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

By William H. Clingman

Distribution of this report is provided in the interest of information exchange. Responsibility for the contents resides in the author or organization that prepared it.

Prepared by
W. H. CLINGMAN & CO.
MANAGEMENT and TECHNOLOGY CONSULTANTS
1600 LTV Tower
Dallas, Texas

for

TECHNOLOGY UTILIZATION OFFICE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Under Contract No. NASw-2368
29 May 1972
ACKNOWLEDGEMENT

The author wishes to acknowledge the guidance and assistance provided throughout the project by Royal G. Bivins, Jr. of the NASA Technology Utilization Office.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY</td>
<td>1</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>INDEXING METHODOLOGY</td>
<td>5</td>
</tr>
<tr>
<td>INDEXING NASA PROGRAMS</td>
<td>7</td>
</tr>
<tr>
<td>GENERATION OF A COMPLETE INDEX</td>
<td>15</td>
</tr>
</tbody>
</table>

## TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE 1. CHECKLIST FOR GENERATING TECHNICAL DESCRIPTORS</td>
<td>6</td>
</tr>
<tr>
<td>TABLE 2. SPECIFICITY OF TYPICAL PAD TECHNICAL PLANS</td>
<td>8</td>
</tr>
<tr>
<td>TABLE 3. SURVEY RESPONDENTS</td>
<td>10</td>
</tr>
<tr>
<td>TABLE 4. PAD TECHNICAL PLAN -- EXCERPT</td>
<td>12</td>
</tr>
<tr>
<td>TABLE 5. KEY WORDS AND INDEX TERMS FOR EXCERPT</td>
<td>13</td>
</tr>
<tr>
<td>TABLE 6. FINAL SET OF INDEX TERMS FOR EXCERPT</td>
<td>14</td>
</tr>
<tr>
<td>TABLE 7. NASA PADS</td>
<td>16</td>
</tr>
</tbody>
</table>

## APPENDICES

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. INDEXING WORKSHEETS</td>
<td>20</td>
</tr>
<tr>
<td>B. REVISED SAMPLE INDEX, SUPPORTING R&amp;T, COMMUNICATIONS</td>
<td>43</td>
</tr>
<tr>
<td>C. REVISED SAMPLE INDEX, POWER &amp; ELECTRIC PROPULSION SRT</td>
<td>63</td>
</tr>
</tbody>
</table>
INDEXING NASA PROGRAMS FOR TECHNOLOGY TRANSFER
METHODS DEVELOPMENT AND FEASIBILITY
FINAL REPORT

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. In this study it was shown that

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 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.

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\textsuperscript{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

Background

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?
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 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

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Man Years</th>
<th>Pages</th>
<th>Man - Years Per Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>78-730-128</td>
<td>Chemical Propulsion</td>
<td>330</td>
<td>6</td>
<td>55</td>
</tr>
<tr>
<td>78-730-73</td>
<td>Earth Observations Supporting R&amp;T</td>
<td>173</td>
<td>1-1/2</td>
<td>115</td>
</tr>
<tr>
<td>61-820-34</td>
<td>Communications Supporting R&amp;T</td>
<td>164</td>
<td>1-1/4</td>
<td>131</td>
</tr>
<tr>
<td>601-61-880-3</td>
<td>TIROS/TOS Improvements</td>
<td>42</td>
<td>1-1/3</td>
<td>32</td>
</tr>
<tr>
<td>604</td>
<td>Nimbus</td>
<td>401</td>
<td>7</td>
<td>57</td>
</tr>
<tr>
<td>604-61-880-3</td>
<td>Meteorological Soundings</td>
<td>53</td>
<td>3-1/2</td>
<td>15</td>
</tr>
<tr>
<td>608</td>
<td>Synchronous Meteorological Satellites</td>
<td>14+</td>
<td>2/3</td>
<td></td>
</tr>
<tr>
<td>610</td>
<td>Cooperative Applications Satellites</td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>680</td>
<td>Applications Technology Satellites</td>
<td>191</td>
<td>3-1/3</td>
<td>57</td>
</tr>
<tr>
<td>640</td>
<td>Earth Resources Survey/Aircraft</td>
<td>176</td>
<td>1-1/2</td>
<td>117</td>
</tr>
<tr>
<td>641</td>
<td>Earth Resources Technology Satellites</td>
<td>60+</td>
<td>1-1/3</td>
<td></td>
</tr>
<tr>
<td>855</td>
<td>Geodetic Satellites</td>
<td>18</td>
<td>6-1/2</td>
<td>3</td>
</tr>
<tr>
<td>51-500-312</td>
<td>Tracking and Data Acquisition</td>
<td>7885</td>
<td>8</td>
<td>980</td>
</tr>
</tbody>
</table>
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

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

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.
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**

<table>
<thead>
<tr>
<th>KEY WORDS</th>
<th>INDEX TERMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STABILIZED SPACECRAFT FEASIBILITY</td>
<td>STABILIZED PLATFORMS</td>
</tr>
<tr>
<td>STABILIZED SPACECRAFT CHARACTERISTICS</td>
<td>SPACECRAFT STABILITY</td>
</tr>
<tr>
<td>SENSOR DEVELOPMENT</td>
<td>STABILITY DERIVATIVES</td>
</tr>
<tr>
<td></td>
<td>DYNAMIC CHARACTERISTICS</td>
</tr>
<tr>
<td></td>
<td>SPACECRAFT STABILITY</td>
</tr>
<tr>
<td>INSTRUMENTATION DEVELOPMENT</td>
<td>SENSORS</td>
</tr>
<tr>
<td></td>
<td>GUIDANCE SENSORS</td>
</tr>
<tr>
<td></td>
<td>SPACECRAFT INSTRUMENTS</td>
</tr>
<tr>
<td></td>
<td>INSTRUMENT PACKAGES</td>
</tr>
<tr>
<td></td>
<td>SPACECRAFT INSTRUMENTS</td>
</tr>
</tbody>
</table>
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
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**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Pages of Technical Plan*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-703-320</td>
<td>Special Support, Technology Applications</td>
<td>5-1/2</td>
</tr>
<tr>
<td>51-500-150</td>
<td>Tracking &amp; Data Acquisition, Supporting R&amp;T</td>
<td>4</td>
</tr>
<tr>
<td>51-500-311)</td>
<td>T&amp;DA, Network Operations &amp; Equipment</td>
<td>3-1/2</td>
</tr>
<tr>
<td>51-500-312)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61-880-160</td>
<td>Supporting R&amp;T, Earth Observations</td>
<td>2-1/3</td>
</tr>
<tr>
<td>61-880-164</td>
<td>Supporting R&amp;T, Communications</td>
<td>2-1/4</td>
</tr>
<tr>
<td>61-880-601</td>
<td>TiROS/TOS Improvements</td>
<td>2-1/3</td>
</tr>
<tr>
<td>61-880-604</td>
<td>Nimbus</td>
<td>7-1/2</td>
</tr>
<tr>
<td>61-880-607</td>
<td>Meteorological Soundings</td>
<td>4</td>
</tr>
<tr>
<td>61-880-608</td>
<td>Synchronous Meteorological Satellite</td>
<td>1-1/2</td>
</tr>
<tr>
<td>61-880-610</td>
<td>Cooperative Applications Satellite</td>
<td>1</td>
</tr>
<tr>
<td>61-880-611</td>
<td>Global Atmospheric Research</td>
<td>1-1/3</td>
</tr>
<tr>
<td>61-880-630</td>
<td>Applications Technology Satellites</td>
<td>3-1/3</td>
</tr>
<tr>
<td>61-880-640</td>
<td>Earth Resources Survey/Aircraft</td>
<td>1-5/6</td>
</tr>
<tr>
<td>61-880-641</td>
<td>Earth Resources Technology Satellite</td>
<td>1</td>
</tr>
<tr>
<td>61-880-855</td>
<td>Geodetic Satellites</td>
<td>3</td>
</tr>
<tr>
<td>70-700-130</td>
<td>OART Supporting Studies</td>
<td>1/2</td>
</tr>
<tr>
<td>70-705-789</td>
<td>OART Advanced Mission Studies</td>
<td>6</td>
</tr>
<tr>
<td>71-710-120</td>
<td>Power &amp; Electric Propulsion SRT</td>
<td>5-1/2</td>
</tr>
<tr>
<td>71-710-704</td>
<td>SERT II</td>
<td>1-1/2</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Duration</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>72-720-718</td>
<td>NERVA</td>
<td>5-2/3</td>
</tr>
<tr>
<td>72-720-321</td>
<td>Nuclear Rocket Development</td>
<td>1/3</td>
</tr>
<tr>
<td>72-720-121</td>
<td>SRT - Nuclear Rocket Systems ( )</td>
<td></td>
</tr>
<tr>
<td>72-720-122</td>
<td>SRT - Nuclear Rocket Propulsion</td>
<td>3-3/4</td>
</tr>
<tr>
<td>74-740-124</td>
<td>Supporting R&amp;T</td>
<td>5-1/2</td>
</tr>
<tr>
<td>74-740-709</td>
<td>Small Space Vehicle Flight Experiments</td>
<td>1</td>
</tr>
<tr>
<td>74-740-711</td>
<td>Scout-Launched Reentry Flight Experiments</td>
<td>1</td>
</tr>
<tr>
<td>74-740-713</td>
<td>Scout-Launched Meteoroid Flight Experiments</td>
<td>1-1/4</td>
</tr>
<tr>
<td>74-740-727</td>
<td>Lifting-Body Flight Research Program</td>
<td>1</td>
</tr>
<tr>
<td>74-740-131</td>
<td>Aerospace Safety Research</td>
<td>1</td>
</tr>
<tr>
<td>75-750-125)</td>
<td>Supporting R&amp;T, RAMC</td>
<td>5</td>
</tr>
<tr>
<td>75-750-730)</td>
<td>Supporting R&amp;T, RAMC</td>
<td>5</td>
</tr>
<tr>
<td>76-760-126</td>
<td>Advanced R&amp;T</td>
<td>3</td>
</tr>
<tr>
<td>76-760-736</td>
<td>General Aviation Aircraft Technology</td>
<td>1-1/2</td>
</tr>
<tr>
<td>76-760-721</td>
<td>V/STOL Aircraft Technology</td>
<td>2-1/2</td>
</tr>
<tr>
<td>76-760-737</td>
<td>Subsonic Aircraft Technology</td>
<td>4</td>
</tr>
<tr>
<td>76-760-720</td>
<td>Subsonic Aircraft Technology Supporting R&amp;T</td>
<td>3-1/2</td>
</tr>
<tr>
<td>76-760-722</td>
<td>Hypersonic Aircraft Technology</td>
<td>1-1/2</td>
</tr>
<tr>
<td>93-980-981</td>
<td>Advanced Studies - OMSF</td>
<td>16</td>
</tr>
<tr>
<td>79-780-129</td>
<td>Basic Research - OART</td>
<td>10</td>
</tr>
<tr>
<td>78-730-128</td>
<td>Chemicals Propulsion R&amp;T</td>
<td>3-1/2</td>
</tr>
<tr>
<td>78-730-731</td>
<td>Chemical Propulsion Experimental Engineering</td>
<td>4-1/2</td>
</tr>
<tr>
<td>77-770-127</td>
<td>Human Factors Systems SRT</td>
<td>5</td>
</tr>
<tr>
<td>77-770-708</td>
<td>Small Biotechnology Flight Projects</td>
<td>1-1/2</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>77-770-735</td>
<td>Orbiting Frog Otholith</td>
<td>2/3</td>
</tr>
<tr>
<td>96-920-976</td>
<td>Space Shuttle</td>
<td>8</td>
</tr>
<tr>
<td>96-960-978</td>
<td>Skylab, Experimental Development</td>
<td>1-5/6</td>
</tr>
<tr>
<td>96-960-964</td>
<td>Skylab, Saturn Workshop I</td>
<td>1-1/3</td>
</tr>
<tr>
<td>96-960-965</td>
<td>Skylab, Apollo Telescope Mount</td>
<td>1-1/3</td>
</tr>
<tr>
<td>96-960-972</td>
<td>Skylab, Saturn IB Vehicle</td>
<td>1</td>
</tr>
<tr>
<td>96-960-973</td>
<td>Skylab, Saturn V Vehicle</td>
<td>1</td>
</tr>
<tr>
<td>96-960-961</td>
<td>Skylab, Spacecraft Modifications</td>
<td>1-1/3</td>
</tr>
<tr>
<td>96-960-996</td>
<td>Skylab, Program Support</td>
<td>5/6</td>
</tr>
<tr>
<td>96-960-991</td>
<td>Skylab, Payload Integration</td>
<td>5/6</td>
</tr>
<tr>
<td>96-940-995</td>
<td>Skylab, Mission Operations</td>
<td>5/6</td>
</tr>
<tr>
<td>96-975-975</td>
<td>Space Station</td>
<td>5</td>
</tr>
<tr>
<td>92-910-914</td>
<td>Apollo Spacecraft</td>
<td>6</td>
</tr>
<tr>
<td>92-910-933</td>
<td>Apollo, Saturn V Vehicle</td>
<td>5-1/3</td>
</tr>
<tr>
<td>92-910-921</td>
<td>Apollo, Mission Control Systems</td>
<td>2</td>
</tr>
<tr>
<td>92-910-924</td>
<td>Apollo Space Operations</td>
<td>2</td>
</tr>
<tr>
<td>92-910-950</td>
<td>Apollo, Launch Operations</td>
<td>1-1/3</td>
</tr>
<tr>
<td>92-910-955</td>
<td>Apollo, Launch Instrumentation</td>
<td>1</td>
</tr>
<tr>
<td>92-910-980</td>
<td>Apollo, Systems Engineering</td>
<td>1-1/2</td>
</tr>
<tr>
<td>92-980-908</td>
<td>Apollo, Advanced Development</td>
<td>1-1/6</td>
</tr>
<tr>
<td>92-910-392</td>
<td>Apollo, Contract Administration</td>
<td>--</td>
</tr>
<tr>
<td>84-810-195</td>
<td>Apollo, Lunar Science</td>
<td>1-1/6</td>
</tr>
<tr>
<td>84-810-385</td>
<td>Apollo, Lunar Data Analysis</td>
<td>1-1/6</td>
</tr>
<tr>
<td>89-830-180</td>
<td>Launch Vehicle Procurement, SRT</td>
<td>2-1/2</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Pages</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>89-830-490</td>
<td>Scout</td>
<td>3-1/2</td>
</tr>
<tr>
<td>89-830-491</td>
<td>Centaur</td>
<td>3-1/2</td>
</tr>
<tr>
<td>89-830-492</td>
<td>Delta</td>
<td>6</td>
</tr>
<tr>
<td>89-830-496</td>
<td>Titan III C</td>
<td>2</td>
</tr>
<tr>
<td>84-840-185</td>
<td>Planetary Exploration, SRT</td>
<td>1/2</td>
</tr>
<tr>
<td>84-840-186</td>
<td>Planetary Exploration, Data Analysis</td>
<td>1-1/6</td>
</tr>
<tr>
<td>84-840-196</td>
<td>Planetary Astronomy</td>
<td>1</td>
</tr>
<tr>
<td>84-840-211</td>
<td>Pioneer</td>
<td>1-1/6</td>
</tr>
<tr>
<td>84-840-215</td>
<td>Viking</td>
<td>2</td>
</tr>
<tr>
<td>84-840-216</td>
<td>Mariner Mars '69</td>
<td>2</td>
</tr>
<tr>
<td>84-840-219</td>
<td>Mariner Mars '71</td>
<td>2</td>
</tr>
<tr>
<td>84-840-220</td>
<td>Mariner Venus Mercury '73</td>
<td>1</td>
</tr>
<tr>
<td>84-840-223</td>
<td>Helios</td>
<td>1-1/6</td>
</tr>
<tr>
<td>85-850-188</td>
<td>Physics &amp; Astronomy, SRT</td>
<td>2</td>
</tr>
<tr>
<td>85-850-352</td>
<td>Physics &amp; Astronomy, Airborne Research</td>
<td>1/2</td>
</tr>
<tr>
<td>85-850-385</td>
<td>Physics &amp; Astronomy, Data Analysis</td>
<td>1-1/2</td>
</tr>
<tr>
<td>85-850-821</td>
<td>Orbiting Solar Observatories</td>
<td>2-3/4</td>
</tr>
<tr>
<td>85-850-831</td>
<td>Orbiting Astronomical Observatories</td>
<td>6</td>
</tr>
<tr>
<td>85-850-832</td>
<td>High Energy Astronomy Observatories</td>
<td>2-1/2</td>
</tr>
<tr>
<td>85-850-850</td>
<td>Explorers</td>
<td>10</td>
</tr>
<tr>
<td>85-850-879</td>
<td>Sounding Rockets</td>
<td>1</td>
</tr>
<tr>
<td>87-870-189</td>
<td>Bioscience, SRT</td>
<td>2</td>
</tr>
<tr>
<td>87-870-191</td>
<td>Planetary Quarantine</td>
<td>1-1/2</td>
</tr>
<tr>
<td>87-870-883</td>
<td>Biosatellite A, B, D</td>
<td>1</td>
</tr>
</tbody>
</table>

*Includes all technical material*
APPENDIX A
INDEXING WORKSHEETS
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

  (0) 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
<table>
<thead>
<tr>
<th>Code</th>
<th>Key Word</th>
<th>Index Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A,B,P</td>
<td>Advanced Signal Processing</td>
<td>Signal Processing; Telemetry; Signal Encoding; Signal Analyzers; Signal Detection</td>
</tr>
<tr>
<td>A</td>
<td>Communication System Analysis</td>
<td>Telecommunication; Satellite Television</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multichannel Communication; Space Communication; Radio Relay Systems; Satellite Networks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Communication Equipment; Telemetry; Pulse Communication; Modulation; Signal Transmission Information Theory; Digital Systems Point to Point Communications; Communication Theory</td>
</tr>
<tr>
<td>A</td>
<td>Communication Techniques</td>
<td>Allocations; Data Links; Networks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Communication Equipment; Radio Equipment; Satellite Television; Radio Relay Systems; Repeaters; Relay; Communication Satellites</td>
</tr>
<tr>
<td>A</td>
<td>Demand Assignment</td>
<td>Demodulators; Digital Systems; Detectors</td>
</tr>
<tr>
<td></td>
<td>Communication Systems</td>
<td>Digital Techniques; Heterodyning</td>
</tr>
<tr>
<td>B</td>
<td>Communication Devices &amp; Circuits</td>
<td>Millimeter waves; Microwave Transmission; Communication Equipment</td>
</tr>
<tr>
<td>B</td>
<td>Communication Satellite Repeater Studies</td>
<td>Data Link; Networks; Network Synthesis; Communicating; Data Transmission</td>
</tr>
<tr>
<td>B</td>
<td>Digital Implementation of Analog Demodulators</td>
<td>Biotelemetry; Bioengineering; Biology; Medical Science; Telecommunication</td>
</tr>
<tr>
<td>B</td>
<td>Millimeter Wave Communications</td>
<td>Spacecraft Communication</td>
</tr>
<tr>
<td>P</td>
<td>Information Network</td>
<td>Communicating; Point to Point Communications</td>
</tr>
<tr>
<td>O</td>
<td>Biomedical Telecommunication</td>
<td>Medical Phenomena; Medical Personnel</td>
</tr>
<tr>
<td>O</td>
<td>Satellite Telecommunication</td>
<td>Diagnosis; Diseases</td>
</tr>
<tr>
<td>O</td>
<td>Biomedical Communication Analysis</td>
<td>Clinical Medicine; Examination</td>
</tr>
<tr>
<td>O</td>
<td>Biomedical Data Interchange</td>
<td>Medical Science; Medical Equipment</td>
</tr>
<tr>
<td>O</td>
<td>Medical School Data Interchange</td>
<td>Hospitals</td>
</tr>
<tr>
<td>O</td>
<td>Diagnostic Center Data Interchange</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Medical Laboratory Interchange</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Hospital Data Interchange</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Biomedical Telecommunication Systems</td>
<td></td>
</tr>
</tbody>
</table>
Telecommunication Hardware
Telecommunication Testing
User Communication Needs
Educational Communications Satellite
Educational Communications System
Projections of User Needs
System Studies
Navigation
Sea Traffic Control
Collision Avoidance
Air Traffic Control
Information Transmission
Satellite to Ship Transmission
Satellite to Aircraft Transmission
Transmission to Mobile Platforms
Data Transmission Analysis
Voice Transmission Systems
Position Determination
Data Transmission Circuits
Voice Transmission Hardware
Position Determination Equipment
Information Transmission Testing
Ship Collision Avoidance

Video Communication;
Facsimile Communication
Telecommunication; Television Systems Tests; Test Equipment
Information; Information Retrieval
Data Retrieval; Documents
Educational Television;
Communications Satellites
Training Devices
Human Factors Engineering
Forecasting; Planning
Systems Analysis
Telecommunication
Navigation Satellites
Navigation; Navigation Aids
Satellite Navigation Systems
All-weather Air Navigation
Ships; Surface Navigation
Collision Avoidance; Collisions
Aircraft Guidance; Air Navigation
Aircraft Traffic Control; Air Traffic;
Aircraft Communication; Tracking (Position)
Telecommunication
Transmission; Information
Data Transmission; Satellite Transmission
Satellite Transmission
Surface Navigation
Satellite Transmission
Aircraft Communication
Satellite Transmission
Platforms; Flying Platforms
Data Transmission; Data Processing
Information Theory; Transmission Efficiency
Voice Communication; Verbal Communication
Voice Data Processing; Signal Encoding
Position (Location); Positioning
Navigation; Position Indicators
Data Links;
Transmission Circuits
Radiotelephones; Broadcasting
Position Indicators; Aircraft Instruments
Navigation Instruments
Transmission Efficiency; Transmission Loss
Signal Transmission; Attenuation Coefficients
Collision Avoidance; Collisions
Traffic Control; Surface Navigation

-25-
D, Q Aircraft Collision Avoidance Systems
D, Q Collision Avoidance Systems
D, Q Search Systems
D, Q Rescue Systems
D, Q Search Hardware
D, Q Rescue Equipment
E Data Collection
E Fixed and Moving Platforms
E Balloons
E Buoys
D, Q Ship Traffic Control
D, Q Aircraft Traffic Control
D, Q Traffic Control Feasibility
D, Q Traffic Control Concepts
D, Q Over-ocean Traffic Control
D, Q Position Fix Equipment
D, Q Collecting Sensor Data
D, Q Automated Platforms
D, Q Fixed Platforms
G Mobile Platforms
G Laser Communications
N Communication Satellites
N Cost Analysis
N Communication Service
N Communication System Analysis
N Spectrum Utilization
N Bandwidth
N Information Theory

Collision Avoidance
Air Traffic Control
Collision Avoidance Systems
Searching; Systems
Search Radar; Reconnaissance
Search Radar
Rescue Operations
Airport Surface Detection Equipment
Spacecraft Recovery
Data Acquisition; Data Reduction
Data Sampling; Observation
Platforms; Flying Platforms
Stabilized Platforms
Balloons; Balloon Flight
Balloons; Navigation Aids
Ships; Surface Navigation
Air Traffic Control; Air Traffic Aircraft Communication; Tracking (Position)
Traffic Control; System Analysis
Traffic Control; System Analysis
Traffic Control; Surface Navigation
Position Indicators; Indicating Instruments
Distance Measuring Equipment; Navigation Instruments
Data Acquisition; Sensors
Platforms; Flying Platforms
Platforms; Stabilized Platforms
Inertial Platforms; Flying Platforms
Lasers; Optical Communication
Visual Signals
Telecommunication
Communication Satellites
Space Communication
Ground-Air-Ground Communications
Cost Estimates
Communicating; Telecommunication
Communication Equipment, Comsat Program
Communication Theory
Frequency Assignment; Communicating
Maximum Useable Frequency
Bandwidth; Channel Capacity
Frequencies
Information Theory; Coding Telecommunication
Communication Theory; Data Transmission
Tracking Data Relay Satellite Systems

Signal Design

Network Communications

Antenna Beam Shaping

Data Processing

Data Management

Parametric Amplifiers

VHF Phased Array Receivers

A

Antennas

Multiple Beam Antennas

Scannable Antennas

High Gain Satellite Antennas

Multiple Narrow Beam Antenna

Shaped Pattern Antenna

Cathode Tubes

High Efficiency Klystron

High Power Tubes

RF Components

High Power Subsystems

Communications Satellite Subsystems

Antenna Beam Shaping

Interference Measurement

Radio Interference

Gravity Field Estimates

Surface Gravity

Satellite: Perturbation

Tracking Stations; Tracking Networks

Satellite Tracking; Relay Satellites

STADAN (Satellite Tracking Network)

Signal Analysis; Signal Generators

Signal Distortion; Signal Reception

Satellite Networks; Communication Satellites Networks

Antennas; Directional Antennas

Antenna Arrays

Antenna Radiation Patterns

Data Processing; Signal Processing

Data Systems

Parametric Amplifiers

Microwave Amplifiers

Very High Frequencies; Phased Arrays

Antenna Arrays; Receivers

High Gain; Spacecraft Communication

Directional Antennas; Steerable Antennas

Inertialless Steerable Antennas

Multiple Beam Interval Scanners

Directional Antennas

Antenna Radiation Patterns

Antenna Arrays

Klystrons; Microwave Tubes

Microwave Tubes; Vacuum Tubes

Power Gain; Vacuum Tube Oscillators

Radio Frequencies; Components

Electronic Equipment; Solid State Devices

Power; Power Limiters

Power Supply Circuits

Communication Satellites

Communication Equipment

Antennas; Directional Antennas

Antenna Arrays

Antenna Radiation Patterns

Interference

Electromagnetic Interference

Radio Frequency Interference

Gravitational Field

Gravimetry; Gravitational Effects

Gravitational Constant

Satellite Perturbation

Gravitational Fields; Satellite Orbits
<p>| 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 | Standard Geometric                                |
|     |                      | Reference System                                  |
| Z   | Standard Geometric  | Geodetic Coordinates                              |
|     | Reference System    | Reference Systems; Inertial Reference Systems     |
| Z   | Standard Gravimetric | Gravitational Field;                              |
|     | Reference System    | 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 | Stabilized Platforms                            |
|     | Feasibility          | Spacecraft Stability                              |
| H   | Stabilized Spacecraft | Stability Derivatives                           |
|     | Characteristics      | Dynamic Characteristics                           |
|     |                      | Spacecraft Stability                              |
| H   | Sensor Development   | Sensors; Guidance Sensors                        |
|     |                      | Spacecraft Instruments                           |
| H   | Instrumentation Develop- | Instrument Packages                |
|     | ment                 | 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                            |</p>
<table>
<thead>
<tr>
<th>A</th>
<th>Applications Spacecraft</th>
<th>Applications Technology Satellites</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Automated Rendezvous</td>
<td>Flight Mechanics; Orbital Rendezvous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rendezvous Trajectories; Unmanned Spacecraft</td>
</tr>
<tr>
<td>A</td>
<td>Manned Rendezvous</td>
<td>Rendezvous Guidance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manned Spacecraft</td>
</tr>
<tr>
<td>A</td>
<td>Rendezvous Feasibility</td>
<td>Space Rendezvous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Command Guidance</td>
</tr>
<tr>
<td>A</td>
<td>Rendezvous Characteristics</td>
<td>Space Rendezvous; Rendezvous Trajectories</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rendezvous Guidance</td>
</tr>
</tbody>
</table>
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
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
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,0) 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,L) 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,0,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

-32-
(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 -- NH₃ or H₂ and biowastes (e.g. CO₂)
   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
<table>
<thead>
<tr>
<th>Code</th>
<th>Key Word</th>
<th>Index Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Mission Analysis</td>
<td>Mission Planning</td>
</tr>
<tr>
<td>M</td>
<td>Space Power Requirements</td>
<td>Missions; Electric Power Plants</td>
</tr>
<tr>
<td>M</td>
<td>Space Missions</td>
<td>Space Missions</td>
</tr>
<tr>
<td>M,B</td>
<td>Solar Power Systems Analysis</td>
<td>Solar Generators; Systems Analysis</td>
</tr>
<tr>
<td>M</td>
<td>Chemical Power Systems Analysis</td>
<td>Direct Power Generators; Fuel Cells; Electric Batteries; Systems Analysis</td>
</tr>
<tr>
<td>M,B</td>
<td>Nuclear Systems Analysis</td>
<td>Nuclear Electric Power Generation Systems Analysis</td>
</tr>
<tr>
<td>M</td>
<td>Electric Propulsion Analysis</td>
<td>Electric Propulsion</td>
</tr>
<tr>
<td>M</td>
<td>Electric Thruster Systems</td>
<td>Electric Rocket Engines</td>
</tr>
<tr>
<td>M</td>
<td>Spacecraft Position Control</td>
<td>Spacecraft Position Indicators</td>
</tr>
<tr>
<td>M</td>
<td>Unmanned Planetary Applications</td>
<td>Spacecraft Maneuvers; Positioning</td>
</tr>
<tr>
<td>M,B</td>
<td>Primary Propulsion Systems</td>
<td>Interplanetary Flight; Interplanetary Spacecraft</td>
</tr>
<tr>
<td>M,B</td>
<td>Planetary and Interplanetary Space Flight</td>
<td>Space Exploration; Planetary Environments</td>
</tr>
<tr>
<td>M</td>
<td>Electric Power System Improvements</td>
<td>Propulsion System Configurations; Propulsion</td>
</tr>
<tr>
<td>M</td>
<td>New Space Environments</td>
<td>Interplanetary Flight; Trajectory Analysis</td>
</tr>
<tr>
<td>M</td>
<td>Improved Reliability</td>
<td>Interplanetary Spacecraft</td>
</tr>
<tr>
<td>M,N</td>
<td>Weight Reduction</td>
<td>Electric Generators; Electric Power; Energy Conversion Efficiency; Weight Analysis</td>
</tr>
<tr>
<td>M,N</td>
<td>Increased Efficiency</td>
<td>Planetary Environments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extraterrestrial Environments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reliability; Reliability Engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Weight; Weight Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy Conversion Efficiency; Power Efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thermodynamic Efficiency</td>
</tr>
<tr>
<td>Code</td>
<td>Topic</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>M</td>
<td>Lengthened Useful Life</td>
<td>Life (Durability); Service Life</td>
</tr>
<tr>
<td>M</td>
<td>New Power System Concepts</td>
<td>Spacecraft Power Supplies; Electric Power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auxiliary Power Sources; Direct Power Generators</td>
</tr>
<tr>
<td>G,M</td>
<td>Nuclear Electric</td>
<td>Nuclear Electric Power Generation</td>
</tr>
<tr>
<td>F</td>
<td>Surface Thermionic Emission</td>
<td>Thermionic Emission; Thermionic Cathodes</td>
</tr>
<tr>
<td>F</td>
<td>Plasma Properties</td>
<td>Plasma Dynamics; Plasma Physics</td>
</tr>
<tr>
<td>G,M</td>
<td>High Strength Metallic Structural Materials</td>
<td>Structural Members; Construction Materials</td>
</tr>
<tr>
<td>G,M</td>
<td>High Temperature Metals</td>
<td>High Strength Alloys; High Strength Steels</td>
</tr>
<tr>
<td>G,M</td>
<td>Electrical Insulator Materials</td>
<td>High Temperature; Metals; Alloys Heat Resistant Alloys</td>
</tr>
<tr>
<td>G,M</td>
<td>New Nuclear System Components</td>
<td>Electric Generators; Nuclear Power Plants</td>
</tr>
<tr>
<td>G,M</td>
<td>Erosion Damage Models</td>
<td>Nuclear Electric Power Generation</td>
</tr>
<tr>
<td>G,M</td>
<td>Cavitation Damage Models</td>
<td>Erosion; Metal Surfaces; Pitting Deterioration</td>
</tr>
<tr>
<td>G,M</td>
<td>Liquid Metal Turbines</td>
<td>Cavitation Corrosion; Erosion</td>
</tr>
<tr>
<td>G,M</td>
<td>Liquid Metal MHD Components</td>
<td>Liquid Metals; Turbines</td>
</tr>
<tr>
<td>G,M</td>
<td>Vapor Liquid Separators</td>
<td>Liquid Metal Cooled Reactors</td>
</tr>
<tr>
<td>G,M</td>
<td>Supersonic Two-Phase Nozzles</td>
<td>Magnetohydrodynamic Generators</td>
</tr>
<tr>
<td>G,M</td>
<td>Advanced System Modeling</td>
<td>Liquid Metals; Magnetohydrodynamic Flow</td>
</tr>
<tr>
<td>G,M</td>
<td>Corrosion Resistant Alloys</td>
<td>Separators</td>
</tr>
<tr>
<td>N</td>
<td>Thermoelectric Materials</td>
<td>Supersonic Flow; Supersonic Nozzles</td>
</tr>
<tr>
<td>G,M</td>
<td>Failure Mode Analysis</td>
<td>Two Phase Flow</td>
</tr>
<tr>
<td>G,M</td>
<td>Measuring Instruments</td>
<td>Dynamic Models; System Analysis</td>
</tr>
<tr>
<td>G,M</td>
<td>Temperature Measurement</td>
<td>Mathematical Models</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corrosion Resistance; Alloys</td>
</tr>
</tbody>
</table>

-35-
Pressure Measurement
Flow Measurement
Electrical Measurements
Spacecraft/Power System Integration
Isotope and Reactor Heat Source
System Assembly

Nuclear Electric Brayton Cycle
Nuclear Electric Rankine Cycle
Nuclear-Thermionic Conversion
Nuclear Thermoelectric Conversion
SNAP-8

Dynamic Power Conversion System
Power Conversion Component Life
Breadboarded Systems
Test Data
Flight Representative System
Ground Tests
Nuclear Ground Tests
Compact Power System
NASA Space Power Facility

Nuclear Electric Safety
Aerodynamic Re-entry Heating
Safety Assessment

Pressure Measurements
Flow Measurement
Electrical Measurement
Spacecraft Power Supplies
Systems Engineering
Nuclear Reactors; Isotopes
Radioactive Materials
Systems Engineering; Assembly
Nuclear Electric Power Generation Brayton Cycle
Nuclear Electric Power Generation Rankine Cycle
Nuclear Electric Power Generation Thermionic Power Generation
Nuclear Electric Power Generation Thermoelectric Power Generation
SNAP-8; SNAP
Electric Generators; Energy Conversion
Life (Durability); Service Life
Breadboard Models
Tests; Test Equipment
Flight Tests; Performance Tests
Ground Tests; Test Facilities Performance Tests
Nuclear Electric Power Generation Ground Tests; Test Facilities
Nuclear Reactions
Systems Engineering; Electric Generators
Space Power Unit Reactors; Test Facility
Spacecraft Power Supplies
Reactor Safety
Aerodynamic Heating
Re-entry Effects
Safety Factors; Safety; Hazards
A Safety In Nuclear Power Design
A Reactor Safety
A Nuclear Electric Power Generation
A System Analysis
A Accident Prevention
A Re-entry; Re-entry Effects
A Re-entry Trajectories
A Aerodynamics
A Space Electric Rocket Tests
A Hardware Tests Using Radioactive Material
A Radioactive Materials; Radiation Hazards
A Radioactive Contaminants; Radioactivity
A Structural Design; Spacecraft Design Performance Tests
A Structural Design Tests
A Performance Tests
A Space Electric Rocket Tests
A Special Testing
A Space Electric Rocket Tests
A Solar Power Systems
A Solar Generators; Photoelectric Generators
A Solar Auxiliary Power Units; Solar Cells
A Solar Cells; Radiation Effects
A Radiation Tolerance; Radiation Dosage
A Extraterrestrial Radiation
A Extraterrestrial Environments
A Metal-silicon Contacts
A Silicon Junctions; Semiconductor Junctions
A Lightweight Solar Cell Array Structures
A Solar Generators; Solar Collectors
A Solar Cells; Arrays; Low Weight
A Energy Conversion Efficiency
A Power Efficiency; Solar Cells
A Low Cost; Solar Cells
A Improved Efficiency Solar Cells
A Solar Generators; Solar Collectors
A Lower Cost Solar Cells
A Power Efficiency; Solar Cells
A Solar Generators; Solar Cells
A Stowing Solar Cell Arrays Compactly
A Packaging; Space Storage
A Launching; Solar Cells
A Solar Generators; Prelaunch Tests
A Re.Transactions Engineering
A Solar Generators; Space Erectable Structures
A Reliable and Automatic Deployment of Arrays
A Solar Generators; Space Erectable Structures
A Large Flexible Arrays
A Solar Cells; Flexible Bodies
A Structural Design
A Dynamic Characteristics
A Dynamic Response
A Spacecraft Guidance
A Spacecraft Guidance and Control
A Systems Engineering;
A Effect on Spacecraft Systems
A Spacecraft Design; Solar Generators
Solar Array Orientation  
R,0,M,K,I

Reliable Drive Equipment  
R,0,M,K,I

New Environmental Extremes  
R,0,M,B

Venus-Mercury Flybys  
R,0,M,B

Solar Probes  
R,0,M,B

Mars Landers  
R,0,M,B

Jupiter Flybys And Orbiters  
R,0,M,B

Chemical Power Systems  
R,J

Non-aqueous Electrolytes  
R,J

Organic Electrolytes  
R,J

Molten Salt Electrolytes  
R,J

Solid Electrolytes  
R,J

High Energy Density Electrodes  
R,P,J

Alkaline Battery Electrochemistry  
R,P,J

Lone Life rechargeable Batteries  
P,M,K,J,R

Synchronous Orbits  
P,M,K,J,R

Low altitude earth orbits  
P,M,K,J,R

Applications Spacecraft  
P,M,K,J,R

Space Science Spacecraft  
P,M,K,J,R

Manned Earth Orbital Vehicles  
P,M,K,J,R

Long life fuel cell systems  
J,R

Shuttle power source  
J,Q,R
Space station emergency power
Lunar shelter electric power
Lunar excursion vehicle power
Rechargeable Fuel Cells
Fuel Cell Reactant Regeneration
Long Duration Missions
Fuel Cell Catalysts
Fuel Cell Electrodes
Fuel Cell Electrolyte Control
High Temperature Batteries
Low Temperature Batteries
Environmental Effects
Electrochemical Reactions
Zero Gravity
Charge Particle Nuclear Radiation
RF Electromagnetic Radiation
High Energy Density Batteries
Sealed, Heat Sterilizable Batteries
Planetary Batteries
Battery Fabrication
Fuel Cell Auxiliary Power
Space Stations; Emergencies
Lunar Shelters
Lunar Surface Vehicles
Auxiliary Power Sources
Fuel Cells; Storage Batteries
Regenerative Fuel Cells
Fuel Cells; Electrodes
Electrochemistry
Fuel Cells; Electrolytes
Electrolytic Cells
High Temperature; Electric Batteries
Low Temperature; Electric Batteries
Space Missions
Electrocatalysts; Fuel Cells
Fuel Cells; Electrodes
Electrochemistry
Fuel Cells; Electrolytes
Electrolytic Cells
Life (Durability)
Spacecraft Environments
Environmental Engineering
Environmental Tests
Electrochemistry
Electrochemical Cells
Weightlessness; Spacecraft Environments
Charged Particles; Nuclear Radiation
Radiation Effects; Spacecraft Environments
Electromagnetic Radiation; Radio Waves
Radiation Effects; Spacecraft Environment
Electric Batteries; Energy Sources
Energy Storage; Electric Power
Electric Batteries; Spacecraft Sterilization
Sterilization
Spacecraft Power Supplies
Electric Batteries; Interplanetary Spacecraft
Fabrication; Electric Batteries
Fuel Cells
Auxiliary Power Sources
<table>
<thead>
<tr>
<th>Codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S,R,O,M</td>
<td>Power Conditioning and Distribution</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Power Processing Circuit Theory</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Circuit Synthesis and Analysis</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Failure Analysis</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Thermal Stresses</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Electrostatic Stresses</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Semiconductor-Magnet Element Interactions</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Improved Efficiency</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Improved Weight</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Improved Reliability</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Space Shuttle Circuits and Devices</td>
</tr>
<tr>
<td>S,R,O,M</td>
<td>Station/Base and Advanced Aircraft</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Lightweight Processors</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Solar Electric Propulsion</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Direct Broadcast Applications</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Isotope Thermoelectric Power Systems</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Long Life Power Systems</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Self-sustaining Systems</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Multikilowatt Processor</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>High Temperature Operation</td>
</tr>
<tr>
<td>R,M,O,S</td>
<td>Improved Maintainability</td>
</tr>
</tbody>
</table>

Power Supply Circuits; Power Supplies
Power Transmission
Power Supply Circuits
Circuits
Circuit Reliability; Failure
Thermal Stresses
Electrostatics; Stresses
Stress Analysis
Semiconductor Devices
Energy Conversion Efficiency
Power Efficiency
Low Weight
Reliability
Solid State Devices
Space Shuttle; Space Stations
Circuits
Aircraft; Space Stations
Low Weight; Electric Generators
Solar Generators; Electric Propulsion
Radio Transmission; Broadcasting
Radio Communication
Thermoelectric Power Generation
Radioisotope Batteries
Radioactive Isotopes
Life (Durability)
Electric Generators; Auxiliary Power Sources
Self Repairing Devices
Life (Durability)
Electric Generators
Spacecraft Power Supplies
High Temperature
High Temperature Tests
Maintainability
Aircraft Electrical System
Reduced Weight
Reduced Complexity
Electric Thruster Technology
Thruster mechanization
Efficient Propellant Acceleration
Electron Bombardment Ion Thrusters
High Efficiency Ion Thrusters
Low Specific Impulse Range
Electrostatic Thrust Vectoring
High Thrust Plasma Accelerators
High Density Plasma Accelerators
Prime Propulsion Applications
Position Control of Manned Space Stations
Position Control of Application Satellites
Small Spacecraft Prime Propulsion
Electric Thruster Applications
Resistojet
Bio-Fuel Cells
Ammonia Fuel Cells
Hydrogen Fuel Cells

Auxiliary Power Sources
Aircraft
Low Weight
Reliability
Rocket Engines; Electric Rocket Engines
Thrust Vector Control
Rockets; Spacecraft Components
Thrust
Propellant Mass Ratio
Propulsive Efficiency
Ion Propulsion; Ion Engines
Electron Beams; Electron-Ion Recombination
Propulsive Efficiency
Specific Impulse
Thrust Vector Control
Electrostatic Propulsion
Thrust; High Thrust
Plasma Accelerators; Plasma Propulsion
Plasma Density
Plasma Accelerators
Electric Propulsion; Spacecraft Propulsion
Propulsion System Configurations
Manned Spacecraft; Space Stations Positioning; Position Errors
Applications Technology Satellites Positioning; Position Errors
Spacecraft; Unmanned Spacecraft Propulsion System Configurations
Spacecraft Propulsion
Electric Rocket Engines
Electric Propulsion
Resistojet Engines; Plasma Engines
Electric Rocket Engines
Biochemical Fuel Cells
Fuel Cells
Ammonia; Fuel Cells
Hydrogen Oxygen Fuel Cells
Reaction Control of Spacecraft

Ion Engines For Vectoring

Ion Engines In Applications Satellites

North-South Station Keeping and Maneuvering

Electron Bombardment Ion Propulsion System

Spacecraft Prime Propulsion

Ground Testing

Power System Modular Configuration

Solar Power Matching Networks

Failure Logic and Switching Networks

Reaction Control; Thrust Control
Altitude Control; Spacecraft Control
Direction Control; Thrust Vector Control
Ion Engines
Ion Engines
Applications Technology Satellites
Station Keeping; Spacecraft Control
Spacecraft Maneuvers
Ion Propulsion; Ion Engines; Electron Beams
Electron-Ion Recombination
Electric Propulsion; Spacecraft Propulsion Propulsion System Configurations
Ground Tests
Space Electric Rocket Tests
Spacecraft Power Supplies Modules
Solar Generators; Power Supplies
Power Supply Circuits
Switching Circuits
System Failures; Fail-Safe Systems
APPENDIX B

REVISED SAMPLE - INDEX

SUPPORTING R&T, COMMUNICATIONS
### INDEXING KEY

**PAD:** 61-880-164  
**Program:** Space Applications  
**Office:** OSSA  
**Project:** Communications

**Center:** JPL

<table>
<thead>
<tr>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>R. Powell</td>
<td>Research and Advanced Development Program Office --Electronics</td>
</tr>
</tbody>
</table>

**Center:** Goddard Space Flight Center

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

<table>
<thead>
<tr>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>D. Silverman</td>
<td>Communications Programs - Systems Programs Chief</td>
</tr>
<tr>
<td>N</td>
<td>G. Andrus</td>
<td>Communications Satellite Programs Chief</td>
</tr>
<tr>
<td>Z</td>
<td></td>
<td>Geodetic Satellites Program Manager</td>
</tr>
</tbody>
</table>

Center: MSC

<table>
<thead>
<tr>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>D. Fielder</td>
<td>E&amp;D Program Planning Office</td>
</tr>
</tbody>
</table>

Center: Ames Research Center

<table>
<thead>
<tr>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>J. Foster</td>
<td>Guidance and Navigation</td>
</tr>
</tbody>
</table>

Center: WS

<table>
<thead>
<tr>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>W. Krabill</td>
<td>Directorate of Applied Science</td>
</tr>
<tr>
<td>R</td>
<td>L. Ross</td>
<td>Directorate of Operations - Project Management Section</td>
</tr>
<tr>
<td>Center: Lewis Research Center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Code</strong></td>
<td><strong>Individual</strong></td>
<td><strong>Organization</strong></td>
</tr>
<tr>
<td>S</td>
<td>R. Alexovich</td>
<td>Spacecraft Technology Division - Special Projects Office</td>
</tr>
<tr>
<td>T</td>
<td>R. Lovell</td>
<td>Spacecraft Technology Division - Spacecraft Systems Section</td>
</tr>
<tr>
<td>U</td>
<td>E. Davison</td>
<td>Spacecraft Technology Division - Flight Projects Branch</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Center: Langley Research Center</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code</strong></td>
</tr>
<tr>
<td>V</td>
</tr>
</tbody>
</table>
KEY WORD INDEX

AIR NAVIGATION
  D - Goddard
  Q - WS

AIR TRAFFIC
  D - Goddard
  Q - WS

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

AIRCRAFT COMMUNICATION
  D - Goddard
  Q - WS

AIRCRAFT GUIDANCE
  D - Goddard
  Q - WS

AIRCRAFT INSTRUMENTS
  D - Goddard
  Q - WS

AIRPORT SURFACE DETECTION EQUIPMENT
  Q - WS

ALL WEATHER AIR NAVIGATION
  D - Goddard
  Q - WS

ALTIMETERS
  Z - Headquarters

ALTITUDE
  Z - Headquarters

ALTITUDE TESTS
  Z - Headquarters
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
COORDINATES
  Z - Headquarters

COST ESTIMATES
  N - Headquarters

DATA ACQUISITION
  D - Goddard
  Q - WS
  E - Goddard

DATA LINK
  O - MSC
  D - Goddard
  Q - WS
  A - JPL
  P - Ames

DATA PROCESSING
  D - Goddard
  Q - WS
  N - Headquarters

DATA REDUCTION
  E - Goddard
  B - Goddard

DATA RETRIEVAL
  M - Headquarters
  O - MSC

DATA SAMPLING
  E - Goddard

DATA SYSTEMS
  N - Headquarters

DATA TRANSMISSION
  P - Ames
  D - Goddard
  Q - WS
  N - Headquarters
  Z - Headquarters

DEMODULATORS
  B - Goddard

DETECTORS
  B - Goddard

CROSSED FIELD AMPLIFIERS
  S - Lewis
DIAGNOSIS
0 - MSC

DIGITAL SYSTEMS
B - Goddard
C - Goddard

DIGITAL TECHNIQUES
B - Goddard

DIRECTIONAL ANTENNAS
A - JPL
B - Goddard

DISEASES
0 - 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
FLYING PLATFORMS
  D - Goddard
  Q - WS
  E - Goddard

FORECASTING
  M - Headquarters

FREQUENCIES
  N - Headquarters

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
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 RADAR
  G - Goddard

OPTICAL TRACKING
  Z - Headquarters

OPTICS
  Z - Headquarters

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

POWER TRANSMISSION
  N - Headquarters

PROPAGATION
  N - Headquarters
  C - Goddard

QUEING THEORY
  D - Goddard

PULSE COMMUNICATION
  A - JPL

RADIO EQUIPMENT
  B - Goddard

RADIO FREQUENCIES
  S - Lewis
RADIO FREQUENCY INTERFERENCE
A - JPL
F - Goddard
N - Headquarters

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

THRESHOLDS
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
  Q - MSC

VOICE COMMUNICATION
  D - Goddard
  Q - WS

VOICE DATA PROCESSING
  D - Goddard
  Q - WS

TRANSLATING WAVE TUBES
  S - Lewis
  N - Headquarters

TRANSPOUNDS
  N - Headquarters

TRANSMITTERS
  N - Headquarters

TROPOSPHERIC SCATTERING
  C - Goddard

ULTRAHIGH FREQUENCIES
  C - Goddard
APPENDIX C

REVISED SAMPLE INDEX

POWER & ELECTRIC PROPULSION SRT
**INDEXING KEY**

<table>
<thead>
<tr>
<th>PAD:</th>
<th>71-710-120</th>
<th>Program:</th>
<th>Power &amp; Electric Propulsion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office:</td>
<td>OART</td>
<td>Project:</td>
<td>Power &amp; Electric Propulsion SRT</td>
</tr>
</tbody>
</table>

**Center: Ames**

<table>
<thead>
<tr>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>G. Goodwin</td>
<td>Director of Astronautics</td>
</tr>
<tr>
<td>B</td>
<td>J. V. Foster</td>
<td>Director of Development</td>
</tr>
</tbody>
</table>

**Center: Lewis**

<table>
<thead>
<tr>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>E. A. Richley</td>
<td>Office of Chief of Operations Analysis &amp; Planning</td>
</tr>
<tr>
<td>D</td>
<td>G. R. Seikel</td>
<td>Electromagnetic Propulsion Division - Plasma Physics Branch</td>
</tr>
<tr>
<td>E</td>
<td>D. R. Packe</td>
<td>Power Systems Division - Reactor Brayton Technology Branch</td>
</tr>
<tr>
<td>F</td>
<td>R. Breitwieser</td>
<td>Direct Energy Conversion Division - Thermionic Branch</td>
</tr>
<tr>
<td>G</td>
<td>S. J. Kaufman</td>
<td>Nuclear Systems Division</td>
</tr>
<tr>
<td>H</td>
<td>M. J. Saari</td>
<td>Power Systems Division - Power Systems Evaluation Branch</td>
</tr>
<tr>
<td>I</td>
<td>D. T. Bernatowicz</td>
<td>Direct Energy Conversion Division - Solar Cell Branch</td>
</tr>
<tr>
<td>J</td>
<td>H. J. Schwartz</td>
<td>Direct Energy Conversion Division - Electrochemistry Branch</td>
</tr>
<tr>
<td>Center: Langley</td>
<td>Code</td>
<td>Individual</td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>C. H. Nelson</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>G. W. Brooks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Center: JPL</th>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>A. Briglio, Jr.</td>
<td>Research and Advanced Development Program Office - Space Power and Electric Propulsion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Center: Goddard</th>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>J. Epstein</td>
<td>Engineering Physics Division - Advanced Power Section</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>W. R. Cherry</td>
<td>Engineering Physics Division</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>T. J. Hennigan</td>
<td>Engineering Physics Division - Electrochemical Power Sources Section</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Center: Manned Spacecraft Center</th>
<th>Code</th>
<th>Individual</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q</td>
<td>W. E. Rice</td>
<td>PPD - Power Generation</td>
</tr>
</tbody>
</table>
KEY WORD INDEX

ACCIDENT PREVENTION
    A - Ames

AERODYNAMIC HEATING
    A - Ames

AERODYNAMICS
    A - Ames

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

AIRCRAFT
    M - JPL

ALKALINE BATTERIES
    P - Goddard
    J - Lewis

ALLOYS
    M - JPL

AMMONIA
    K - LRC

APPLICATIONS TECHNOLOGY SATELLITES
    L - LRC
    B - Ames
    C - Lewis
    P - Goddard
    M - JPL
    K - LRC
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

CAVITATION CORROSION
M - JPL

CHEMICAL AUXILIARY POWER UNITS
J - Lewis

CATHODES
C - Lewis

CESIUM DIODES
F - Lewis

CESIUM PLASMA
F - 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
<table>
<thead>
<tr>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRIC ROCKET ENGINES</td>
<td>M - JPL, K - LRC, L - LRC, D - Lewis</td>
</tr>
<tr>
<td>ELECTRICAL INSULATION</td>
<td>M - JPL, F - Lewis, N - Goddard</td>
</tr>
<tr>
<td>ELECTRICAL MEASUREMENT</td>
<td>G - Lewis, M - JPL</td>
</tr>
<tr>
<td>ELECTROCATALYSTS</td>
<td>J - Lewis</td>
</tr>
<tr>
<td>ELECTROCHEMICAL CELLS</td>
<td>J - Lewis, P - Goddard</td>
</tr>
<tr>
<td>ELECTROCHEMISTRY</td>
<td>J - Lewis, P - Goddard</td>
</tr>
<tr>
<td>ELECTRODES</td>
<td>J - Lewis, P - Goddard</td>
</tr>
<tr>
<td>ELECTROLYTES</td>
<td>J - Lewis</td>
</tr>
<tr>
<td>ELECTROLYTIC CELLS</td>
<td></td>
</tr>
<tr>
<td>ELECTRON-ION RECOMBINATION</td>
<td>L - LRC, D - Lewis, C - Lewis</td>
</tr>
</tbody>
</table>
ELECTRON BEAMS
  L - LRC
  C - Lewis

ELECTROSTATIC PROPULSION
  L - LRC
  D - Lewis
  C - Lewis

ELECTROSTATICS
  O - Goddard
  M - JPL

ENERGY CONVERSION
  H - Lewis
  G - Lewis

ENERGY CONVERSION EFFICIENCY
  O - Goddard
  M - JPL
  I - Lewis
  N - Goddard

ENERGY SOURCES
  P - Goddard
  M - JPL
  J - Lewis

ENERGY STORAGE
  P - Goddard
  M - JPL
  J - 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

FISSION PRODUCTS
G - Lewis

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

FLIGHT TESTS
H - Lewis

FLOW MEASUREMENT
G - Lewis
M - JPL
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
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
O - 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
MERCURY (PLANET)

M - JPL
B - Ames

METAL SURFACES

M - JPL

METALS

M - JPL

MISSION PLANNING

M - JPL

MISSIONS

M - JPL

MODULES

C - Lewis

MOLTEN SALT ELECTROLYTES

J - Lewis

NUCLEAR ELECTRIC POWER GENERATION

G - Lewis
M - JPL
E - Lewis
H - Lewis
A - Ames
F - Lewis
N - Goddard
B - Ames

NUCLEAR ELECTRIC PROPULSION

G - Lewis
L - Langley
M - JPL

NUCLEAR POWER PLANTS

G - Lewis
M - JPL

MONTE CARLO METHOD
G - Lewis

NEUTRALIZERS
C - Lewis

NEUTRON SPECTRA
G - Lewis

NUCLEAR FUEL ELEMENTS
G - Lewis
NUCLEAR REACTORS  
G - Lewis  
H - Lewis  

ORGANIC COMPOUNDS  
J - Lewis  

PACKAGING  
M - JPL  

PERFORMANCE TESTS  
H - Lewis  
A - Ames  

PHOTOELECTRIC GENERATORS  
O - Goddard  

PITTING  
M - JPL  

PLANETARY ENVIRONMENTS  
M - JPL  

PLASMA ACCELERATORS  
L - LRC  
D - Lewis  

PLASMA DENSITY  
L - LRC  
D - Lewis  

PLASMA DYNAMICS  
F - Lewis  

PLASMA ENGINES  
K - LRC  

PLASMA PHYSICS  
F - Lewis  

PLASMA PROPULSION  
L - LRC  
D - Lewis  

P-N JUNCTIONS  
I - Lewis
POLARIZATION
    P - Goddard
    J - Lewis

POSITION. ERRORS
    L - LRC

POSITIONING
    M - JPL
    L - LRC

POWER EFFICIENCY
    O - Goddard
    L - Lewis
    M - JPL
    N - Goddard

POWER SUPPLIES
    C - Lewis

    O - Goddard
    M - JPL

POWER SUPPLY CIRCUITS
    C - Lewis

    O - Goddard
    M - JPL

POWER TRANSMISSION
    O - Goddard
    M - JPL

PRELAUNCH TESTS
    O - Goddard
    M - JPL

PRESSURE MEASUREMENTS
    G - Lewis
    M - JPL
PROPELLANT MASS RATIO
L - LRC
D - Lewis

PROPULSION
M - JPL
B - Ames

PROPULSION SYSTEM CONFIGURATIONS
L - LRC
D - Lewis
C - Lewis
M - JPL
B - Ames

PROPULSIVE EFFICIENCY
L - LRC
D - Lewis
C - Lewis

RADIATION DOSAGE
M - JPL

RADIATION EFFECTS
I - Lewis
O - Goddard
G - Lewis
M - JPL

RADIATION HAZARDS
A - Ames

RADIATION TOLERANCE
O - Goddard
M - JPL

RADIO COMMUNICATION
M - JPL

RADIO TRANSMISSION
M - JPL
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

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
   O - Goddard
   M - JPL
   K - LRC
   E - Lewis
<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLAR GENERATORS Cont'd</td>
<td>I</td>
<td>Lewis</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Lewis</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Ames</td>
</tr>
<tr>
<td>SOLAR POSITION</td>
<td>O</td>
<td>Goddard</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>JPL</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>LRC</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>Lewis</td>
</tr>
<tr>
<td>SOLAR PROBES</td>
<td>O</td>
<td>Goddard</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>JPL</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Ames</td>
</tr>
<tr>
<td>SOLID STATE DEVICES</td>
<td>O</td>
<td>Goddard</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>JPL</td>
</tr>
<tr>
<td>SPACE ELECTRIC ROCKET TESTS</td>
<td>A</td>
<td>Ames</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Lewis</td>
</tr>
<tr>
<td>SPACE ENVIRONMENT SIMULATION</td>
<td>O</td>
<td>Goddard</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>JPL</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Ames</td>
</tr>
<tr>
<td>SPACE ERECTABLE STRUCTURES</td>
<td>O</td>
<td>Goddard</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>JPL</td>
</tr>
<tr>
<td>SPACE EXPLORATION</td>
<td>M</td>
<td>JPL</td>
</tr>
<tr>
<td>SPACE MISSIONS</td>
<td>M</td>
<td>JPL</td>
</tr>
<tr>
<td>SPACE NAVIGATION</td>
<td>M</td>
<td>JPL</td>
</tr>
</tbody>
</table>
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
<table>
<thead>
<tr>
<th>Category</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATIONARY ORBITS</td>
<td>P - Goddard</td>
</tr>
<tr>
<td></td>
<td>M - JPL</td>
</tr>
<tr>
<td></td>
<td>K - LRC</td>
</tr>
<tr>
<td>STERILIZATION</td>
<td>P - Goddard</td>
</tr>
<tr>
<td></td>
<td>M - JPL</td>
</tr>
<tr>
<td></td>
<td>J - Lewis</td>
</tr>
<tr>
<td>STORAGE BATTERIES</td>
<td>P - Goddard</td>
</tr>
<tr>
<td></td>
<td>M - JPL</td>
</tr>
<tr>
<td></td>
<td>K - LRC</td>
</tr>
<tr>
<td></td>
<td>J - Lewis</td>
</tr>
<tr>
<td>STRESS ANALYSIS</td>
<td>O - Goddard</td>
</tr>
<tr>
<td></td>
<td>M - JPL</td>
</tr>
<tr>
<td>STRESSES</td>
<td>O - Goddard</td>
</tr>
<tr>
<td></td>
<td>M - JPL</td>
</tr>
<tr>
<td>STRUCTURAL DESIGN</td>
<td>O - Goddard</td>
</tr>
<tr>
<td></td>
<td>M - JPL</td>
</tr>
<tr>
<td></td>
<td>K - LRC</td>
</tr>
<tr>
<td></td>
<td>I - Lewis</td>
</tr>
<tr>
<td></td>
<td>A - Ames</td>
</tr>
<tr>
<td>STRUCTURAL MEMBERS</td>
<td>M - JPL</td>
</tr>
<tr>
<td>SUPersonic Flow</td>
<td>M - JPL</td>
</tr>
<tr>
<td>SUPersonic Nozzles</td>
<td>M - JPL</td>
</tr>
</tbody>
</table>

-87-
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  
Q - 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  

-88-
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