TECHNOLOGY FOR SPACE STATION EVOLUTION - A WORKSHOP

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

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ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

CREW GENERATED WASTES PROCESSING AND RECLAMATION

Background

Scope – This effort includes the design, development and evaluation of a waste processing system for recovery of useful products from crew generated wastes (e.g., urine, feces, brines, crew trash, etc.).

Objectives – Develop advanced waste processing technologies for the recovery of usable water and gases such as oxygen and nitrogen from heterogeneous wastes such as feces and non-metallic trash. Application of the technology to liquid wastes will also be explored with the goal of developing a single waste processing system which is operable on any waste regardless of its liquid or solid state. Significant reduction in the amounts of water and gases needed to be resupplied may be possible through on-orbit processing of these wastes. Additional life-cycle savings are also possible by reducing these wastes to high density residues. Development of a technology suitable for simultaneously processing heterogeneous wastes and liquid wastes such as urine, humidity condensate and waste hygiene water will reduce on-board resources by combining separate processes into a common, single unit.

Requirement – Crew trash and ECLSS waste can be as high as 6-8 lb/man-day. This represents a significant storage or return-to Earth logistics problem. Waste processing has the potential to reduce this penalty while providing useful products such as water, N_2 and CO_2.

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Program Plan

Approach - The effort will begin with the screening of candidate technologies through analysis, literature surveys and small-scale laboratory studies. The most promising candidate technologies identified in these studies will be further developed through analysis and laboratory experiments for detailed parametric studies. These studies will be used as the basis for selecting the most promising candidate(s) and developing, designing and fabricating a breadboard subsystem. The breadboard will be used in extensive performance evaluations and optimization studies. Results from the breadboard testing will be used to develop, design and fabricate an optimized breadboard system which will be tested to determine overall performance, safety, reliability, resource requirements, reclamation products, etc. Analytical models will be validated and refined as the development program progresses.

Deliverables - Development documentation (e.g., trade-off data, test results, etc.).

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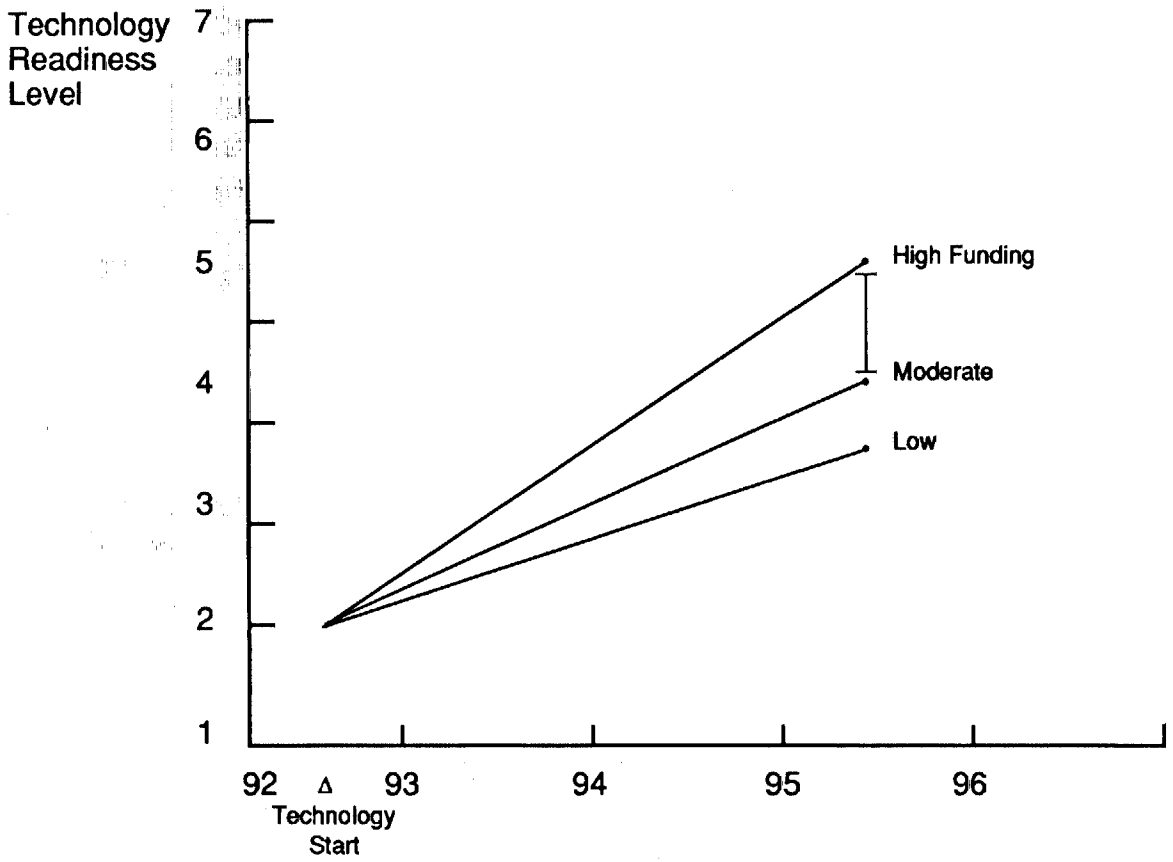
Technology Assessment



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WATER RECLAMATION - PRE- AND POST-TREATMENT

Background

Scope – Space station baseline uses expendable chemicals for urine pretreatment and thermal stabilization for potable and hygiene waste water pretreatment. Expendable sorption beds and biocide addition are used for post treating both potable and hygiene product waters. This effort will evaluate existing pre- and post-treatment processes and will identify and characterize alternatives that eliminate or minimize expendables. Candidate processes will be selected and demonstrated at a breadboard level.

Objectives – To improve waste water pre- and post-treatment processes for urine, hygiene, and potable water processors.

Rationale – The payback for developing alternative pre- and post-treatment processes that eliminate/minimize expendibles and maximize water recovery efficiency is the reduction of IVA tasks and logistics (resupply/return) penalties.

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WATER RECLAMATION - PRE- AND POST-TREATMENT

Program Plan

Approach-

1) Quantify existing baseline pre- and post-treatment processes
2) Identify alternate processes through literature search
3) Develop analytical models and trade candidate processes
4) Select most promising processes for development
5) Characterize processes at bench top level
6) Select and develop pre- and post-treatment hardware at breadboard level
7) Conduct breadboard performance characterization tests

Deliverables-

1) Development documentation, i.e., literature search, analytical models, tradeoffs, test results, etc.
2) Deliver breadboard hardware

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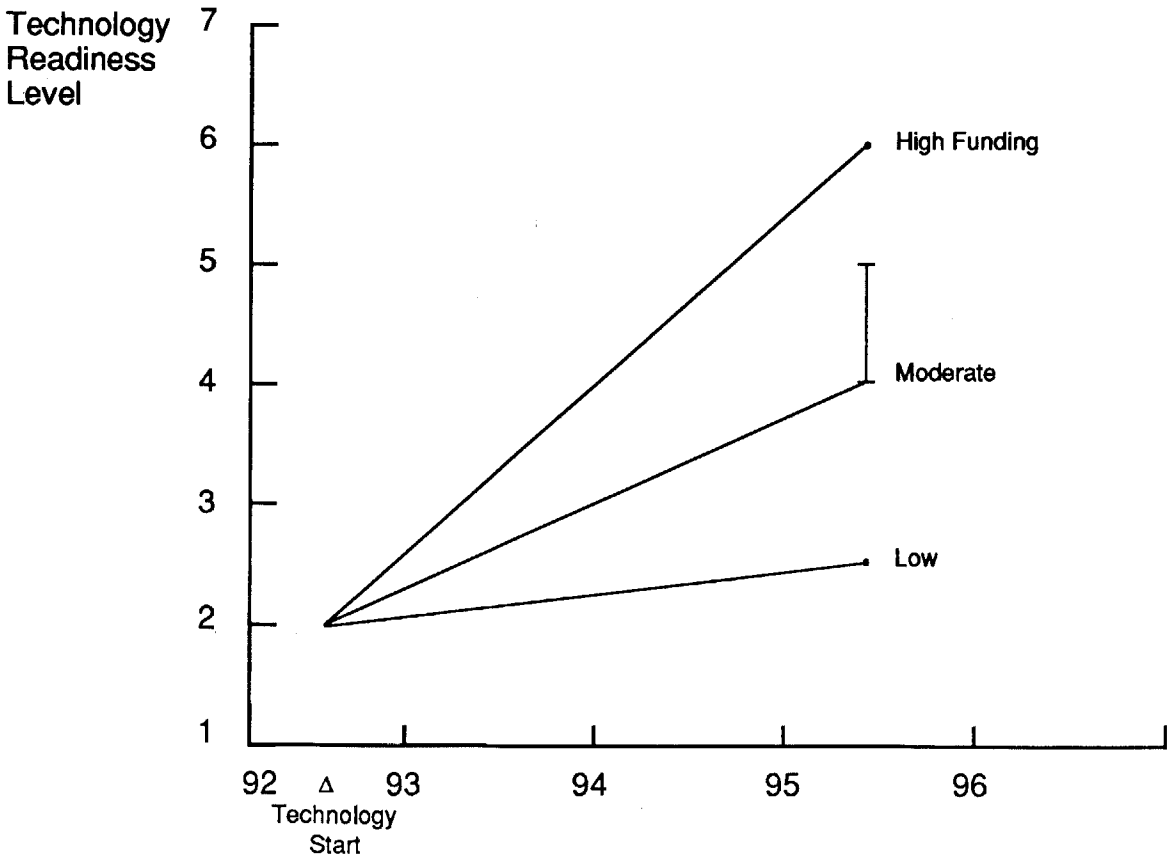
Technology Assessment



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SIMPLIFIED WASTE WATER PROCESSING

Background

Scope – Baselined space station waste water processing incorporates three waste water streams with individual processors and separate finished water post-treatment and storage requirements. Evaluation of waste water sources, baseline urine/hygiene/potable water processors and finished water distribution are required to identify and evaluate system simplification and resulting scarring. Concept validation tests will provide basis for selection, development and testing of an integrated breadboard system.

Objectives – Simplification of multiple waste water stream processing.

Requirement – Combining waste water sources and processing into a single waste stream will simplify water recovery processing; post treatment, storage, and distribution. Single stream processing results in reducing system complexity.

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SIMPLIFIED WASTE WATER PROCESSING

Program Plan

Approach -

1) Identify and evaluate system simplification and scarring impacts
2) Analyze and model candidate approaches
3) Evaluate candidate integrated system compatibility with single stream water processing approach
4) Select single stream process concept
5) Concept verification testing at fractional capacity

Deliverables -

1) Development documentation, i.e., analytical model, tradeoffs, test data, etc.
2) Preliminary system design

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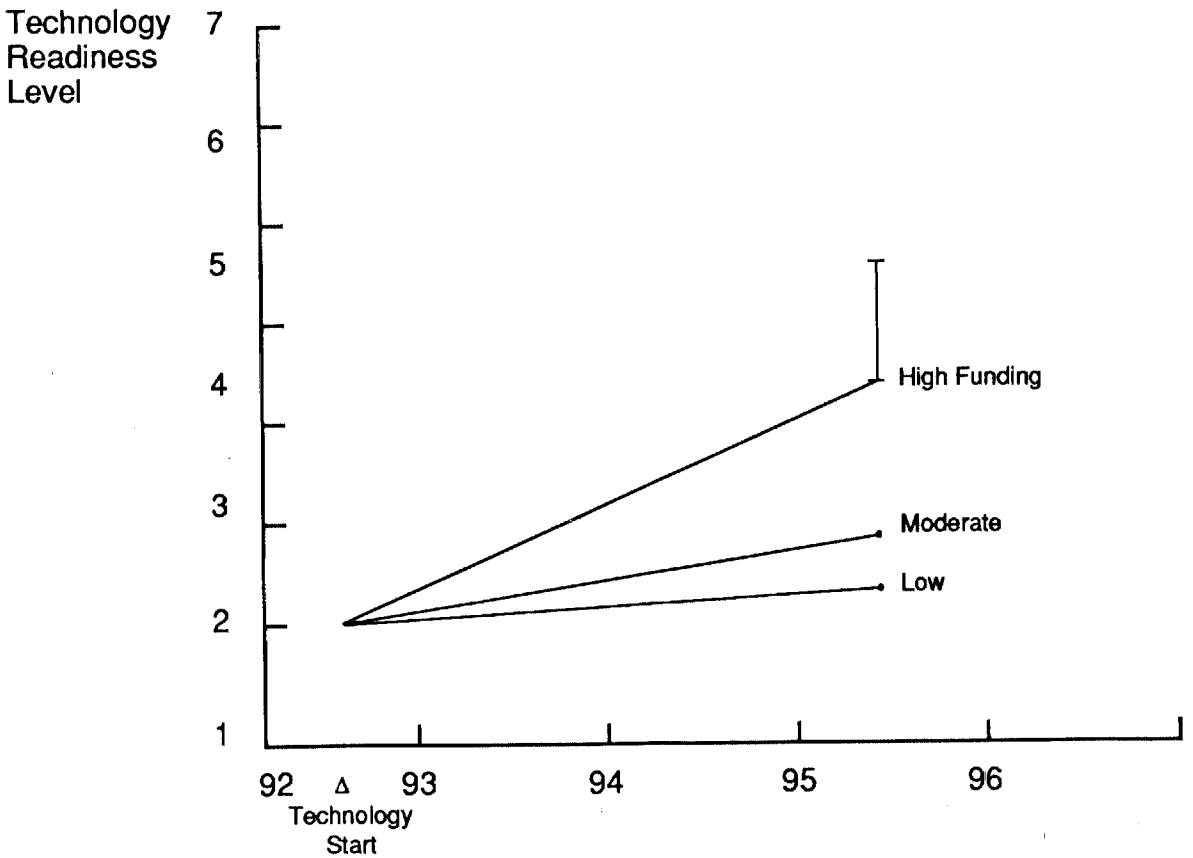

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ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

IMPROVED TRACE CONTAMINANT REMOVAL

Background

Scope – The Present Trace Contaminant Control (TCC) subsystem is designed for continuous contaminant removal with only selected fire upset control capability. No experiment upset capability is included. Expendable TCC sorbent beds are replaced on 90-day intervals.

Objectives -

1) Increased TCC system flexibility is necessary to accommodate upsets due to fire & hazardous upsets.
2) Expendable sorbents are to be reduced or eliminated.
3) Scarring required to handle upset conditions are to be defined.

Requirement – Eliminate or minimize expendables to reduce resupply and return logistics, crew time, and storage requirements. Improved flexibility of TCC to support space station utilization as an experimental platform is required.

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IMPROVED TRACE CONTAMINANT REMOVAL

Program Plan

Approach – Investigate alternate or improved high-temperature catalytic oxidizers and improved sorbent beds. Evaluate techniques for IN-SITU bed regeneration, plasma catalysis, and high effectiveness catalysts. Define TCC designs to process upset conditions and test feasibility and breadboard concepts, and fabricate a prototype unit.

Deliverables – Deliverables include a technology assessment report, feasibility and breadboard test reports. Design data and prototype unit will be delivered for integrated system testing. A continued evaluation of evolving space station requirements will be made. Program and cost plans will be generated for flight hardware.

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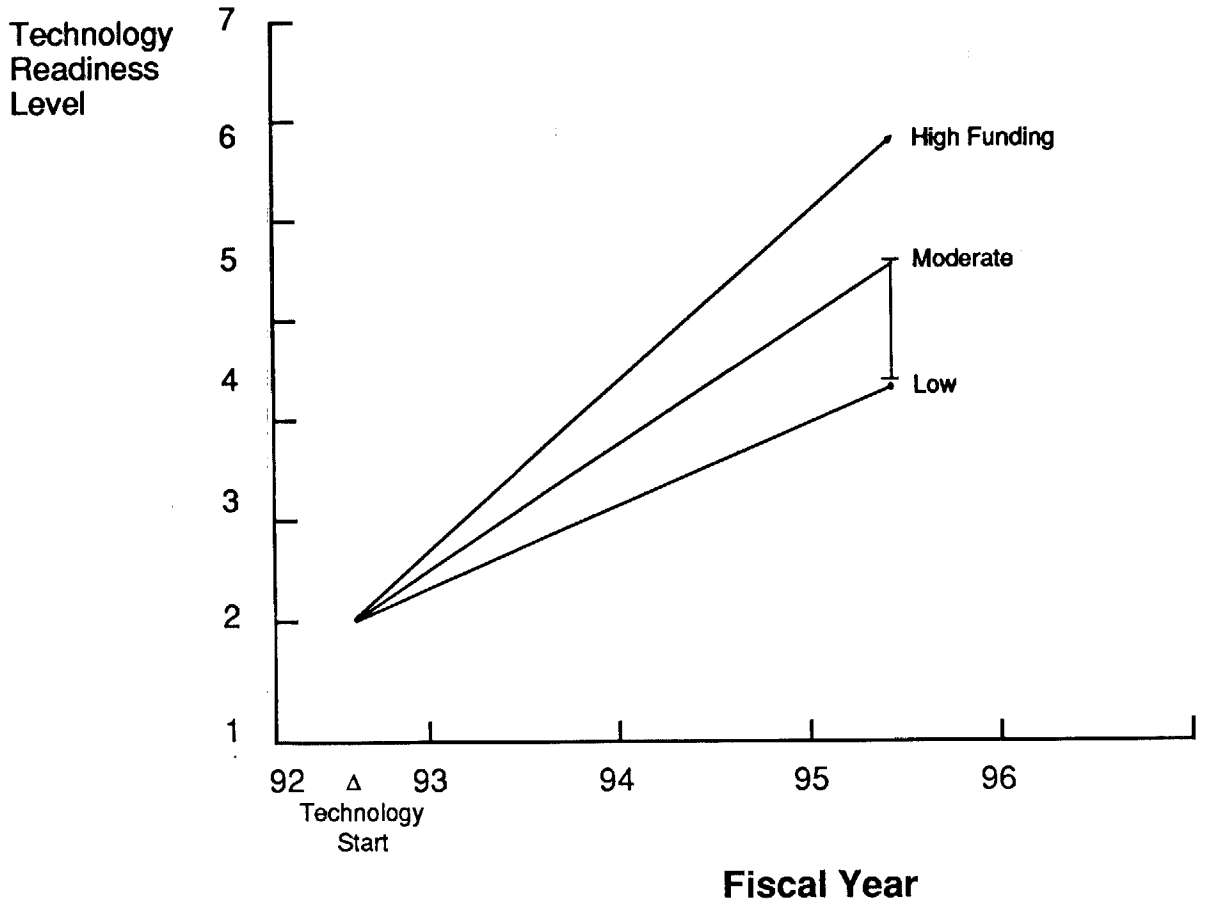

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ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

REAL TIME MICROBIAL ANALYSIS

Background

Scope – The safety of the space station crew depends in the effective control of water reclamation systems as well as the verification of an uncontaminated on-orbit water supply. Micobiological contaminants such as bacteria, yeasts and molds, and viruses are particularly troublesome. Routine enumeration of total bacteria counts at concentrations below 1 CFU/100ml will be required to verify the acceptability of reclaimed water prior to use. Additional enumeration of aerobic, anaerobic, gram positive, gram negative, coliform, and enteric bacteria, as well as yeasts and molds will also be required on a less frequent basis. Present off-line culture technologies used to perform these monitoring functions are inherently labor intensive, require excessive sample quantities from the limited water supply in order to meet sensitivity requirements, require a minimum of 48 hours for the confirmation of results, and have substantial recurring costs associated with the resupply of expendables and return of wastes. This effort includes the design, fabrication and evaluation of a breadboard unit for on-line real-time microbiological monitoring of water.

Objectives – The objective of this effort will be to develop a microbiological analysis method that is amenable to on-line, real-time microbiological monitoring and to demonstrate the feasibility of the application via the development, design, fabrication, and testing of a breadboard unit.

Requirement – The payback from the successful development of a suitable microbial monitor will be the reduction of demands on crew time and other resources as well as the provision of a sensor and instrumentation unit that will be compatible with an overall life support system automation and control strategy.

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REAL TIME MICROBIAL ANALYSIS

Program Plan

Approach – The effort will begin with identification and laboratory assessment of potential methods for on-line, real-time enumeration of total bacteria. Laboratory testing to confirm sensitivity, selectivity, and overall reliability will be conducted. Parametric studies will be used to optimize the most promising method(s). The feasibility of adapting the total bacteria method(s) to provide additional enumeration of aerobic, anaerobic, gram, positive, gram negative, coliform, and enteric bacteria, as well as yeasts and molds will be evaluated. Results of these studies will be used to establish a breadboard design which will be fabricated and tested to confirm that the required sensitivity and selectivity demonstrated in the laboratory testing have been maintained as well as to assess mechanical reliability, resource requirements, ultimate automation potential, etc. The effort will culminate with the delivery of an optimized breadboard device for additional testing, to be supported by the contractor for a period of six months.

Deliverables – Development documentation (final report)
Breadboard on-line real-time microbial monitor
Instruction and Maintenance manual.

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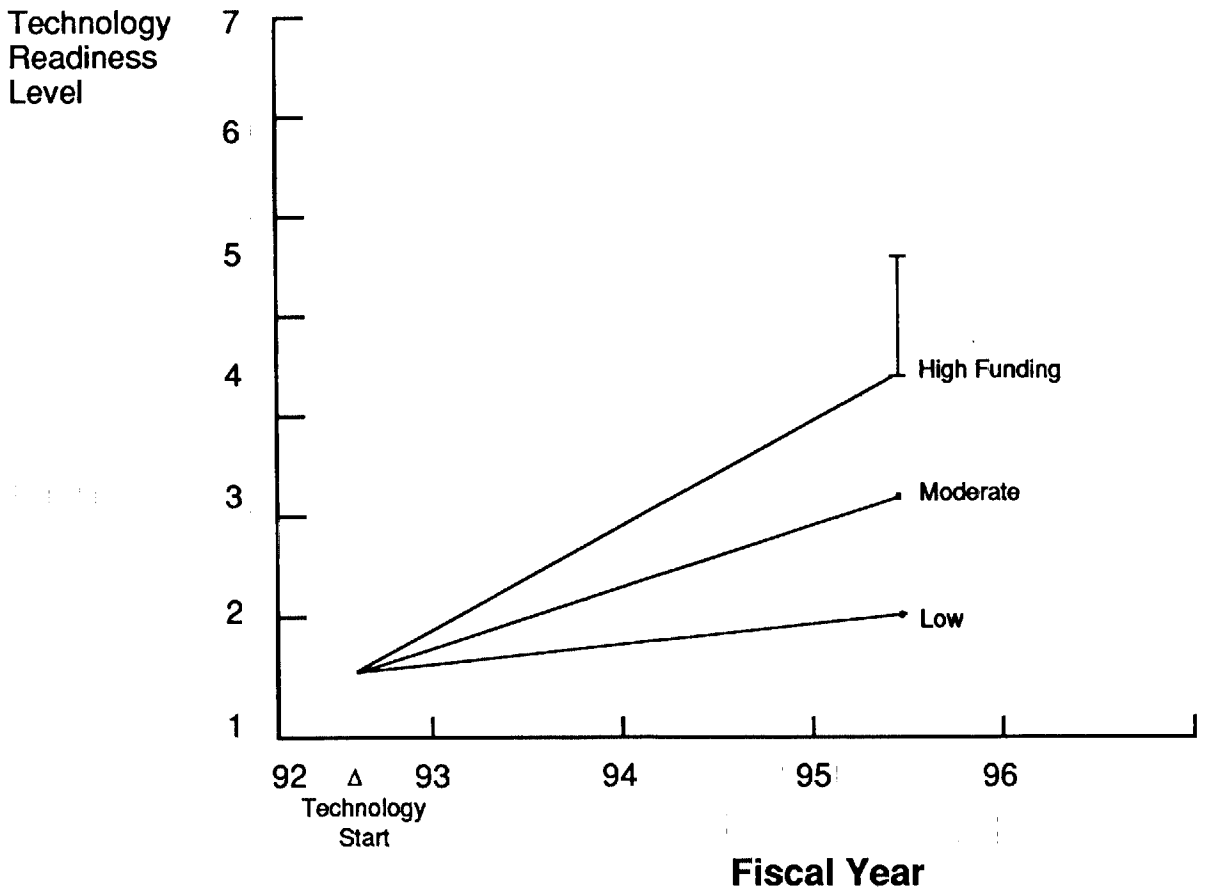

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Recommendations/Issues for Environmental Control and Life Support Systems

Issues

- Regenerable System Long Term Process Evaluation (Air and Water)

- Microgravity Fire Signature Identification

Recommendations

- Continued Emphasis on Systems Analysis Relative to Technology Development

- Continued Emphasis on Automation/Sensors

Additional Technology Areas for Consideration

- CO_2 Reduction by Products Utilization and Catalysis

- "Smart" Fire Detection and Improved Suppression System

- Improved Liquid/Gas Separation
- Noise Reduction (Rotating Equipment)
- N_2 Generation (From N_2 Sources Such as Crew Metabolic Byproducts)

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