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TECHNOLOGY FOR SPACE STATION EVOLUTION - A WORKSHOP

EXTRAVEHICULAR ACTIVITY TECHNOLOGY DISCIPLINE

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TECHNOLOGY FOR SPACE STATION EVOLUTION -A WORKSHOP

TECHNOLOGY DISCIPLINE SUMMARY FOR EXTRAVEHICULAR ACTIVITY (EVA)

Extravehicular Activity includes all activity outside the pressured volume of the space vehicle, although common usage tends to imply only manned activity. The scope of the activities describe herein will focus on manned EVA systems including interfaces with robotic work aids and systems.

Traditionally, manned extravehicular activities have been costly and perceived to be risky. In order for ELBA to become a routine, cost-effective mission resource, particular attention needs to be given to reducing logistics requirements and increasing productivity. EVA operations also tend to be very uncomfortable and tiring, and involve extensive preparation. Current suits, for example, operate at 4.3 psi and require the astronaut to perform extensive pre-breathing to reduce the bends risk to an acceptable level. Suits used for advanced Space Station Freedom EVA operations will be pressurized to 8.3 psi. This means that greater attention must be placed on glove and joint mobility.

A new dimension has been added to EVA operations for future missions, i.e., cooperative efforts involving EVA crew members with telerobots. This will require that particular attention be given to how best to interface the EVA crew members with telerobotic operations physically and logically. This will include work in information display, information transfer, and system control.

The key work system elements involved in Extravehicular Activity are the following:

Extravehicular Mobility Unit (EMU)
Air Lock and EMU Support Equipment
Tools, Mobility Aids and Work Stations
Telerobotic Work Aids Interfaces

These elements are addressed in the sections that follow.

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BACKGROUND

SCOPE - The major subsystems comprising the Extravehicular Mobility Unit are the Portable Life Support System (PLSS) and the Pressure Suit Assembly.

Major issues which must be addressed for the PLSS are life cycle cost, reliability, logistics and productivity. Technological advances are needed in (a) life support processes (understanding and conceptual development), (b) oxygen supply, (c) carbon dioxide and humidity control, (d) prime movers (e.g., fans and pumps), (e) automatic control, (f) heat rejection, power sources, and (g) avionics.

Major issues which must be addressed for the Pressure Suit Assembly are high cost, limited life, increase in the EVA environmental envelope, productivity, reliability, safety, serviceability and maintainability. Technologies which must be addressed include (a) gloves, (b) pressure vessel (suit), and (c) materials.

OBJECTIVE - The objective for this technology area is to develop, demonstrate and space qualify in earth orbit prototype Portable Life Support and EVA Suit systems responsive to the needs of future Space Station Freedom missions.

RATIONALE - Current EVA systems are uncomfortable, require extensive pre-breathing procedures, are reliable only for limited use and are extremely costly to maintain and prepare for operation. New technologies being developed (AX-5 and ZPS suit systems) and advanced portable life support systems are needed if man is to maintain a permanent presence in space and perform the required routine EVA operations safely, reliably and economically.

EVA *EXTRAVEHICULAR MOBILITY UNIT*

PROGRAM PLAN

APPROACH -

1. PLSS: (a) Conduct research efforts to develop a basic understanding of the life support processes and to identify and assess promising new concepts in order to reduce weight, volume, servicing and logistics requirements, (b) develop innovative concepts for storage and regulation of oxygen supplies to achieve small volume and increased operational flexibility, (c) develop regenerative techniques for control of carbon dioxide and humidity to reduce weight and resupply requirements, (d) improve understanding of thermal and physiological processes to improve crew productivity, comfort and system efficiency, (e) develop alternative processes and materials for heat rejection for reduced weight, volume and power requirements, (f) develop new power sources concepts for long life and low resupply weight, and (g) apply advanced avionics techniques for communication and control, e.g., voice systems, advanced displays and miniaturization, to achieve low power requirements, improved productivity and easier training.

2. Advanced Pressure Suit Assemblies: (a) Develop glove manufacturing techniques and (b) improved glove materials in order to prolong glove life, improve EVA crew productivity, improve glove producibility, and lower manufacturing cost; and (c) conduct pressure suit materials research and development efforts in order to provide lighter-weight suits with improved environmental protection.

3. Use the technologies developed in tasks 1 and 2 above to develop an integrated PLSS and Pressure Suit Assembly for test and evaluation in orbit.

DELIVERABLES -

1. Advanced-technology Portable Life Support System
2. Advanced-technology Pressure Suit Assembly
3. Integrated EMU for test in orbit

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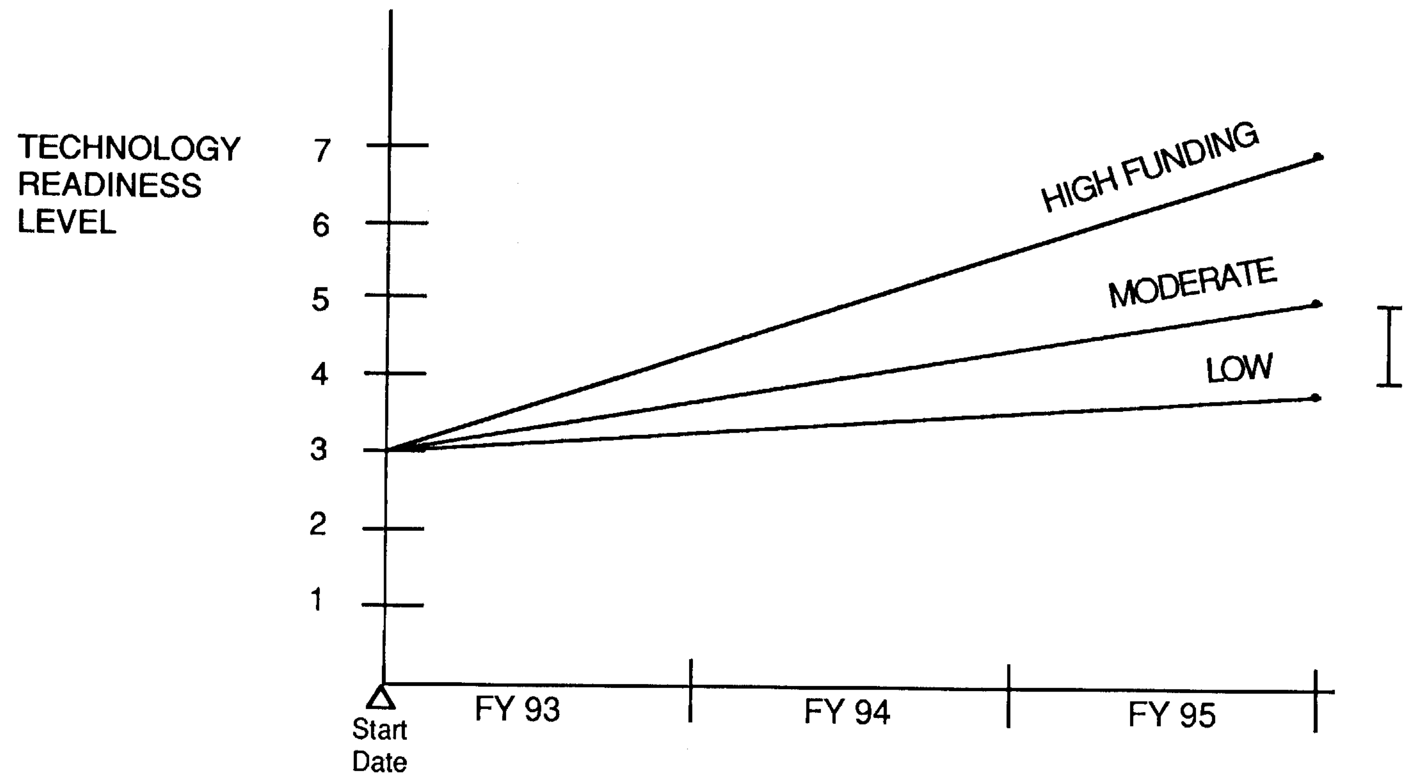
EVA

EXTRAVEHICULAR MOBILITY UNIT

TECHNOLOGY ASSESSMENT



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EVA *AIRLOCK AND EMU SUPPORT EQUIPMENT*

BACKGROUND

SCOPE - Software, oxygen supply, fluid interfaces, electrical interfaces, automation, and materials. Major issues which must be addressed include crew productivity and system reliability, safety, serviceability and maintainability.

OBJECTIVES - Objectives of this technology area are to develop (a) software for automatic EVA systems checkout; (b) oxygen supply systems to reduce portable life support systems volume requirements, increase durability and reduce power; and (c) fluid and electrical interfaces to facilitate management of umbilical connections.

RATIONALE - Operational costs and time spent in servicing current portable life support and suit systems are extremely high. Space Station Freedom and other future space missions will require order of magnitude improvements in serviceability and performance checkout; it will no longer be practical to rely on ground-based maintenance and checkout of EVA systems to the extent we do on current STS operation. More and more of the maintenance, servicing and checkout must be performed on-orbit. This will require adaptation of new procedures and technologies.

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EVA *AIRLOCK AND EMU SUPPORT EQUIPMENT*

PROGRAM PLAN

APPROACH -

1. Automated Checkout: Develop software programs to perform automated checkout of critical portable life support and suit systems. Base these programs on artificial intelligence techniques (i.e., knowledge-based techniques), and apply to the EMU design as it evolves.

2. Oxygen Supply: Develop high-pressure recharge techniques. Conduct research to identify and develop improved materials. Fabricate and test a prototype oxygen supply system.

3. Fluid and Electrical Interfaces: Develop a rotary coupling to facilitate management of umbilical interfaces between the portable life support systems and the fluid and electrical supply systems on board the space station. These umbilicals are for use prior to exiting from the EVA air lock before performing extravehicular activities, and after return to the air lock.

DELIVERABLES -

1. A prototype, knowledge-based automated checkout system for the EMU.

2. A prototype, high-pressure oxygen supply system for the portable life support system.

3. A prototype, rotary coupling for fluid and electrical interfaces between the EMU and the airlock fluid and electrical supply systems.

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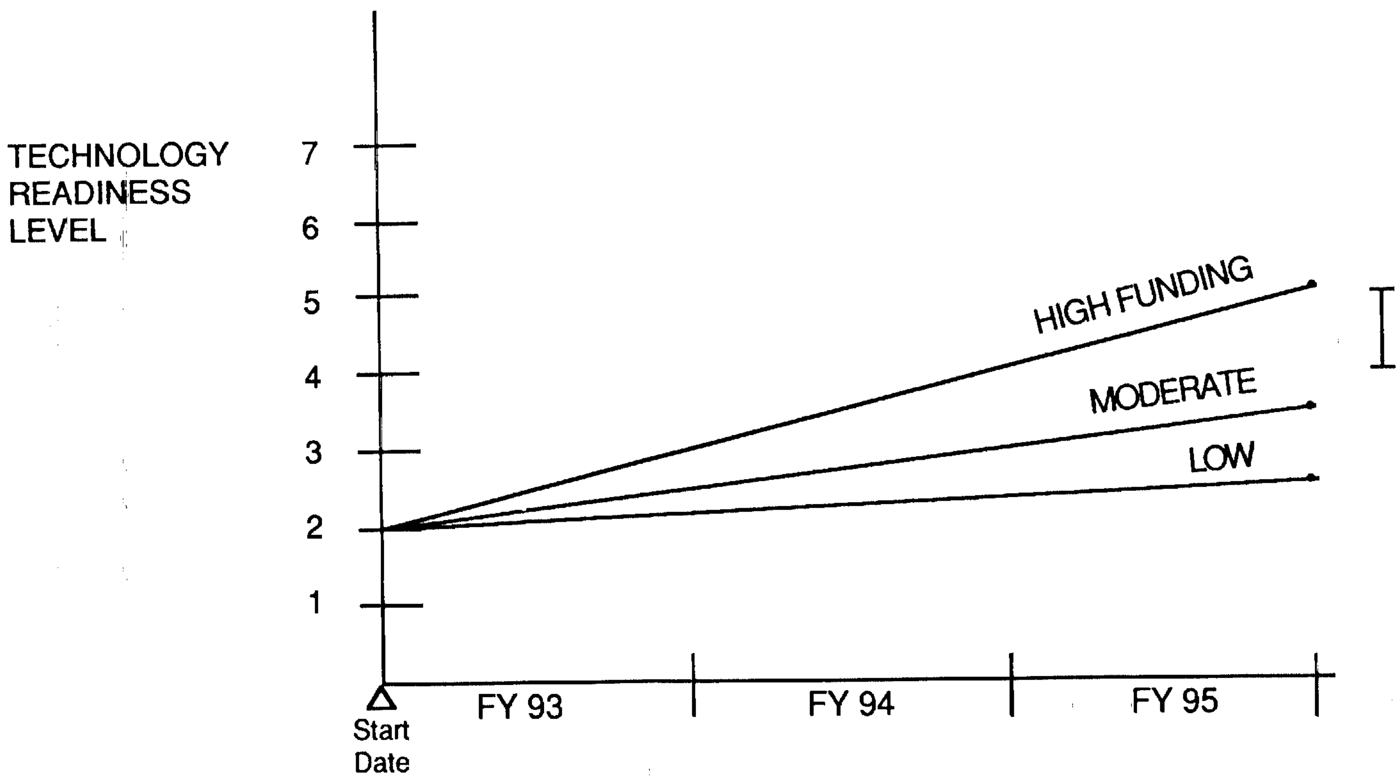
EVA

EXTRAVEHICULAR MOBILITY UNIT

<u>TECHNOLOGY ASSESSMENT</u>



BACKGROUND

SCOPE - Productivity, safety, cost, end effectors, tools, repair/maintenance processes and kits, EVA work stations, and crew rescue and equipment retrieval.

OBJECTIVES - The objectives of this technology area are to develop and evaluate procedures, concepts and equipments for: (a) end effectors and tools which will allow the EVA crew member to work more productively; (b) repair and maintenance processes and kits to maintain and restore EVA system operations; (c) EVA work stations for increasing EVA productivity and safety; and (d) crew rescue and equipment retrieval.

RATIONALE - A goal of automation and telerobotics programs is to minimize the amount of manned extravehicular activity required for Space Station Freedom and other future space missions. However, substantial amounts of EVA activities will still be required, even after achieving this "minimum" level. Long-duration missions onboard the space station will probably benefit greatly from the use of end effectors and tools designed either for performing specific tasks, where it makes sense to do so, or for more general-pupose applications, e.g., wrenches, pliers, etc. Extensive EVA operations will also require the use of EVA work stations. Long-duration missions will also require a capability to repair and maintain EMU systems on orbit; repair and maintenance processes and kits are needed. Finally, for safety purposes, there is need for a capability to rescue an EVA astronaut in the event that he should lose his tether and drift away from the space station; similarly there is a need for a capability to retrieve equipment which may also be adrift.

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EVA *TOOLS, MOBILITY AIDS AND WORK STATIONS*

PROGRAM PLAN

APPROACH -

Develop and evaluate (a) advanced technology end effectors and tools (e.g., smart tools and end effector which may either simplify greatly the EVA astronaut's task or reduce his work load substantially), (b) EVA work stations which are articulable and compatible with robots and humans, (c) repair and maintenance processes and kits, and (d) crew rescue and equipment survival concepts. Facilities required include ground laboratories, water tank facilities, the KC-135 Variable-Gravity In-Flight Simulator, and the Space Shuttle. Depending on individual requirements, one or more of these facilities may be required to evaluate a particular technology.

DELIVERABLES -

1. Prototype end effectors and tools for evaluation in ground simulation facilities, the KC-135 Variable-Gravity In-Flight simulator, and the Space Shuttle.

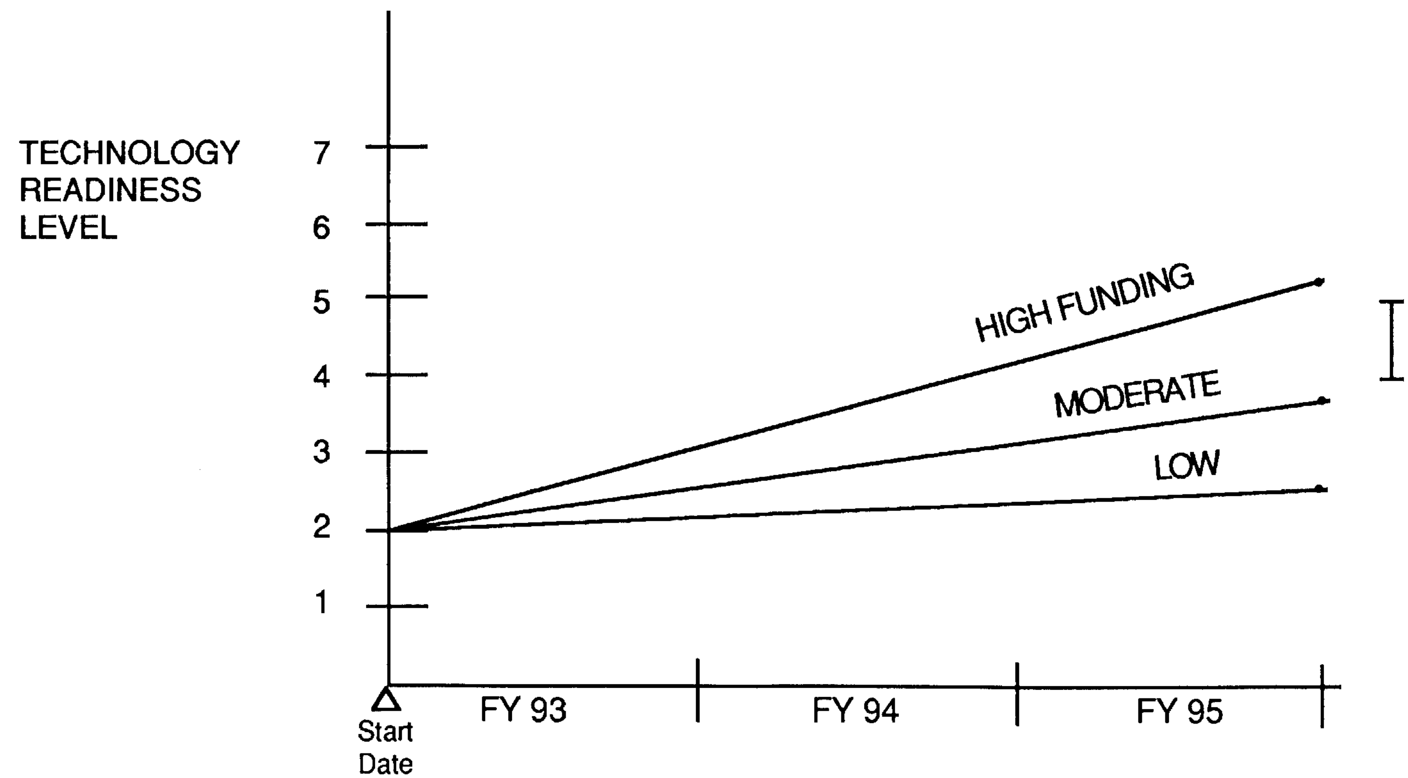
2. Prototype EVA work stations for evaluation in neutral-buoyancy test facilities, the KC-135 Variable-Gravity In-Flight Simulator, and the Space Shuttle.

3. Prototype repair and maintenance processes and kits for evaluation in neutral buoyancy test facilities, the KC-135 Variable-Gravity In-Flight Simulator, and the Space Shuttle.

4. Concepts, simulations and prototype hardware for crew rescue and equipment retrieval.

EVA *TOOLS, MOBILITY AIDS AND WORK STATIONS*

TECHNOLOGY ASSESSMENT



TECHNOLOGY FOR SPACE STATION EVOLUTION -A WORKSHOP

EVA *TELEROBOTIC WORK AIDS INTERFACES*

BACKGROUND

SCOPE - Information acquisition, information transfer, information display, artificial intelligence, proximity operations, sensors, command and control.

OBJECTIVE - The objective of this technology area is to achieve compatibility between EVA Astronauts and telerobots through a synergistic relationship between the two in performing EVA tasks.

RATIONALE - Robots are being developed to help reduce the amount of EVA time required of the EVA astronaut, to perform those tasks which may be performed more effectively through application of telerobotic technology, and to make most productive use of human and other resources of Space Station Freedom. There will certainly be many tasks which can be performed most productively through a cooperative or interactive relationship between EVA astronauts and one or more telerobots. This relationship needs to be understood and exploited in order to accomplish missions and tasks safely, economically and productively.

TECHNOLOGY FOR SPACE STATION EVOLUTION -A WORKSHOP

EVA *TELEROBOTIC WORK AIDS INTERFACES*

PROGRAM PLAN

APPROACH -

1. Information Acquisition and Display: Develop versatile multi-modal sensory display systems for use in the space suit which (a) are easy to adjust (spatial and temporal resolution, dynamic range vs. band width, etc.), and (b) provide easy information capture, storage and retrieval. Displays may be visual, aural, tactile, or some combination.

2. Control Systems and Artificial Intelligence: (a) Develop human-oriented control systems for use in controlling the telerobot either by the EVA astronaut, the IVA astronaut, or some combination, (b) develop techniques for automation transparency, smooth operational mode change and graceful human intervention, and (c) apply artificial intelligence techniques which provide a proper and effective amount of "autonomy" to the telerobot - enough so that the astronaut's work load is reasonable and productive, but in such a way that safety is not compromised.

3. Proximity Sensors: Develop sensors which do not depend on line-of-sight in order to minimize the likelihood of collision between the EVA astronaut and robot; develop passive sensors for safety override and active path control around obstacles.

4. control and Command Input Techniques: Develop non-manual techniques such as voice or by movement to control motions and tasks of the telerobot in order to reduce manual input requirements and EVA astronaut work load, and to increase productivity.

TECHNOLOGY FOR SPACE STATION EVOLUTION -A WORKSHOP

EVA *TELEROBOTIC WORK AIDS INTERFACES*

PROGRAM PLAN
(CONTINUED)

DELIVERABLES -

1. Advanced information acquisition and display concepts, systems and procedures for use in cooperative efforts between EVA astronauts and robots.

2. Advanced control systems concepts, techniques and hardware to facilitate the interaction between the EVA astronaut and robot in carrying out EVA missions and tasks.

3. Sensor concepts, hardware and procedures for minimizing the likelihood of collision between EVA astronaut and robot; and passive sensors for override and active path control.

4. Concepts, hardware and procedures for non-manual control of robot motions and tasks, e.g., use of aural inputs or eye movement.

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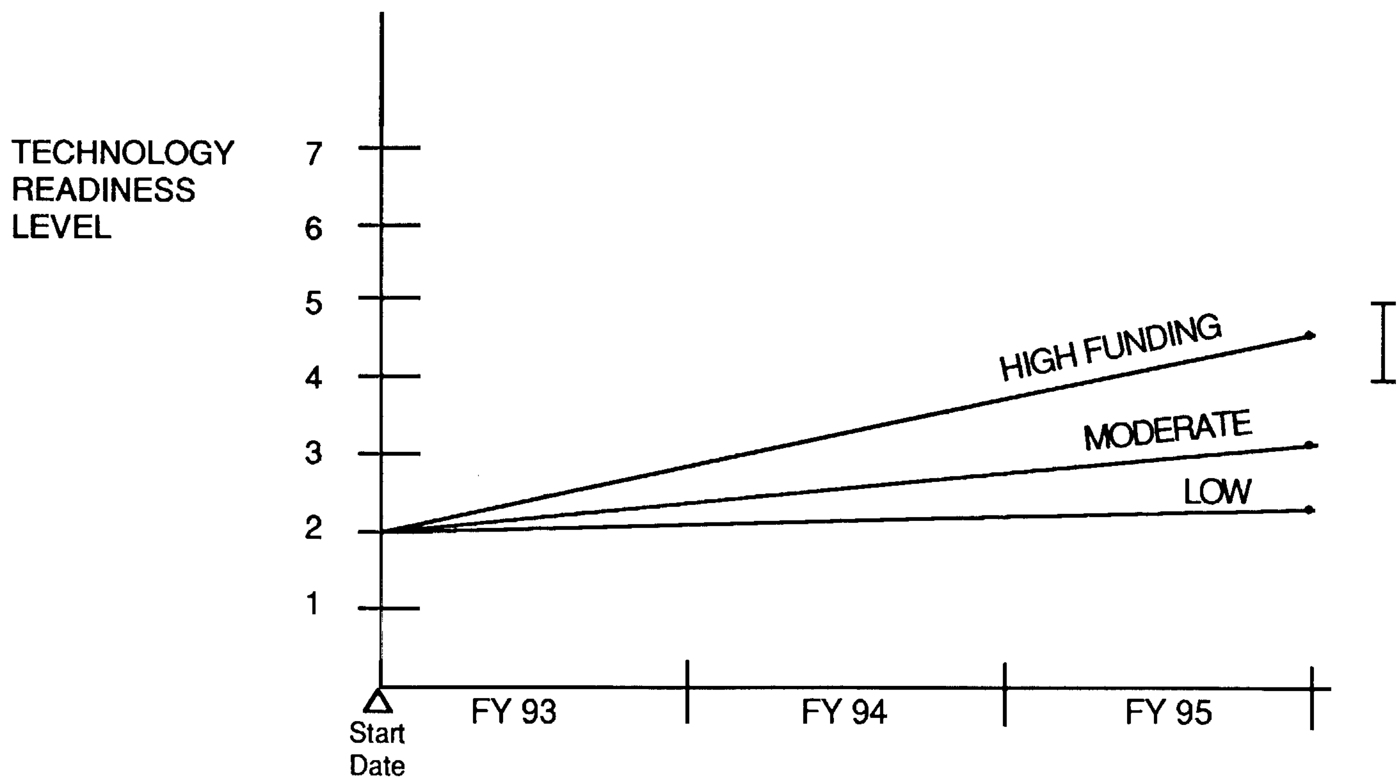
EVA *TELEROBOTIC WORK AIDS INTERFACES*

TECHNOLOGY ASSESSMENT



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