NASA WIRING FOR SPACE APPLICATIONS PROGRAM

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Washington, DC

NASA Code XS Overview

- **ORGANIZATION**
- **CHARTER**
- **PROGRAMS**

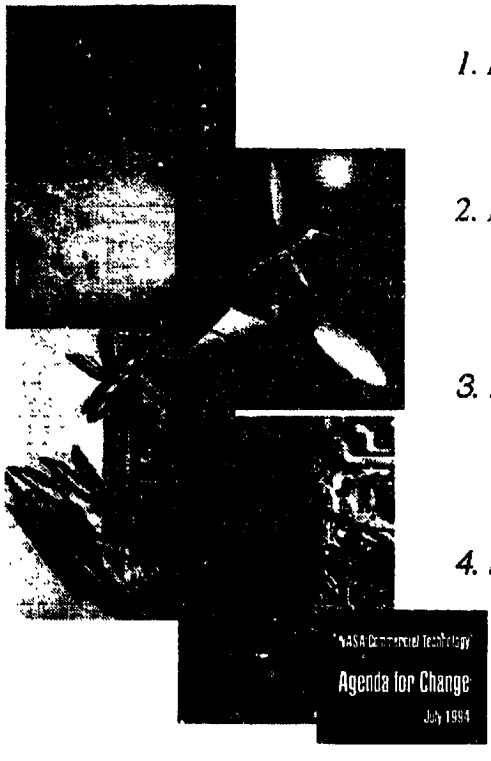
NASA Strategic Plan

- Enterprises
  - Aeronautics
  - Mission to Planet Earth
  - Space Science
  - Human Exploration
  - **Space Technology**
- Function
  - Communications
  - Human Resources
  - Physical Resources

Mission

Pioneer,With Industry, the Development and Use of Space Technology to Secure National Economic Competitiveness, Promote Industrial Growth and to Support Sp..ce Missions

Space Technology Enterprise Goals



1. Reduce the Cost of Access to Space

- Reusable Launch Vehicle
- Expendable Launch Vehicle
- In-Space Transportation

2. Provide Innovative Technologies to Enable Ambitious, Future Space Missions (ITP)

- Spacecraft Systems (Power, Propulsion, Structures, etc.)
- Instrument Technologies
- Operations

3. Build Capability in the U. S. Space Industry Through Focused Space Technology Efforts

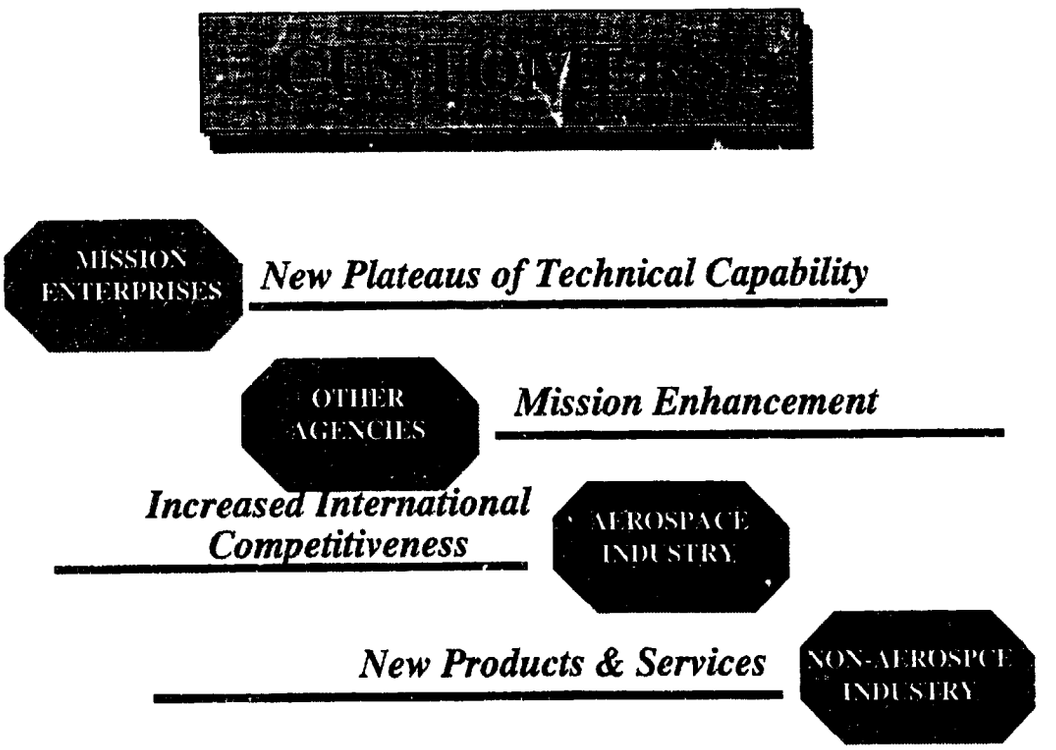
- Communications
- Remote Sensing
- Space Processing

4. Share the Harvest of Space Technology with the U.S. Industrial Community

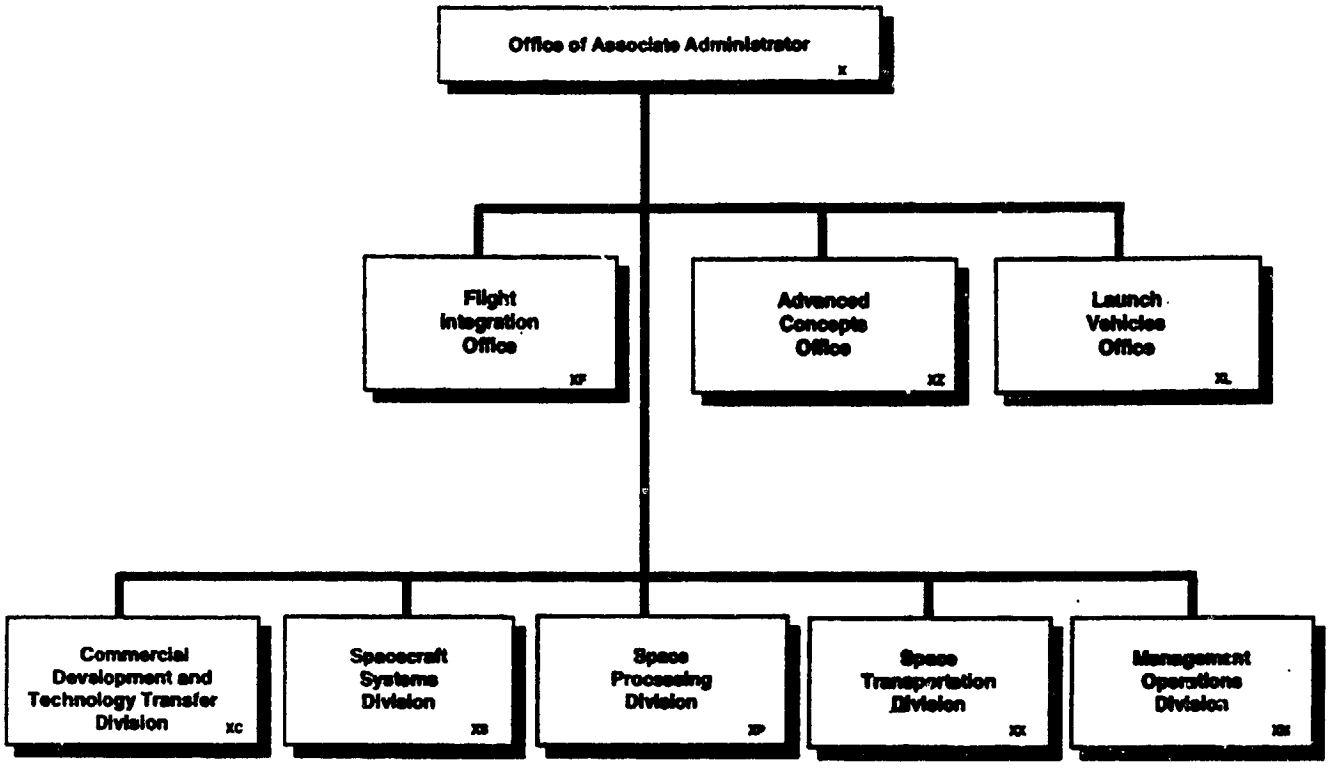
- Technology Transfer - "Agenda for Change" (New Way of Doing Business)

Operating Principles !

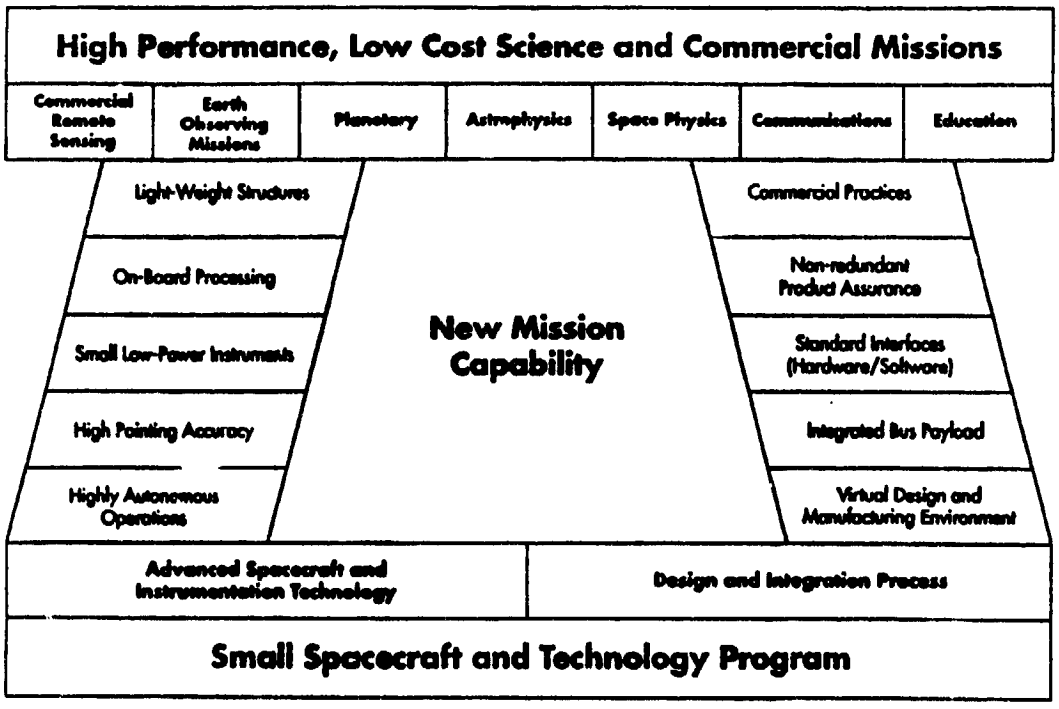
- Meet the Customers Needs
- Work With Industry
- Reduce the Cost of Access to Space
- Commercialization of Space Is Essential to NASA
- Commercialization and Technology Transfer Is Everybody's Job
- Consider Commercialization at Technology Program Initiation
- Effectively Use Space Station



OFFICE OF SPACE ACCESS AND TECHNOLOGY



Foundation for Future Missions



NEW MILLENNIUM / ESSP

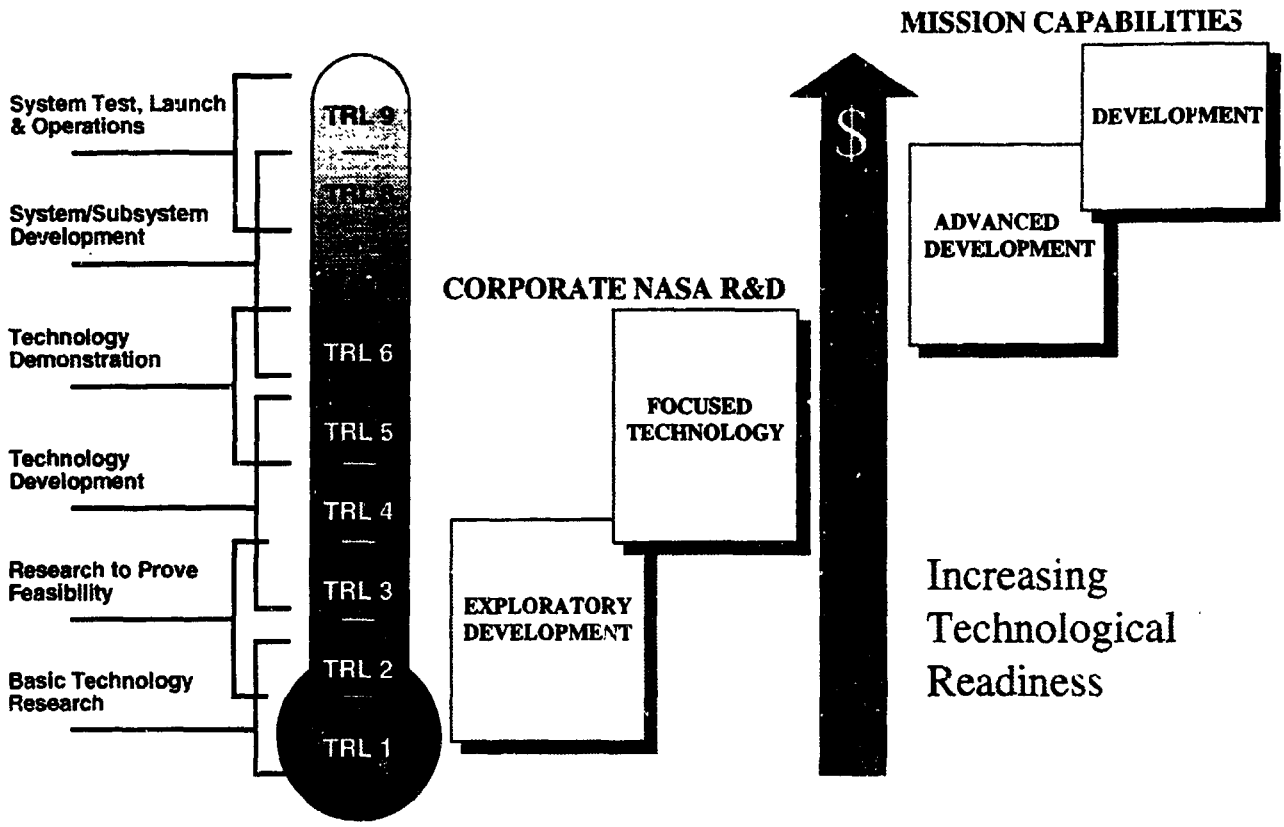
CHALLENGES

- Replace large, multi-instrument spacecraft with multiple small single instrument "sciencecraft"
  - Change focus from "instruments on a spacecraft" to "the instrument is the spacecraft"
- Return information, not data
- Wide, unconstrained interaction with users and information distribution to users
- Low initial cost, low operations cost

Small Spacecraft Tech Initiative

- Lewis
  - Payloads
    - Hyper Spectral (30M, 358 Bands)
    - UV cosmic measurement
    - Cloud detection/editing
  - 20 Technology Demonstrations
    - Integrated Thermal/Structural Design
    - Advanced power concepts
    - Autonomous on-orbit maintenance
    - Advanced C&DH and data bus arch.
    - Data compression
- Clark
  - Payloads
    - 3-meter panchromatic (world view)
    - CO_2 detection in atmosphere
    - Room temp. X-Ray detectors
  - 36 Technology Demonstrations
    - Advanced attitude control
    - Advanced photovoltaic concepts
    - Advanced power management and distribution
    - On-board processing
    - No shock release devices

Technology Readiness Levels (TRLs)



TECHNOLOGY ENTERPRISE STATUS

Access to Space

- National Space Transportation Policy Issued, NASA Implementation Plan Approved by OSTP & OMB
- Cooperative A[illegible]ments for X-33 & X-34 Signed With Industrial Partners
- 2000 Hour Ground Test of Ion Flight Experiment Prototype Thruster Successfully Completed

Innovative Technologies

- Parallel Contracts for SSTI Awarded, spacecraft construction started, launch date established and launch vehicle selection completed.
- New Millennium Spacecraft Technology Program Defined With Codes S & Y
- Mars Pathfinder Micro-Rover Fabrication Nearing Completion

Space Applications

- ACTS Fully Operational
- Commercial Remote Sensing Program Has Leveraged $38.5M of Industry Funding, and Led to the Creation of 25 New Products, Over 140 New Jobs, and Revenues Exceeding $66M and Is Developing Hyperspectral Capability Which Will Enable Movement Into New Markets
- Starting Large Animal Trials on Diabetes Treatment, Based on in-Space Developed Technology of Microencapsulation

Technology Transfer

- Agenda for Change Plan Approved, Agency-Wide Team Established, Performance Measurement Metrics Collected, and Technology Transfer Principle Added to NASA Strategic Plan

SUMMARY IMPLEMENTATION STRATEGY!

- **Develop Technology in Cooperation With and Responsive to User Requirements, With Upfront Consideration of Dual Use**
- **Proactively Transfer Technology to NASA Missions, Other Agencies and Aerospace and Non-Aerospace Industries**

Background

SPACE MISSIONS WITH ELECTRICAL WIRING SYSTEM FAILURE

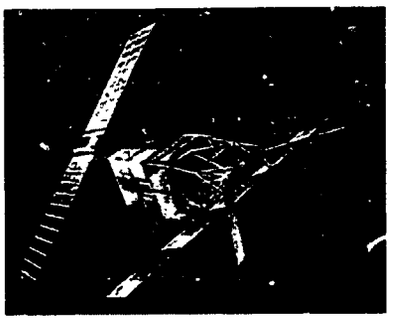
Mission	Cause	Result
Gemini 8	Electrical Wiring Short	Shortened Mission - Near Loss of Crew
Apollo 204	Damaged Insulation, Electrical Spark, 100% O_2	Fire, 3 Astronauts Lost
Apollo 13	Damaged Insulation/Short Circuit/Flawed Design	Oxygen Tank Explosion, Mission Incomplete
STS - 6	Abrasion of Insulation/Arc Tracking	Wire Insulation Pyrolysis 6 Conductors Melted
STS - 28	Damaged Insulation/Arc Tracking	Teleprinter Cable Insulation Pyrolysis
Magellan	Wrong Connection, Wiring Short	Wiring Insulation Pyrolysis - Ground Processing
Spacelab	Damaged Insulation/Arc Tracking	Wiring Insulation Pyrolysis During Maintenance
Delta 178/GOES-G	Mechanical or Electrochemical Insulation Damage	Loss of Vehicle
ESA - Olympus	Electrical Wiring Short	Loss of Solar Array

NASA Wiring for Space Applications Program

- **OBJECTIVES:**
  - Improve safety, performance, and reliability of wiring systems for space applications
  - Develop improved wiring technologies for NASA flight programs and commercial applications

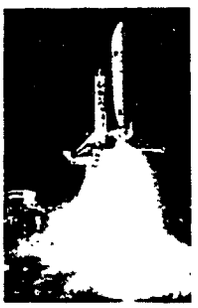
ELECTRICAL POWER WIRING PROGRAM

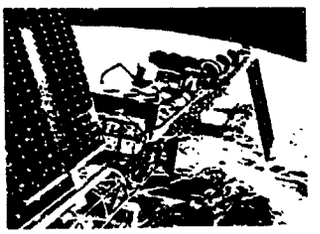
GOAL: TO PROVIDE A TECHNOLCGY BASE FOR THE DEVELOPMENT OF LIGHTWEIGHT, ARC TRACK-RESISTANT AND RELIABLE WIRING SYSTEMS FOR AEROSPACE APPLICATIONS.



APPROACH

- IDENTIFY MISSION REQUIREMENTS AND APPLICATION ENVIRONMENTS
- EVALUATE POTENTIAL WIRING SYSTEMS AND ESTABLISH A DATABASE
- INVESTIGATE ADVANCED TECHNOLOGIES RELEVANT TO WIRING FAILURE PREVENTION, DETECTION, AND ISOLATION.
- ESTABLISH GUIDELINES AND RECOMMENDATIONS



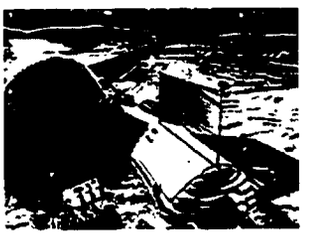


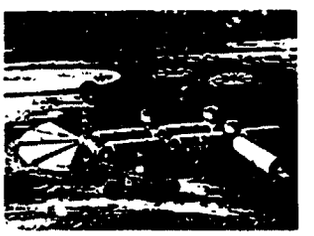
TECHNOLOGICAL DEVELOPMENTS

- NEW INSULATING MATERIALS
- NEW WIRING CONSTRUCTIONS
- IMPROVED SYSTEM DESIGN
- ADVANCED CIRCUIT PROTECTION

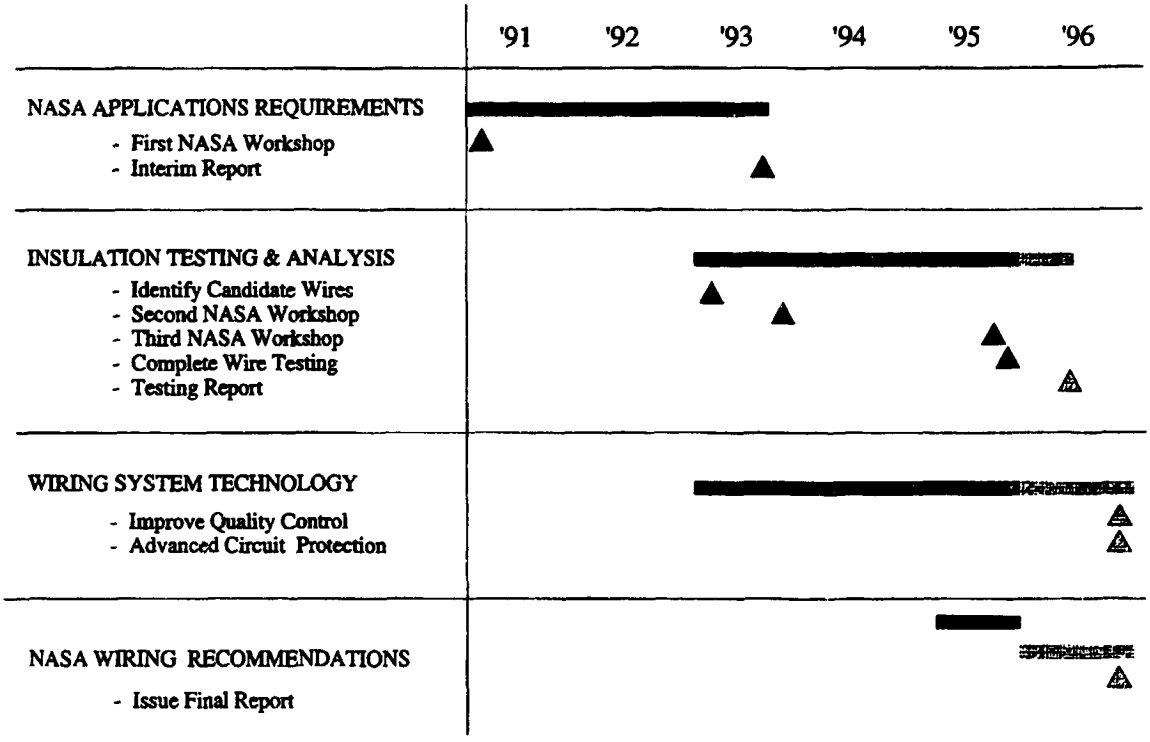
APPLICATIONS

- PRESSURIZED MODULES
- TRANS-ATMOSPHERIC VEHICLES
- LEO/GEO ENVIRONMENTS
- LUNAR AND MARTIAN ENVIRONMENTS





NASA Wiring for Space Applications Program



- **ACCOMPLISHMENTS:**
  - First Workshop, July 1991:
    - Wiring system operational experience
    - NASA wiring requirements
    - Wire manufacturing technologies

    Proceedings: "First NASA Workshop on Wiring for Space Applications", NASA CP-10145, July, 1994

  - Interim Report, June 1993:
    - NASA spacecraft environments
    - NASA unique testing requirements
    - Related wiring programs

    Report: "Operational Environments for Electrical Power Wiring on NASA Spacecraft", NASA TM-106655, June 1994

  - Second Workshop, July 1993:
    - Program overviews: NASA, AF, NAWC, ESA
    - Space wiring failures
    - Candidate wiring constructions
    - New wiring insulation
    - Test methodology and standardization

    Proceedings: "Second NASA Workshop on Wiring for Space Applications", NASA CP-3244, October, 1993

NASA Wiring for Space Applications Program

- **R & D PROGRAMS:**
  - System design
  - Candidate wiring constructions
  - New insulating materials
  - Protection techniques
  - Quality control

- **ORGANIZATIONS:**
  - NASA
  - DOD laboratories
  - FAA
  - Aerospace Industry
  - ESA
  - Academia
  - Technical committees

Tests Performed vs. Wiring Constructions Matrix.

Construction \ Test	Examine Product	Workmanship	Wire Wall Thickness	Conductor Diameter	Finished Diameter	Finished Weight	Wire Surface Markability	Impulse Dielectric	Insulation Resistance	Spark Test	Dry Dielectric Test	Voltage Withstand	Dielectric Constant	CIV/CEV (AC & DC)	Surface Resistance	Time/Current to Smoke	Wire Fusing Time	Dry Arc Resistance	BSI Dry Arc Resistance	Arc Tracking - SSF	Arc Tracking - NHB Method	Arc Tracking - MIL-W-2223	Dielectric Strength	Abrasion	Dynamic Cut Through	Flex Life	Notch Propagation	Stiffness and Springback	Crush Resistance	Insulation Impact Resistance	Tensile Strength	Wire to Wire Rub	Aging Stability	Thermal Index	Thermal Shock	Thermal Aging	Cold Bend	Thermal Cycling	Flammability - Aircraft	Toxicity - Burning	Smoke Quantity
MIL-W-81381/7	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●
MIL-W-81381/11	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●
MIL-[illegible] 22759/12	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●
MIL-[illegible]759/16	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-22759/18	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-22759/32	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-22759/34	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●
MIL-W-22759/43	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-16878	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
SSQ-21652	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
SSQ-21656	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MP571-0086	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Filotex - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●
Tensolite - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●
Thermatics - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●
Gore HS-725	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	○	○	●	●	●	●	●	○	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Nema #3 - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Barcel - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Nema #2 - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
DuPont (P-FP)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Brand Rex - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Champlain - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
TRW - PFPI	●	●	●	●	●	●	●	○	●	○	●	○	●	○	●	●	●	●	●	●	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●

Tests Performed vs. Wiring Constructions Matrix (Cont'd).

Construction \ Test	Flame Propagation	Flash Point of Liquids	Wire Flammability	Odor Assessment	Offgassing	Arc Tracking - 30% O_2	Wet Arc Tracking (ASTM)	Hydrolysis (ASTM)	Wet Arc Tracking (SAE)	Fluid Immersion	Forced Hydrolysis (SAE)	Humidity Resistance	Wicking	Impact of LOX and GOX	Fluid Compatability	Gas Compatability	Weight Loss	CIV/CEV - Vacuum	Outgassing (VCM)	Arc Tracking - Vacuum	Weathering Resistance	VUV Exposure	VUV/AO Exposure	Radiation Exposure	AO Exposure	Arc Tracking - µg	Flame Spread Rate - µg	Corona Discharge - Plasma	Debris Impacts	Electrostatic Dust
MIL-W-81381/7	○	●	●	○		○	●	●	●	●	●	●	●	●	○	○	●	○	○	○	●	○	○	○	○	○	○	○	○	○
MIL-W-81381/11	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	○	●	●	●	●	●
MIL-W-22759/12	●	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	○	○	○	●	●	●
MIL-W-22759/16	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-22759/18	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-22759/32	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-22759/34	●	●	●	●	●	○	●	●	●	●	●	●	●	●	●	○	●	○	●	○	●	●	●	○	○	○	○	○	○	○
MIL-W-22759/43	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MIL-W-16878	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
SSQ-21652	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
SSQ-21656	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MP571-0086	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Filotex - TKT	○	●	○	○	○	○	●	●	●	●	●	●	●	●	○	○	●	○	○	○	●	○	○	○	○	○	○	○	○	○
Tensolite - TKT	○	●	○	○	○	○	●	●	●	●	●	●	●	●	○	○	●	○	○	○	●	○	○	○	○	○	○	○	○	○
Thermatics - TKT	○	●	○	○	○	○	●	●	●	●	●	●	●	●	○	○	●	○	○	○	●	○	○	○	○	○	○	○	○	○
Gore HS-725	○	●	○	○	○	●	●	●	●	●	●	●	●	●	○	●	●	●	○	●	●	○	○	●	●	●	●	●	●	●
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Barcel - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Nema #2 - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
DuPont (P-FP)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Brand Rex - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Champlain - TKT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
TRW - PFPI	○	●	○	○	○	○	●	●	●	●	●	●	●	●	○	○	●	○	○	○	●	○	○	○	○	○	○	○	○	○

Key:

- ● Tests performed by DOD programs [11 - 13]
- ○ Some DOD testing, more necessary [11 - 13]
- ● Tests performed by NASA programs [26, 56, 57]
- ○ Some NASA testing, more necessary [26, 56, 57]
- **● Tests not required for this program**
- **○ Additional tests to be performed**

NASA Wiring for Space Applications Program

- **ACTIVITIES:**

  - Third Workshop, July 1995:

    - Program status: NASA, AF, NAWC, FAA, ESA
    - Wiring test results
    - Advancements in materials and constructions
    - New system topologies

  - Final Report, 1996:

    - Comprehensive test results
    - Recommendations and guidelines

  - Transfer Technology to NASA Flight Programs and Aerospace Industry

- **CONCLUSIONS:**

  - Wiring system failures in space and commercial applications have shown the need for arc track resistant wiring constructions

  - Preliminary data indicates the performance of the Tensolite and Filotex hybrid constructions are the best of the various candidates

  - One construction will be recommended after comprehensive evaluation and analysis of all testing data

  - Detailed presentations of the test efforts and results to date will follow

Wiring Workshop Charge

Determine next steps for:

- s/c wiring
- new wiring advances
- circuit protection
- improvement in quality control measures