1.2.2.2.4.1 Monitor orbit parameters/state vector computation and maintanance

1.2.2.2.5 Select, route, and monitor navigation data to other user subsystems, payloads, experiments, and other Space Station program elements

1.2.2.3 Attitude control and stabilization (ACS)

1.2.2.3.1 Select ACS modes and submodes of operation

1.2.2.3.2 Select ACS actuators to be used

1.2.2.3.3 Input ACS commands and data

1.2.2.3.3.1 Select attitude deadbands

1.2.2.3.3.2 Select rate deadbands

1.2.2.3.3.3 Select maneuver deadbands

1.2.2.3.4 Initiate/enable ACS functions

1.2.2.3.4.1 Attitude and translation

1.2.2.3.4.2 Effector

1.2.2.3.4.3 Momentum management

1.2.2.3.4.4 Pointing mount control

1.2.2.3.5 Monitor automatic ACS functions
- 1.2.2.3.5.1 Attitude angles
- 1.2.2.3.5.2 Attitude errors
- 1.2.2.3.5.3 Angular rates
- 1.2.2.3.5.4 Translation rates

1.2.2.3.6 Control manual ACS functions

1.2.2.3.7 Select attitude reference frames

1.2.2.3.8 Terminate ACS functions

1.2.2.3.9 Monitor pointing control data and commands routed to solar panels, radiators, and payloads pointing systems

1.2.2.3.10 Monitor tether control during tether operations
- 1.2.2.3.10.1 Determine tethered objects' location
- 1.2.2.3.10.2 Determine tethered objects' relative motion states

1.2.2.3.11 Monitor status of ACS actuators
- 1.2.2.3.11.1 RCS propellant quantities, temperatures and pressures
- 1.2.2.3.11.2 RCS thrusters and propellant source
- 1.2.2.3.11.3 Control moment gyros' stored momentums
- 1.2.2.3.11.4 Space Station's mass properties

1.2.2.3.12 Monitor status and usage rate of ACS consumables

1.2.2.4 Orbit maintenance and adjustment
- 1.2.2.4.1 Monitor orbit parameters/state vector
- 1.2.2.4.2 Obtain orbit adjust maneuver data
  - 1.2.2.4.2.1 Required burn attitude
  - 1.2.2.4.2.2 Required thrust level
  - 1.2.2.4.2.3 Actuator selection

1.2.2.4.2.4 Required burn start time
1.2.2.4.2.5 Required burn duration
1.2.2.4.2.6 Time to ignition
1.2.2.4.2.7 Delta-V to go
1.2.2.4.2.8 Time to go
1.2.2.4.2.9 Attitude errors
1.2.2.4.2.10 Thrust vector errors
1.2.2.4.2.11 Residual delta-V errors

1.2.2.4.3 Prepare for orbit adjust maneuvers

1.2.2.4.4 Perform attitude maneuvers

1.2.2.4.5 Initiate and monitor orbit adjust maneuvers

1.2.2.4.6 Set up post-maneuver states

1.2.2.4.6.1 Safe thrust activators

1.2.2.5 Perform traffic control

1.2.2.5.1 Identify and monitor other vehicles and objects in Space Station area of influence

1.2.2.5.2 Compute/propagate constellation relative state

1.2.2.5.2.1 Obtain relative bearings and bearing rates of other traffic

1.2.2.5.2.2 Obtain relative elevations and elevation rates of other traffic

1.2.2.5.2.3 Obtain ranges and range rates to other traffic

1.2.2.5.2.4 Obtain ranges and range rates between other vehicles/objects

1.2.2.5.3 Initiate collision avoidance maneuvers of other traffic in area of influence

1.2.2.5.4 Initiate/enable collision maneuvers of the Space Station itself

1.2.2.5.5 Manage constellation orbit maneuvers

1.2.2.5.6 Schedule deployment/rendezvous
1.2.2.5.7 Manage rendezvous
1.2.2.6 Perform tracking
1.2.2.6.1 Long-range object tracking
1.2.2.6.2 Proximity tracking
1.2.2.6.3 Object catalog maintenance
1.2.2.6.4 Tracking data conditioning
1.2.2.6.5 Device management
1.2.2.6.6 Command interface processing
1.2.2.7 Perform time and frequency management
1.2.2.7.1 Time source management
1.2.2.7.2 Time update
1.2.2.7.3 Frequency source management
1.2.2.7.4 Device management
1.2.2.7.5 Command interface processing
1.2.2.8 Perform administration and logistics
1.2.2.8.1 Plan and schedule GN&C crew activities for shifts
1.2.2.8.2 Plan and schedule resupply of GN&C expendables
1.2.2.8.3 Assess compatibility of planned GN&C operations with scheduled payload and experiment operations; resolve conflicts as required

1.2.3 Structures and Mechanical
1.2.3.1 Monitor gimbals
1.2.3.2 Operate MRMS
1.2.3.2.1 Position Space Station elements
1.2.3.2.2 Berth payloads
1.2.3.2.3 Dock Orbiter
1.2.3.3 Perform camera operations
1.2.3.3.1 Inspect system
1.2.3.3.2 Perform payload inspection and observation

1.2.3.4 Perform system and payload maintenance
1.2.3.5 Mechanism control safety

1.2.4 Data Management System (DMS)
1.2.4.1 Support operational interfaces
1.2.4.1.1 Perform sequence operations
1.2.4.1.2 Support operations and procedures
1.2.4.1.3 Initiate Space Station safety
1.2.4.1.4 Develop operations events schedule
1.2.4.2 Monitor displays and controls
1.2.4.3 Participate in technology accommodation
1.2.4.4 Perform maintenance on the DMS
1.2.4.5 Initiate and support data transmission
1.2.4.5.1 Validate payload commands
1.2.4.5.2 Check payload commands
1.2.4.5.3 Validate core commands and data
1.2.4.6 Perform flight data base management
1.2.4.6.1 Support update/access synchronization
1.2.4.6.2 Perform data file management
1.2.4.6.3 Perform device management
1.2.4.7 Monitor and check status of system
1.2.4.7.1 Monitor core
1.2.4.7.2 Monitor customer
1.2.4.7.3 Provide diagnostic support
1.2.4.7.4 Perform system test and evaluation

1.2.5 Thermal Control System (TCS)
1.2.5.1 Manage thermal load
1.2.5.2 Monitor subsystem daily
1.2.5.3 Replace panels
1.2.5.4 Upkeep system
1.2.5.5 Monitor heat rejection
1.2.5.6 Perform maintenance
1.2.5.7 Project thermal load capacity available

1.2.6 Environmental Control and Life Support System (ECLSS)

1.2.6.1 Monitor and control pressure, atmosphere, temperature, and humidity
1.2.6.2 Change filters
1.2.6.3 Maintain the system
1.2.6.3.1 Perform device management
1.2.6.3.2 Support command interface procedures
1.2.6.4 Perform waste and water management
1.2.6.4.1 Potable water
1.2.6.4.2 Grey water
1.2.6.5 Perform fire detection and control
1.2.6.6 Perform maintenance

1.2.7 Communication and Tracking System (C&T)
1.2.7.1 Communication network control
1.2.7.2 Communication equipment control
1.2.7.3 Communication equipment status monitoring
1.2.7.4 Failure detection and recovery
1.2.7.5 Command processing
1.2.7.6 Communication interface control
1.2.7.7 Telemetry control
1.2.7.8 Review up-link communication schedule
1.2.7.9 Acknowledge ground requests
1.2.7.10 Monitor up-link transmissions
1.2.7.11 Review down-link requirements
1.2.7.12 Establish voice link with ground
1.2.7.13 Monitor down-link transmissions

1.2.8 Propulsion System
1.2.8.1 Transfer of logistics module residual fuel and logistics module disconnect
1.2.8.2 Perform maintenance
1.2.8.3 Connect logistics module umbilical
1.2.8.4 Perform reboost maneuver
1.2.8.5 Support contingency repair

1.2.9 Electrical Power System (EPS)

1.2.9.1 Replace equipment including:
1.2.9.1.1 Solar array
1.2.9.1.2 Regenerable fuel cell
1.2.9.1.3 Power conditioning
1.2.9.2 Perform maintenance of random failures
1.2.9.3 Support power management
1.2.9.4 Evaluate array performance
1.2.9.5 Perform array deployment
1.2.9.6 Support device management
1.2.9.7 Perform general maintenance
1.2.9.7.1 Change batteries
1.2.9.8 Support system walk-around
1.2.9.9 Configure power distribution
1.2.9.10 Project energy available

1.2.10 Manage facilities resources
1.2.10.1 Manage flight system facilities
1.2.10.1.1 Flight resource management
1.2.10.1.1.1 Load scheduling
1.2.10.1.1.2 System executive
1.2.10.1.1.3 Initialization and configuration control
1.2.10.1.1.4 Configure data processing equipment
1.2.10.1.1.5 Facility status
1.2.10.1.1.6 Reconfigure/disconnect payloads and core system
1.2.10.1.1.7 Display and control device management
1.2.10.1.1.8 Display and control command interface processing
1.2.10.1.2 Displays and controls
1.2.10.1.2.1 Device management
1.2.10.1.2.2 Command interface processing

1.2.10.2 Manage ground system facilities
1.2.10.2.1 Interface management
1.2.10.2.2 Schedule/status compare
1.2.10.2.3 Transmit reconfiguration schedule
1.2.10.2.4 Ground status database management
1.2.10.2.5 Adjust for unscheduled mode change
1.2.10.3 Contingency operations
1.2.10.3.1 Station operations
1.2.10.3.2 Crew operations

1.3 Maintenance and Servicing

1.3.1 Perform service operations
1.3.1.1 Perform equipment service
1.3.1.1.1 Service subsystem equipment
1.3.1.1.2 Service free flyers and platform mounted payloads
1.3.1.1.3 Repair parts
1.3.1.1.3.1 Adjust payloads
1.3.1.1.3.2 Service and repair payloads
1.3.1.1.3.3 Changeout items
1.3.1.1.3.4 Package items for Shuttle return
1.3.1.2 Monitor and determine status
1.3.1.2.1 Perform CRT display check
1.3.1.2.2 Perform digital readout check
1.3.1.2.3 Perform status light indication check
1.3.1.2.4 Perform controls status check
1.3.1.2.5 Perform visual station check
1.3.1.2.6 Initiate computer routine for subsystem status display

1.3.2 Perform equipment repair
1.3.2.1 Procedures development
1.3.2.2 Fault isolation

1.3.2.3 Operation of test equipment
1.3.2.4 Equipment safing
1.3.2.5 Visual inspection
1.3.2.6 Software enhancement
1.3.2.7 ORU replacement
1.3.2.8 Realignment
1.3.2.9 Verification of corrective action
1.3.2.10 Equipment maintenance
1.3.2.11 Obtain flight data file operations procedures

1.3.3 Assist in equipment modification/growth/upgrade

1.3.4 Perform unplanned servicing as required

1.3.5 Perform satellite servicing
1.3.5.1 Participate in rendezvous plans
1.3.5.1.1 Initiate procedures for rendezvous and docking
1.3.5.1.2 Perform EVA operations
1.3.5.1.3 Service attached modules
1.3.5.1.4 Initiate configuration changes
1.3.5.1.5 Investigate target opportunity
1.3.5.1.6 Support ongoing experiments

1.4 Logistics, Resupply, and Stowage

1.4.1 Supply and inventory management
1.4.1.1 Spare and repair parts inventory
1.4.1.2 Trend monitoring
1.4.1.3 Short-range logistics planning
1.4.1.4 Addition/deletion of inventory items
1.4.1.5 Transfer items to and from Space Shuttle
1.4.1.6 Retrieve and package items for return to Earth
1.4.1.7 Medical supplies inventory
1.4.1.8 Clothing inventory
1.4.1.9 Construction materials inventory

1.4.1.10 Propellant inventory
1.4.1.11 ECLS supply inventory
1.4.1.12 Deliver spare/repair parts for maintenance
1.4.1.13 Obtain flight data file operations procedures

1.4.2 Logistics module support
1.4.2.1 Deployment verification
1.4.2.2 Perform and verify attachment operations
1.4.2.3 Perform and verify interface operations
1.4.2.4 Prepare non-operative equipment for Earth return
1.4.2.5 Obtain flight data file operations procedures

1.4.3 Stowage and restowage
1.4.3.1 Upper stages
1.4.3.2 Satellites
1.4.3.3 Mission specific hardware
1.4.3.4 Medical items
1.4.3.5 Personal items
1.4.3.6 Galley supplies and equipment
1.4.3.7 Obtain flight data file operations procedures

1.5 Crew Activities/Operations Planning and Scheduling

1.5.1 Call up and read out crew schedule data

1.5.2 Call up and read out crew off-duty roster

1.5.3 Conduct regular crew activity planning meetings

1.5.4 Update schedules

1.5.5 Assign personnel

1.5.6 Maintain crew activity log

1.5.7 Make announcements

1.5.8 Obtain flight data file operations procedures

1.6 Housekeeping

1.6.1 General maintenance/cleanup

1.6.1.1 Collect wet/dry trash

1.6.1.2 Air revitalization subsystem and water microbial filter changeout

1.6.1.3 General restowage

1.6.1.4 Clean waste management compartment

1.6.1.5 Replace lights and clean fixtures

1.6.1.6 Clean personal hygiene equipment

1.6.1.7 Perform clothing maintenance

1.6.1.8 Perform trash management

1.6.1.9 Support contamination control and cleaning of surfaces, windows, etc.

1.6.1.10 Clean workstation areas

1.6.1.11 Clean personal quarters

1.6.1.12 Clean laboratory areas

1.6.2 Meal preparation

1.6.2.1 Take out food

1.6.2.2 Cook food

1.6.2.3 Eat meal

1.6.2.4 Sanitize and stow utensils and unused food

1.6.2.5 Clean galley

1.6.2.6 Clean dining and wardroom area

2.0 PERSONAL MAINTENANCE

2.1 Health Maintenance

2.1.1 Perform exercise

2.1.2 Monitor health status

- 2.1.2.1 Record routinely checked biomedical parameters (physical/dental)
- 2.1.2.2 Schedule, implement, document required exercise routines
- 2.1.2.3 Perform nutrition analyses
- 2.1.2.4 Record medications used/quantities remaining and treatments administered

2.2 Provide Emergency Medical Services

2.2.1 Provide psychological support

2.2.2 Provide emergency care

2.3 Perform Personal Hygiene Activities

2.3.1 Shave

2.3.2 Perform whole body cleansing

2.3.3 Perform partial body cleansing

2.3.4 Trim hair/nails

2.3.5 Cleanse hair/scalp

2.3.6 Perform dental/oral hygiene

2.4 Perform Recreation/Leisure Activities

2.4.1 Watch T.V.

2.4.2 Look out of window

2.4.3 Write in journal

2.4.4 Read

2.4.5 Listen to music

2.4.6 Use computer

2.4.7 Spend time alone

2.4.8 Take pictures out of windows

2.4.9 Communicate with family

2.4.10 Play games (electronic, etc.)

2.5 Sleep

3.0 EVA (EXTRAVEHICULAR ACTIVITIES)

This topic area includes planned and unplanned EVAs, with and without MMU. EVA will support Space Station activities and payload/experiment operations.

3.1 Perform Pre-EVA Activities

- 3.1.1 Pre-breathe
- 3.1.2 Unstow/prepare equipment
- 3.1.3 Obtain FDF procedures and/or checklists
- 3.1.4 Perform EMU checkout
- 3.1.5 Perform PLSS checkout
- 3.1.6 Perform MMU checkout
- 3.1.7 Don/initiate EMU/PLSS/MMU system(s)
- 3.1.8 Enter airlock
- 3.1.9 Activate airlock
- 3.1.10 Open hatch
- 3.1.11 Egress airlock

3.2 Perform EVA

- 3.2.1 Support assembly, deployment, positioning, mating/demating of Space Station structures during, and subsequent to, build-up
- 3.2.2 Perform routine maintenance/repair
  - 3.2.2.1 Perform utilities connection/disconnection/reconnection
- 3.2.3 Perform contingency/emergency maintenance/repair
  - 3.2.3.1 Repair meteoroid penetration of pressure vessel
  - 3.2.1.2 Repair external equipment
- 3.2.4 Perform on-orbit assembly of large space structures
  - 3.2.4.1 Position, configure/reconfigure, extend/retract antennas, solar arrays, sensors, and/or equipment
- 3.2.5 Support payload or experiment operations
  - 3.2.5.1 Clean optical surfaces

3.2.5.2 Activate, deactivate, safe, or manually override experiments or payloads

3.2.5.3 Retrieve samples

3.2.5.4 Replace materials (e.g., film, data tapes)

3.2.5.5 Enhance experiments or payloads

3.2.5.6 Perform utilities connection/disconnection/reconnection

3.2.6 Inspect and/or replace modular equipment and ORUs

3.2.7 Perform refueling operations

3.2.7.1 Resupply propellant

3.2.8 Transfer cargo

3.2.9 Transfer disabled crewmember or perform crew rescue

3.2.9 Capture debris

3.3 Post-EVA Activities

3.3.1 Enter airlock

3.3.2 Close hatch

3.3.3 Repress airlock

3.3.4 Doff EMU/PLSS/MMU

3.3.5 Stow Equipment

3.3.6 Perform EMU/PLSS/MMU maintenance/servicing/cleaning

4.0 ORBITAL MISSION SPECIFIC OPERATIONS

4.1 Science Experiments and Applications

4.1.1 Remove new experiments and applications systems from Orbiter

4.1.2 Attach new experiments to appropriate operating positions

4.1.3 Assemble support instrumentation

4.1.4 Perform functional and operational checkout

4.1.5 Communicate with POCC

4.1.6 Monitor parameters and routine operations

4.1.7 Remove/replace supplies/consumables

4.1.8 Maintain and service equipment

4.1.9 Perform equipment and instrument upgrade/changeout

4.1.10 Perform operational adjustments and control

4.1.11 Monitor contaminants/radiation

4.1.12 Participate in the development and operations of science applications systems

- 4.1.12.1 Study bone demineralization in microgravity
  - 4.1.12.1.1 Maintain and monitor rat colony
  - 4.1.12.1.2 Measure mass of rats
  - 4.1.12.1.3 Acquire, process, and store rat blood sample
  - 4.1.12.1.4 Sacrifice rats, acquire and store tissue samples
  - 4.1.12.1.5 Analyze blood and urine samples
  - 4.1.12.1.6 Perform histological analysis

4.1.12.2 Study human metabolic work in microgravity
4.1.12.2.1 Set up equipment for metabolic experiment
4.1.12.2.2 Prepare subject for metabolic testing
4.1.12.2.3 Monitor metabolic work
4.1.12.2.4 Analyze metabolic experiment data
4.1.12.3 Study vestibular function in microgravity
4.1.12.3.1 Set up for vestibular experiment
4.1.12.3.2 Conduct vestibular function experiment
4.1.12.3.3 Analyze vestibular experiment data

4.1.13 Monitor and tend to Earth delivery
4.1.13.1 Collect data, analyze, compact, and transmit (real/non-real time)

4.1.14 Perform required EVA

4.2 Payload Support

4.2.1 Payload-Space Station interfaces
4.2.1.1 Stowage
4.2.1.2 Assembly
4.2.1.3 Installation
4.2.1.4 Umbilical mate/demate
4.2.1.5 Payload spacecraft safing

4.2.2 Payload Operations
4.2.2.1 Real-time systems diagnostics and evaluation
4.2.2.2 Power up/down
4.2.2.3 Instrument calibration/recalibration
4.2.2.4 Materials supply/resupply
4.2.2.5 Servicing and maintenance
4.2.2.5.1 Routine maintenance
4.2.2.5.2 Health trend analysis
4.2.2.5.3 Fault detection and isolation
4.2.2.5.4 Payload reconfiguration support
4.2.2.6 Data collection, analysis, and transmission

4.2.2.7 Procedures planning
4.2.2.8 Payload alignment
4.2.2.9 Instrument reconfiguration/addition/removal
4.2.2.10 Tethered operations
4.2.2.11 Antenna management
4.2.2.12 Periodic collection of samples and film
4.2.2.13 Preparation of samples for Earth return
4.2.2.14 Obtain flight data file operations procedures
4.2.2.15 Consumables resupply
4.2.2.16 Umbilical connection/disconnection
4.2.2.17 Payload attachment/detachment
4.2.2.18 Spacecraft safing

4.2.3 Upper stage support for payloads

4.3 Unmanned Platform Support

4.3.1 Platform assembly

4.3.2 Activation for normal activity

4.3.3 Perform functional and operational checkout

4.3.4 Attach payloads to the platforms

4.3.5 Instrument calibration

4.3.6 Monitor platform systems and payloads

4.3.7 Remote servicing and maintenance

4.3.8 Platform retrieval

4.3.9 Payload safing

4.3.10 Platform reboost

4.3.11 Film/samples retrieval

4.3.12 Antenna management

4.3.13 Consumables resupply

4.3.14 Changeout and replacement of equipment

4.3.15 Obtain flight data file operations and procedures

4.4 Manage Customer/Operator Data

4.4.1 Customer/operator delivered data

4.4.1.1 Manage real-time data return

4.4.1.1.1 Acquire real-time data

4.4.1.1.2 Prioritize real-time data

4.4.1.1.3 Monitor real-time data

4.4.1.1.4 Dispatch real-time data

4.4.1.1.5 Format real-time data

4.4.1.2 Manage delayable data return

4.4.1.2.1 Acquire delayed payload data

4.4.1.2.1.1 Acquire payload data electronically (TDRSS)

4.4.1.2.1.2 Acquire non-electronic payload data (Shuttle)

4.4.1.2.2 Prioritize delayed data

4.4.1.2.3 Monitor delayed data

4.4.1.2.4 Dispatch delayed data

4.4.1.2.5 Format delayed data

4.4.1.2.6 Manage data storage space

4.4.1.3 Distribute data

4.4.1.3.1 Preprocessing

4.4.1.3.1.1 Receive signals

4.4.1.3.1.2 Demodulate signals

4.4.1.3.1.3 Decrypt data

4.4.1.3.1.4 Detect and correct errors

4.4.1.3.1.5 Sync frames

4.4.1.3.2 Capture data

4.4.1.3.2.1 Demultiplex frames

4.4.1.3.2.2 Demultiplex packets

4.4.1.3.2.3 Order packets

4.4.1.3.2.4 Extract video

4.4.1.3.2.5 Extract audio

4.4.1.3.3 Route and transmit

4.4.1.3.3.1 Retrieve archived/stored data

4.4.1.3.3.2 Encrypt critical information

4.4.1.3.3.3 Construct packets as per ISO standards

4.4.1.3.3.4 Insert error codes

4.4.1.3.3.5 Enqueue packets to distribution network

4.4.1.3.4 Verify quality

4.4.1.3.4.1 Detect transmission errors

4.4.1.3.4.2 Correct transmission errors

4.4.1.3.4.3 Request necessary retransmissions

4.4.1.4 Manage deliverable customer data

4.4.1.4.1 Manage customer-data interface

4.4.1.4.1.1 Process

4.4.1.4.1.2 Present

4.4.1.4.1.3 Provide transparent interfaces

4.4.1.4.2 Capture customer data

4.4.1.4.2.1 Demultiplex frames

4.4.1.4.2.2 Demultiplex packets

4.4.1.4.2.3 Order packets

4.4.1.4.2.4 Extract video

4.4.1.4.2.5 Extract audio

4.4.1.4.3 Handle customer data

4.4.1.4.4 Acquire ancillary data

4.4.1.4.5 Convert customer data to level 0
- 4.4.1.4.5.1 Check for transmission error
- 4.4.1.4.5.2 Provide indication of data quality

4.4.1.4.6 Convert customer data to level 1A, 1B, 2
- 4.4.1.4.6.1 Convert if purchased by customer
- 4.4.1.4.6.2 Convert by using database defined method

4.4.1.4.7 Convert audio and video for transmission

4.4.1.4.8 Merge customer data with ancillary data

4.4.1.4.9 Account for customer usage
- 4.4.1.4.9.1 Accumulate usage data
- 4.4.1.4.9.2 Compute usage statistics
- 4.4.1.4.9.3 Document/disseminate statistics
- 4.4.1.4.9.4 Compute charges
- 4.4.1.4.9.5 Produce/disseminate bills

4.4.1.4.10 Route and transmit
- 4.4.1.4.10.1 Retrieve archived/stored data
- 4.4.1.4.10.2 Encrypt critical information
- 4.4.1.4.10.3 Construct packets as per ISO standards
- 4.4.1.4.10.4 Insert error codes
- 4.4.1.4.10.5 Pack/ship information transmitted via Shuttle
- 4.4.1.4.10.6 Enqueue packets to distribution network

4.4.1.4.11 Archive/store customer payload data
- 4.4.1.4.11.1 Archive up to 2 years
- 4.4.1.4.11.2 Secure archived payload data

4.4.1.4.11.3 Maintain archives catalog
4.4.1.4.11.4 Permit use of archives for data exchange
4.4.1.4.11.5 Permit modification of operational information

4.4.1.5 Manage deliverable core data
4.4.1.5.1 Core data interface management
4.4.1.5.2 Core data capture
4.4.1.5.3 Data extraction
4.4.1.5.4 Displays and controls
4.4.1.5.5 Engineering data analysis
4.4.1.5.6 Core data accounting

4.4.2 Customer/Operator Supplied Data
4.4.2.1 Validate payloads commands data
4.4.2.1.1 Validate payload command destination
4.4.2.1.2 Validate payload command operation
4.4.2.2 Check SSOS service requirements
4.4.2.3 Validate core commands/data
4.4.2.4 Provide ancillary data
4.4.2.5 Support customer systems operations
4.4.2.5.1 Customer data operation
4.4.2.5.2 Customer payload operations
4.4.2.5.3 Support OTV operations
4.4.2.5.4 Support OMV operations
4.4.2.5.5 Customer payload checkout/servicing
4.4.2.6 SSPE checkout and servicing
4.4.2.7 Manage customer-supplied video data
4.4.2.8 Manage customer-supplied audio data
4.4.2.9 Provide archive search/retrieval
4.4.2.10 Support intercustomer data transport

4.5 Schedule and Execute Operations

4.5.1 Develop recurring operations masters
4.5.1.1 Develop normal day payload operations
4.5.1.2 Develop normal day core operations

4.5.1.3 Develop mode compatibility matrix

4.5.1.4 Develop major event operations

4.5.2 Develop short-term schedules

4.5.2.1 Confirm payload and core schedules

4.5.2.2 Incorporate new/revised operations

4.5.2.3 Check for conflicts

4.5.2.4 Check for facilities capabilities

4.5.2.5 Resolve conflicts

4.5.2.6 Check unresolved restricted/constrained commands

4.5.2.7 Maintain short-term schedules

4.5.3 Develop operating events schedule

4.5.3.1 Time tag operations

4.5.3.2 Check schedule conflicts

4.5.3.3 Maintain operating events schedule

4.5.3.4 Adjust for unscheduled mode changes

4.5.4 Sequence operations

4.5.4.1 Sequence payload operations

4.5.4.2 Sequence core system operations

4.5.4.3 Command scheduled mode changes

4.5.4.4 Check for executability

4.5.5 Payload control and monitor

4.5.5.1 Payload status monitor

4.5.5.2 Onboard man-machine interface

4.5.5.3 Payload emergency handling

4.5.5.4 Quick-look processing

4.5.5.5 Perform payload status display

4.5.6 Command generation

4.5.6.1 Generate uplink command

4.5.6.2 Generate downlink command

4.6 Space Station Flight and Proximity Operations

4.6.1 Space Station flight operations

4.6.1.1 Attitude control

4.6.1.2 Reboost

4.6.1.3 Support tethered operations

4.6.1.4 Perform traffic control within terminal traffic control zone (within 100nm)

4.6.1.5 Guidance support

4.6.2 Orbiter support and proximity operations

4.6.2.1 Monitor/verify correct rendezvous/departure paths

4.6.2.2 Voice and data communications

4.6.2.3 Verify docking port ready

4.6.2.4 Perform SS/Orbiter interface and safing operations

4.6.2.5 Verify docking complete

4.6.2.6 Perform Orbiter crew briefings

4.6.2.7 Support SS/Orbiter crew changeover

4.6.2.8 Obtain flight data file operations procedures

4.6.2.9 Support on-orbit construction and assembly of Space Station

4.6.3 Upperstage support and proximity operations

4.6.3.1 Fueling coordination (LH_2, LOX, MMH, N_2O_2, Hydrazine)

4.6.3.1.1 Fuel transfer, loading, unloading

4.6.3.1.2 Storage

4.6.3.1.3 Pressure check

4.6.3.1.4 Leak check

4.6.3.2 Upperstage maintenance

4.6.3.3 Launch operations

4.6.3.4 Command and control of vehicles

4.6.3.5 Monitor/verify correct rendezvous/departure path

4.6.3.6 Docking/berthing facility readiness

4.6.3.7 Vehicle safing

4.6.3.8 Initiate/control collision avoidance maneuvers of SSPE's during proximity operations

4.6.3.9 Obtain flight data file operations procedures

4.6.4 Mobile RMS (MRMS) operations

4.6.4.1 Space Station module berthing

4.6.4.2 Upperstage berthing

4.6.4.3 Monitor/control the docking/undocking and the berthing/unberthing of other SSPE's at the Space Station

4.6.4.4 MRMS camera operations

4.6.4.5 Support SS and spacecraft servicing

4.6.4.6 Obtain flight data file operations procedures

4.7 Support Robotics Operations

4.7.1 Command and control

4.7.1.1 Schedule robot operation

4.7.1.2 Manage robotics operational data base

4.7.1.3 Provide high level control and monitor

4.7.1.4 Maintain robot RF link

4.7.1.5 Support robot teleoperation

4.7.1.6 Coordinate activities of multiple robots

4.7.2 Robot health maintenance

4.7.2.1 Routine maintenance

4.7.2.2 Fault diagnostics

5.0 SKILLS MAINTENANCE/TRAINING ACTIVITIES

This section describes skills maintenance and on-the-job training (OJT) activities while on-orbit. The methods are: 1) adaptive training software incorporated into SSIS/DMS workstations and/or operational consoles; 2) personal workstations for training.

5.1 Perform On-Orbit Skills Maintenance Training

5.1.1 Maintain propellant handling skills

5.1.2 Maintain proximity operations skills
- 5.1.2.1 MRMS
- 5.1.2.2 Orbital Maneuvering Vehicle
- 5.1.2.3
- 5.1.2.4 OTV

5.1.3 Maintain EVA skills
- 5.1.3.1 EMU
- 5.1.3.2 MMU

5.1.4 Maintain servicing, maintenance and/or repair skills

5.1.5 Maintain on-orbit construction/assembly skills

5.1.6 Maintain emergency operations skills

5.2 Perform On-The-Job Training (OJT) On-Orbit

5.2.1 Perform OJT for experiment operations

5.2.2 Perform OJT for payload operations

5.2.3 Perform OJT for maintenance, servicing, and/or repair