

SECTION VII

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APPENDIX A DESCRIPTION OF PROCESS

DISCIPLINE WORKING GROUPS¹

Over the past two years, the Discipline Working Groups developed Discipline Science Plans for each NASA Life Sciences Division science disciplines. The plans describe the research required to support NASA life sciences goals and responsibilities.

NASA Life Sciences Goals	
Goal —	Ensuring the health, safety, and productivity of humans in space
Goal —	Acquiring fundamental scientific knowledge in space life sciences

The discipline plans, which include lists of critical questions that are prioritized within subdisciplinary categories, are:

1. Behavior, Performance and Human Factors
2. Regulatory Physiology
3. Cardiopulmonary
4. Environmental Health
5. Musculoskeletal
6. Neuroscience
7. Radiation Health
8. Cell and Developmental Biology
9. Plant Biology
10. Life Support, including CELSS
11. Planetary Protection
12. Exobiology

EXECUTIVE STEERING COMMITTEE²

GOALS

1. Define a robust research program and identify priorities required for exploration class missions based on current knowledge and the projected and realistic resources within the next 5 to 15 years. Include ground-based research, availability of facilities, flight opportunities, and international cooperation. Identify the risks associated with the proposed program.
2. In the event that a robust program is not possible, due to constraints such as availability of projected resources or schedule limitations, is there an alternative option for an adequate program? Identify the risks associated with such a program.
3. What are the most important (from a life sciences standpoint) robotic precursor missions and planetary protection research to be undertaken prior to human exploration?

Footnote 1. Discipline Working Groups — Extramural and center advisory groups (membership in Appendix F) that in conjunction with the Life Sciences Division Discipline Scientists, developed Science Plans (including a total of 500 critical questions) for each of the 12 NASA Life Sciences, science disciplines: Behavior, Performance and Human Factors; Regulatory Physiology; Cardiopulmonary; Environmental Health; Musculoskeletal; Neuroscience; Radiation Health; Cell and Developmental Biology; Plant Biology; Life Support, including CELSS; Planetary Protection; Exobiology.

Footnote 2. Executive Steering Committee — Discipline Working Group Chairpersons (see Footnote 1) or alternates, plus Headquarters and Center program managers and scientists (including program office representatives from Space Shuttle, Space Station Freedom, Aeronautics Exploration and Technology) who evaluated, revised and prioritized critical questions from Life Sciences Discipline Science Plans and developed a summary White Paper. See Appendix D for details of membership.

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4. Unrelated to applications, define the most promising and unique science activities that would be enabled by exploration mission(s).

STEP 1 *Identify What Needs To Be Known.*

Discipline Plans. The science discipline plans constitute the unconstrained Space Life Sciences program. The critical questions contained in the plans form the basis for determining recommendations.

For each discipline, identify and categorize all critical questions within each subdiscipline according to the following five categories: Each question may apply to more than one category. However, indicate the primary category of application by noting so with an asterisk (*). The committee was partitioned into discipline groups for completion of step 1 through step 5.

Categories for Research Program Critical Questions:

1. **Environmental Health and Life Support Systems:** Focuses on the activities required for sustaining a safe, livable, and habitable environment (artificial gravity can be considered during deliberations).
2. **Countermeasure Systems:** Assumes microgravity transfer vehicle. This includes activities required for developing, testing and validating countermeasures to ensure crew health and performance, and to minimize health risks throughout the mission(s).
3. **Medical Care Systems:** Focuses on activities required for acquiring the knowledge, procedures, and technology necessary for ensuring crew health.
4. **Enabled Science:** Activities that include the most promising and unique science enabled by exploration mission(s).
5. **Basic Science:** Activities that are not necessarily related to exploration missions, but offer scientifically promising and unique opportunities to pursue fundamental knowledge.

STEP 2: *Assumption for Assessing Criticality*

If the Agency commits to going to Mars (i.e., a 2014 - 2018 time frame) with a crew of five or six, identify within your discipline the critical questions for such a mission. Assess the criticality of each according to the scale below, and record your response in the appropriate column on the data sheet.

Criticality Scale

Level 1	Consensus That Answer Is Required For Mars Missions (Known Effect And Known Problem For Mission)
Level 2	Answers Might Be Required, But The Science Basis To Evaluate Risk Is Not Adequate
Level 3	Required For Practical Optimization of Resources (Or Counter measure Effectiveness) And Minimalization Of Risk
Level 4	Important Science That Is Relevant To Exploration Mission(s).

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STEP 3: *Assess Science Readiness Status for Research and Missions (For each critical question identified in Step 2)*

Science Readiness Levels

Level 1	Only Folklore of Practitioners And Anecdotal Data Available
Level 2	Basic Scientific Concept Formulated
Level 3	Ground Models Developed, Flight Validation Required
Level 4	Flight Validation Performed
Level 5	Countermeasures Identified
Level 6	Countermeasures Tested
Level 7	Operational Requirements Established

STEP 4: *Assess the Readiness of Technology Necessary for Research or Missions (For each critical question identified in Step 2)*

Technology Readiness Levels

Level 1	Technology Need Identified
Level 2	Technology And Conceptual Solution Available
Level 3	Component And/Or Breadboard Validation In Laboratory Environment Exists
Level 4	Component And/Or Breadboard Validation In Relevant Ground Or Space Environment Completed
Level 5	System/Subsystem Prototype Demonstration In A Relevant Ground Or Space Environment Completed
Level 6	System Prototype Demonstration In A Space Environment
Level 7	Actual System Completed And "Flight Qualified" Through Test And Demonstration
Level 8	Actual System "Flight Proven" Through Successful Mission Operations

STEP 5: *Determine Schedule Requirements Necessary for Critical Questions (For each critical question identified in Step 2)*

Schedule Questionnaire

1. When is the information required? (Near-Term (i.e., Less than 5 years) =1, Mid-Term (i.e., 6 to 10 years) = 2, Far-Term (i.e., More than 10 years) = 3)
2. What is the research time and effort required? (Substantial =1, Moderate =2, Low = 3)
3. Is there a clearly defined sequential path of scientific investigations? (Yes =1, No = 2, Do Not Know at This Time = 3)
4. Are parallel or alternative pathways appropriate? (Yes =1, No =2, Do Not Know at This Time = 3)

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STEP 6: *Prioritization of Disciplinary Critical Questions*

All critical questions, from Step 2, have now been partitioned into five categories (i.e., Environmental Health and Life Support Systems, Countermeasure Systems, Medical Care Systems, Enabled Science and Basic Science). In addition, each question has been assigned one of four levels of criticality. Step 6 is a discussion and review of these findings to determine if specific items need to be recategorized or reprioritized.

- *Include additional critical questions from the Disciplinary Plans or as ad hoc inputs from the Executive Steering Committee resulting from these discussions, as necessary.*

STEP 7: *Implementation Strategies For Life Sciences - Matching Resources to Programmatic Options*

- *Include discussion of national and international cooperative activities including specific flight platforms, as necessary.*
- *Complete for each critical question identified in Step 2 and record responses on data sheet.*

(a) Discussion and Validation of Schedule and Requirements -

1. Discuss and validate the discipline groups inputs on the data sheets provided. The critical questions have been ordered with reference to time criticality (based on assessments in Steps 3, 4, and 5) within each criticality level (i.e., 1 through 4) for three of the five categories (i.e., Environmental Health and Life Support Systems, Countermeasure Systems, and Medical Care Systems).

(b) Platform Requirements -

1. What facilities are necessary to complete the activity (i.e., ground, Shuttle/Spacelab, SSF, robotic precursor missions, unmanned free-flyer, Moon outposts)? (*Record response by marking "X" in the appropriate column; provide comments if "other" columns or robotic precursors are selected.*)

2. Are flight validation studies required and in what sequence? (*Yes = 1, No = 2; if yes, provide written comments.*)

(c) Resource Requirements - People and Facility Needs

1. Are current ground facilities (NASA Centers, Universities and private industry) sufficient to support the activity? (*Yes = 1, No = 2; if no, provide written comment on other facilities necessary to complete this activity*)

2. Is there a sufficient life sciences community of outstanding scientists committed or able to be recruited to support the activity? (*Yes = 1, No = 2*)

3. Will the activity serve as a vehicle for attracting new scientists into the NASA community? (*Yes = 1, No = 2*)

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(d) Discipline Consolidation -

Can this critical activity be grouped with any others from different disciplines?

- ___ 1 No - Can Not Be Grouped
- ___ 2 Do Not Know At This Time
- ___ 3 If Yes, Specify Discipline(s) and Provide Comments
- ___ 4 Behavior, Performance and Human Factors
- ___ 5 Regulatory Physiology
- ___ 6 Cardiopulmonary
- ___ 7 Environmental Health
- ___ 8 Musculoskeletal
- ___ 9 Neurosciences
- ___ 10 Radiation Health
- ___ 11 Cell and Developmental Biology
- ___ 12 Plant Biology
- ___ 13 Life Support, including CELSS
- ___ 14 Planetary Protection
- ___ 15 Exobiology

STEP 8: ***Committee Products and Recommendations.** The Committee is repartitioned into groups representing the categories (i.e., Environmental Health and Life Support Systems, Countermeasure Systems, Medical Care Systems, Enabled and Basic Science).*

1. Develop a White Paper for each category and include recommendations and priorities for constrained and robust life sciences programs:

AEROSPACE MEDICINE ADVISORY COMMITTEE³

GOAL - To recommend an integrated Life Sciences research strategy for human exploration missions.

PRODUCT - Organize critical research or technology development questions into explainable, defensible, executable areas of focus and include consideration of optimum sequence.

STEP 1 For each critical question determine whether the SSF centrifuge can be used to resolve the issue. If the centrifuge is required, indicate by placing an "X" in the appropriate column on the data sheet.

STEP 2 Review data and develop draft report for Life Sciences strategic considerations for human exploration missions.

Footnote 3. Aerospace Medicine Advisory Committee (AMAC) — A NASA Advisory Council committee that reviewed, and in some cases, revised and reprioritized critical questions to generate this report. See Appendices A & B for details of membership and process.

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APPENDIX C AMAC CHARTER FOR THIS REPORT

The Aerospace Medicine Advisory Committee (AMAC) is charged to develop an implementation strategy in support of human Mars exploration missions. This plan will identify specific projects and areas of research, both basic and applied, within NASA and in collaboration with other government agencies and countries which will contribute to these objectives.

In view of the tight fiscal constraints facing NASA and OSSA in the out-years, the plan should prioritize the research needs on spacelabs and SSF in order to support advanced human space flight missions. This process should include a review and prioritization of the projects, research hardware and other laboratory facilities which will be necessary to carry out this research in a phased and timely manner.

In developing the plan the Space Life Science Division 1991 Strategic Plan should be reviewed. Inputs from other advisory committees should also be obtained. Specifically include participation of the Life Sciences Advisory Subcommittee of the Space Science and Applications Advisory Committee as well as the National Academy of Science Committee on Space Biology and Medicine and other advisory committees as appropriate. Participation from a wide ranging group representing experts from other government agencies and countries is encouraged.

On a final note, the plan should recommend a strategy which is consistent with the budgets and schedules for implementing the manned space flight goals mentioned above.

The plan should be available by mid January 1992 to serve as a basis for establishing the 1993 to 2005 mission planning and resources baseline.

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