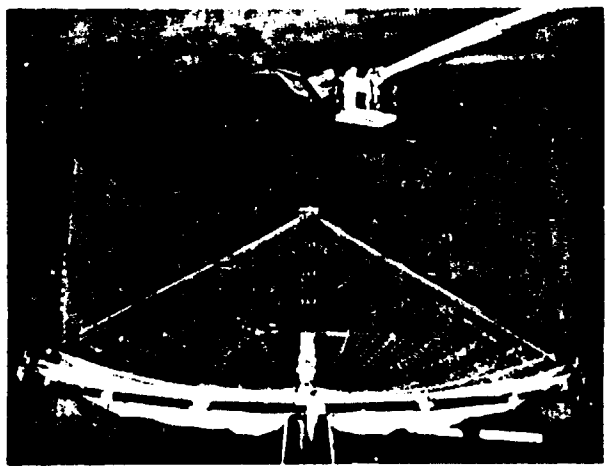
NASA OFFICE OF AERONAUTICS & SPACE TECHNOLOGY

MATERIALS AND STRUCTURES DIVISION

SAMUEL L. VENNERI
DIRECTOR

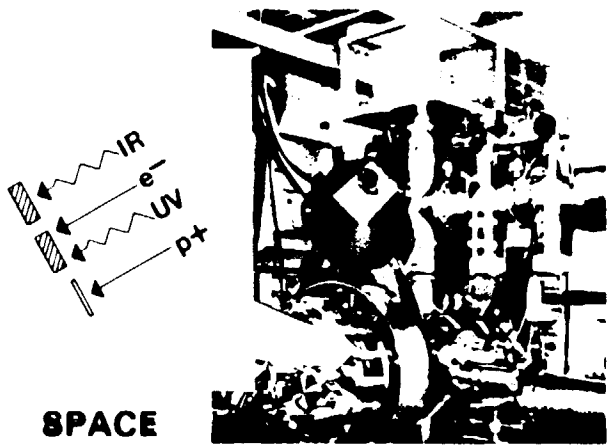
MATERIALS AND STRUCTURES

STRUCTURAL CONCEPTS



DYNAMICS OF FLEXIBLE STRUCTURES

AEROTHERMAL STRUCTURES



SPACE DURABLE MATERIALS

NASA

OAST

RM85-1288 (3)

SPACE R&D BUDGET ($, M)

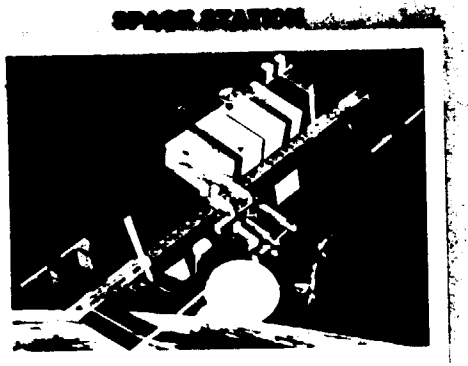
OAST

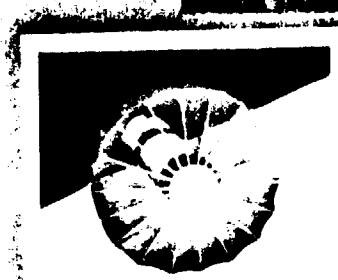
MATERIALS AND STRUCTURES DIVISION

	FY 88	FY 89	PLANNED FY 90-94
R&T BASE			
MATERIALS & STRUCTURES R&T	17.2	20.0	
CSTI			
CONTROL OF FLEXIBLE STRUCTURES	16.3	14.6	110
PRECISION SEGMENTED REFLECTORS	4.9	4.9	10
PATHFINDER			
SAMPLE ACQUISITION, ANALYSIS & PRESERVATION	-	1.0	30
IN-SPACE ASSEMBLY & CONSTRUCTION	-	1.0	35
RESOURCE PROCESSING PILOT PLANT	-	-	25

RM

SPACE MATERIALS AND STRUCTURES





CANDIDATE MATERIALS

- LIGHT ALLOYS
- METAL-MATRIX COMPOSITES
- C-C COMPOSITES
- CERAMIC-MATRIX COMP.
- COATINGS
- POLYIMIDE FILMS
- RESIN-MATRIX COMP.

RM 500.0

SPACE ENVIRONMENTAL EFFECTS

ENVIRONMENT	ORBIT	MATERIALS & SYSTEMS AFFECTED	EXTENT
VACUUM OUTGASSING	ALL ORBITS	OPTICS, THERMAL CONTROL, ELECTRONICS	MEDIUM TERM SEVERE
ATOMIC OXYGEN & GLOW	LEO	STRUCTURAL, TRIBO, OPTIC & THERMAL CONTROL	MEDIUM, LONG TERM SEVERE CATASTROPHIC UNKNOWN
CONTAMINATION	ALL ORBITS	OPTICS, THERMAL CONTROL, ELECTRONICS	SHORT, LONG TERM SEVERE
THERMAL CYCLES	ALL ORBITS	THERMAL CONTROL, STRUCTURAL, SYSTEMS	MEDIUM TERM SEVERE CATASTROPHIC
SOLAR RADIATION	ALL ORBITS	OPTICS, THERMAL CONTROL, STRUCTURAL, ELECTRONICS	MEDIUM TERM SEVERE CATASTROPHIC
VACUUM U.V.	ALL ORBITS	OPTICS, THERMAL, STRUCTURAL, TRIBO	MEDIUM, LONG TERM SEVERE, CATASTROPHIC UNKNOWN
MICRO-METEORITES & DEBRIS	ORBIT DEPENDENT DATA LACKING	STRUCTURAL, LARGE OPTICS, PRESSURE VESSELS, SOLAR	LONG TERM SEVERE CATASTROPHIC
SPACECRAFT CHARGING	GEO, POLAR	THERMAL & OPTIC SURFACES, ELECTRONICS	SHORT, LONG TERM SEVERE, CATASTROPHIC UNKNOWN
ELECTRO-MAGNETIC INTERACTIONS AND PLASMAS	ORBIT DEPENDENT (LEO), MEO, POLAR	THERMAL & OPTIC SURFACES, ELECTRONICS, HIGH POWER	SHORT, LONG TERM SEVERE CATASTROPHIC
VAN ALLEN RADIATION	ORBIT DEPENDENT LEO, MEO, POLAR	THERMAL & OPTIC SURFACES, ELECTRONICS, STRUCTURAL	SHORT, MEDIUM, LONG TERM SEVERE

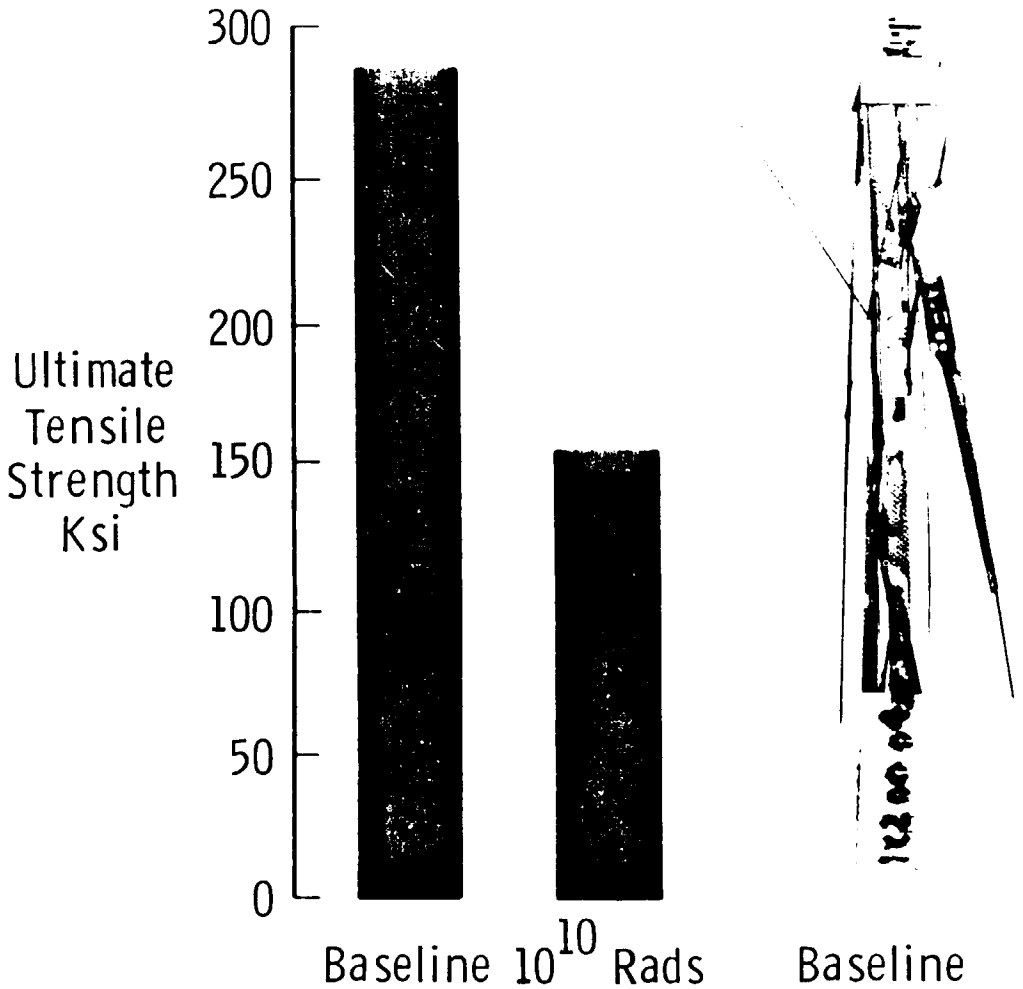
SPACE ENVIRONMENTAL EFFECTS

OAST

MAJOR ISSUES

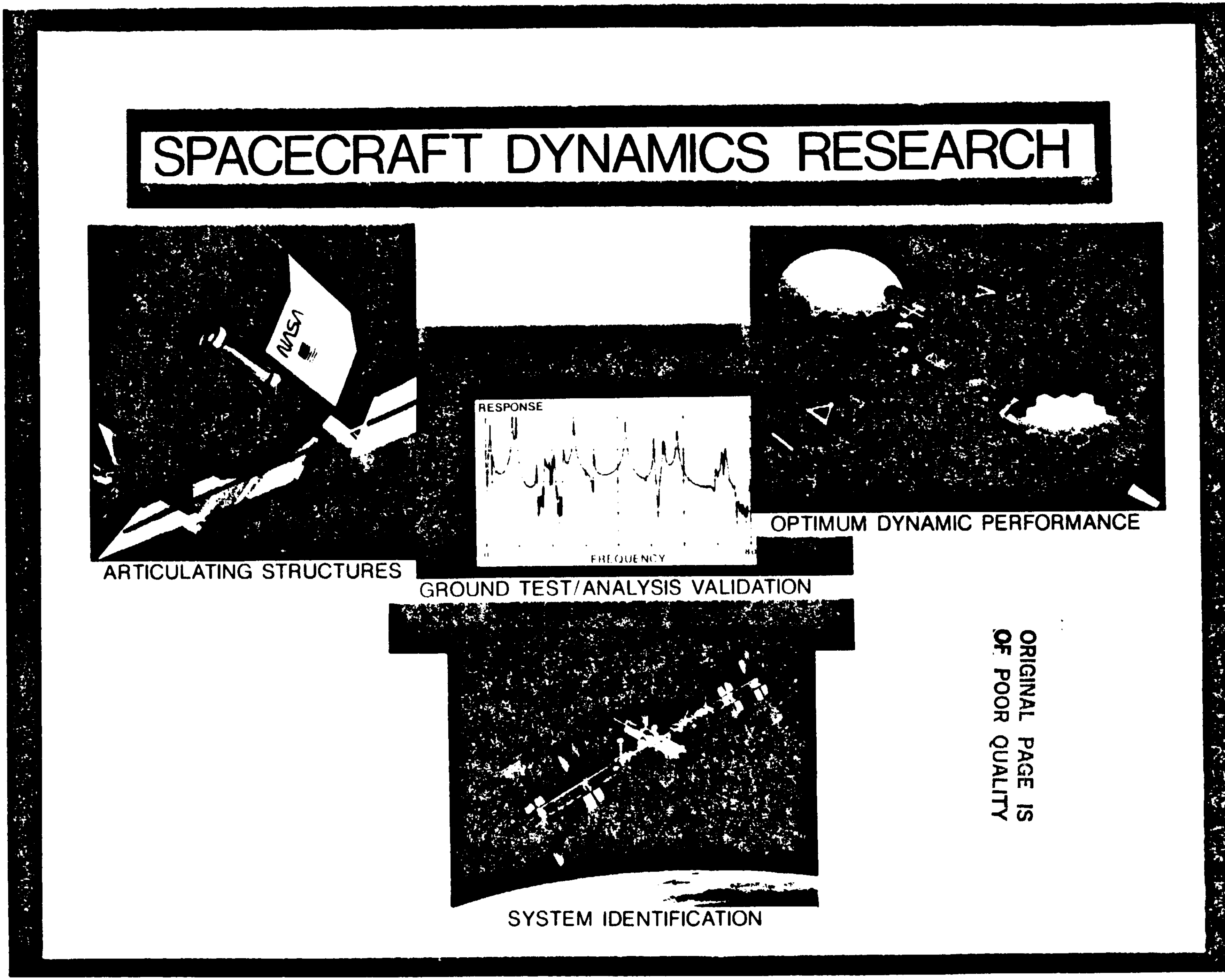
- ROLE OF MATERIALS IN SYSTEMS FAILURES
- UNKNOWNS OF COMPLEX NATURAL ENVIRONMENT
- LIMITATIONS OF GROUND-BASED SIMULATION
- USE OF "OFF-THE-SHELF" MATERIALS
- ENGINEERING BASIS FOR CERTIFICATION

RADIATION EFFECTS ON THE TENSILE PROPERTIES OF T300/CE339 $(0)_4$ 1 MEV ELECTRONS AT 5×10^7 RADS/HR



LDEF MATERIALS SPECIMENS

- Polymeric films
- Polymeric matrix composites for tensile, compression, flexure, and CTE testing
- Metal matrix composites for CTE testing
- Polished metals
- Glasses, optical filters, optical fibers
- Ceramics
- Solar cells
- Solid rocket materials



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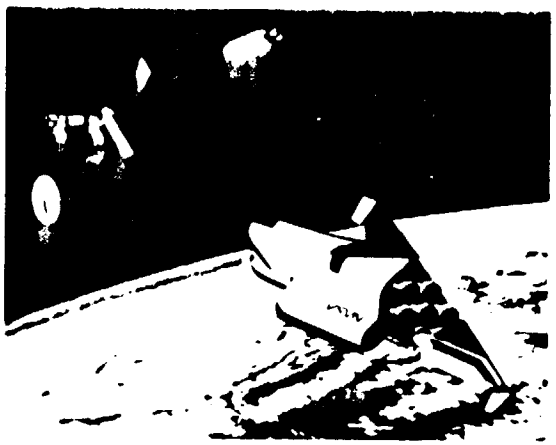
VEHICLE APPLICATIONS

High Temperature Materials Research

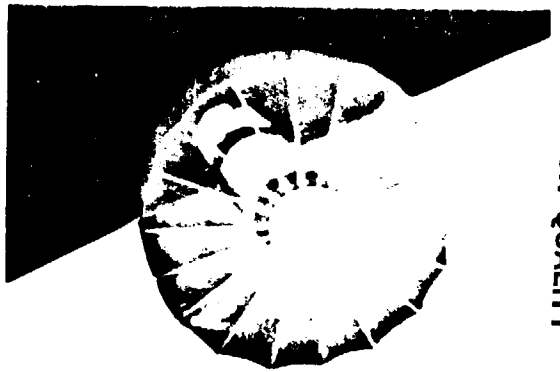


Space Transportation

Hypersonic Vehicle

Candidate Materials

- Carbon-Carbon
- Superalloys
- Titanium
- Al alloys (Fe,Ce)



Orbital Transfer Vehicle

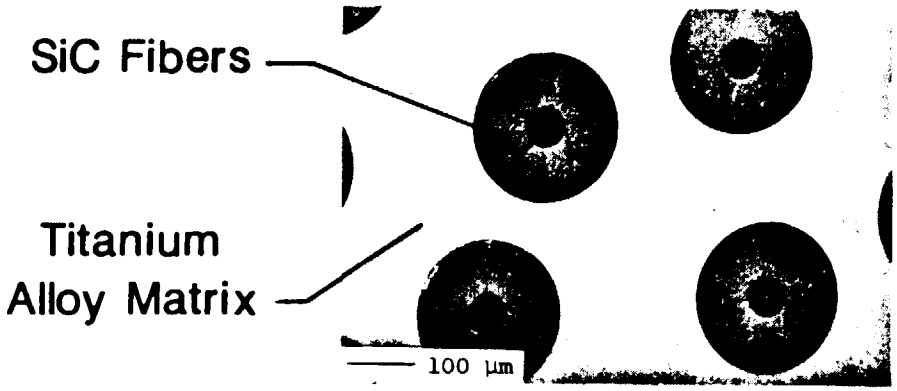
RM 504.4

MATERIALS AND STRUCTURES

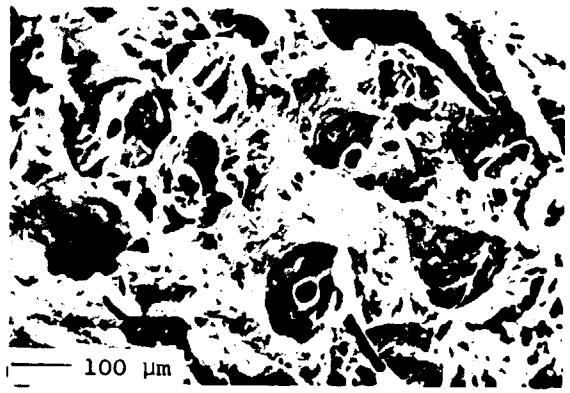
TECHNOLOGY NEEDS

- MATERIALS
- STRUCTURAL CONCEPTS
  - LEADING EDGES/NOSE CAP
  - ACTIVELY COOLED CONCEPTS
  - CONTROL CONCEPTS
  - WING
  - CRYOGENIC TANK STRUCTURE
  - SEALS
- LOADS
  - CONCEPTUAL WEIGHT ESTIMATION
  - AEROTHERMAL LOADS
  - AEROTHERMOELASTICITY
  - AEROACOUSTICS
  - LANDING DYNAMICS
- TESTING
  - COMBINED MECHANICAL, THERMAL, LH_2 LOADS
  - INSTRUMENTATION

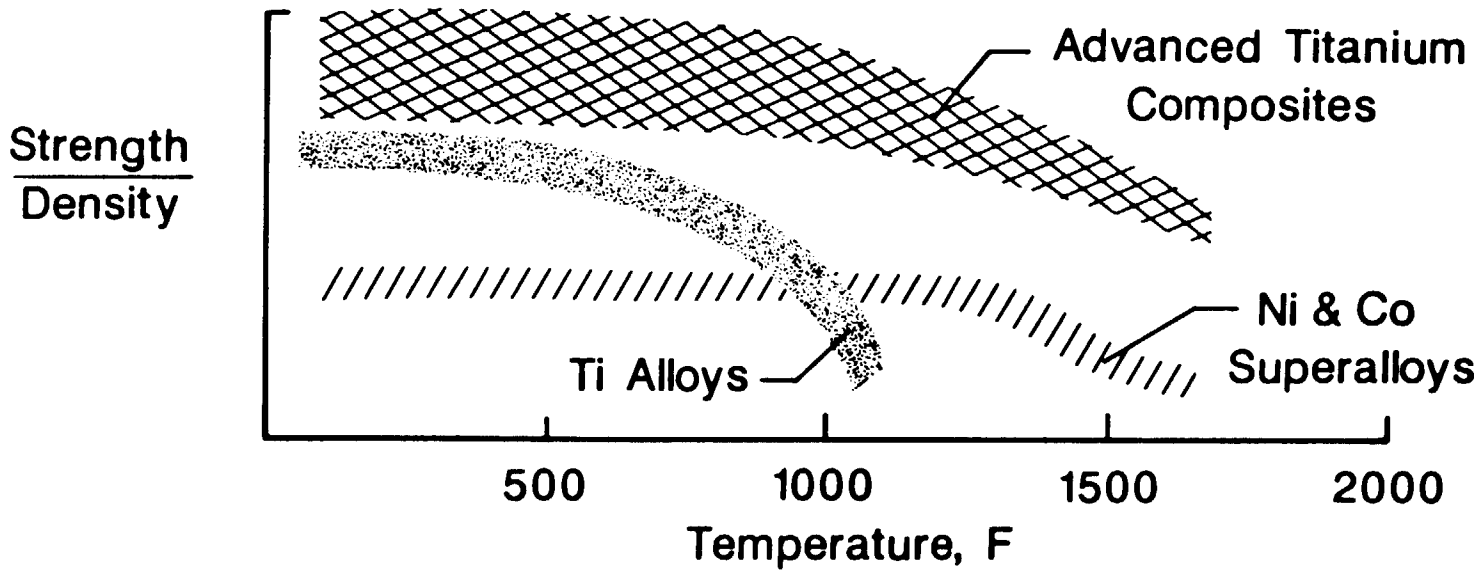
HIGH TEMPERATURE METAL MATRIX COMPOSITES
SiC FIBER REINFORCED TITANIUM ALLOYS



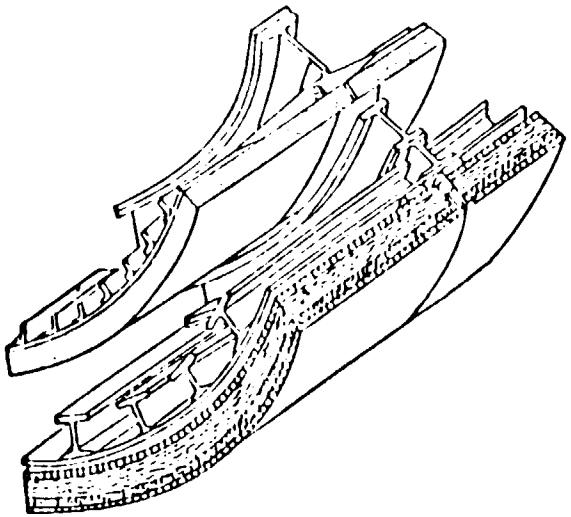
Polished Cross Section



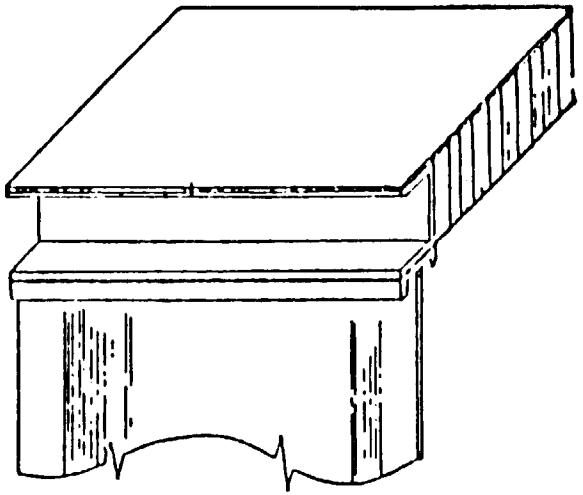
Fracture Surface



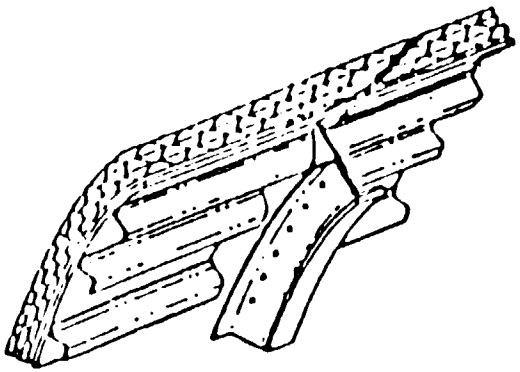
ADVANCED STRUCTURAL CONCEPTS



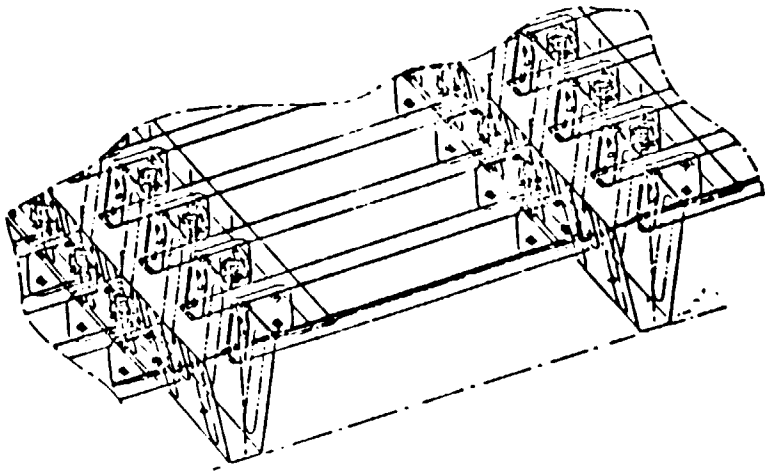
SIDEWALL CONSTRUCTION



HONEYCOMB CORE SANDWICH

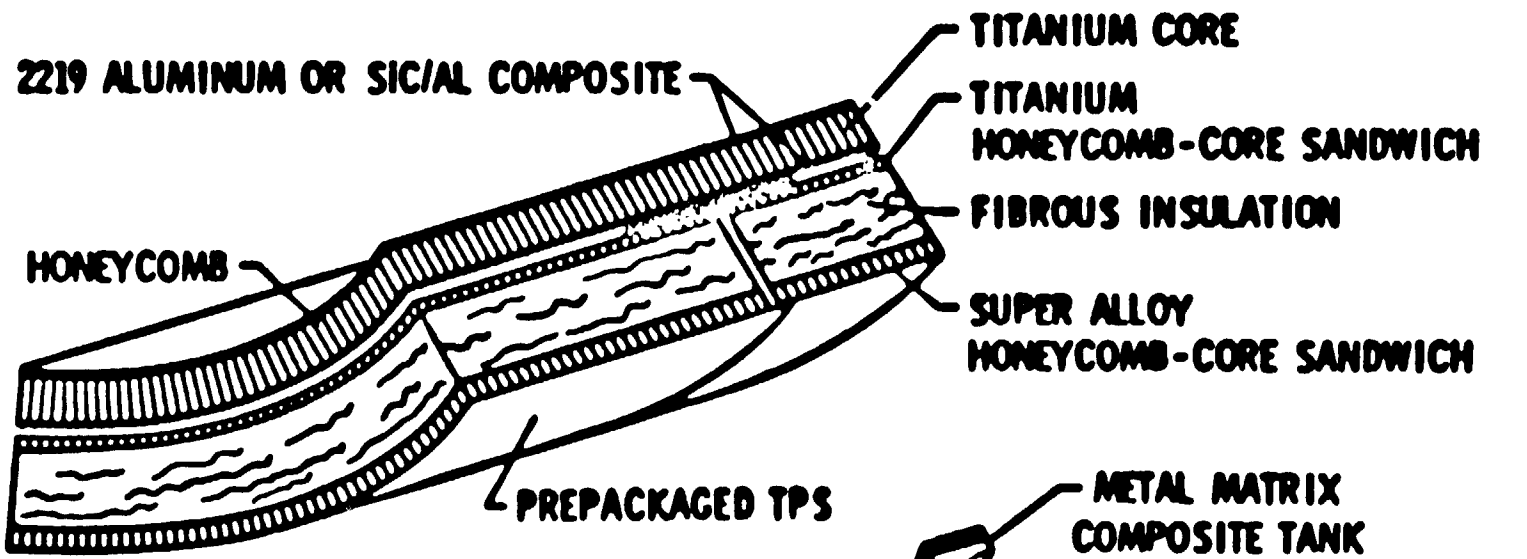


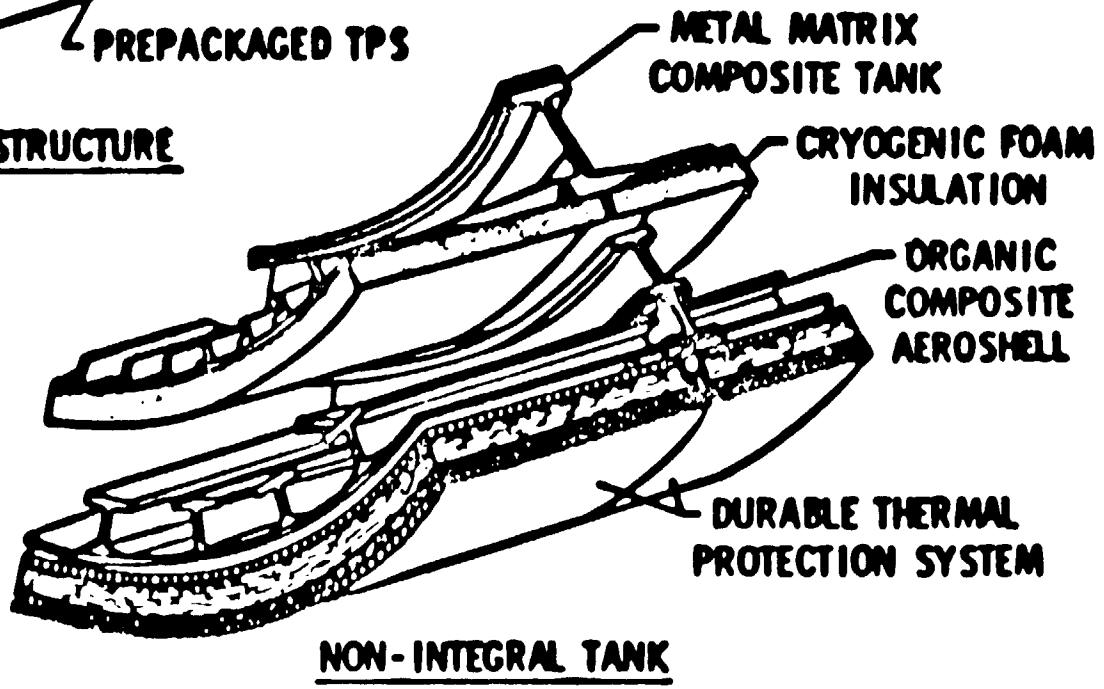
TITANIUM MULTIWALL



CARBON-CARBON TPS

INTEGRAL AND NON-INTEGRAL TANK STRUCTURE TPS CONCEPTS



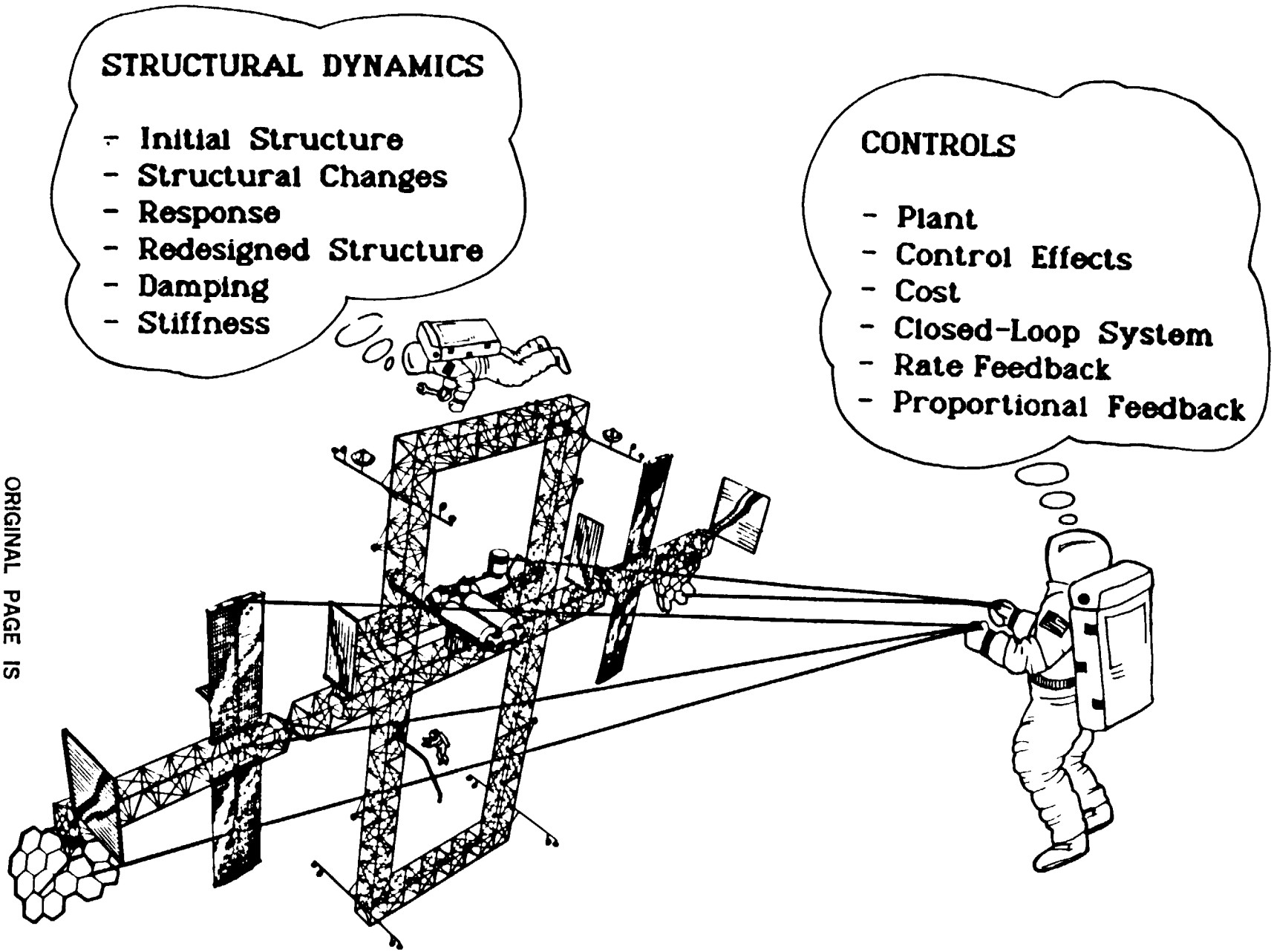


RM 503.0

CIVILIAN SPACE TECHNOLOGY INITIATIVE (CSTI)

LARGE SPACE STRUCTURES AND CONTROL

- CONTROL/STRUCTURE INTERACTION
- PRECISION SEGMENTED REFLECTORS



RM 510.2

CONTROLS-STRUCTURES INTERACTION (CSI) TECHNOLOGY

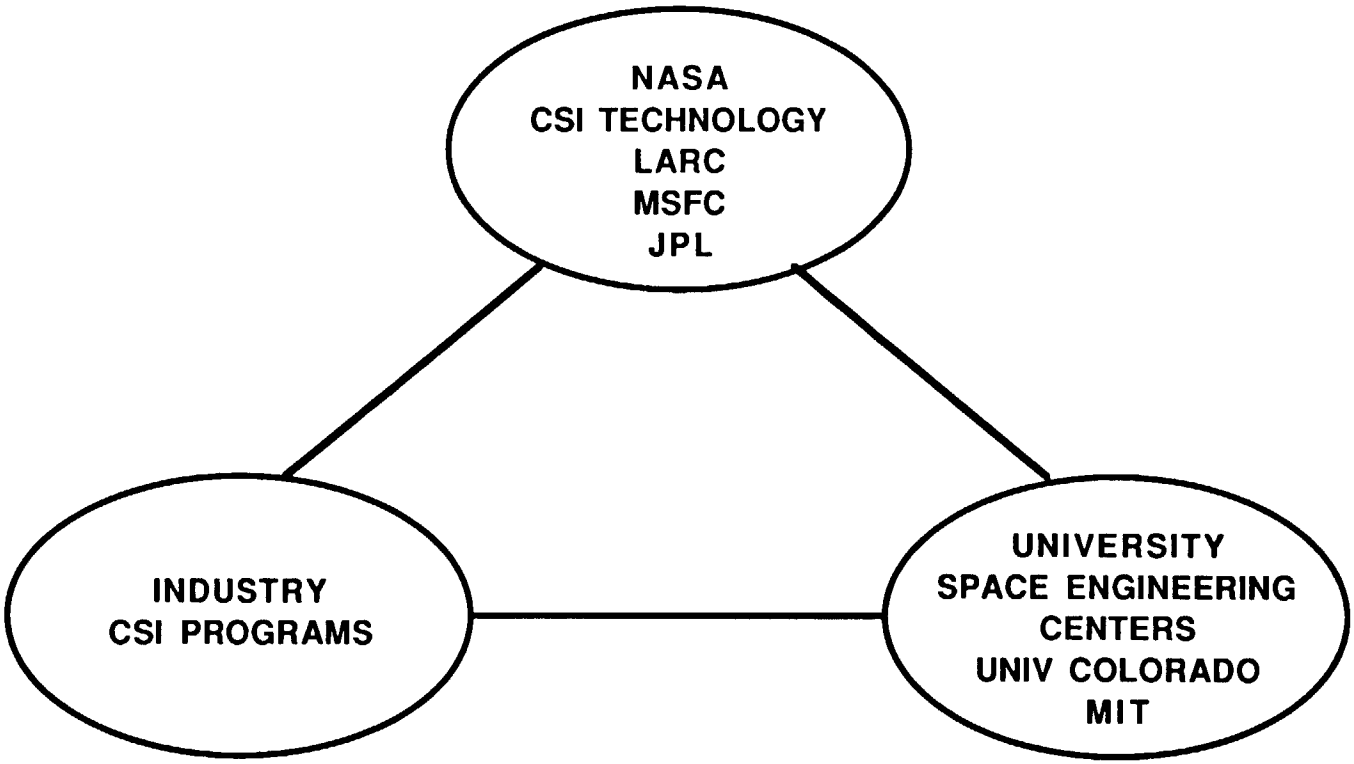
GOAL:

DEVELOP VALIDATED CSI TECHNOLOGY FOR INTEGRATED DESIGN/ANALYSIS AND QUALIFICATION OF LARGE FLEXIBLE SPACE SYSTEMS AND PRECISION SPACE STRUCTURES

OBJECTIVES:

- DEVELOP AND VALIDATE INTEGRATED DESIGN/ANALYSIS METHODS
- DEVELOP AND DEMONSTRATE GROUND TEST METHODS/TECHNIQUES TO PREDICT ON-ORBIT PERFORMANCE
- OBTAIN IN-SPACE EXPERIMENTAL DATA TO VALIDATE DESIGN/ANALYSIS AND GROUND TEST METHODS
- ESTABLISH DESIGN METHODS AND CRITERIA FOR QUALIFICATION OF SPACECRAFT FOR FUTURE SPACE MISSIONS

CONTROL-STRUCTURES INTERACTION TECHNOLOGY



CONTROL OF FLEXIBLE STRUCTURES (COFS)

MAJOR DELIVERABLES

INTEGRATED DESIGN/ANALYSIS METHODS

- INTEGRATED CONTROLS-STRUCTURES INTERACTION (CSI) DESIGN/ANALYSIS METHODOLOGY

GROUND TEST EXPERIMENTS

- CSI TESTBEDS AT LARC, JPL AND MSFC
- ACTIVE STRUCTURAL ELEMENTS WITH EMBEDDED SENSORS AND ACTUATORS

IN-SPACE FLIGHT EXPERIMENTS

- SMALL SCALE, LOW COST CSI IN-SPACE FLIGHT EXPERIMENTS
- CONTROLS AND STRUCTURES EXPERIMENT IN SPACE (CASES) SCHEDULED FOR SHUTTLE LAUNCH IN 1993

CSTI

PRECISION SEGMENTED REFLECTORS

ENABLE LIGHTWEIGHT, THERMALLY STABLE, PRECISION SURFACES WITH ACTIVE CONTROL

GOALS

- VALIDATED DATABASE FOR HYBRID COMPOSITE REFLECTOR MATERIALS
- LIGHTWEIGHT, LOW-COST, THERMALLY STABLE REFLECTOR PANEL WITH PRECISE SURFACE TOLERANCE
- RELIABLE SENSORS, ACTUATORS, CONTROL METHODOLOGY
- GROUND DEMONSTRATION VALIDATION OF MULTI PANEL SYSTEM

SIGNIFICANCE TECHNOLOGY FOR CONSTRUCTION OF LARGE REFLECTORS WITH MICRON SMOOTHNESS DOES NOT EXIST. COST AND WEIGHT PENALTIES PROHIBIT USING CURRENT AND PROJECTED MATERIALS DEVELOPMENTS

OAST

PRIMARY CENTER RESPONSIBILITIES

LANGLEY RESEARCH CENTER

PRIMARY TRUSS STRUCTURE
- BASELINE PAC-TRUSS
- ERECTABLE -VS- DEPLOYABLE
- ROBOTIC COMPATIBILITY (BUT NO ACTUAL ROBOTICS)

ADVANCED PANEL MATERIALS
- ADVANCED ULTRA-LOW CTE RESINS
- GRAPHITE/GLASS COMPOSITE (ADVANCED PROCESSING)

ADVANCED MAGNETIC SUSPENSION ACTUATORS

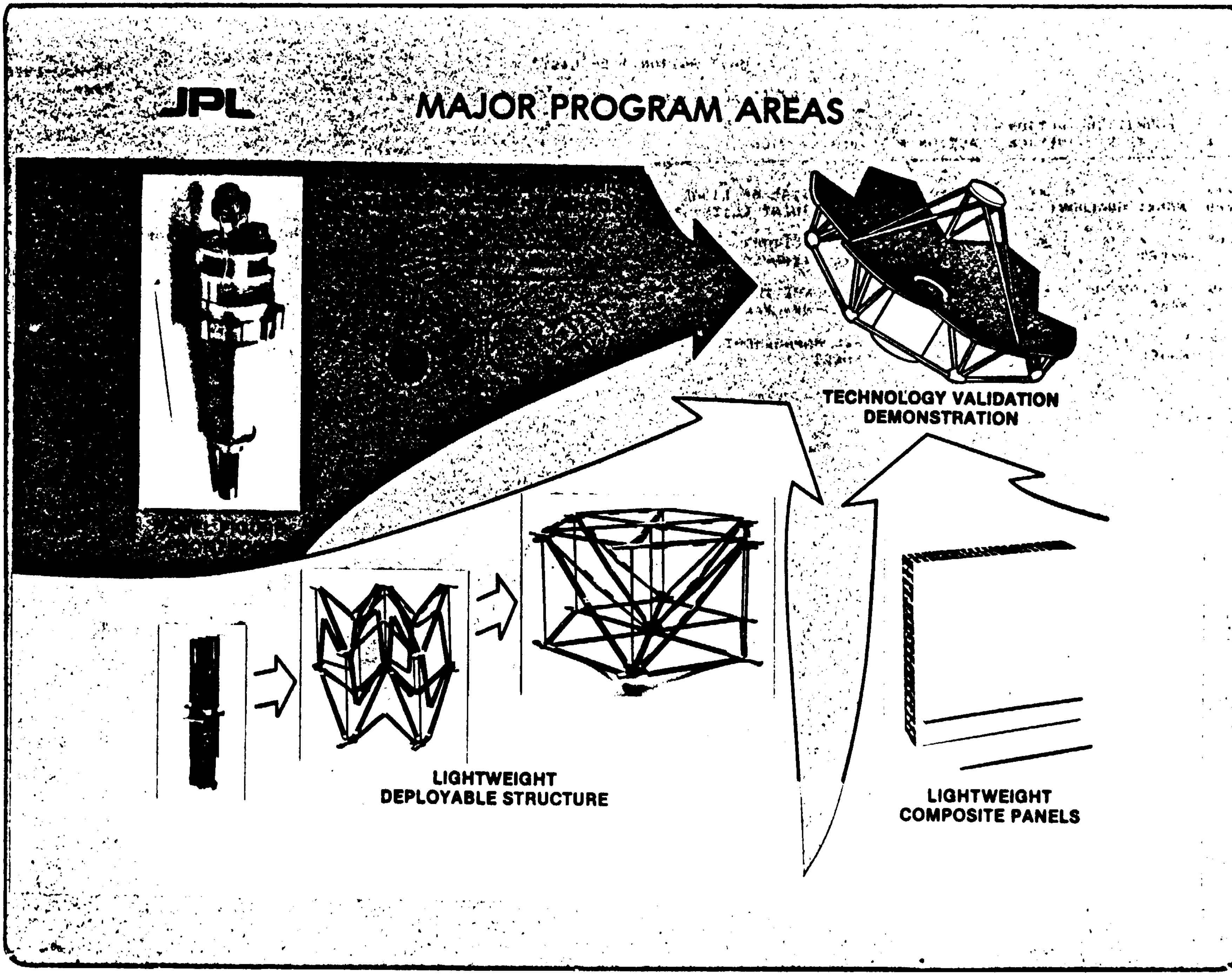
JET PROPULSION LABORATORY

SYSTEM DEFINITION, INTEGRATION AND TEST

PANEL DEVELOPMENT
- CONCEPTS
  - MATERIAL SYSTEMS (BASELINE - GRAPHITE/EPOXY)
  - "DEFORMABLE" SURFACE
- SURFACE ACCURACY
- REPRODUCIBILITY (1- TO 2-METER PANELS)
- DURABILITY
- PANEL MATERIALS ADVANCED GR/EP
- COATINGS AND ADHESIVES

OVERALL CONTROL STRATEGY
- FIGURE AND VIBRATION CONTROL METHODOLOGY
- BASELINE SENSORS AND ACTUATORS

CONCEPT FOR "ACTIVE" PRIMARY STRUCTURES FOR STATIC AND DYNAMIC TUNING



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PATHFINDER

- IN-SPACE ASSEMBLY AND CONSTRUCTION
- SAMPLE ACQUISITION, ANALYSIS ANDPRESERVATION
- RESOURCE PROCESSING PILOT PLANT

PATHFINDER

IN-SPACE ASSEMBLY AND CONSTRUCTION

PROGRAM OBJECTIVE:

DEVELOP TECHNOLOGY TO ENABLE THE IN-SPACE ASSEMBLY AND CONSTRUCTION FOR VARIOUS CLASSES OF SPACE STRUCTURAL CONCEPTS TO SUPPORT LONG-RANGE NASA MISSIONS

- MARS TRANSFER VEHICLE
- LARGE AEROBRAKES
- DEPLOYABLE FUEL DEPOT PLATFORMS
- PRESSURE VESSELS, HABITAT AND HANGER ENCLOSURES, FUEL TANKS
- LUNAR CARGO VEHICLE
- LARGE ASTRONOMICAL INSTRUMENTS

IN-SPACE ASSEMBLY AND CONSTRUCTION

MAJOR DELIVERABLES

- METHODS TELEROBOTICALLY FABRICATING PERMANENT JOINTS (E.G. WELDING)
- CONCEPT FOR HIGH-LOAD CARRYING MECHANICAL JOINTS
- "SPACE CRANE" CONCEPT FOR MANIPULATING LARGE MASSES
- ARCHITECTURE AND SPECIFICATION OF A GENERALPURPOSE, SPACE-BASED SYSTEM FOR LARGE-SCALE ASSEMBLY AND CONSTRUCTION
- VALIDATED TELEROBOTIC METHODS FOR PRECISE MANIPULATING, POSITIONING AND HOLDING OF LARGE STRUCTURAL COMPONENTS
- CONCEPT FOR LARGE-SCALE UTILITIES INSTALLATION
- VALIDATED METHODS FOR INTEGRATED TELEROBOTIC MANIPULATION, PRECISE POSITIONING AND JOINING OF LARGE, MASSIVE SPACE SYSTEMS
- SOFTWARE SYSTEM FOR IN-SPACE ASSEMBLY AND CONSTRUCTION SIMULATION, OPERATIONAL SEQUENCING AND PROCESS MONITORING

PATHFINDER

SAMPLE ACQUISITION, ANALYSIS AND PRESERVATION (SAAP)

PROGRAM OBJECTIVE:

DEVELOP THE TECHNOLOGY FOR REMOTE COLLECTION, ANALYSIS AND PRESERVATION OF EXTRA-TERRESTRIAL MATERIAL SAMPLES TO ENABLE EXPLORATION, RESOURCE IDENTIFICATION AND SITE SELECTION FOR A PILOTED MISSION (MARTIAN EMPHASIS)

- SITE AND SAMPLE SELECTION
- SAMPLE ACQUISITION
  - SURFACE SAMPLES
  - FRESH ROCK
  - SUB-SURFACE
- SAMPLE ANALYSIS
- CONTAINMENT AND PRESERVATION
- SAAP SYSTEM CONCEPTS

SAMPLE ACQUISITION, ANALYSIS AND PRESERVATION

MAJOR DELIVERABLES

- MULTI-SPECTRAL REMOTE SAMPLE SENSING AND SCREENING CONCEPT
- MULTI-PURPOSE SAMPLE ACQUISITION END-EFFECTOR
- MATERIALS AND CONTAINER DESIGN FOR SAMPLE PRESERVATION
- METHODS FOR PHYSICAL/CHEMICAL ANALYSIS
- AUTOMATED ROCK CORING DRILL CONCEPT AND HARDWARE
- SAAP LABORATORY SAMPLE ACQUISITION AND PREPARATION TESTBED
- SAAP LABORATORY SAMPLE ANALYSIS TESTBED
- INTEGRATED TRANSPORTABLE SAAP "FIELD" TESTBED
- SITE SELECTION PHYSICAL/CHEMICAL DATABASE FOR A MARS MISSION
- SYSTEM CONCEPT FOR A MARS MISSION SAAP SYSTEM WITH VALIDATED TESTBED HARDWARE, AUTOMATION AND CONTROL

PATHFINDER

RESOURCE PROCESSING PILOT PLANT

PROGRAM OBJECTIVE:

DEVELOP TECHNOLOGY TO ENABLE THE EXPLOITATION OF EXTRA-TERRESTRIAL RESOURCES FOR LIFE SUPPORT, PROPULSION AND CONSTRUCTION (LUNAR EMPHASIS)

- BASIC PRODUCTION METHODS
  - OXYGEN
  - METALS
  - CONSTRUCTION MATERIALS (E.G. BRICKS, GLASS)
- PROCESS ENGINEERING
- MATERIAL PREPARATION
- PILOT PLANT DEVELOPMNENT
- MINING

MATERIALS AND STRUCTURES TECHNOLOGY

SPACE TECHNOGY NEEDS:

- SPACE DURABLE/DIMENSIONALLY STABLE MATERIALS
- ADVANCED THERMAL PROTECTION CONCEPTS
- ADVANCED SPACE STRUCTURAL CONCEPTS
  IN-SPACE CONSTRUCTION
- LARGE SPACE STRUCTURES, DYNAMICS AND CONTROL
  CONTROL-STRUCTURE INTRERACTION
- GROUND TEST/FLIGHT EXPERIMENTS METHODOLOGY

GOAL:

BROAD TECHNOLOGY BASE TO SUPPORT FUTURE NASA MISSION REQUIREMENTS

- CSTI
- PATHFINDER

IMPACT OF ENVIRONMENTAL FACTORS ON SYSTEMS

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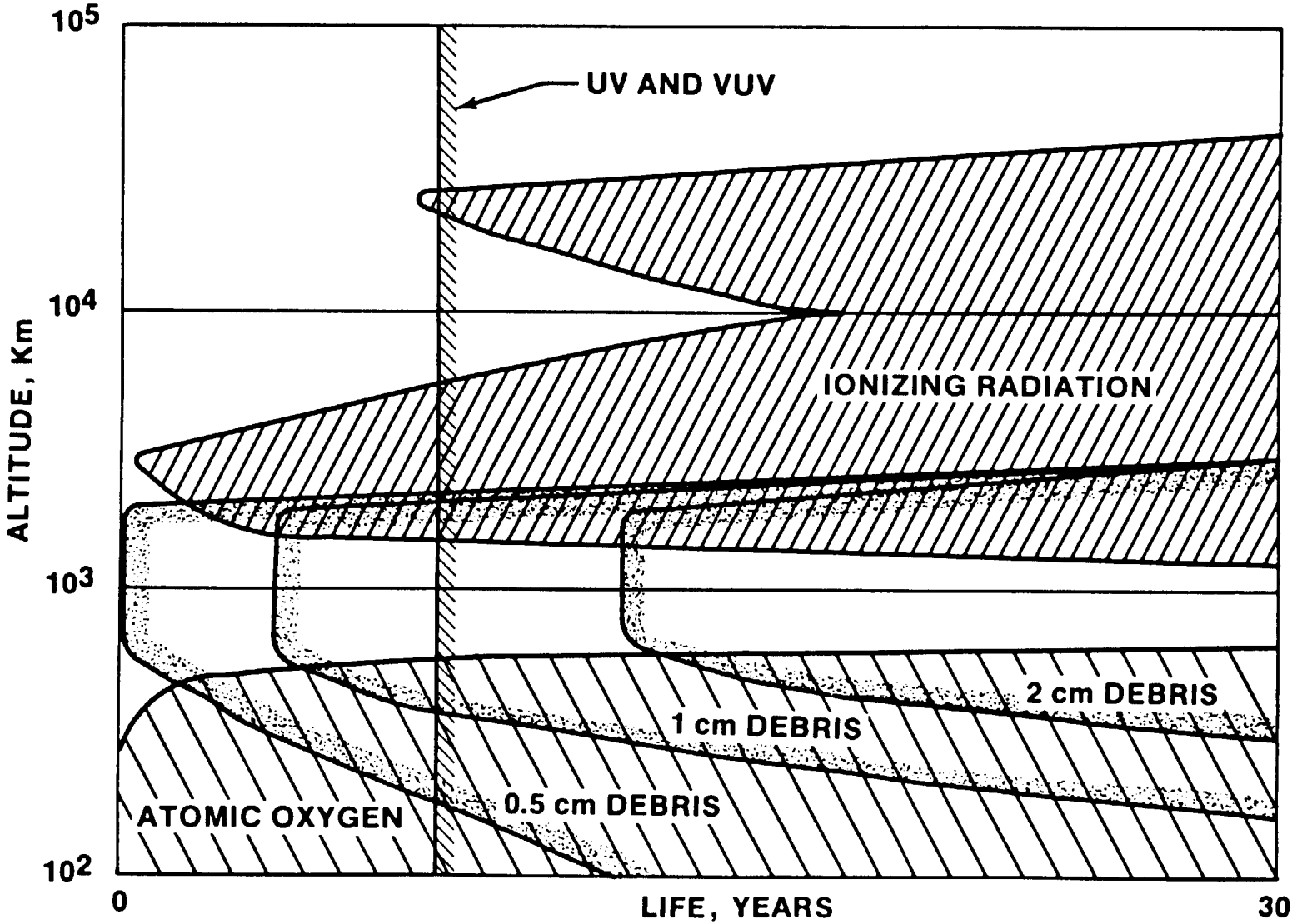

SPACE ENVIRONMENTAL EFFECTS

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CONCERNS

- LARGER SPACECRAFT
- VULNERABLE LIGHTWEIGHT MATERIALS
- MINIMUM GAGE STRUCTURES
- LARGER ONBOARD POWER SOURCES
- LONGER FLIGHT DURATIONS
- HAZARDOUS ORBITS

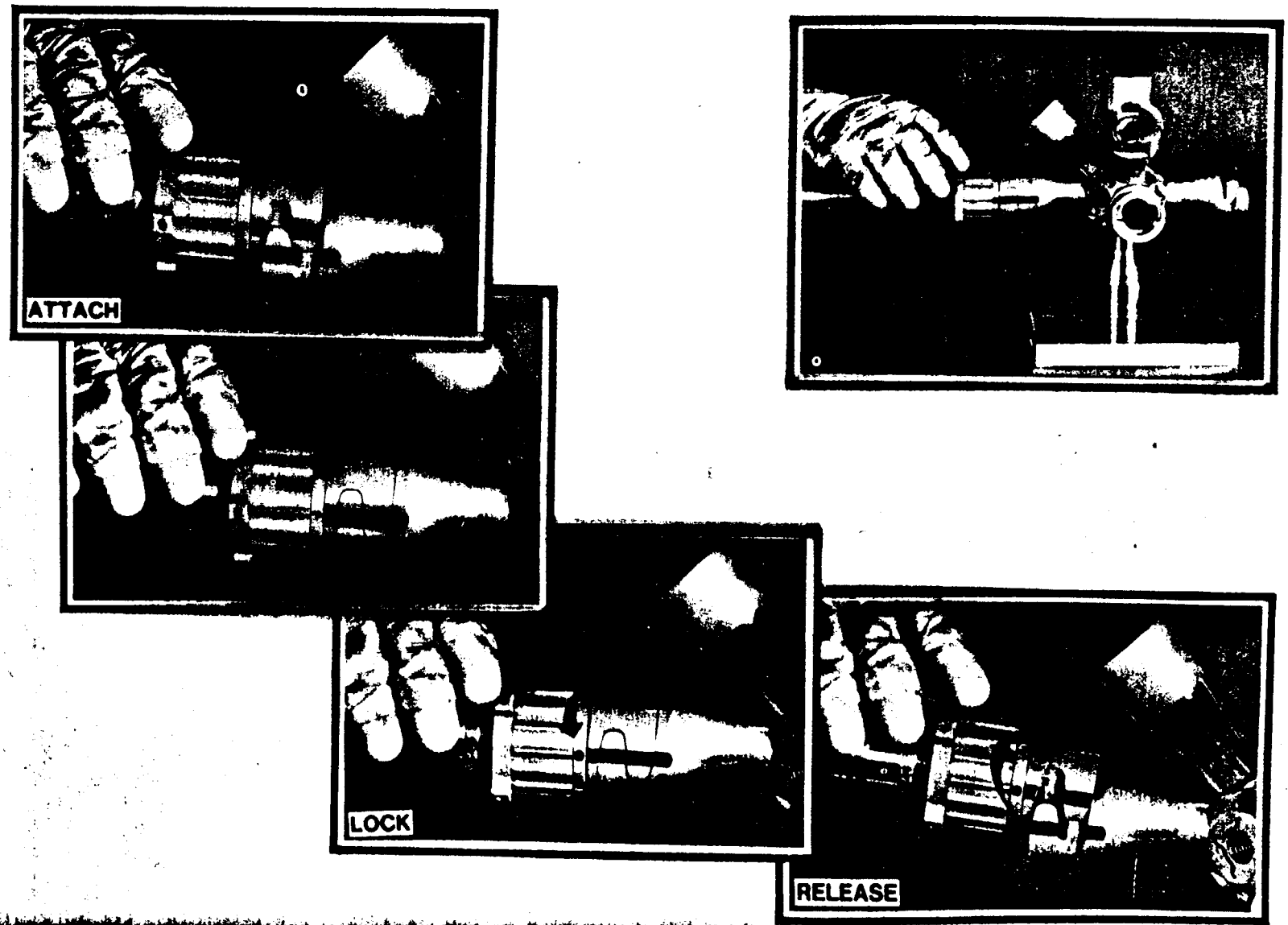
CURRENT/ADVANCED COATINGS FOR SPACECRAFT

COATING TYPE / SUBSTRATE	COATING COMPOSITION / DESIGNATION	CONCERNS
ANODIZED/ ALUMINUM ALLOYS	CHROMIC ACID ANODIZE SULFURIC ACID ANODIZE OXALIC ACID ANODIZE	THERMOMECHANICAL STABILITY
ANODIZED Al FOIL/ GRAPHITE-EPOXY COMPOSITES	CHROMIC ACID ANODIZE ON A-1100 FOIL	THERMOMECHANICAL STABILITY ADHESIVE STABILITY
WHITE PAINTS/ Al, COMPOSITES	ZINC OXIDE-SILICATE / Z-93 ZINC OXIDE-SILICONE / S13GLO ZINC ORTHOTITINATE-SILICATE / YB-71 CHEMGLAZE, A-276	THERMOMECHANICAL STABILITY ATOMIC OXYGEN
BLACK PAINTS/ Al, COMPOSITES	CHEMGLAZE, Z-306 IITRI, D=111	THERMOMECHANICAL STABILITY ATOMIC OXYGEN
THIN FILMS (<5000A)/ OPTICS, RADIATORS, SOLAR VOLTAICS	SILICON DIOXIDE ON ORGANICS ALUMINUM LEAD-TIN	ATOMIC OXYGEN DEFECT CONTENT DEBRIS IMPACT

LDEF COATINGS AND COATING SPECIMENS

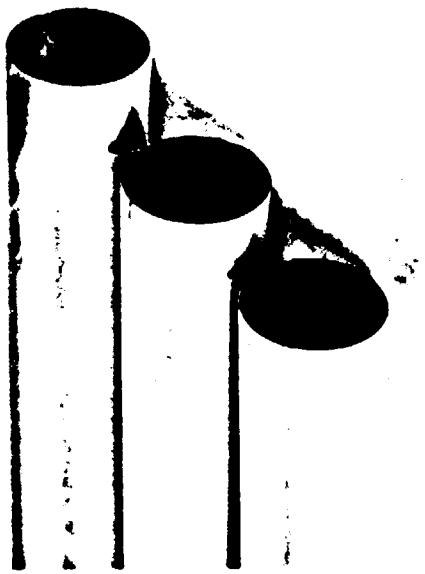
- White paints with organic and inorganic binders
- Black paints
- Anodized aluminum
- Ceramic sputter deposited coatings
- Mettallic coatings
- Second-surface mirrors
- Optical solar reflectors
- Sputter deposited coatings over graphite/epoxy

QUICK ATTACHMENT JOINT DEVELOPED FOR SPACE STATION DESIGNED FOR ASTRONAUT GLOVE HANDLING



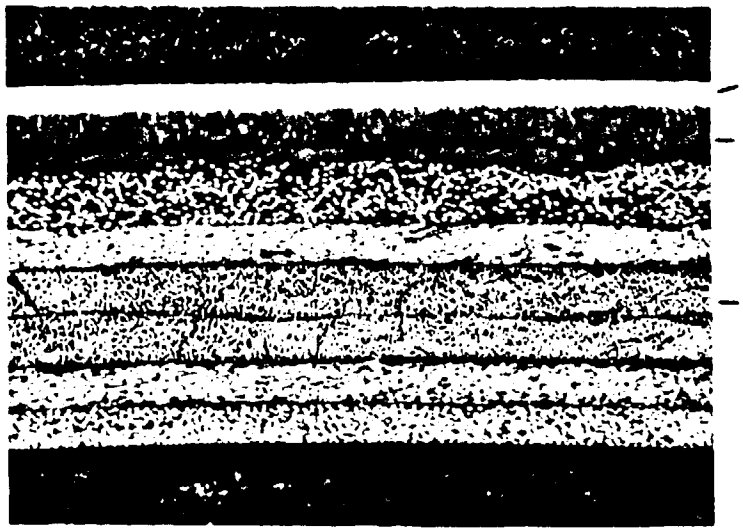
COMPOSITE TUBE WITH Al FOIL COATING

P75/934 (+60,-60,0,0,-60,+60)



COMPOSITE TUBES

2 INCH DIAMETER

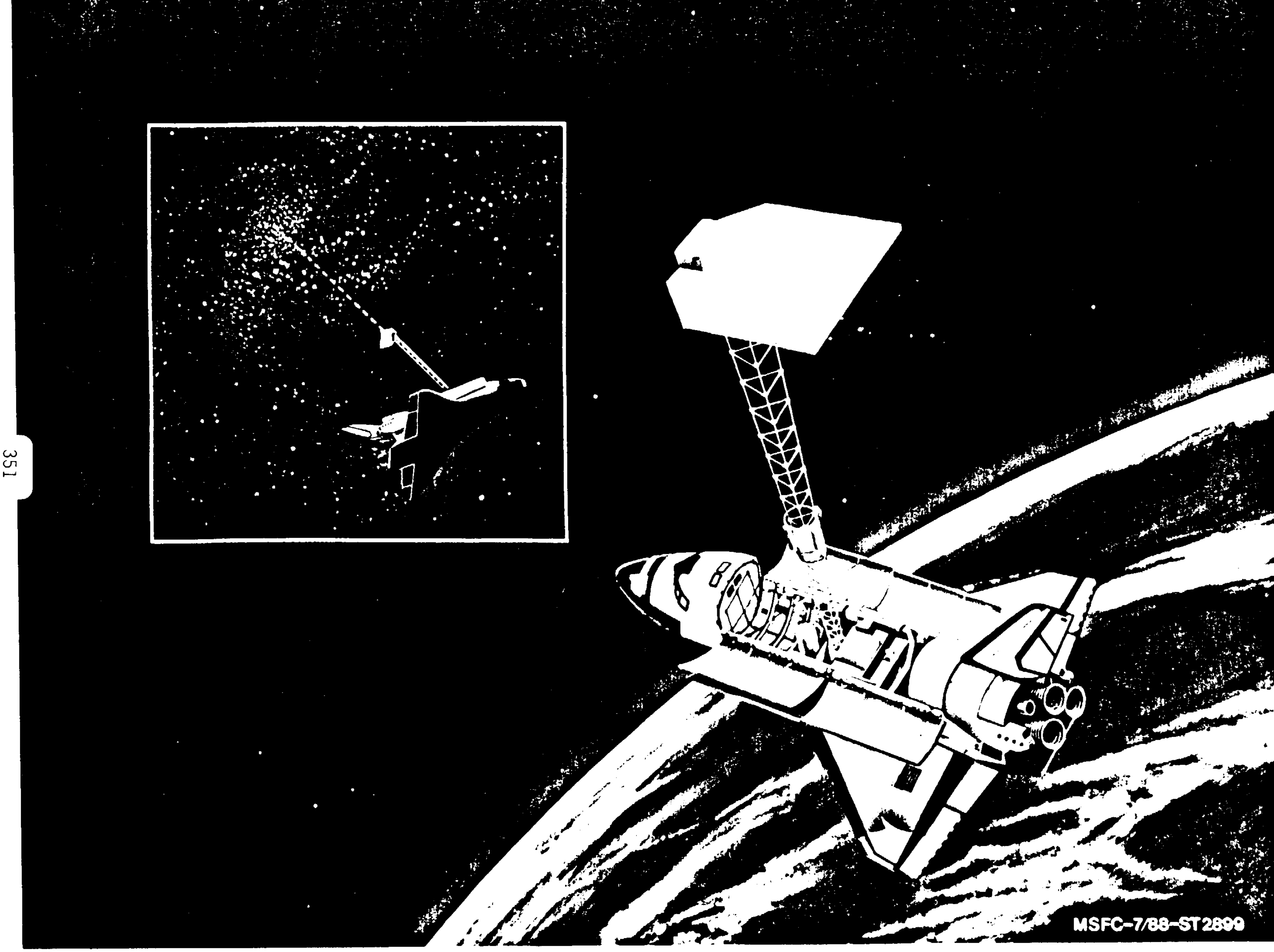


TUBE CROSS-SECTION

NASA CSI PROGRAM ELEMENTS

- CONFIGURATIONS AND CONCEPTS
- INTEGRATED ANALYSIS AND DESIGN
- GROUND TEST METHODOLOGY
- IN-SPACE FLIGHT EXPERIMENTS
- GUEST INVESTIGATOR PROGRAM

CONTROL AND STRUCTURES EXPERIMENT IN SPACE (CASES)



HYPERSONIC FLIGHT REQUIRES MATERIALS THAT ARE:

- LIGHTWEIGHT
- HIGH TEMPERATURE
- HIGH STIFFNESS AT ELEVATED TEMPERATURE
- HIGH STRENGTH AT ELEVATED TEMPERATURE
- MINIMUM GAGE
- OXIDATION RESISTANT

MATERIALS

METALLICS

- LIGHT ALLOYS AND INTERMETALLICS
- ADVANCED MMC
- PROCESSING AND JOINING

NONMETALLICS

- CARBON-CARBON
- CERAMICS
- CERAMIC MATRIX COMPOSITES

NON-STRUCTURAL MATERIALS

- SEALS AND LUBRICANTS
- COATINGS
- INSULATION

PRECISION SEGMENTED REFLECTORS
MAJOR DELIVERABLES

PANELS: 1-METER, 3-MICRON RMS PRECISION

- MATERIALS
- CONSTRUCTION
- DURABILITY

2-METER, 10-MICRON RMS, LARGE -SCALE PANEL
1-MICRON RMS, ADVANCED CONCEPT PANEL

BACK-UP TRUSS: 10-METER CONCEPT VALIDATION MODEL
4-METER TESTBED VERSION

- ERECTABLE/DEPLOYABLE
- 1-MM PRECISION
- ADVANCED HIGH-PRECISION JOINTS

CONTROLS: PANEL ALIGNMENT SYSTEM

- SUB-MICRON PRECISION
- SENSORS AND ACTUATORS
- MULTI-PANEL CONTROL ALGORITHM

"ACTIVE MEMBER" VIBRATION SUPPRESSION

MULTI-PANEL INTEGRATED TESTBED (PANELS, TRUSS, CONTROLS)

RESOURCE PROCESSING PILOT PLANT

MAJOR DELIVERABLES

- PROCESSES TO PRODUCE OXYGEN, LUNAR CONSTRUCTION MATERIALS, AND LUNAR METALS
- OXYGEN LIQUEFACTION PROCESS FOR LUNAR ENVIRONMENT
- BENEFICIATION PROCESS FOR LUNAR MATERIALS
- CONCEPTUAL DESIGN OF LUNAR PILOT PLANT
- LABORATORY PILOT PLANTS TO VALIDATE PRODUCTION OF LUNAR OXYGEN, CONSTRUCTION MATERIALS, AND METALS
- SOLIDS HANDLING AND TRANSPORT FOR LUNAR PROCESSING TESTBED, INCLUDING TELEROBOTIC CONCEPTS FOR COLLECTION, HANDLING, AND SORTING LUNAR MATERIALS
- BENCHTOP PILOT PLANTS COMPATIBLE WITH AUTONOMOUS OPERATION WHICH REQUIRE A MINIMAL DEGREE OF MONITORING AND MAINTENANCE
- LUNAR MINING CONCEPT