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TECHNOLOGY FOR SPACE STATION EVOLUTION - A WORKSHOP

STRUCTURES AND MATERIALS TECHNOLOGY DISCIPLINE

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TECHNOLOGY FOR SPACE STATION EVOLUTION -A WORKSHOP

BACKGROUND

SCOPE — To provide the materials, processes and data base to permit the design, fabrication, maintenance and inspection of a manned, on-orbit space station and its supporting subsystems that will withstand prolonged usage and provide durability in a space environment.

OBJECTIVES — To develop environmentally tolerant materials and material systems for space application; to develop on-orbit repair processes; and to explore the science for on-orbit Non-Destructive Evaluation (NDE).

RATIONALE — Current non-metallic materials available for space station design cannot withstand the prolonged exposure to various elements of space environment without severe degradation in their mechanical and/or physical properties. Increased survivability, durability, and performance are needed. In addition, knowledge is lacking of on-orbit repair, construction and inspection techniques needed to permit maintenance and system integrity of a manned space station.

PROGRAM PLAN

APPROACH -

1. Conduct basic materials development and characterization to (1) improve the environmental resistance of polymeric basic materials and (2) obtain high-performance materials capable of increasing structure efficiencies.
2. Expose advanced materials to space environments to acquire a reliable and verified design database. Establish for these materials a set of failure criteria and design allowables. Develop ground-based test methods and facilities that permit ground simulation of space environments, and correlate this data with actual space exposure.
3. Develop procedures, acceptance criteria, and inspection techniques for conducting in-space repair, refubishment, and certification.
4. Develop processes and NDE certification for in-space construction of evolutionary structural concepts.

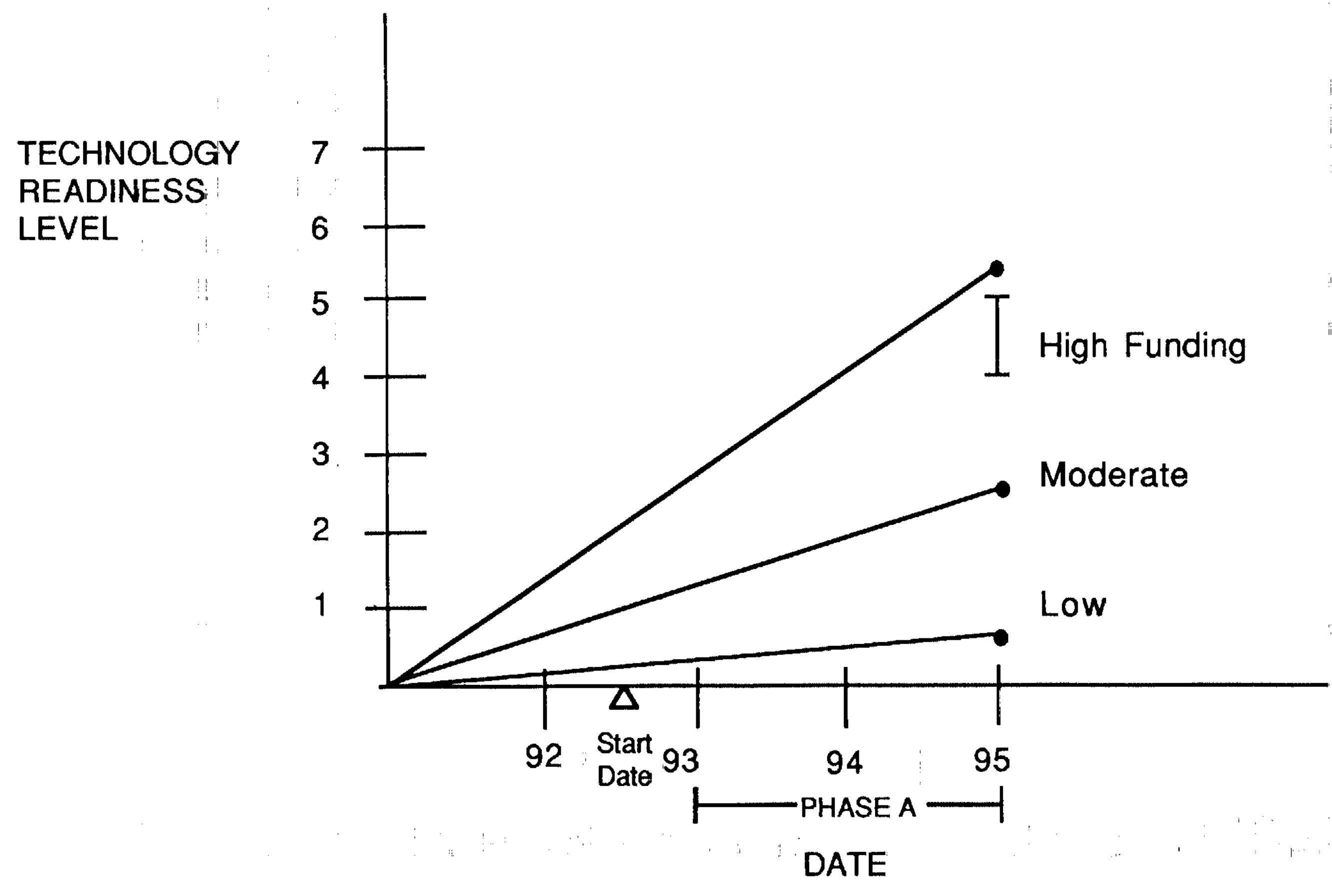
DELIVERABLES -

1. An approved materials list for space system application and a supporting data base.
2. A demonstration of ground-based space environment simulation and correlation.
3. Recommended NDE procedures and structural certification criteria.

TECHNOLOGY FOR SPACE STATION EVOLUTION -A WORKSHOP

STRUCTURES AND MATERIALS *MATERIALS*

TECHNOLOGY ASSESSMENT



BACKGROUND

SCOPE - Ground and flight demonstrations of a series of large space structures aimed at significantly reducing or eliminating EVA requirements for construction on future NASA missions.

OBJECTIVES - 1) Develop automated assembly methods and associated tools for constructing a wide variety of advanced space structures. Demonstrate the feasibility of automated assembly on a full-scale testbed. 2) Develop advanced erectable structures including mechanical and welded joints and associated assembly aids. Establish accurate EVA timelines through the use of full-scale ground tests and a demonstration flight test. 3) Develop deployable linear and area truss structures for advanced mission applications. Demonstrate the reliability of deployable structures through full-scale deployment tests and analysis.

RATIONALE - The limiting consideration for many new missions is the ability to build large structures at a reasonable cost. Because of the lack of experience with large space structures, mission studies tend to be limited to small spacecraft. The development and demonstration of large space structures would open up mission design ranges as well as improve the agency's ability to predict mission costs.

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STRUCTURES & MATERIALS *SPACE CONSTRUCTION*

PROGRAM PLAN

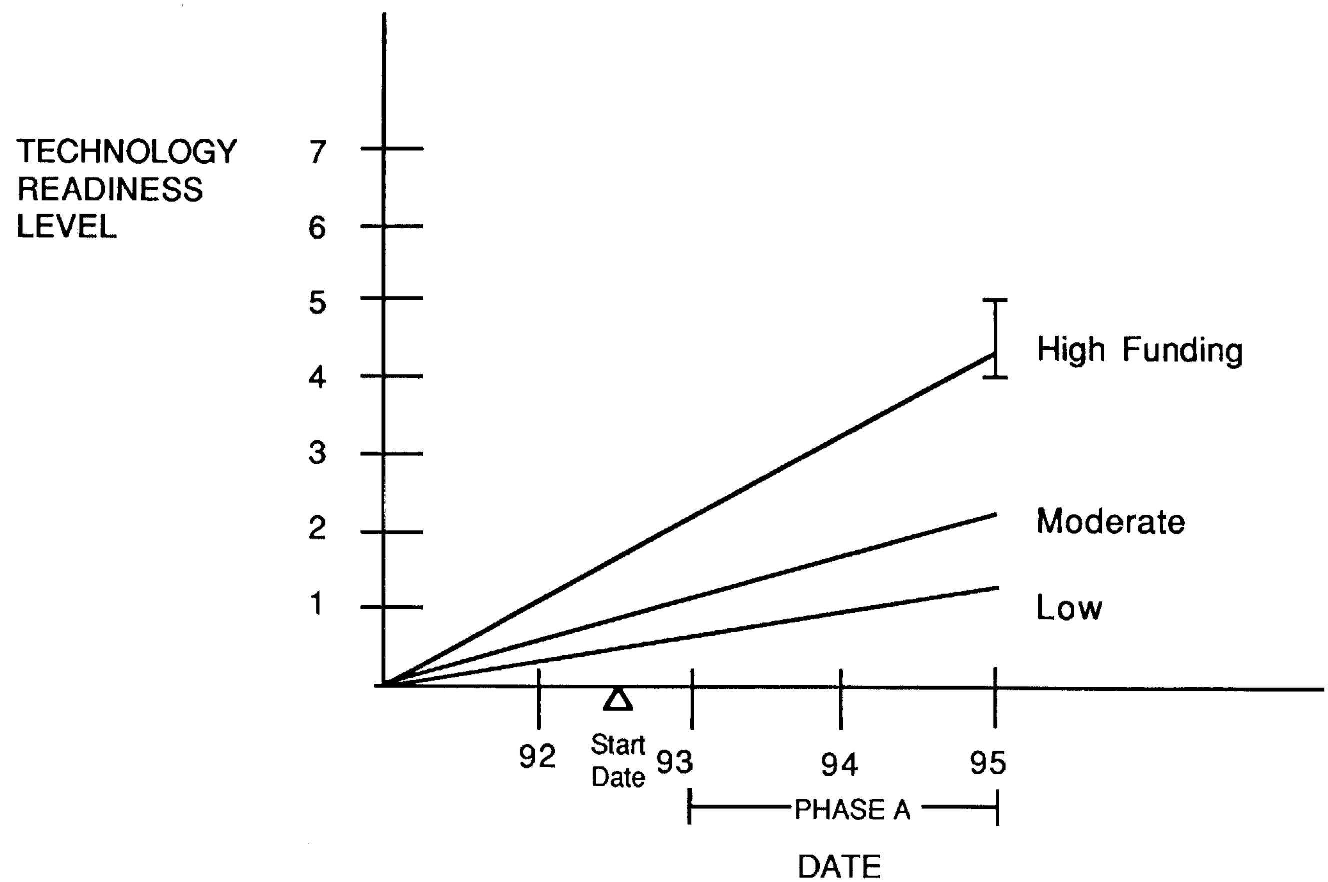
APPROACH -

1. **Develop a large robotic arm (space crane) and associated end effectors for assembling large spacecraft. Demonstrate the operation of the arm and develop assembly timelines using a full-scale ground testbed.**
2. **Develop lightweight composite mechanical joint and welded joints for exploration vehicles, hangars, and reflectors. Demonstrate these new structures through EVA ground tests and through one selected flight test.**
3. **Develop large-scale deployable truss structures. Demonstrate the viability of deployables through a ground demonstration of a large truss platform.**

DELIVERABLES -

1. **Demonstrated space crane and end effectors. Automated assembly scenarios and timelines.**
2. **Demonstrated lightweight composite joints and welding techniques. EVA timelines validated by ground and flight tests.**
3. **Large-scale validated deployable structural concepts. Validated deployment analysis.**

TECHNOLOGY ASSESSMENT



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STRUCTURES & MATERIALS *SPACE CONSTRUCTION*

ISSUES

- Minimum availability of EVA to do construction.
- Reliability of robotic assembly.
- Demonstrations are needed to accrue confidence in space construction methods and timelines.
- Piece-by-piece manual construction is EVA-intensive.

RECOMMENDATIONS

- Develop automated assembly testbed.
- Develop integrated deployable and/or modular structural components.
- Develop rapid EVA-erectable assembly scenarios. Advocate In-Space Construction Flight Experiments.
- Continue to develop new space suit to extend EVA time and astronaut efficiency.

BACKGROUND

SCOPE — The dynamics of the Space Station Freedom in its Assembly Complete and evolutionary growth versions, including the characterization of the dynamics of the Station and attached manipulators, payloads, fueling systems and vehicles, and the interaction of the control systems of these components with the Station structural dynamics and attitude control system.

OBJECTIVES — To develop a well-verified dynamic model of the Assembly Complete Station and the analytical and experimental modeling tools to confidently extend the dynamic model to evolutionary configurations. Assured stability, improved performance and reduced dynamic loads will be achieved through application of the dynamic model.

RATIONALE — Even in its Assembly Complete configuration, the Space Station Freedom represents a complex structural dynamic environment. In its evolution of configurations, with the addition of larger power systems, manipulators, fuel storage and transfer systems, and berthed vehicles, the dynamics of the Station will become extremely complex. Uncertainties in modeling can lead to conservatism in dynamic loads analysis, unexpected interaction of control systems of the station and flexible manipulator and appendages, and potential failure to maintain fuels in configuration for transfer. Because of the size and flexibility of the Station, it is impossible to ground test in full scale. Therefore, a well-coordinated program of component and scale model ground tests, on-orbit tests, and analysis is necessary.

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PROGRAM PLAN

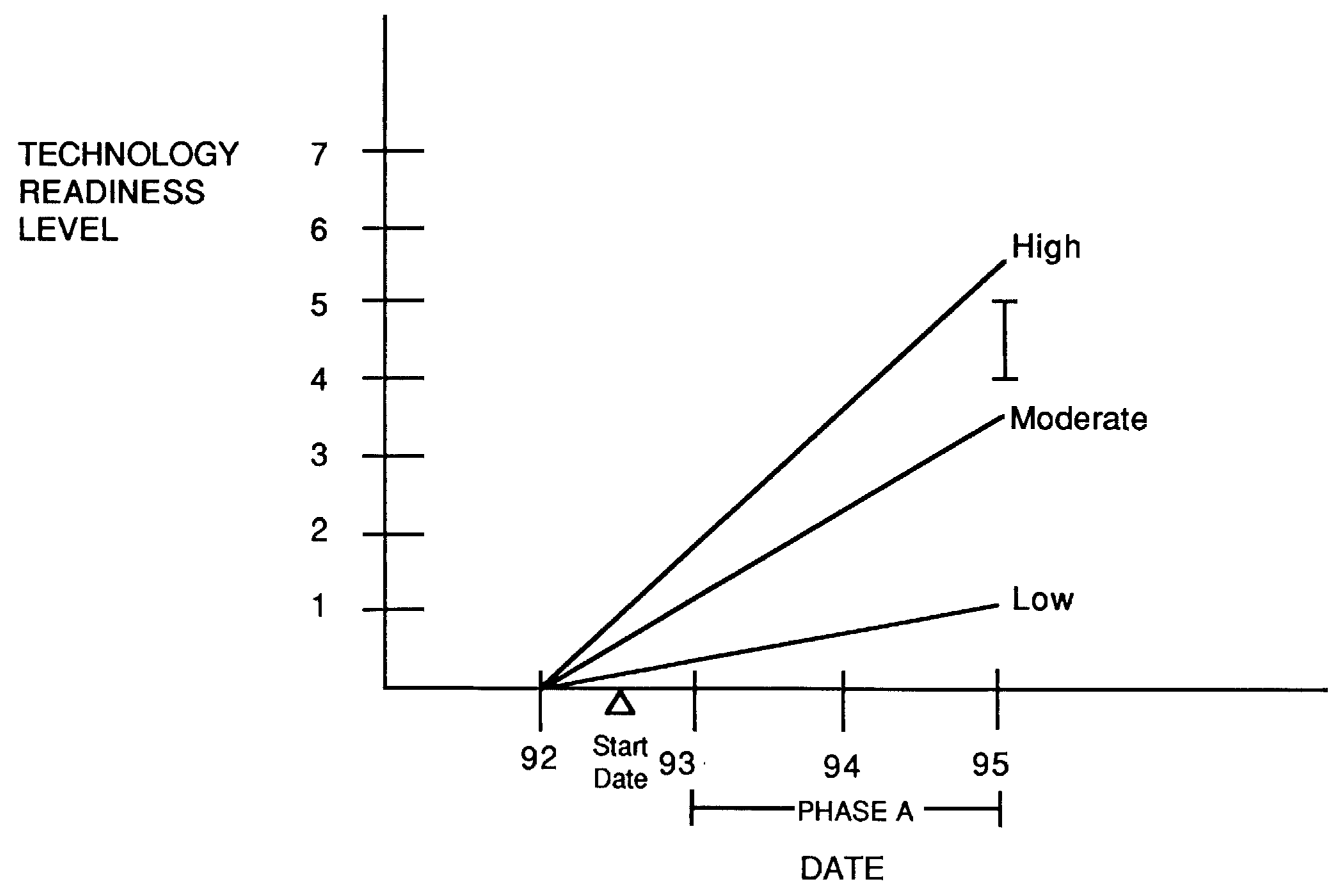
APPROACH:

1. Develop the instrumentation and algorithms to characterize the dynamics of the Station during assembly and at Assembly Complete, in order to establish a well-understood benchmark for evolution and to provide a system for structural health monitoring for extended life.
2. Develop a comprehensive ability to model the dynamic structure control interactions, not only of the Station dynamics and attitude control system, but of the attached interacting manipulators and active payloads. This includes ground and flight CSI experimentation and analytical development.
3. Develop approaches to dynamic load limiting and alleviation, so as to extend the structural envelope into the range necessary for evolution. This includes schemes for reduction and alleviation of loads due to proximity operations; station reboost and maneuver; EVA and manipulator motion; docking; and berthing. Microgravity management approaches will be explored for conflicting demands of evolving Station.
4. Develop a comprehensive model of the dynamics of the station, including multibody and large-angle behavior of various sub-assemblies and appendages, and their respective controllers, which includes potentially geometric nonlinear and chaotic motion, for use in final verification of load alleviation and control schemes.
5. Develop simplified yet nonlinear model of fluid dynamic behavior and slosh, for the purposes of modeling cryogenic on-board fuels, and the fuel of berthed vehicles.

DELIVERABLES :

1. A thoroughly documented linear dynamic model of the Assembly Complete Station and the instrumentaiton system for health monitoring.
2. An analysis capability for design and assessment of multiple interacting control systems on a flexible vehicle.
3. Design approaches and prototype hardware for load alleviation and isolation (for microgravity management).
4. A comprehensive, nonlinear structural dynamic model of the Assembly Complete and evolutionary station configurations.
5. An analysis capability for nonlinear slosh of fluids in low gravity.

TECHNOLOGY ASSESSMENT



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