INDEXING NASA PROGRAMS FOR TECHNOLOGY TRANSFER METHODS DEVELOPMENT AND FEASIBILITY
FINAL REPORT

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SUMMARY

A major part of the NASA Technology Utilization Program involves the identification of technology which can contribute to solving a nonaerospace problem. Regional Dissemination Centers are engaged in this type of activity for industrial clients. Application Teams also often seek out personnel at NASA centers that are cognizant of technologies relevant to a specific nonaerospace need. Previous studies have identified several problems in searching the literature for nonaerospace users. As a result it was desired to have an index to all NASA ongoing programs, where the index was designed for technology transfer. That is, the focus in the index would be on the technologies being developed rather than on the aerospace problems being solved.

In a previous study an indexing methodology was developed which assigned descriptors to projects based on a limited description of technical plan. The objective of the present project was to evaluate the application of this methodology to indexing ongoing NASA programs. These programs are comprehended by the NASA Program Approval Documents (PADS). Each PAD contains a technical plan for the area it covers. It was proposed that these could be used to generate an index to the complete NASA program.

To test this hypothesis two PADS were selected by the NASA Technology Utilization Office for trial indexing. These covered communications and power and electric propulsion. A sample index was prepared for each PAD. The index associated with each descriptor had a list of NASA technical managers and their organizations. The implication of the index was that the area of responsibility for each manager would involve technology relevant to the descriptor.

This was tested by sending to each manager a list of the descriptors associated with his area. The manager was asked to delete inaccurate descriptors and add others that had been omitted. When the manager deleted a broad term obviously related to his work, this deletion was not retained. Of the additions recommended by the managers, only those in the NASA Thesaurus or with a thesaurus equivalent were included.

In all 33 individuals were contacted and responses were obtained from 25. There were 783 descriptors that had been chosen relevant to the work of these 25 technical managers. The latter recommended 114 deletions and 188 additions. Of these, 103 deletions and 100 additions were retained. Thus 87% of the original 783 descriptors had been retained as being accurate. Also 87% of the descriptors in the final list had been present in the original index. This is a measure of the completeness of the indexing. These results confirmed the feasibility of the proposed approach for indexing NASA programs for technology transfer.

In addition to a set of PADS, information has been collected on the individual or organization responsible for each part of the technical plans. The next step in preparing a complete index would be to outline each of the technical plans, listing events in accordance with the indexing methodology. Each item on the list would then be assigned a responsible individual or organization using the information that has been collected. Key words would be chosen. These would then be expanded into the final list of descriptors using the NASA Thesaurus. The final step would be the organization and production of the index itself.

This project has demonstrated the feasibility of indexing ongoing NASA programs using PADS as the source of information. The same indexing methodology, however, could be applied to other documents containing a brief description of technical plan. The nature of the methodology is such that the index generated would be particularly suited to technology transfer. Physical principles and novel relationships involved in the developing technology would be covered. The results of this project show that over 85% of the concepts in the technology should be covered by the indexing. Also over 85% of the descriptors chosen would be accurate. This completeness and accuracy for the indexing is considered quite satisfactory for application in technology transfer.

INTRODUCTION

One of the primary aims of the NASA Technology Utilization Program is to facilitate the transfer of NASA developed technology to nonaerospace users. To achieve such transfer requires that there be a link between the nonaerospace user and the NASA data bank and/or the ongoing NASA programs developing the technology. The latter case is particularly important when an active approach is being taken to technology transfer. In this case it is often necessary to locate technical personnel with knowledge useful in an application engineering program. The people engaged in an ongoing program are often in the best position to clearly see the work which must be done to apply their technology to a specific nonaerospace problem.

It is unlikely that a nonaerospace problem would be covered directly in an index to the NASA data bank. In addition there are no current indexes to ongoing in-house programs. The present program was a first step toward providing an index to all NASA programs for use in technology transfer. The material needed to generate a complete index has been gathered. Sample indexes to two NASA programs were prepared and these were used to demonstrate the feasibility of the indexing methodology. The application of this methodology to generate a complete index is discussed in the final section of this report.

The present indexing of NASA technology is done primarily for the aerospace user. Thus, the focus of this indexing is on the aerospace problem solved rather than on the technology which contributed to the solution. A study has shown that when the Regional Dissemination Centers search the NASA data bank for nonaerospace users (Application Teams) less than 40% of the relevant documents in the data bank are found.[1] In this study it was shown that

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[1]"A Study of NASA Literature Search Strategies -- Final Report" by William H. Clingman; prepared for Technology Utilization Division, National Aeronautics and Space Administration under Contract No. NASW-2085; September 26, 1970.

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simultaneous but independent searches are highly nonuniform in their results, retrieving different documents from the collection. This pattern of nonuniform retrieval and low recall is probably peculiar to the nonaerospace user.

Fundamental difficulties were found in searching for the nonaerospace user. Specific words must be selected from the aerospace vocabulary in order to conduct the literature search. The user's problem, however, cannot really be described with precision using these words. Thus, any one of a large number of specific terms may have been used to index a document containing relevant technology. Determining a priori which one was used is a fundamental problem. For example, it was found that on the average 70% of the relevant documents not retrieved by a given RDC strategy were indexed at most under only one of the terms used in the literature search by the RDC. It was evident from the results of this study that the literature search specialist cannot determine how relevant documents were indexed from a knowledge of the nonaerospace problem alone.

In a second study[2] the feasibility was established of providing an index

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[2] Indexing Research and Technology Resumes For Technology Transfer" by William H. Clingman; prepared for Technical Information Services Company under NASA Contract No. NASw-1812; November 21, 1969.

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which focuses on the technology rather than the aerospace problem. Specifically the feasibility of indexing NASA work units was established from this standpoint. In selecting index terms information was used on the objective and approach to be taken in the work unit R&D projects. It was shown that such an index could be prepared which would accurately cover with aerospace terms the technology resulting from these research projects. In the present project the applicability of this same indexing methodology to NASA Program Approval Documents (PADS) has been established. Starting with the written technical plans in these PADS the above methodology could be applied to generate a complete index to the ongoing NASA program. This special index could then lead the Application Teams to the individuals and organizations carrying out work relevant to the nonaerospace user.

INDEXING METHODOLOGY

The indexing methodology that has been used consists of three steps. First, the indexer reorganizes the available information so as to chronologically list all events of the proposed research program as described in the technical plan. In preparing the list of events, cause and effect relationships are considered in arriving at the proper order. In listing any particular event the indexer asks whether the events already listed are sufficient to enable the event being listed to take place. It is not intended that specialized technical knowledge on the part of the indexer be applied to such a consideration. What is intended is that general logical relationships be considered as a guide in extracting from the written material as much information as possible. For example, if the event being listed by the indexer is the assembly of a piece of hardware, then one could conclude that the parts being assembled must already be available. If one or more of these parts has not been discussed in an already listed event, then the indexer could scan the written material to determine whether such information is available.

Second, using the checklist of questions given in Table 1 the indexer selects key words from the list of chronological events. Key words are also selected using the original written material. The terms used should include those related to the physical principles and novel relationships in the technology being developed or applied.

Third, the NASA Thesaurus is used to convert the key words into a final set of descriptors. In general there will be several descriptors corresponding to each key word. The indexer uses the hierarchial relationships in the Thesaurus to identify descriptors which pertain to the R&D program but were not thought of in listing the key words. The Thesaurus is thus used to suggest new terms to the indexer so that the indexing of each part of the technical program can be as complete as possible even though the available information is limited.

This methodology was applied in a previous study[2] to indexing Research and Technology Resumes. In that program the indexing accuracy was 95% and completeness was 88%. That is, 95% of the descriptors chosen based only on a brief statement of technical plan did apply to technology which resulted from the project. Also, 88% of the terms chosen by NASA to index all reports resulting from the project were covered by the descriptors which were generated from the brief statement of technical plan. From these results it was concluded that the application of this same methodology to ongoing NASA programs should be evaluated.

TABLE 1

CHECKLIST FOR GENERATING TECHNICAL DESCRIPTORS

Bachground

What new technology, if any, had led to this program?
What is the aerospace need giving rise to this program?

Experimental Methods

What type of experimental procedures will be used?
If analysis is to be done will novel mathematical techniques or computer programming be used?
What special characteristics will be required of the experimental equipment?
What procedures will be used to test or control the quality of products or processes developed in the program?

Novel Materials

What kind of novel materials, if any, will be involved in the program?
What will be their composition or form?
How will they be made?
What will be their desired novel properties?
How will they be applied?

Novel Equipment

What kind of novel equipment, if any, will be involved in the program?
What will it do and how will it work?
What novel materials or components will be used in this equipment?
How will it be assembled?
What will be its applications?

End Results

What will be the end result of the R & D program?
If a new product or process is to be developed, what will it do?
What problems must be solved to accomplish the end result?
What will completion of the R & D program make possible?
What are the anticipated applications of the work to be done?

INDEXING NASA PROGRAMS

Three things are considered necessary to develop an index to NASA programs. First is a written description of the technical work in progress. This description needs to be in sufficient detail to allow the development of descriptors, yet not so detailed that the indexing job is overwhelming. Second, there must exist a means of analyzing the technical description to obtain accurate and complete descriptors. The indexing methodology discussed in the previous section was evaluated for this purpose. Third, there needs to be a way of associating different parts of the written description with the individuals and/or organizational entities within the NASA Field Centers that are carrying out the work. For each PAD information has been obtained from NASA Headquarters on the responsible organization or individual for each part of the technical plan in that PAD.

The technical plans which have been written as a part of the NASA Program Approval Documents were analyzed as a solution to the first requirement. In particular it was desired to determine whether these plans were presented in sufficient detail to obtain technical descriptors of the work from them. The specificity of a statement in a technical plan can be roughly measured in terms of the number of professional man-years of technical work described per page of single-spaced typewritten material. In the previous study[2] this measure of specificity ranged from 5 to 72. In the statements involving a high number of man-years per page high accuracy and completeness could still be achieved. For example, in Resume 127-52-01-02-23 the specificity of the statement of technical plans was 72 man-years per page. This resume concerned the development of an integrated advanced life support system. The statement of technical plan was in fact only 4 sentences long. Even so 93% of the terms used by NASA in indexing all reports from the project were covered by 17 descriptors generated solely from the statement of technical plan.

The specificity of the statements of technical plans for a sampling of PADS is shown in Table 2. There is a wide range of specificities. Many of these, however, fall within the range that was examined in the previous program on indexing Resumes. A single PAD covers a very large program compared to a single Resume. The written technical statement of plan in the PAD is a proportionately greater size. The hypothesis was thus made that the above indexing methodology could be applied to PADS with an accuracy and completeness comparable to that achieved in the previous study.

This hypothesis was tested in the present program. Two PADS were selected by the NASA Technology Utilization Office for trial indexing, Communications Supporting Research and Technology and Space Electric Power Systems. A sample

TABLE 2

SPECIFICITY OF TYPICAL PAD TECHNICAL PLANS

Number	Title	Man Years	Pages	Man - Years Per Page
78-730-128) 78-730-731)	Chemical Propulsion	330	6	55
61-820-;61-880-;				
160	Earth Observations Supporting R&T	173	1-1/2	115
164	Communications Supporting R&T	164	1-1/4	131
601	TIROS/TOS Improvements	42	1-1/3	32
604	Nimbus	401	7	57
607	Meteorological Soundings	53	3-1/2	15
608	Synchronous Meteorological Satellites	14+	2/3	
610	Cooperative Applications Satellites	5	1	5
680	Applications Technology Satellites	191	3-1/3	57
640	Earth Resources Survey/Aircraft	176	1-1/2	117
641	Earth Resources Technology Satellites	60+	1-1/3	
855	Geodetic Satellites	18	6-1/2	3
51-500-312	Tracking and Data Acquisition	7885	8	980

index for each of these PADS was prepared using the above methodology. Each of these indexes has been prepared and submitted to the NASA Technology Utilization Office as a separate document and should be considered as a part of this final report.

Included with each sample index are the worksheets that were used to prepare them. These worksheets are also in Appendix A of this report. The first worksheet is a listing of events and areas of technical activity taken from the written objective and technical plan in the PAD. Most of the listed events are taken directly from the PAD. Some are implied by the technical plan. Where possible the chronological order of events was considered in order to derive areas of technical activity implied by but not specifically mentioned in the technical plan.

Next to specific events or entire areas of technical activity on this first worksheet are code letters in parentheses. These code letters are the same as used in the sample index and correspond to the individual who is cognizant of this specific technical activity in the program. In some cases these individuals are individual investigators and in other cases they are project managers. In all cases the individual is reported to have sufficient knowledge of the technologies involved in his part of the program to direct an application team to the specific individuals that can contribute to a problem solution.

The next step in preparing the index was to derive a set of key words and key phrases from the list of events. The NASA Thesaurus was then used to select descriptors corresponding to each key word or phrase. The key words and descriptors are listed on the second worksheet for each program. Also listed next to each key word is the code letter for the cognizant individual.

The sample index for each program was then prepared. In the index the descriptors are listed in alphabetical order. Under each descriptor is given a list of individuals and their NASA Center. Each individual is reported to be cognizant of activities involving technology related to the descriptor. The individuals were listed using their code letter and a key was given at the beginning of the index. This format would allow efficient updating of the total index as individual responsibilities and organizations change.

The next step was to evaluate the accuracy and completeness of the sample indexes. Each of the technical managers included in the indexes was contacted either by mail or personal interview. The interviews were held with Messrs. D. Fielder and W. E. Rice at the Manned Spacecraft Center and with N. McAvoy at Goddard Space Flight Center. In all 33 individuals were contacted and responses were obtained from 25. A list of those responding is given in Table 3.

Each manager was asked to verify the accuracy of the descriptors chosen for

TABLE 3

SURVEY RESPONDENTS

Name	Center	Terms	Respondent Deletions	Final Deletions	Respondent Additions	Final Additions
G. W. Brooks	Langley	33	1	1	4	2
G. R. Seikel	Lewis	29	5	5	5	1
D. Silverman	Hdq.	8	2	0	17	4
J. Miller	Goddard	4	0	0	39	22
T. Lynch	Goddard	48	0	0	1	1
W. E. Rice	MSC	1	0	0	0	0
D. Fielder	MSC	20	0	0	0	0
G. Oer	Goddard	59	3	2	3	3
H. Hoffman	Goddard	8	0	0	2	2
W. R. Cherry	Goddard	77	16	14	1	0
N. McAvoy (Int)	Goddard	3	1	1	1	1
G. Clark	Goddard	17	2	1	2	2
C. H. Nelson	Langley	36	0	0	0	0
R. V. Powell	JPL	58	27	25	8	3
D. T. Berntowicz	Lewis	18	8	7	4	2
W. Krabill	Wallop's Station	58	0	0	6	3
R. Alexovich	Lewis	9	2	2	3	3
H. J. Schwartz	Lewis	50	20	19	0	0
R. Breitwieser	Lewis	7	0	0	11	4
G. Andrus	Hdq.	20	2	1	24	19
E. A. Richley	Lewis	26	0	0	13	7
S. J. Kaufman	Lewis	45	25	25	26	17
D. R. Packe	Lewis	2	0	0	2	1
J. Foster	Ames	10	0	0	2	1
A. Briglio	JPL	137	0	0	14	2
		783	114	103	188	100

his part of the corresponding PAD. These descriptors had been chosen based only on the information contained in the PAD. The individual was also asked to list additional descriptors that had been omitted. Based on the responses obtained, additions and deletions were made to the original index. Revised indexes were prepared and submitted as a separate document to the NASA Technology Utilization Office. These revised indexes are in Appendices B and C of this final report.

In Table 4 is shown an example of an excerpt from the PAD #61-880-164, Supporting R&T, Communications. Mr. H. Hoffman at Goddard Space Flight Center has responsibility for this part of the work. In Table 5 are shown the key words that were chosen based solely on the excerpt in Table 4. Also in Table 5 are shown the index terms derived from the key words using the NASA Thesaurus. After Mr. Hoffman reviewed these terms he added the two additional ones shown in Table 6. This example illustrates the indexing and evaluation process.

Every addition and deletion recommended by the technical managers was not included in the revised index. Deletions not included were those in which the term was a broad one that was obviously applicable to the work. Many of the recommended deletions were terms related to the application of the technology. These were all included in the revised indexes. Of the recommended deletions, 35% were application related. Of the recommended additions, only those in the NASA Thesaurus or with a thesaurus equivalent were included. Table 3 shows the number of additions and deletions for each respondent in the survey. The format of the revised indexes shows where the additions and deletions were made. Additions are shown to the right of the left column. Deletions are shown as missing lines from the left column.

In all there were 783 descriptors that had been chosen relevant to the work of the 25 technical managers who had responded. The managers recommended 114 eliminations and 188 additions. Of these, 103 eliminations and 100 additions were retained. Thus in the revised index 87% of the original 783 descriptors have been retained as being accurate. Also 87% of the descriptors in the revised index were present in the original. This is a measure of the completeness of the indexing.

These results are consistent with those obtained in our previous study of indexing Research and Technology Resumes. The results demonstrate the applicability to PADS of the previously developed indexing techniques. The results also confirm the feasibility of the proposed approach for indexing NASA programs for technology transfer.

TABLE 4

PAD TECHNICAL PLAN -- EXCERPT

Applications Technology efforts will include studies of the feasibility and characteristics of stabilized spacecraft; sensor and instrumentation development and spacecraft technology activities.

TABLE 5

KEY WORDS AND INDEX TERMS FOR EXCERPT

KEY WORDS	INDEX TERMS
STABILIZED SPACECRAFT FEASIBILITY	STABILIZED PLATFORMS SPACECRAFT STABILITY
STABILIZED SPACECRAFT CHARACTERISTICS	STABILITY DERIVATIVES DYNAMIC CHARACTERISTICS SPACECRAFT STABILITY
SENSOR DEVELOPMENT	SENSORS GUIDANCE SENSORS SPACECRAFT INSTRUMENTS
INSTRUMENTATION DEVELOPMENT	INSTRUMENT PACKAGES SPACECRAFT INSTRUMENTS

TABLE 6

FINAL SET OF INDEX TERMS FOR EXCERPT

ORIGINAL:

STABILIZED PLATFORMS
SPACECRAFT STABILITY
STABILITY DERIVATIVES
DYNAMIC CHARACTERISTICS
SENSORS
GUIDANCE SENSORS
SPACECRAFT INSTRUMENTS
INSTRUMENT PACKAGES

Added by Technical Manager:

ATTITUDE INDICATORS
ATTITUDE CONTROL

GENERATION OF A COMPLETE INDEX

Based on the results of the trial indexing discussed above it is proposed that a complete index to ongoing NASA programs could be developed using the information presented in the Technical Plan section of all PADS. A complete collection of PADS has been assembled. A list of the PADS and the length of their written technical plan is shown in Table 7. There is a total of 246 pages devoted to the technical plans. It is proposed that a complete index to ongoing programs could be produced by indexing this material using the methodology discussed above. The cost would be higher than indexing a report of the same size because of the detailed nature of the indexing. The cost should be approximately comparable to that of indexing in depth an equivalent amount of Tech Brief Material.

In addition to a complete set of PADS information has also been collected on the individual or organization responsible for each part of the technical plan. For OART and T&DA this information is in the form of RTOP collections. For the other areas the information is in the form of lists which were obtained from the program offices at NASA Headquarters.

The first step in preparing a complete index would be to outline each of the technical plans, listing events in accordance with the indexing methodology. Each item on the list would then be assigned a responsible individual or organization using the information that has been collected. Key words would be chosen. Using the Thesaurus these would then be expanded into the final list of descriptors as discussed above. The final step would of course be the organization and production of the index itself.

This project has demonstrated the feasibility of indexing ongoing NASA programs using PADS as the source of information. The same indexing methodology, however, could be applied to other documents containing a brief description of technical plan. The nature of the methodology is such that the index generated would be particularly suited to technology transfer. Physical principles and novel relationships involved in the developing technology would be covered. The results of this project show that over 85% of the concepts in the technology should be covered by the indexing. Also over 85% of the descriptors chosen would be accurate. This completeness and accuracy for the indexing is considered quite satisfactory for application in technology transfer.

TABLE 7

NASA PADS

Number	Title	Pages of Technical Plan*
10-703-320	Special Support, Technology Applications	5-1/2
51-500-150	Tracking & Data Acquisition, Supporting R&T	4
51-500-311) 51-500-312)	T&DA, Network Operations & Equipment	3-1/2
61-880-160	Supporting R&T, Earth Observations	2-1/3
61-880-164	Supporting R&T, Communications	2-1/4
61-880-601	TIROS/TOS Improvements	2-1/3
61-880-604	Nimbus	7-1/2
61-880-607	Meteorological Soundings	4
61-880-608	Synchronous Meteorological Satellite	1-1/2
61-880-610	Cooperative Applications Satellite	1
61-880-611	Global Atmospheric Research	1-1/3
61-880-630	Applications Technology Satellites	3-1/3
61-880-640	Earth Resources Survey/Aircraft	1-5/6
61-880-641	Earth Resources Technology Satellite	1
61-880-855	Geodetic Satellites	3
70-700-130	OART Supporting Studies	1/2
70-705-789	OART Advanced Mission Studies	6
71-710-120	Power & Electric Propulsion SRT	5-1/2
71-710-704	SERT II	1-1/2

72-720-718	NERVA	5-2/3
72-720-321	Nuclear Rocket Development	1/3
72-720-121 72-720-122	SRT - Nuclear Rocket Systems) SRT - Nuclear Rocket Propulsion)	3-3/4
74-740-124	Supporting R&T	5-1/2
74-740-709	Small Space Vehicle Flight Experiments	1
74-740-711	Scout-Launched Reentry Flight Experiments	1
74-740-713	Scout-Launched Meteoroid Flight Experiments	1-1/4
74-740-727	Lifting-Body Flight Research Program	1
74-740-131	Aerospace Safety Research	1
75-750-125) 75-750-730)	Supporting R&T, RAMC	5
76-760-126	Advanced R&T	3
76-760-736	General Aviation Aircraft Technology	1-1/2
76-760-721	V/STOL Aircraft Technology	2-1/2
76-760-737	Subsonic Aircraft Technology	4
76-760-720	Subsonic Aircraft Technology Supporting R&T	3-1/2
76-760-722	Hypersonic Aircraft Technology	1-1/2
93-980-981	Advanced Studies - OMSF	16
79-780-129	Basic Research - OART	10
78-730-128	Chemicals Propulsion R&T	3-1/2
78-730-731	Chemical Propulsion Experimental Engineering	4-1/2
77-770-127	Human Factors Systems SRT	5
77-770-708	Small Biotechnology Flight Projects	1-1/2

77-770-735	Orbiting Frog Otholith	2/3
96-920-976	Space Shuttle	8
96-960-978	Skylab, Experimental Development	1-5/6
96-960-964	Skylab, Saturn Workshop I	1-1/3
96-960-965	Skylab, Apollo Telescope Mount	1-1/3
96-960-972	Skylab, Saturn IB Vehicle	1
96-960-973	Skylab, Saturn V Vehicle	1
96-960-961	Skylab, Spacecraft Modifications	1-1/3
96-960-996	Skylab, Program Support	5/6
96-960-991	Skylab, Payload Integration	5/6
96-940-995	Skylab, Mission Operations	5/6
96-975-975	Space Station	5
92-910-914	Apollo Spacecraft	6
92-910-933	Apollo, Saturn V Vehicle	5-1/3
92-910-921	Apollo, Mission Control Systems	2
92-910-924	Apollo Space Operations	2
92-910-950	Apollo, Launch Operations	1-1/3
92-910-955	Apollo, Launch Instrumentation	1
92-910-980	Apollo, Systems Engineering	1-1/2
92-980-908	Apollo, Advanced Development	1-1/6
92-910-392	Apollo, Contract Administration	--
84-810-195	Apollo, Lunar Science	1-1/6
84-810-385	Apollo, Lunar Data Analysis	1-1/6
89-830-180	Launch Vehicle Procurement, SRT	2-1/2

89-830-490	Scout	3-1/2
89-830-491	Centaur	3-1/2
89-830-492	Delta	6
89-830-496	Titan III C	2
84-840-185) 84-840-186)	Planetary Exploration, SRT	1/2
84-840-196	Planetary Astronomy	1
84-840-384	Planetary Exploration, Data Analysis	1-1/6
84-840-811	Pioneer	1-1/6
84-840-815	Viking	2
84-840-816	Mariner Mars '69	2
84-840-819	Mariner Mars '71	2
84-840-820	Mariner Venus Mercury '73	1
84-840-823	Helios	1-1/6
85-850-188	Physics & AStronomy, SRT	2
85-850-352	Physics & Astronomy, Airborne Research	1/2
85-850-385	Physics & Astronomy, Data Analysis	1-1/2
85-850-821	Orbiting Solar Observatories	2-3/4
85-850-831	Orbiting Astronomical Observatories	6
85-850-832	High Energy Astronomy Observatories	2-1/2
85-850-850	Explorers	10
85-850-879	Sounding Rockets	1
87-870-189	Bioscience, SRT	2
87-870-191	Planetary Quarentine	1-1/2
87-870-883	Biosatellite A, B, D	1

*Includes all technical material

APPENDIX A

INDEXING WORKSHEETS

PAD: 61-880-164 | Program: Space Applications

Office: OSSA | Project: Communications Supporting R&T

Chronological List of Events

Advanced Systems
- Advanced Signal processing - S
  - (A) System Approach - technique studies,
    - (A) Communication systems analysis,
      demand assignment communication systems
      signal processing
  - (B) Hardware Development
    - Communications satellite repeater studies
      digital implementation of analog demodulators
      millimeter wave communications
  - (P) Future information network

(O) Biomedical Telecommunications by Satellite - Applicability
- Definition of Needs - Interchange of data -
  between medical schools, diagnostic centers,
  laboratories and hospitals
- System Studies
- Hardware Tests

User Communications For Planned Systems
- (M) Determination of Needs
  Provide Continuing Updated Projections
- (C) Educational Communications Satellite System Study
- Evaluation

(D,Q) Navigation/Traffic Control
- Information Transmission from satellite to ships, aircraft
  mobile platforms
  - System Analysis - data transmission
    voice transmission
    position determination techniques
  - Hardware Development - data transmission
    voice transmission
    position determination equipment
  - Evaluation

Collision Related Studies
- System Analysis
  - Search -- rescue -- collision prevention
- Hardware Development
  - Search -- rescue -- collision prevention
- (E) Evaluation
  - Data collection and retrieval from fixed and moving platforms (balloons and buoys)

Traffic Control
- System Analysis - feasibility -- concept studies
  - over-ocean traffic control ships
  - land traffic control aircraft -
  - aircraft collision avoidance
- Hardware Development
  - position fix and collect sensor data from automated, fixed, and mobile platforms
- Evaluation

Communications
- Communication Technique Evaluation
  - (G) Laser communications
  - (N) Cost Factors for communication satellites
  - (N) Effect of parameters on communication services
  - (N) Efficient use of spectrum
  - (F) Tracking Data Relay Satellite systems
  - (F) Signal Design
  - (E) Network Communications
  - (A) Antenna beam shaping
  - (N) Data Processing
  - (N) Data Management
- Hardware Development
  - (F) Parametric Amplifiers
  - (F) VHF phased array receivers
  - (A) Antennas
  - (A) Multiple beam scannable high gain satellite antennas
  - (B) Multiple narrow beam shaped pattern antenna
  - (S) Cathode tubes
  - (S) High Efficiency Klystron tubes
  - (S) High power tubes
  - (S) RF Components
  - (T) High Power Communications Satellite Subsystems
- Testing
  - (A) Antenna beam shaping
  - Interference measurement
    - Radio interference

Improved Communication Satellite

Geodesy

(Z) Improved gravity field estimates
    Combine surface gravity and satellite perturbation
    Derive field from optical, doppler, a surface gravity data
        Models from these data
        Validate and test fields

(Z) Standard geometric and gravimetric reference system
    Development of requirements

Altimeters
    Test bed for evaluation
        Altimeters
        Altimeter Data
        Transmission Techniques

Applications Technology

(H) Stabilized Spacecraft
    feasibility study
    characteristics study

Sensor and Instrumentation Development

(A) Synchronous Orbit Thruster Motor
    Optimum attitude/period control
        Thruster selection

(A) Rendezvous with applications spacecraft
    Automated & Manned
        feasibility and characteristics

PAD: 61-880-164 Program: Space Applications

Office: OSSA Project: Communications Supporting R&T

Code	Key Word	Index Terms
A,B,P	Advanced Signal Processing	Signal Processing; Telemetry; Signal Encoding; Signal Analyzers; Signal Detection
A	Communication System Analysis	Telecommunication; Satellite Television Multichannel Communication; Space Communication; Radio Relay Systems; Satellite Networks
A	Communication Techniques	Communication Equipment; Telemetry Pulse Communication; Modulation; Signal Transmission Information Theory; Digital Systems Point to Point Communications; Communication Theory
A	Demand Assignment Communication Systems	Allocations; Data Links; Networks
B	Communication Devices & Circuits	Communication Equipment; Radio Equipment Satellite Television; Radio Relay Systems
B	Communication Satellite Repeater Studies	Repeaters; Relay; Communication Satellites
B	Digital Implementation of Analog Demodulators	Demodulators; Digital Systems; Detectors Digital Techniques; Heterodyning
B	Millimeter Wave Communications	Millimeter waves; Microwave Transmission Communication Equipment
P	Information Network	Data Link; Networks; Network Synthesis Communicating; Data Transmission
0	Biomedical Telecommunication	Biotelemetry; Bioengineering Biology; Medical Science; Telecommunication
0	Satellite Telecommunication	Spacecraft Communication
0	Biomedical Communication Analysis	Communicating; Point to Point Communications
0	Biomedical Data Interchange	Data Link; Data Retrieval
0	Medical School Data Interchange	Medical Phenomena; Medical Personnel Diagnosis; Diseases
0	Diagnostic Center Data Interchange	Clinical Medicine; Examination
0	Medical Laboratory Interchange	Medical Science; Medical Equipment
0	Hospital Data Interchange	Hospitals
0	Biomedical Telecommunication Systems	---

O	Telecommunication Hardware	Video Communication; Facsimile Communication
O	Telecommunication Testing	Telecommunication; Television Systems Tests; Test Equipment
M	User Communication Needs	Information; Information Retrieval Data Retrieval; Documents
C	Educational Communications Satellite	Educational Television; Communications Satellites
C	Educational Communications System	Training Devices Human Factors Engineering
M	Projections of User Needs	Forecasting; Planning
M	System Studies	Systems Analysis Telecommunication
D, Q	Navigation	Navigation Satellites Navigation; Navigation Aids Satellite Navigation Systems All-weather Air Navigation
D, Q	Sea Traffic Control	Ships; Surface Navigation
D, Q	Collision Avoidance	Collision Avoidance; Collisions Aircraft Guidance; Air Navigation
D, Q	Air Traffic Control	Air Traffic Control; Air Traffic; Aircraft Communication; Tracking (Position) Telecommunication
D, Q	Information Transmission	Transmission; Information Data Transmission; Satellite Transmission
D, Q	Satellite to Ship Transmission	Satellite Transmission Surface Navigation
D, Q	Satellite to Aircraft Transmission	Satellite Transmission Aircraft Communication
D, Q	Transmission to Mobile Platforms	Satellite Transmission Platforms; Flying Platforms
D, Q	Data Transmission Analysis	Data Transmission; Data Processing Information Theory; Transmission Efficiency
D, Q	Voice Transmission Systems	Voice Communication; Verbal Communication Voice Data Processing; Signal Encoding
D, Q	Position Determination	Position (Location); Positioning Navigation; Position Indicators
D, Q	Data Transmission Circuits	Data Links; Transmission Circuits
D, Q	Voice Transmission Hardware	Radiotelephones; Broadcasting
D, Q	Position Determination Equipment	Position Indicators; Aircraft Instruments Navigation Instruments
D, Q	Information Transmission Testing	Transmission Efficiency; Transmission Loss Signal Transmission; Attennation Coefficients
D, Q	Ship Collision Avoidance	Collision Avoidance; Collisions Traffic Control; Surface Navigation

D, Q	Aircraft Collision Avoidance	Collision Avoidance Air Traffic Control
D, Q	Collision Avoidance Systems	Collision Avoidance Systems
D, Q	Search Systems	Searching; Systems Search Radar; Reconnaissance
D, Q	Rescue Systems	Rescue Operations
D, Q	Search Hardware	Airport Surface Detection Equipment Search Radar
D, Q	Rescue Equipment	Spacecraft Recovery
E	Data Collection	Data Acquisition; Data Reduction Data Sampling; Observation
E	Fixed and Moving Platforms	Platforms; Flying Platforms Stabilized Platforms
E	Balloons	Balloons; Balloon Flight Balloon Sounding
E	Buoys	Buoys; Navigation Aids
D, Q	Ship Traffic Control	Ships; Surface Navigation
D, Q	Aircraft Traffic Control	Air Traffic Control; Air Traffic Aircraft Communication; Tracking (Position)
D, Q	Traffic Control Feasibility	Traffic Control; System Analysis
D, Q	Traffic Control Concepts	Traffic Control; System Analysis
D, Q	Over-ocean Traffic Control	Traffic Control; Surface Navigation
D, Q	Position Fix Equipment	Position Indicators; Indicating Instruments Distance Measuring Equipemtn; Navigation Instruments
D, Q	Collecting Sensor Data	Data Acquisition; Sensors
D, Q	Automated Platforms	Platforms; Flying Platforms
D, Q	Fixed Platforms	Platforms; Stabilized Platforms
D, Q	Mobile Platforms	Inertial Platforms; Flying Platforms
G	Laser Communications	Lasers; Optical Communication Visual Signals
N	Communication Satellites	Telecommunication Communication Satellites Space Communication Ground-Air-Ground Communications
N	Cost Analysis	Cost Estimates
N	Communication Service	Communicating; Telecommunication Communication Equipment, Comsat Program
N	Communication System Analysis	Communication Theory
N	Spectrum Utilization	Frequency Assignment; Communicating Maximum Useable Frequency
N	Bandwidth	Bandwidth; Channel Capacity Frequencies
N	Information Theory	Information Theory; Coding Telecommunication Communication Theory; Data Transmission

F	Tracking Data Relay Satellite Systems	Tracking Stations; Tracking Networks Satellite Tracking; Relay Satellites STADAN (Satellite Tracking Network)
F	Signal Design	Signal Analysis; Signal Generators Signal Distortion; Signal Reception
F	Network Communications	Satellite Networks; Communication Satellites Networks
A	Antenna Beam Shaping	Antennas; Directional Antennas Antenna Arrays Antenna Radiation Patterns
N	Data Processing	Data Processing; Signal Processing
N	Data Management	Data Systems
F	Parametric Amplifiers	Parametric Amplifiers Microwave Amplifiers
F	VHF Phased Array Receivers	Very High Frequencies; Phased Arrays Antenna Arrays; Receivers
A	Antennas	Antennas
A, B	Multiple Beam Antennas	Multiple Beam Interval Scanners
A	Scannable Antennas	Directional Antennas; Steerable Antennas Inertialess Steerable Antennas
A	High Gain Satellite Antennas	High Gain; Spacecraft Communication
B	Multiple Narrow Beam Antenna	Multiple Beam Interval Scanners Directional Antennas
B	Shaped Pattern Antenna	Antenna Radiation Patterns Antenna Arrays
S	Cathode Tubes	
S	High Efficiency Klystron	Klystrons; Microwave Tubes
S	High Power Tubes	Microwave Tubes; Vacuum Tubes Power Gain; Vacuum Tube Oscillators
S	RF Components	Radio Frequencies; Components Electronic Equipment; Solid State Devices
T	High Power Subsystems	Power; Power Limiters Power Supply Circuits
T	Communications Satellite Subsystems	Communication Satellites Communication Equipment
A	Antenna Beam Shaping	Antennas; Directional Antennas Antenna Arrays Antenna Radiation Patterns
A	Interference Measurement	Interference Electromagnetic Interference
A	Radio Interference	Radio Frequency Interference
	Gravity Field Estimates	Gravitational Field Gravimetry; Gravitational Effects
Z	Surface Gravity	Gravitational Constant
Z	Satellite Perturbation	Satellite Perturbation Gravitational Fields; Satellite Orbits

Z	Optical Data	Optical Tracking Optics; Optical Measurement Optical Properties; Optical Measuring Instruments
Z	Doppler Data	Doppler Effect; Doppler Navigation
Z	Gravity Measurement	Gravimetry; Gravimeters Gravitational Fields; Geodesy
Z	Gravity Calculations	Gravitation Theory; Gravitational Constant Gravitational Fields;
Z	Gravity Field Models	Gravitational Fields
Z	Standard Geometric Reference System	Geodetic Coordinates Reference Systems; Inertial Reference Systems Reference Systems
Z	Standard Gravimetric Reference System	Gravitational Field; Coordinates; Inertial Reference Systems
Z	Altimeters	Altimeters
Z	Altimeter Test Bed	Flight Instruments; Tests Altitude Tests; Test Equipment
Z	Altimeter Data	Altitude Position (Location)
Z	Altimeter Transmission Techniques	Altimeters Data Transmission
H	Stabilized Spacecraft Feasibility	Stabilized Platforms Spacecraft Stability
H	Stabilized Spacecraft Characteristics	Stability Derivatives Dynamic Characteristics Spacecraft Stability
H	Sensor Development	Sensors; Guidance Sensors Spacecraft Instruments
H	Instrumentation Development	Instrument Packages Spacecraft Instruments
A	Synchronous Orbit	Synchronous Satellites Syncom Satellites; Satellite Orbits
A	Thruster Motor	Rocket Engines; Thrust Thrust Vector Control
A	Optimum Attitude Control	Attitude Control; Rocket Engine Control Satellite Attitude Control
A	Optimum Period Control	Orbits; Satellite Orbits Spacecraft Guidance
A	Thruster Selection	Rocket Engines; Spacecraft Propulsion Propulsion System Performance
A	Spacecraft Rendezvous	Space Rendezvous Rendezvous Spacecraft

A	Applications Spacecraft	Applications Technology Satellites
A	Automated Rendezvous	Flight Mechanics; Orbital Rendezvous Rendezvous Trajectories; Unmanned Spacecraft
A	Manned Rendezvous	Rendezvous Guidance Manned Spacecraft
A	Rendezvous Feasibility	Space Rendezvous Command Guidance
A	Rendezvous Characteristics	Space Rendezvous; Rendezvous Trajectories Rendezvous Guidance

PAD: 71-710-120 Program: Power and Electric Propulsion

Office: OART Project: Supporting Research & Technology

Chronological List of Events:

Analysis of Alternative Power Systems

(M) Power versus mission
- Future mission analysis -- space power requirements
- Assessment of solar, chemical and nuclear systems -- electric propulsion analysis
- Small solar powered, electric thruster systems for spacecraft position control and unmanned planetary applications
- (B) Primary propulsion systems (solar and nuclear) for planetary and interplanetary missions

(M) Improvements in existing electric power systems
- New space environments -- improve reliability -- reduce weight -- increase efficiency -- lengthen useful life

(M) New System Concepts
- New space environments -- improve reliability -- reduce weight -- increase efficiency -- lengthen useful life

(G,M) Development of Nuclear Electric
- (M) Research to provide fundamental information needed for advanced systems
  - (F) Thermionic emission of surfaces -- theoretical and experimental -- plasma properties
  - High strength, high temperature metallic structural materials
  - Electrical Insulator Materials
- Research on new components and design techniques
  - Erosion and cavitation damage models for liquid turbines
  - (M) Liquid metal MHD components -- vapor liquid separators, supersonic two-phase nozzles,
  - Analysis and modeling of advanced systems
- Technology Development
  - High temperature, high strength refractory alloys -- corrosion resistant
  - (N) Insulator and thermoelectric materials -- for light-weight, high performance systems
  - (G) Evaluate major component designs
  - Evaluate failure modes of selected components, subsystems, and systems
  - Instruments for temperature, pressure flow, and electrical measurements

(Q) Spacecraft power system integration peculiar to nuclear systems

System Assembly
(G) AEC supplied heat source
NASA spacecraft
(E) Brayton, Rankine, thermionic, and/or thermoelectric conversion
(H) SNAP-8
long life (10,000/m), 30-50 kwe, reactor space power system
manned and unmanned applications
(G) System design -- reactor + a dynamic power conversion system
performance and life development of components for power conversion
bread boarded power conversion systems -- test data
compact, flight-representative system -- non-nuclear and then nuclear ground test
NASA Space Power Facility
(A) Nuclear Electric Safety
Design of specific space power system
Investigate basic phenomena -- aerodynamic re-entry heating
Develop technology base for assessment of safety of nuclear space power systems
To provide inputs to system designers
Safety analysis of specific systems
Advanced research in aerodynamics and re-entry dynamics
Structural design and hardware tests using radioactive material
Special testing
(R,O) Development of Solar Power
Research
(M) Improve resistance to degradation in space radiation environment up to 10 years life
Better metal-silicon contacts to take advantage of new light weight structures
(I) New solar cells with improved efficiency
(I) New solar cells with reduced costs

(M) Technology Development
Storing compactly large solar cell arrays for launch
Automatic deployment of large, lightweight arrays -- reliability
(M,K,I) Large Flexible Arrays
Structural & Flight dynamic interactions with
guidance and control
other spacecraft systems
Solar array orientation drive equipment
low power -- reliable
(M,B) Extend capability to new environmental extremes
Venus-Mercury flybys
Solar probes
Mars landers
Jupiter flybys and orbiters

(J,R) Development of Chemical Power

Research

non-aqueous electrolytes (organic, molten salt, solid)

(P) high energy density anodes and cathodes

basic electrochemistry of alkaline batteries

fuel cell catalysts, electrodes, and electrolyte control

(P) batteries for high and low temperature extremes

Environmental effects on electrochemical reactions

Zero gravity -- charge particle nuclear radiation

RF electromagnetic radiation

Technology Development

(P,M,J) High energy-density batteries - sealed, heat sterilizable

Use on capsules which enter or land on planetary surfaces

engineer and fabricate

(P,M,K,J) Rechargeable batteries -- long life

use on synchronous and low altitude earth orbits

applications and space science spacecraft

Manned earth and orbital vehicles

(J) One year fuel cell power systems

extension of life from a few weeks

Q shuttle power source

Emergency power systems on manned space stations

Electric Power for lunar shelters and lunar excursion vehicles

Development of Rechargeable Fuel Cells

Regeneration of fuel cell reactants

Extend usefulness to long duration missions

would complement solar cell and nuclear power systems

(S,R,O,M) Development of Power Conditioning and Distribution Systems

Research

Improvements in analytical theory of power processing circuits

Improvements in synthesis and dynamic analysis of power processing circuits

Identification, measurement, and control of stresses limiting life

Thermal, electrostatic, and other stresses

Failure analysis

Semiconductor-magnetic element interactions

(S) Technology

Identification of new processing and distribution concepts

Improved efficiency, weight, and reliability

(S) Development and demonstration

Solid state systems

Space shuttle circuits and devices

Station/Base and advanced aircraft

(M) Development of light weight processors
Solar electric propulsion
Direct broadcast applications

(N) Power systems technology -- isotope, thermoelectric
10 years life minimum

Long Range Objectives
Spacecraft missions of 10 years or longer without manual repair or resupply

(M) 50-100 KW single unit power processor
operating temperature range extended to 200-300°C from 50-85°C.

(S) Aircraft electrical system improvement
maintenance, weight, reliability, and complexity

Development of Electric Engines

(K) Resistojet -- NH_3 or H_2 and biowastes (e.g. CO_2)
reaction control system applications -- manned space stations
technology ready status in 3-5 years

(C) Ion engines with electric vectoring capability -- applications
North-South station keeping and maneuvering

(C) Electron Bombardment ion propulsion system -- spacecraft prime propulsion
Ground operation of complete closed loop system -- modular configuration
Solar power matching networks -- failure logic and switching networks

(L,D) Electric Thruster Technology

(L,D) Advanced thruster research -- physical phenomena -- mechanization -- efficient acceleration of propellants to propulsion velocities

(C) High efficiency electron bombardment ion thrusters in the low specific impulse range (1,000-3,000 sec.) to reduce power requirements

Electrostatic thrust vectoring of electron bombardment ion engines

High thrust, high density plasma accelerators for prime propulsion applications

Advanced Thruster Technology -- to improve candidate thruster systems for:

Position control of manned space stations-resistojet

Position control of applications satellites -- electric vectoring

Prime propulsion for small, automated spacecraft

PAD:	71-710-120	Program:	Power and Electric Propulsion
Office:	OART	Project:	Supporting Research and Technology

Code	Key Word	Index Terms
M	Mission Analysis	Mission Planning
M	Space Power Requirements	Missions; Electric Power Plants
M	Space Missions	Space Missions
M,B	Solar Power Systems Analysis	Solar Generators; Systems Analysis Direct Power Generators
M	Chemical Power Systems Analysis	Direct Power Generators; Fuel Cells; Electric Batteries; Systems Analysis
M,B	Nuclear Systems Analysis	Nuclear Electric Power Generation Systems Analysis
M	Electric Propulsion Analysis	Electric Propulsion
M	Electric Thruster Systems	Electric Rocket Engines
M	Spacecraft Position Control	Spacecraft Position Indicators Spacecraft Maneuvers; Positioning
M	Unmanned Planetary Applications	Interplanetary Flight; Interplanetary Spacecraft Space Exploration; Planetary Environments
M,B	Primary Propulsion Systems	Propulsion System Configurations; Propulsion
M,B	Planetary and Interplanetary Space Flight	Interplanetary Flight; Trajectory Analysis Interplanetary Spacecraft
M	Electric Power System Improvements	Electric Generators; Electric Power; Energy Conversion Efficiency; Weight Analysis
M	New Space Environments	Planetary Evnironments Extraterrestrial Environments
M	Improved Reliability	Reliability; Reliability Engineering
M,N	Weight Reduction	Low Weight; Weight Analysis
M,N	Increased Efficiency	Energy Conversion Efficiency; Power Efficiency Thermodynamic Efficiency

M	Lengthened Useful Life	Life (Durability); Service Life
M	New Power System Concepts	Spacecraft Power Supplies; Electric Power Auxiliary Power Sources; Direct Power Generators
G,M	Nuclear Electric	Nuclear Electric Power Generation Nuclear Electric Propulsion
F	Surface Thermionic Emission	Thermionic Emission; Thermionic Cathodes
F	Plasma Properties	Plasma Dynamics; Plasma Physics
G,M	High Strength Metallic Structural Materials	Structural Members; Construction Materials High Strength Alloys; High Strength Steels
G,M	High Temperature Metals	High Temperature; Metals; Alloys Heat Resistant Alloys
G,M,F,N	Electrical Insulator Materials	Electrical Insulation
G,M	New Nuclear System Components	Electric Generators; Nuclear Power Plants Nuclear Electric Power Generation
G,M	Erosion Damage Models	Erosion; Metal Surfaces; Pitting Deterioration
G,M	Cavitation Damage Models	Cavitation Corrosion; Erosion
G,M	Liquid Metal Turbines	Liquid Metals; Turbines Liquid Metal Cooled Reactors
G,M	Liquid Metal MHD Components	Magnetohydrodynamic Generators Liquid Metals; Magnetohydrodynamic Flow
G,M	Vapor Liquid Separators	Liquid Vapor Equilibrium Separators
G,M	Supersonic Two-Phase Nozzles	Supersonic Flow; Supersonic Nozzles Two Phase Flow
G,M	Advanced System Modeling	Dynamic Models; System Analysis Mathematical Models
G,M	Corrosion Resistant Alloys	Corrosion Resistance; Alloys
N	Thermoelectric Materials	Thermoelectric Materials
G,M	Failure Mode Analysis	Failure; System Failures Reliability Engineering
G,M	Measuring Instruments	Measuring Instruments
G,M	Temperature Measurement	Temperature Measuring Instruments Temperature Measurement

G,M	Pressure Measurement	Pressure Measurements
G,M	Flow Measurement	Flow Measurement
G,M	Electrical Measurements	Electrical Measurement
Q	Spacecraft/Power System Integration	Spacecraft Power Supplies Systems Engineering
G	Isotope and Reactor Heat Source	Nuclear Reactors; Isotopes Radioactive Materials
G,M	System Assembly	Systems Engineering; Assembly
E	Nuclear Electric Brayton Cycle	Nuclear Electric Power Generation Brayton Cycle
H	Nuclear Electric Rankine Cycle	Nuclear Electric Power Generation Rankine Cycle
F	Nuclear-Thermionic Conversion	Nuclear Electric Power Generation Thermionic Power Generation
N	Nuclear Thermoelectric Conversion	Nuclear Electric Power Generation Thermoelectric Power Generation
H	SNAP-8	SNAP-8; SNAP
H,G	Dynamic Power Conversion System	Electric Generators; Energy Conversion
H,G	Power Conversion Component Life	Life (Durability); Service Life
H	Breadboarded Systems	Breadboard Models
H	Test Data	Tests; Test Equipment
H	Flight Representative System	Flight Tests; Performance Tests
H	Ground Tests	Ground Tests; Test Facilities Performance Tests
H	Nuclear Ground Tests	Nuclear Electric Power Generation Ground Tests; Test Facilities Nuclear Reactions
H	Compact Power System	Systems Engineering; Electric Generators
H	NASA Space Power Facility	Space Power Unit Reactors; Test Facility Spacecraft Power Supplies
A	Nuclear Electric Safety	Reactor Safety
A	Aerodynamic Re-entry Heating	Aerodynamic Heating Re-entry Effects
A	Safety Assessment	Safety Factors; Safety; Hazards

A	Safety In Nuclear Power Design	Reactor Safety Nuclear Electric Power Generation
A	Safety Analysis of Specific Systems	System Analysis Accident Prevention
A	Re-entry Dynamics	Re-entry; Re-entry Effects Re-entry Trajectories
A	Aerodynamics	Aerodynamics
A	Hardware Tests Using Radioactive Material	Radioactive Materials; Radiation Hazards Radioactive Contaminants; Radioactivity
A	Structural Design Tests	Structural Design; Spacecraft Design Performance Tests
A	Special Testing	Space Electric Rocket Tests
R,O	Solar Power Systems	Solar Generators; Photoelectric Generators Solar Auxiliary Power Units; Solar Cells
R,O,M	Radiation Degradation of Solar Cells	Solar Cells; Radiation Effects Radiation Tolerance; Radiation Dosage
R,O,M	Space Radiation Environment	Extraterrestrial Radiation Extraterrestrial Environments
R,O	Metal-silicon Contacts	Silicon Junctions; Semiconductor Junctions Electric Contacts
R,O	Lightweight Solar Cell Array Structures	Solar Generators; Solar Collectors Solar Cells; Arrays; Low Weight
R,O.I	Improved Efficiency Solar Cells	Energy Conversion Efficiency Power Efficiency; Solar Cells
R,O,I	Lower Cost Solar Cells	Low Cost; Solar Cells
R,O,M	Stowing Solar Cell Arrays Compactly	Packaging; Space Storage Solar Generators
R,O,M	Launching Large Solar Cell Arrays	Launching; Solar Cells Solar Generators; Prelaunch Tests
R,O,M	Reliable and Automatic Deployment of Arrays	Reliability Engineering Solar Generators; Space Erectable Structures
R,O,M,K,I	Large Flexible Arrays	Solar Cells; Flexible Bodies Solar Generators
R,O,M,K,I	Structural Interactions	Structural Design
R,O,M,K,I	Flight Dynamic Interactions	Dynamic Characteristics Dynamic Response
R,O,M,K,I	Spacecraft Guidance and Control	Spacecraft Guidance Spacecraft Control
R,O,M,K,I	Effect on Spacecraft Systems	Systems Engineering; Spacecraft Design; Solar Generators

R,O,M,K,I	Solar Array Orientation	Solar Collectors Solar Auxiliary Power Units Solar Generators; Solar Position; Solar Cells
R,O,M,K,I	Reliable Drive Equipment	Mechanical Drives Aerospace Environments
R,O,M,B	New Environmental Extremes	Aerospace Environments Environmental Tests Space Environment Simulation
R,O,M,B	Venus-Mercury Flybys	Venus Atmosphere Venus Probes Mercury (Planet)
R,O,M,B	Solar Probes	Solar Probes
R,O,M,B	Mars Landers	Mars Excursion Module
R,O,M,B	Jupiter Flybys And Orbiters	Jupiter (Planet) Jupiter Atmosphere
R,J	Chemical Power Systems	Spacecraft Power Supplies Electrochemical Cells Electric Power Chemical Auxiliary Power Units
R,J	Non-aqueous Electrolytes	Electrolytes Ion Exchange Membrane Electrolytes Molton Salt Electrolytes
R,J	Organic Electrolytes	Electrolytes Organic Compounds
R,J	Molten Salt Electrolytes	Molten Salt Electrolytes
R,J	Solid Electrolytes	Electrolytes; Electric Conductors Ion Exchange Membrane Electrolytes
R,P,J	High Energy Density Electrodes	Electrodes; Fuel Cells Electrochemical Cells; Polarization
R,P,J	Alkaline Battery Electro-chemistry	Electrochemical Cells; Electrochemistry Alkaline Batteries
P,M,K,J,R	Lone Life rechargeable Batteries	Life (Durability); Electric Batteries Storage Batteries
P,M,K,J,R	Synchronous Orbits	Synchronous Satellites Stationary Orbits
P,M,K,J,R	Low altitude earth orbits	Low Altitude; Earth Orbits
P,M,K,J,R	Applications Spacecraft	Applications Technology Satellites
P,M,K,J,R	Space Science Spacecraft	Scientific Satellites
P,M,K,J,R	Manned Earth Orbital Vehicles	Earth Orbits Manned Spacecraft
J,R	Long life fuel cell systems	Life (Durability); Fuel Cells
J,Q,R	Shuttle power source	Space Shuttle Spacecraft Power Supplies

J,R	Space station emergency power	Space Stations; Emergencies Auxiliary Power Sources
J,R	Lunar shelter electric power	Lunar Shelters Auxiliary Power Sources
J,R	Lunar excursion vehicle power	Lunar Surface Vehicles Auxiliary Power Sources
J,R	Rechargeable Fuel Cells	Fuel Cells; Storage Batteries Regenerative Fuel Cells
J,R	Fuel Cell Reactant Regeneration	Regenerative Fuel Cells
J,R	Long Duration Missions	Life (Durability) Space Missions
J,R	Fuel Cell Catalysts	Electrocatalysts; Fuel Cells
J,R	Fuel Cell Electrodes	Fuel Cells; Electrodes Electrochemistry
J,R	Fuel Cell Electrolyte Control	Fuel Cells; Electrolytes Electrolytic Cells
J,R,P	High Temperature Batteries	High Temperature; Electric Batteries
J,R,P	Low Temperature Batteries	Low Temperature; Electric Batteries
J,R	Environmental Effects	Spacecraft Environments Environmental Engineering Environmental Tests
J,R	Electrochemical Reactions	Electrochemistry Electrochemical Cells
J,R	Zero Gravity	Weightlessness; Spacecraft Environments
J,R	Charge Particle Nuclear Radiation	Charged Particles; Nuclear Radiation Radiation Effects; Spacecraft Environments
J,R	RF Electromagnetic Radiation	Electromagnetic Radiation; Radio Waves Radiation Effects; Spacecraft Environment
R,P,M,J	High Energy Density Batteries	Electric Batteries; Energy Sources Energy Storage; Electric Power
R,P,M,J	Sealed, Heat Sterilizable Batteries	Electric Batteries; Spacecraft Sterilization Sterilization
R,P,M,J	Planetary Batteries	Spacecraft Power Supplies Electric Batteries; Interplanetary Spacecraft
R,P,M,J	Battery Fabrication	Fabrication; Electric Batteries
J,R	Fuel Cell Auxiliary Power	Fuel Cells Auxiliary Power Sources

S,R,O,M	Power Conditioning and Distribution	Power Supply Circuits; Power Supplies Power Transmission
S,R,O,M	Power Processing Circuit Theory	Power Supply Circuits
S,R,O,M	Circuit Synthesis and Analysis	Circuits
S,R,O,M	Failure Analysis	Circuit Reliability; Failure
S,R,O,M	Thermal Stresses	Thermal Stresses
S,R,O,M	Electrostatic Stresses	Electrostatics; Stresses Stress Analysis
S,R,O,M	Semiconductor-Magnet Element Interactions	Semiconductor Devices
S,R,O,M	Improved Efficiency	Energy Conversion Efficiency Power Efficiency
S,R,O,M	Improved Weight	Low Weight
S,R,O,M	Improved Reliability	Reliability
S,R,O,M	Solid State Systems	Solid State Devices
S,R,O,M	Space Shuttle Circuits and Devices	Space Shuttle; Space Stations Circuits
S,R,O,M	Station/Base and Advanced Aircraft	Aircraft; Space Stations
R,M,O,S	Lightweight Processors	Low Weight; Electric Generators
R,M,O,S	Solar Electric Propulsion	Solar Generators; Electric Propulsion
R,M,O,S	Direct Broadcast Applications	Radio Transmission; Broadcasting Radio Communication
R,M,O,S,N	Isotope Thermoelectric Power Systems	Thermoelectric Power Generation Radioisotope Batteries Radioactive Isotopes
R,M,O,S,N	Long Life Power Systems	Life (Durability) Electric Generators; Auxiliary Power Sources
R,M,O,S	Self-sustaining Systems	Self Repairing Devices Life (Durability)
R,M,O,S	Multikilowatt Processor	Electric Generators Spacecraft Power Supplies
R,M,O,S	High Temperature Operation	High Temperature High Temperature Tests
R,M,O,S	Improved Maintainability	Maintainability

R,M,O,S	Aircraft Electrical System	Auxiliary Power Sources Aircraft
R,M,O,S	Reduced Weight	Low Weight
R,M,O,S	Reduced Complexity	Reliability
L,D	Electric Thruster Technology	Rocket Engines; Electric Rocket Engines Thrust Vector Control
L,D	Thruster mechanization	Rockets; Spacecraft Components Thrust
L,D	Efficient Propellant Acceleration	Propellant Mass Ratio Propulsive Efficiency
L,D,C	Electron Bombardment Ion Thrusters	Ion Propulsion; Ion Engines Electron Beams; Electron-Ion Recombination
L,D,C	High Efficiency Ion Thrusters	Propulsive Efficiency
L,D,C	Low Specific Impulse Range	Specific Impulse
L,D,C	Electrostatic Thrust Vectoring	Thrust Vector Control Electrostatic Propulsion
L,D	High Thrust Plasma Accelerators	Thrust; High Thrust Plasma Accelerators; Plasma Propulsion
L,D	High Density Plasma Accelerators	Plasma Density Plasma Accelerators
L,D	Prime Propulsion Applications	Electric Propulsion; Spacecraft Propulsion Propulsion System Configurations
L,D	Position Control of Manned Space Stations	Manned Spacecraft; Space Stations Positioning; Position Errors
L,D	Position Control of Application Satellites	Applications Technology Satellites Positioning; Position Errors
L,D	Small Spacecraft Prime Propulsion	Spacecraft; Unmanned Spacecraft Propulsion System Configurations Spacecraft Propulsion
L,D	Electric Thruster Applications	Electric Rocket Engines Electric Propulsion
K	Resistojet	Resistojet Engines; Plasma Engines Electric Rocket Engines
K	Bio-Fuel Cells	Biochemical Fuel Cells Fuel Cells
K	Ammonia Fuel Cells	Ammonia; Fuel Cells
K	Hydrogen Fuel Cells	Hydrogen Oxygen Fuel Cells

K	Reaction Control of Spacecraft	Reaction Control; Thrust Control Altitude Control; Spacecraft Control
C	Ion Engines For Vectoring	Direction Control; Thrust Vector Control Ion Engines
C	Ion Engines In Applications Satellites	Ion Engines Applications Technology Satellites
C	North-South Station Keeping and Maneuvering	Station Keeping; Spacecraft Control Spacecraft Maneuvers
C	Electron Bombardment Ion Propulsion System	Ion Propulsion; Ion Engines; Electron Beams Electron-Ion Recombination
C	Spacecraft Prime Propulsion	Electric Propulsion; Spacecraft Propulsion Propulsion System Configurations
C	Ground Testing	Ground Tests Space Electric Rocket Tests
C	Power System Modular Configuration	Spacecraft Power Supplies Modules
C	Solar Power Matching Networks	Solar Generators; Power Supplies Power Supply Circuits
C	Failure Logic and Switching Networks	Switching Circuits System Failures; Fail-Safe Systems

APPENDIX B

REVISED SAMPLE - INDEX

SUPPORTING R&T, COMMUNICATIONS

INDEXING KEY

PAD: 61-880-164

Office: OSSA

Program: Space Applications

Project: Communications

Center: JPL

Code	Individual	Organization
A	R. Powell	Research and Advanced Development Program Office --Electronics

Center: Goddard Space Flight Center

Code	Individual	Organization
B J	T. Lynch J. Eckerman	Communications and Navigation Division
C	J. Miller	Communications and Navigation Division - Communications Technology Section
D E	G. Oer C. Cote	Communications and Navigation Division - Navigation & Data Collections Branch
F	G. Clark	Manned Flight Planning and Analysis Division - Advanced Plans and Techniques Branch
G	N. McAvoy	Advanced Development Division--Quantum Optics Section
H	H. Hoffman	Earth Observation Systems and Systems Engineering Division - Stabilization and Control Branch

I	E. Hymowitz	Earth Observation Systems and Systems Engineering Division - SATS Study Manager
K	S. Stevens	International Projects Office
L	H. Gerwin	ATS F&G Project

Center: Headquarters

Code	Individual	Organization
M	D. Silverman	Communications Programs - Systems Programs Chief
N	G. Andrus	Communications Satellite Programs Chief
Z		Geodetic Satellites Program Manager

Center: MSC

Code	Individual	Organization
O	D. Fielder	E&D Program Planning Office

Center: Ames Research Center

Code	Individual	Organization
P	J. Foster	Guidance and Navigation

Center: WS

Code	Individual	Organization
Q	W. Krabill	Directorate of Applied Science
R	L. Ross:	Directorate of Operations - Project Management Section

Center: Lewis Research Center

Code	Individual	Organization
S	R. Alexovich	Spacecraft Technology Division - Special Projects Office
T	R. Lovell	Spacecraft Technology Division - Spacecraft Systems Section
U	E. Davison	Spacecraft Technology Division - Flight Projects Branch

Center: Langley Research Center

Code	Individual	Organization
V	R. Parker	Flight Instrumentation Division

KEY WORD INDEX

ANTENNA ARRAYS
F - Goddard
B - Goddard
A - JPL

ANTENNA RADIATION PATTERNS
B - Goddard
A - JPL

ANTENNAS
A - JPL   S - Lewis   N - Headquarters

APPLICATIONS TECHNOLOGY SATELLITES

ATTENUATION COEFFICIENTS
D - Goddard
Q - WS

ATTITUDE CONTROL
H - Goddard

ATTITUDE INDICATORS
H - Goddard

BALLOON FLIGHT
E - Goddard

BALLOON SOUNDING
E - Goddard

BALLOONS
E - Goddard

BANDWIDTH
N - Headquarters

BIOENGINEERING
O - MSC

BIOLOGY
O - MSC

BIOTELEMETRY
O - MSC

BROADCASTING
D - Goddard   N - Headquarters
Q - WS   C - Goddard

BUOYS
E - Goddard

CHANNEL CAPACITY
N - Headquarters

CLINICAL MEDICINE
O - MSC

CODING
N - Headquarters

COLLISION AVOIDANCE
D - Goddard
Q - WS

COLLISIONS
D - Goddard
Q - WS

COMMAND GUIDANCE
A - JPL

COMMUNICATING
O - MSC
M - Headquarters
P - Ames
N - Headquarters

COMMUNICATION EQUIPMENT
B - Goddard
N - Headquarters
T - Lewis
A - JPL

COMMUNICATION SATELLITE
B - Goddard
T - Lewis

COMMUNICATION THEORY
A - JPL
C - Goddard
N - Headquarters

COMMUNICATIONS SATELLITES
C - Goddard
N - Headquarters
F - Goddard

COMPONENTS
S - Lewis

COMSAT PROGRAM
N - Headquarters

CONTROL
Q - WS

DIAGNOSIS
O - MSC

DIGITAL SYSTEMS
C - Goddard
B - Goddard

DIGITAL TECHNIQUES
B - Goddard

DIRECTIONAL ANTENNAS
A - JPL
B - Goddard

DISEASES
O - MSC

DISTANCE MEASURING EQUIPMENT
D - Goddard
Q - WS

DOCUMENTS
M - Headquarters

DOPPLER EFFECT
Z - Headquarters

DOPPLER NAVIGATION
Z - Headquarters

DYNAMIC CHARACTERISTICS
H - Goddard

EDUCATIONAL TELEVISION
C - Goddard N - Headquarters

ELECTROMAGNETIC INTERFERENCE
A - JPL

ELECTRONIC EQUIPMENT
S - Lewis

EXAMINATION
O - MSC

FACSIMILE COMMUNICATION
O - MSC M - Headquarters

FLIGHT INSTRUMENTS
Z - Headquarters

FADING
N - Headquarters
C - Goddard

FLYING PLATFORMS
D - Goddard
Q - WS
E - Goddard

FORECASTING
M - Headquarters

FREQUENCIES
N - Headquarters F- Goddard

FREQUENCY ASSIGNMENT
N - Headquarters

FREQUENCY MODULATION
C - Goddard

GEODESY
Z - Headquarters

GEODETIC COORDINATES
Z - Headquarters

GRAVIMETERS
Z - Headquarters

GRAVIMETRY
Z - Headquarters

GRAVITATION THEORY
Z - Headquarters

GRAVITATIONAL CONSTANT
Z - Headquarters

GRAVITATIONAL EFFECTS
Z - Headquarters

GRAVITATIONAL FIELDS
Z - Headquarters

GROUND-AIR-GROUND COMMUNICATIONS
N - Headquarters

GUIDANCE SENSORS
H - Goddard

HETERODYNING
B - Goddard

HIGH GAIN
A - JPL

HOSPITALS
O - MSC

HUMAN FACTORS ENGINEERING
C - Goddard

INDICATING INSTRUMENTS
D - Goddard
Q - WS

INERTIAL PLATFORMS
D - Goddard
Q - WS

INERTIAL REFERENCE SYSTEMS
Z - Headquarters

INFORMATION
M - Headquarters
D - Goddard
Q - WS

INFORMATION RETRIEVAL
M - Headquarters

INFORMATION THEORY
A - JPL
D - Goddard
Q - WS
N - Headquarters

INSTRUMENT PACKAGES
H - Goddard

INTERFERENCE
A - JPL

KLYSTRONS N - Headquarters
S - Lewis

LASERS
G - Goddard

INSTRUMENT LANDING SYSTEMS
Q - WS

IONOSPHERIC DISTURBANCES
C - Goddard

LOW NOISE
C - Goddard

MEDICAL EQUIPMENT
O - MSC

MEDICAL PERSONNEL
O - MSC

MEDICAL PHENOMENA
O - MSC

MEDICAL SCIENCE
O - MSC

MICROWAVE AMPLIFIERS
F - Goddard

MICROWAVE TRANSMISSION
B - Goddard

MICROWAVE TUBES
S - Lewis

MILLIMETER WAVES
B - Goddard
C- Goddard

MODULATION
A - JPL

MULTICHANNEL COMMUNICATION
A - JPL

MULTIPLE BEAM INTERVAL SCANNERS

B - Goddard

NAVIGATION
D - Goddard
Q - WS

NAVIGATION AIDS
D - Goddard
Q - WS
E - Goddard

MICROWAVES
A - JPL
C - Goddard

MIXING CIRCUITS
C - Goddard

NAVIGATION INSTRUMENTS
D - Goddard
Q - WS

NAVIGATION SATELLITES
D - Goddard
Q - WS

NETWORK SYNTHESIS
P - Ames

NETWORKS
A - JPL
P - Ames
F - Goddard

OBSERVATION
E - Goddard

OPTICAL COMMUNICATION
G - Goddard

OPTICAL MEASUREMENT
Z - Headquarters

OPTICAL MEASURING INSTRUMENTS
Z - Headquarters

OPTICAL PROPERTIES
Z - Headquarters

OPTICAL TRACKING
Z - Headquarters

OPTICS
Z - Headquarters

OPTICAL RADAR
G - Goddard

PARAMETRIC AMPLIFIERS
F - Goddard
C - Goddard

PHASED ARRAYS
F - Goddard

PHASE LOCKED SYSTEMS
A - JPL

PLANNING
M - Headquarters

PLATFORMS
D - Goddard

E - Goddard

POINT TO POINT COMMUNICATIONS
O - MSC

POSITION INDICATORS
D - Goddard
Q - WS

POSITION (LOCATION)
Z - Headquarters
D - Goddard
Q - WS

POSITIONING
D - Goddard
Q - WS

POWER
T - Lewis
N - Headquarters

POWER GAIN
S - Lewis
A - JPL

POWER LIMITERS
T - Lewis

POWER SUPPLY CIRCUITS
T - Lewis

PULSE COMMUNICATION
A - JPL

RADIO EQUIPMENT
B - Goddard

RADIO FREQUENCIES
S - Lewis

POWER TRANSMISSION
N- Headquarters

PROPAGATION
N - Headquarters
C - Goddard

QUEING THEORY
D - Goddard

RADIO FREQUENCY INTERFERENCE

A - JPL | N- Headquarters | F - Goddard

RADIO RELAY SYSTEMS

B - Goddard
A - JPL

RADIO TELEPHONES

D - Goddard
Q - WS

RECEIVERS

F - Goddard | N- Headquarters | C - Goddard

RECONNAISSANCE

D - Goddard
Q - WS

REFERENCE SYSTEMS

Z - Headquarters

RELAY

B - Goddard

RELAY SATELLITES

F - Goddard

REPEATERS

B - Goddard

RESCUE OPERATIONS

D - Goddard
Q - WS

SATELLITE NAVIGATION SYSTEMS
D - Goddard
Q - WS

SATELLITE NETWORKS
A - JPL
F - Goddard

Z - Headquarters

SATELLITE PERTURBATION
Z - Headquarters

SATELLITE TELEVISION

B - Goddard

SATELLITE TRACKING
F - Goddard

SATELLITE TRANSMISSION
D - Goddard
Q - WS

SEARCH RADAR
D - Goddard
Q - WS

SEARCHING
D - Goddard
Q - WS

SENSORS
H - Goddard
D - Goddard
Q - WS

SHIPS
D - Goddard
Q - WS

SIGNAL ANALYZERS
A - JPL
S - Lewis
P - Ames
F - Goddard

SCATTERING
C - Goddard

SCINTILLATION
C - Goddard

SIGNAL DETECTION
- A - JPL
- S - Lewis
- P - Ames

SIGNAL DISTORTION
- F - Goddard

SIGNAL ENCODING
- A - JPL
- S - Lewis
- P - Ames
- D - Goddard
- Q - WS

SIGNAL GENERATORS
- F - Goddard

SIGNAL PROCESSING
- A - JPL
- S - Lewis
- P - Ames
- N - Headquarters

SIGNAL RECEPTION
- F - Goddard

SIGNAL TRANSMISSION
- D - Goddard
- Q - WS
- A - JPL

SOLID STATE DEVICES
- S - Lewis

SPACE COMMUNICATION
- A - JPL
- N - Headquarters

SPACECRAFT COMMUNICATION
- A - JPL
- O - MSC

SOLAR CELLS
- N - Headquarters

SPACE INSTRUMENTS
H - Goddard

SPACECRAFT RECOVERY

Q - WS

SPACECRAFT STABILITY
H - Goddard

STABILITY DERIVATIVES
H - Goddard

STABILIZED PLATFORMS
E - Goddard
D - Goddard
Q - WS
H - Goddard

STADAN (SATELLITE TRACKING NETWORK)
F - Goddard

STEARABLE ANTENNAS
A - JPL

SURFACE NAVIGATION
D - Goddard
Q - WS

SYSTEM ANALYSIS
D - Goddard
Q - WS

SYSTEMS
D - Goddard
Q - WS

SYSTEMS ANALYSIS
M - Headquarters
C - Goddard

STATIONS
C - Goddard

STATIONARY ORBITS
N - Headquarters

SURVEILLANCE
Q - WS
D - Goddard

SYSTEMS ENGINEERING
M - Headquarters

TELECOMMUNICATION
- M - Headquarters
- D - Goddard
- Q - WS
- N - Headquarters
- A - JPL
- O - MSC

TELEMETRY
- A - JPL
- S - Lewis
- P - Ames

TELEVISION SYSTEMS
- O - MSC
- C - Goddard

TELEVISION TRANSMISSION
- M - Headquarters

TEST EQUIPMENT
- O - MSC
- Z - Headquarters

TESTS
- O - MSC
- C - Goddard
- Z - Headquarters

THRESHHOLDS
- C - Goddard
- D - Goddard

TRACKING NETWORKS
- F - Goddard
- N - Headquarters

TRACKING (POSITION)
- D - Goddard
- Q - WS

TRACKING STATIONS
- F - Goddard

TRAINING DEVICES
- C - Goddard

TRAFFIC CONTROL
- D - Goddard
- N - Headquarters
- Q - WS
- C - Goddard

TRANSMISSION
- D - Goddard
- Q - WS

TRANSMISSION CIRCUITS
D - Goddard
Q - WS

TRANSMISSION EFFICIENCY
D - Goddard
Q - WS

TRANSMISSION LOSS
D - Goddard
Q - WS

UNMANNED SPACECRAFT
A - JPL

VERBAL COMMUNICATION
D - Goddard
Q - WS

VIDEO COMMUNICATION
Ø - MSC

VOICE COMMUNICATION
D - Goddard
Q - WS

VOICE DATA PROCESSING
D - Goddard
Q - WS

TRAVELLING WAVE TUBES
S - Lewis
N - Headquarters

TRANSPONDERS
N - Headquarters

TRANSMITTERS
N - Headquarters

TROPOSPHERIC SCATTERING
C - Goddard

ULTRAHIGH FREQUENCIES
C - Goddard

APPENDIX C

REVISED SAMPLE INDEX

POWER & ELECTRIC PROPULSION SRT

INDEXING KEY

PAD:	71-710-120	Program:	Power & Electric Propulsion
Office:	OART	Project:	Power & Electric Propulsion SRT

Center: Ames

Code	Individual	Organization
A	G. Goodwin	Director of Astronautics
B	J. V. Foster	Director of Development

Center: Lewis

Code	Individual	Organization
C	E. A. Richley	Office of Chief of Operations Analysis & Planning
D	G. R. Seikel	Electromagnetic Propulsion Division - Plasma Physics Branch
E	D. R. Packe	Power Systems Division -Reactor Brayton Technology Branch
F	R. Breitwieser	Direct Energy Conversion Division - Thermionic Branch
G	S. J. Kaufman	Nuclear Systems Division
H	M. J. Saari	Power Systems Division -Power Systems Evaluation Branch
I	D. T. Bernatowicz	Direct Energy Conversion Division - Solar Cell Branch
J	H. J. Schwartz	Direct Energy Conversion Division - Electrochemistry Branch

Center: Langley

Code	Individual	Organization
K	C. H. Nelson	Office of Director For Space
L	G. W. Brooks	Office of Director For Structures

Center: JPL

Code	Individual	Organization
M	A. Briglio, Jr.	Research and Advanced Development Program Office - Space Power and Electric Propulsion

Center: Goddard

Code	Individual	Organization
N	J. Epstein	Engineering Physics Division - Advanced Power Section
O	W. R. Cherry	Engineering Physics Division
P	T. J. Hennigan	Engineering Physics Division - Electrochemical Power Sources Section

Center: Manned Spacecraft Center

Code	Individual	Organization
Q	W. E. Rice	PPD - Power Generation

KEY WORD INDEX

ARRAYS

O - Goddard

ASSEMBLY

M - JPL

ATTITUDE CONTROL
K - LRC

AUXILIARY POWER SOURCES
M - JPL

O - Goddard

N - Goddard
J - Lewis

BIOCHEMICAL FUEL CELLS
K - LRC

BRAYTON CYCLE
E - Lewis G - Lewis

BREADBOARD MODELS
H - Lewis

BROADCASTING

M - JPL

CAVIATATION CORROSION

M - JPL

CATHODES
C - Lewis

CESIUM DIODES
F - Lewis

CESIUM PLASMA
F - Lewis

CHEMICAL AUXILIARY POWER UNITS

J - Lewis

CIRCUIT RELIABILITY

O - Goddard
M - JPL

CIRCUITS

O - Goddard
M - JPL

CONSTRUCTION MATERIALS

M - JPL

CORROSION RESISTANCE

M - JPL

DETERIORATION

M - JPL

DIRECT POWER GENERATORS
M - JPL
B - Ames

DIRECTION CONTROL
C - Lewis

DYNAMIC CHARACTERISTICS

O - Goddard
M - JPL
K - LRC

DYNAMIC MODELS
G - Lewis
M - JPL

DYNAMIC RESPONSE

O - Goddard
M - JPL
K - LRC

CRITICAL MASS
G - Lewis

CROSS SECTIONS
G - Lewis

DIODES
G - Lewis

EARTH ORBITS
P - Goddard
M - JPL
K - LRC
J - Lewis

ELECTRIC BATTERIES
M - JPL
P - Goddard
K - LRC
J - Lewis

ELECTRIC CONDUCTORS

J - Lewis

ELECTRIC CONTACTS

O - Goddard

ELECTRIC GENERATORS
H - Lewis
G - Lewis

M - JPL
O - Goddard

N - Goddard

ELECTRIC POWER
M - JPL

P - Goddard
J - Lewis

ELECTRIC POWER PLANTS
M - JPL

ELECTRIC PROPULSION
L - LRC
D - Lewis
C - Lewis

M - JPL
O - Goddard

EFFICIENCY
C - Lewis

ENVIRONMENTAL TESTS

O - Goddard
M - JPL
B - Ames
J - Lewis

EROSION

M - JPL

EXTRATERRESTRIAL ENVIRONMENTS

O - Goddard
M - JPL

EXTRATERRESTRIAL RADIATION

O - Goddard
M - JPL

FABRICATION

P - Goddard
M - JPL
J - Lewis

FAILURE

O - Goddard
M - JPL
G - Lewis

FAIL-SAFE SYSTEMS
C - Lewis

FLEXIBLE BODIES

O - Goddard
M - JPL
K - LRC
I - Lewis

FLIGHT TESTS
H - Lewis

FLOW MEASUREMENT
G - Lewis
M - JPL

FISSION PRODUCTS
G - Lewis

FUEL CELLS
K - LRC
J - Lewis

P - Goddard
M - JPL

GROUND TESTS
H - Lewis
C - Lewis

HAZARDS
A - Ames

HEAT RESISTANT ALLOYS

M - JPL

HIGH STRENGTH ALLOYS

M - JPL

HIGH STRENGTH STEELS

M - JPL

HIGH TEMPERATURE

M - JPL
O - Goddard

J - Lewis
P - Goddard
G - Lewis

HIGH TEMPERATURE TESTS

M - JPL
O - Goddard

HIGH THRUST

D - Lewis

HYDROGEN OXYGEN FUEL CELLS
K - LRC

GIMBALS
C - Lewis

HEAT EXCHANGERS
G - Lewis

LIFE (DURABILITY) - Cont'd

H - Lewis
G - Lewis

O - Goddard

N - Goddard
P - Goddard
K - LRC

LIQUID METAL COOLED REACTORS

G - Lewis
M - JPL

LIQUID METALS

G - Lewis
M - JPL

LIQUID VAPOR EQUILIBRIUM

M - JPL

LOW ALTITUDE

P - Goddard
M - JPL
K - LRC
J - Lewis

LOW COST

O - Goddard
I - Lewis

LOW TEMPERATURE

J - Lewis

P - Goddard

LOW WEIGHT

O - Goddard
M - JPL
N - Goddard

LOW THRUST

L - Langley

MAINTAINABILITY

M - JPL
O - Goddard

MAGNETOHYDRODYNAMIC FLOW

M - JPL

MAGNETOHYDRODYNAMIC GENERATORS

M - JPL

MANNED SPACECRAFT

L - LRC
D - Lewis
P - Goddard
M - JPL
K - LRC

MARS EXCURSION MODULE

O - Goddard
M - JPL
B - Ames

MATHEMATICAL MODELS

G - Lewis
M - JPL

MEASURING INSTRUMENTS

G - Lewis
M - JPL

MECHANICAL DRIVES

O - Goddard
M - JPL
K - LRC

RADIOACTIVE CONTAMINANTS
A - Ames

RADIOACTIVE ISOTOPES

M - JPL
O - Goddard

N - Goddard

RADIOACTIVE MATERIALS
A - Ames
G - Lewis

RADIOACTIVITY
A - Ames

RADIOISOTOPE BATTERIES

M - JPL
O - Goddard

N - Goddard

RANKINE CYCLE
H - Lewis G - Lewis

REACTION CONTROL
K - LRC

REACTOR SAFETY
A - Ames

REACTIVITY
G - Lewis

RE-ENTRY
A - Ames

RE-ENTRY EFFECTS
A - Ames

RE-ENTRY TRAJECTORIES
A - Ames

REGENERATIVE FUEL CELLS
J - Lewis

RELIABILITY

M - JPL

O - Goddard

RELIABILITY ENGINEERING

O - Goddard

M - JPL

RESISTOJET ENGINES

K - LRC

ROCKET ENGINES

L - LRC

D - Lewis

ROCKETS

L - LRC

D - Lewis

SAFETY

A - Ames

SAFETY FACTORS

A - Ames

SCIENTIFIC SATELLITES

P - Goddard

M - JPL

K - LRC

SELF REPAIRING DEVICES

M - JPL

O - Goddard

SEMICONDUCTOR DEVICES

O - Goddard

M - JPL

SEMICONDUCTOR JUNCTIONS

O - Goddard

SEPARATORS

M - JPL

SERVICE LIFE

H - Lewis

M - JPL

SILICON JUNCTIONS

O - Goddard

SNAP

H - Lewis

SNAP 8

H - Lewis

SOLAR AUXILIARY POWER UNITS

O - Goddard
M - JPL
K - LRC
I - Lewis

SOLAR CELLS

O - Goddard
M - JPL
I - Lewis
K - LRC

SOLAR COLLECTORS

O - Goddard
M - JPL
K - LRC
I - Lewis

SOLAR GENERATORS

E - Lewis
O - Goddard
M - JPL
K - LRC

SOLAR GENERATORS Cont'd

I - Lewis
C - Lewis

B - Ames

SOLAR POSITION

O - Goddard
M - JPL
K - LRC
I - Lewis

SOLAR PROBES

O - Goddard
M - JPL
B - Ames

SOLID STATE DEVICES

O - Goddard
M - JPL

SPACE ELECTRIC ROCKET TESTS

A - Ames
C - Lewis

SPACE ENVIRONMENT SIMULATION

O - Goddard
M - JPL
B - Ames

SPACE ERECTABLE STRUCTURES

O - Goddard
M - JPL

SPACE EXPLORATION

M - JPL

SPACE MISSIONS

M - JPL

SPACE NAVIGATION

M - JPL

SPACE POWER UNIT REACTORS
H - Lewis

SPACE SHUTTLE

O - Goddard
M - JPL

Q - MSC

SPACE STATIONS

O - Goddard
M - JPL

L - LRC
D - Lewis

SPACE STORAGE

M - JPL

SPACECRAFT
L - LRC
D - Lewis

SPACECRAFT COMPONENTS
L - LRC

SPACECRAFT CONTROL

O - Goddard
M - JPL
K - LRC

C - Lewis

SPACECRAFT DESIGN

O - Goddard
M - JPL
K - LRC

A - Ames

SPACECRAFT GUIDANCE

M - JPL
K - LRC

SPACECRAFT MANEUVERS
M - JPL
C - Lewis

SPACECRAFT POSITION INDICATORS
M - JPL

SPACECRAFT POWER SUPPLIES

M - JPL
O - Goddard

J - Lewis
Q - MSC
P - Goddard
H - Lewis
C - Lewis

SPACECRAFT PROPULSION
L - LRC
D - Lewis
C - Lewis

SPACECRAFT STERILIZATION

P - Goddard
M - JPL

SPECIFIC IMPULSE
L - LRC
D - Lewis
C - Lewis

STATION KEEPING
C - Lewis

STATIONARY ORBITS

P - Goddard
M - JPL
K - LRC

STERILIZATION

P - Goddard
M - JPL
J - Lewis

STORAGE BATTERIES

P - Goddard
M - JPL
K - LRC
J - Lewis

STRESS ANALYSIS

O - Goddard
M - JPL

STRESSES

O - Goddard
M - JPL

STRUCTURAL DESIGN

O - Goddard
M - JPL
K - LRC
I - Lewis
A - Ames

STRUCTURAL MEMBERS

M - JPL

SUPERSONIC FLOW

M - JPL

SUPERSONIC NOZZLES

M - JPL

SWITCHING CIRCUITS
C - Lewis

SYNCHRONOUS SATELLITES
P - Goddard
M - JPL
K - LRC
J - Lewis

SYSTEM ANALYSIS
G - Lewis
M - JPL
A - Ames
B - Ames

SYSTEM FAILURES
G - Lewis
M - JPL
C - Lewis

SYSTEMS ENGINEERING
Q - MSC
G - Lewis
M - JPL
H - Lewis

O - Goddard
K - LRC

TEMPERATURE MEASUREMENT
G - Lewis
M - JPL

TEMPERATURE MEASURING INSTRUMENTS

M - JPL

TEST EQUIPMENT
H - Lewis

TEST FACILITIES
H - Lewis C - Lewis

TESTS
H - Lewis

THERMAL STRESSES

O - Goddard
M - JPL

THERMIONIC CATHODES
F - Lewis

THERMIONIC EMISSION
F - Lewis

THERMIONIC POWER GENERATION
F - Lewis

THERMODYNAMIC EFFICIENCY
M - JPL
N - Goddard

THERMOELECTRIC MATERIALS
N - Goddard

THERMOELECTRIC POWER GENERATION
N - Goddard
G - Lewis
M - JPL
O - Goddard

THRUST
L - LRC
D - Lewis

THRUST CONTROL
K - LRC

THRUST VECTOR CONTROL
L - LRC
D - Lewis
C - Lewis

TRAJECTORY ANALYSIS
M - JPL
B - Ames

TURBINES
G - Lewis
M - JPL

THERMIONIC CONVERTERS
F - Lewis
M - JPL
G - Lewis

THERMIONIC EMITTERS
F - Lewis

TRANSPORT THEORY
G - Lewis

TWO PHASE FLOW

M - JPL

UNMANNED SPACECRAFT

L - LRC
D - Lewis

VENUS ATMOSPHERE

M - JPL
B - Ames

VENUS PROBES

O - Goddard
M - JPL
B - Ames

WEIGHT ANALYSIS

M - JPL
N - Goddard

WEIGHTLESSNESS

J - Lewis