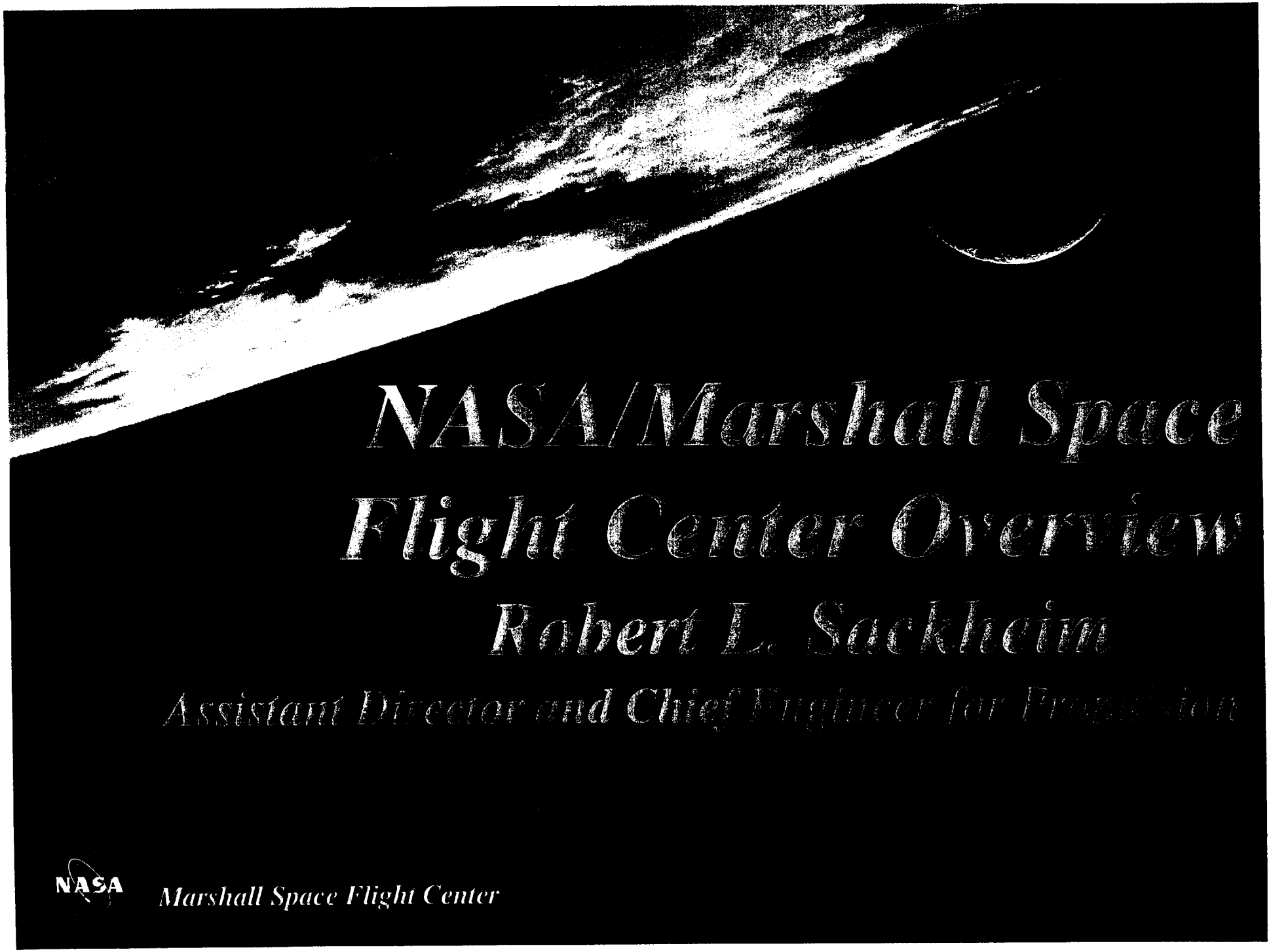


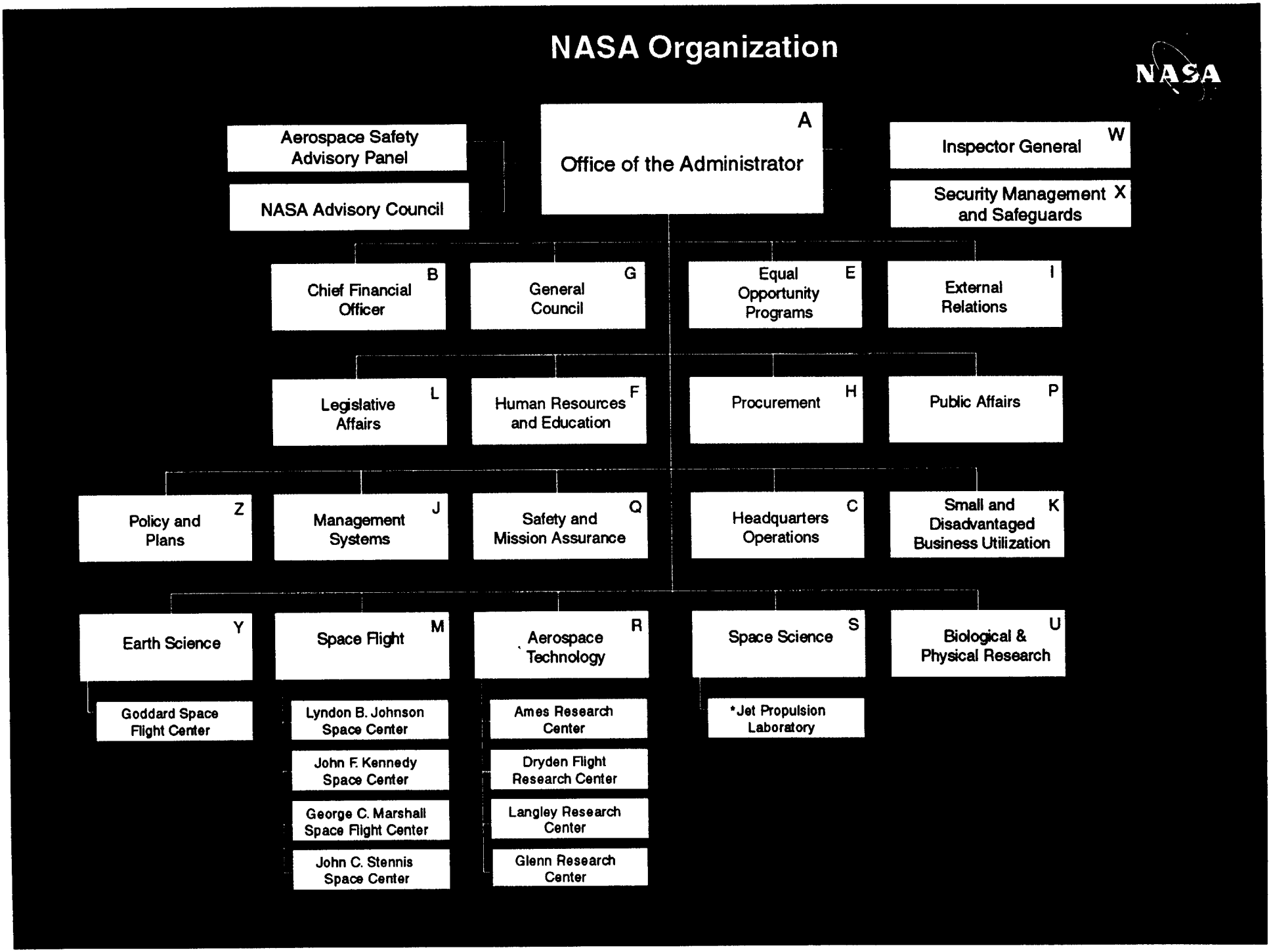
NASA/Marshall Space Flight Center Overview

Robert L. Sackheim

Assistant Director and Chief Engineer for Propulsion

NASA *Marshall Space Flight Center*

NASA Organization



George C. Marshall Space Flight Center

A.G. Stephenson
Director

J.W. Kennedy
Deputy Director

S.P. Saucier
Associate Director

A. Roth
Associate Director for Policy and Review

R.L. Sackheim
Assistant Director and Chief Engineer for Space Propulsion

J.W. Bilbro
Assistant to the Director for Space Optics

Safety & Mission Assurance

A.H. Goodson
Director

J.M. Ellis
Deputy Director

Procurement

S.P. Beale
Director

B.W. Butler
Deputy Director

Office of Chief Financial Officer

D.K. Bates
Director

J.C. Alexander (Act.)
Deputy/Finance

F.D. Mayhall (Act.)
Deputy/Resources

Office of Chief Counsel

W.A. Hicks
Chief Counsel

J.R. Frees
Deputy Director

Equal Opportunity

C.H. Scales
Director

Space Shuttle Projects Office

A.A. McCool
Manager

2nd Generation RLV Program Office

D.E. Smith
Director

D.L. Dumbacher
Deputy Director

Systems Management Office

A. Roth (Act.)
Director

Space Transportation Directorate

D.A. Kross
Director

C.E. Singer (Act.)
Deputy Director

Science Directorate

A.F. Whitaker (Act.)
Director

Vacant
Deputy Director

Flight Projects Directorate

N.J. Davis
Director

Vacant
Deputy Director

Engineering Directorate

J.W. Kilpatrick
Director

Vacant
Deputy Director

Center Operations Directorate

S.S. Cloud
Director

J.H. Carter
Deputy Director

Customer & Employee Relations Directorate

T.H. Washington
Director

S.L. Cloud
Deputy Director

Unofficial

Marshall Space Flight Center

Acres

4.6 Million

$1.0 Billion

54

19

Reasons for Being Here

Marshall Space Flight Center

- NASA/MSFC seeks to build on previous contacts/relationships with Russian rocket institutions
- We want to better understand Russian rocket products and technical capabilities
- The U.S. launch vehicle and spacecraft industry are already using many Russian propulsion products
  - NASA/MSFC needs better technical knowledge and understanding of these products as this use increases
- We desire to promote stronger technical and professional ties/relationships between Russian and NASA propulsion communities

THINGS THAT WILL NOT BE ADDRESSED OR NOT OF INTEREST TO NASA IN THIS FIRST INTERACTION

- **No discussion of any explicit business/ commerce arrangements**
- **NASA unable at this time to make any commitments during this interaction**
- **While we desire to learn as much as we can, we are not interested in proprietary or business-sensitive details that we are not free to share**

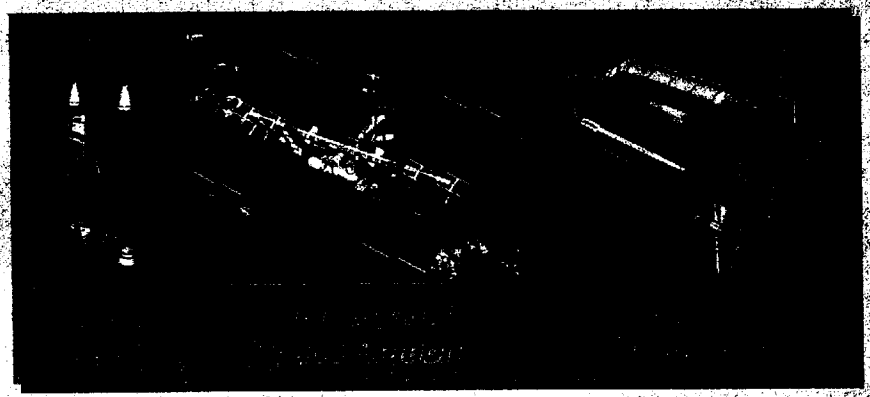
MSFC Program Evolution

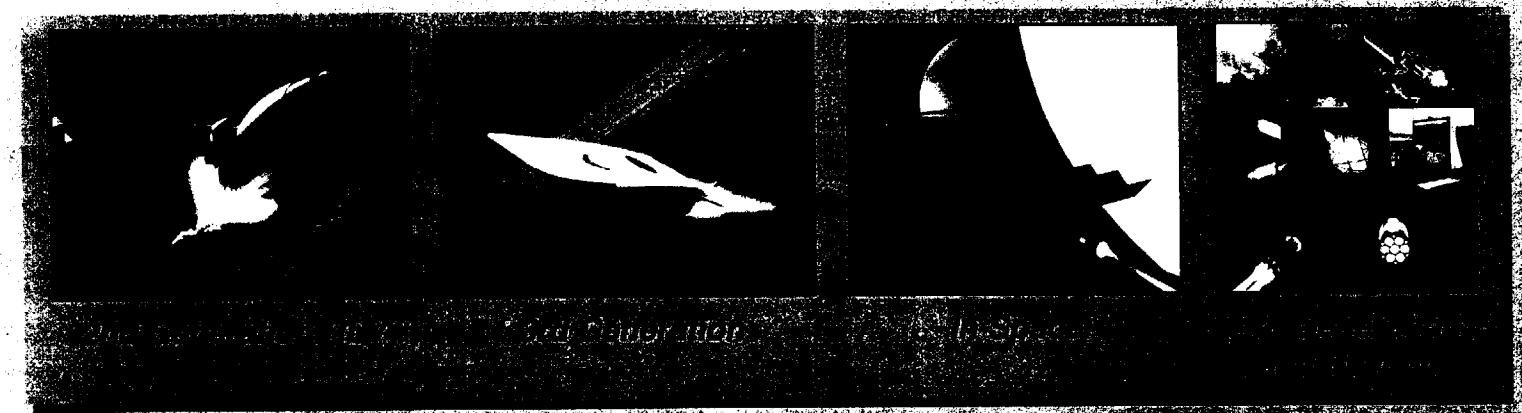
Marshall Space Flight Center

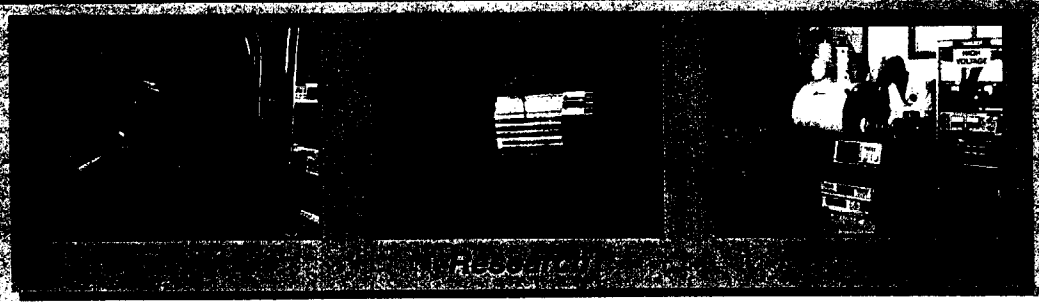
	1950's	1960's	1970's	1980's	1990's	2000 and Beyond
Booster and Space Transportation Vehicles	Jupiter C Mercury Juno I Engines: • A Series • S3D • RL 10 • H–1 • F–1 • J–2 Juno II Saturn I	Agena Centaur D–1 Saturn IB Saturn V	Space Shuttle	IUS RSRM PAM A, F TOS	MC–1 Super Lightweight External Tank	Space Station Manufacturing Shuttle Upgrades 2nd Gen RLV X–38 RBCC
Payloads	Pioneer Series Explorer Series	Pegasus 1, 2, and 3 LRV	ASTP Experiments ATM Skylab HEAO's 1, 2, and 3	Spacelab Missions	Chandra Hubble Space Telescope TSS BATSE	Microgravity & Science Experiments Gravity Probe B SOMTC Solar Power Panels

Scope

- **Scope of Space Propulsion includes: earth-to-orbit, in-space, and on-board spacecraft propulsion.**



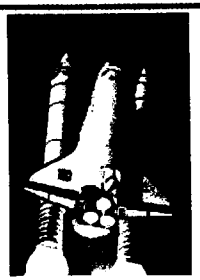




NASA

Privatization
??

GENERATION 1



(GEN 1) Reusable Launch Vehicle (RLV)

Space Shuttle

1981–2020(?)

GENERATION 2

Space Launch Initiative (SLI)

- Increase Safety by Factor of 100
- Decrease Cost to Orbit by Factor of 10

2006–2011

GENERATION 3

- Hypersonics
- Combined Cycle Engine/Powerplant

>2025

GENERATION 1A

Shuttle Safety, Reliability/Operability Upgrades

Shuttle Derived Vastly Improved RLV

Brandnew "Clean Sheet" Design

INTEGRATED IN-SPACE TRANSPORTATION PROGRAM (IISTP)

Upper Stages, Onboard In-Space Propulsion (ISP)

- Advanced Chemical
- Cryogenic Fluid Management
- Electric Propulsion
- Propellantless
- Nuclear
- Etc.

2000 ➡ ∞

GENERATION 4

Based on Very Advanced Propulsion Physics; e.g., Fission, Fusion, Magnetohydrodynamic/ Electromagnetics, Antimatter, etc.

>2030–?

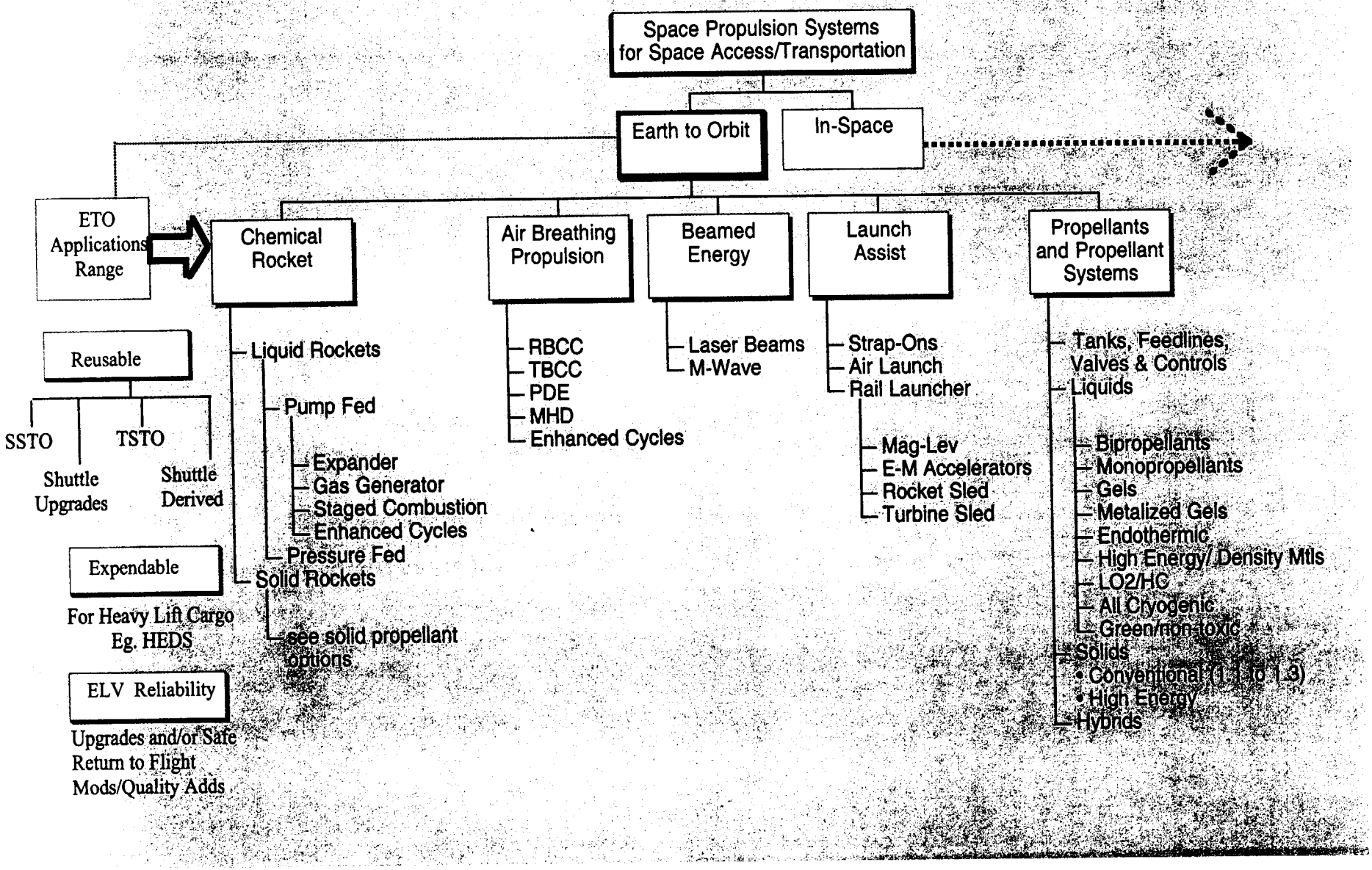
NASA Priorities

Marshall Space Flight Center

1. Safe/Reliable Shuttle Operations
2. Launch/Integrate/Operate International Space Station
3. Low-Cost Access to Space

MSFC HAS KEY ROLES IN ALL THREE

Earth to Orbit Propulsion Systems



Highway to Space

Marshall Space Flight Center

Today: Space Shuttle
1st Generation RLV
- Low-rate Space Transportation
- ISS Re-supply, Crew Exchange
- Orbital Scientific Platform
- Satellite Deployment
- Satellite Retrieval and Repair
- Mission-limiting Cost/Reliability

Early Next Decade:
2nd Generation RLV (SLI)
- High-rate Commercial Space Transportation
- ISS Re-supply, Crew Exchange
- Spacecraft and Satellite Delivery, Deployment, Retrieval, Service, Return
- Payload platform missions
- Exploration Vehicle Crew Transfer, etc..
- 100x Safer, 10x Cheaper

Before Mid-Century:
4th Generation RLV
- Routine Passenger Space Travel
- 20,000x Safer, 1000x Cheaper

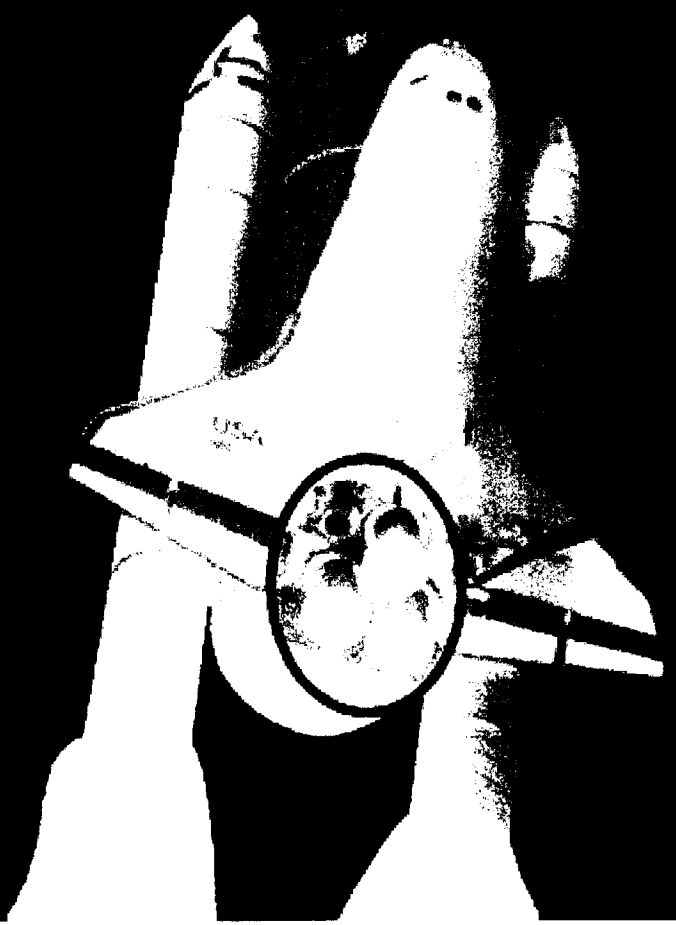
By the Quarter Century:
3rd Generation RLV
- New Markets Enabled
- Multiple Platforms / Destinations
- 10,000x Safer, 100x Cheaper

Space Shuttle Propulsion Systems

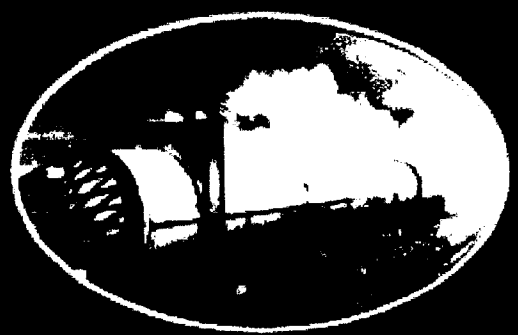
NASA

Reusable Solid Rocket Booster

External Tank



Reusable Solid Rocket Motor



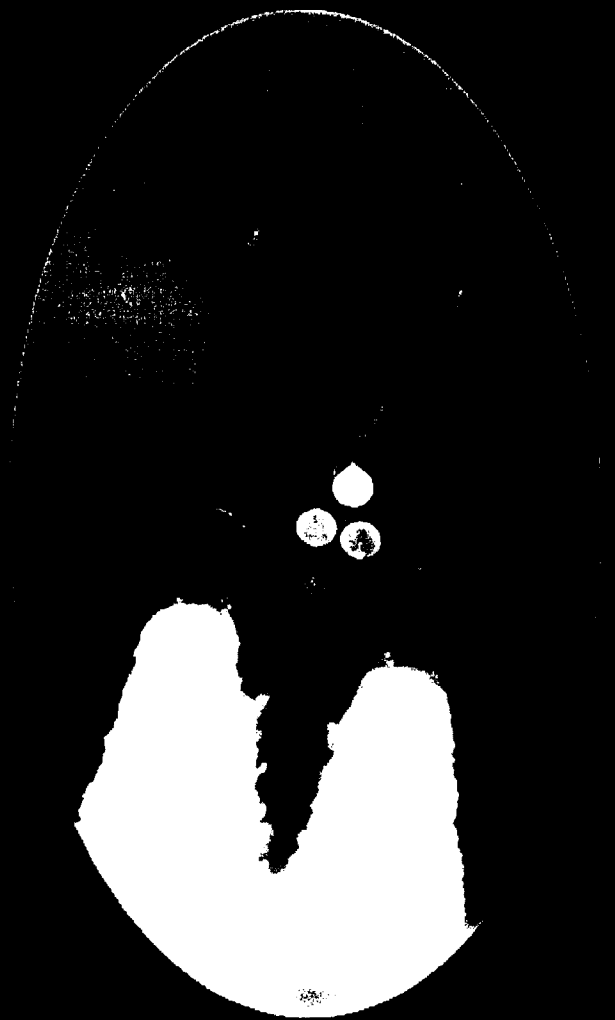
Space Shuttle Main Engine

MSFC Shuttle Projects
Proposed Safety "Upgrades"

NASA

Space Shuttle Main Engine

- Extra Large Throat Main Combustion Chamber
- Robust Nozzle
- Advanced Health Management System



External Tank

- Friction Stir Welding

Reusable Solid Rocket Motor

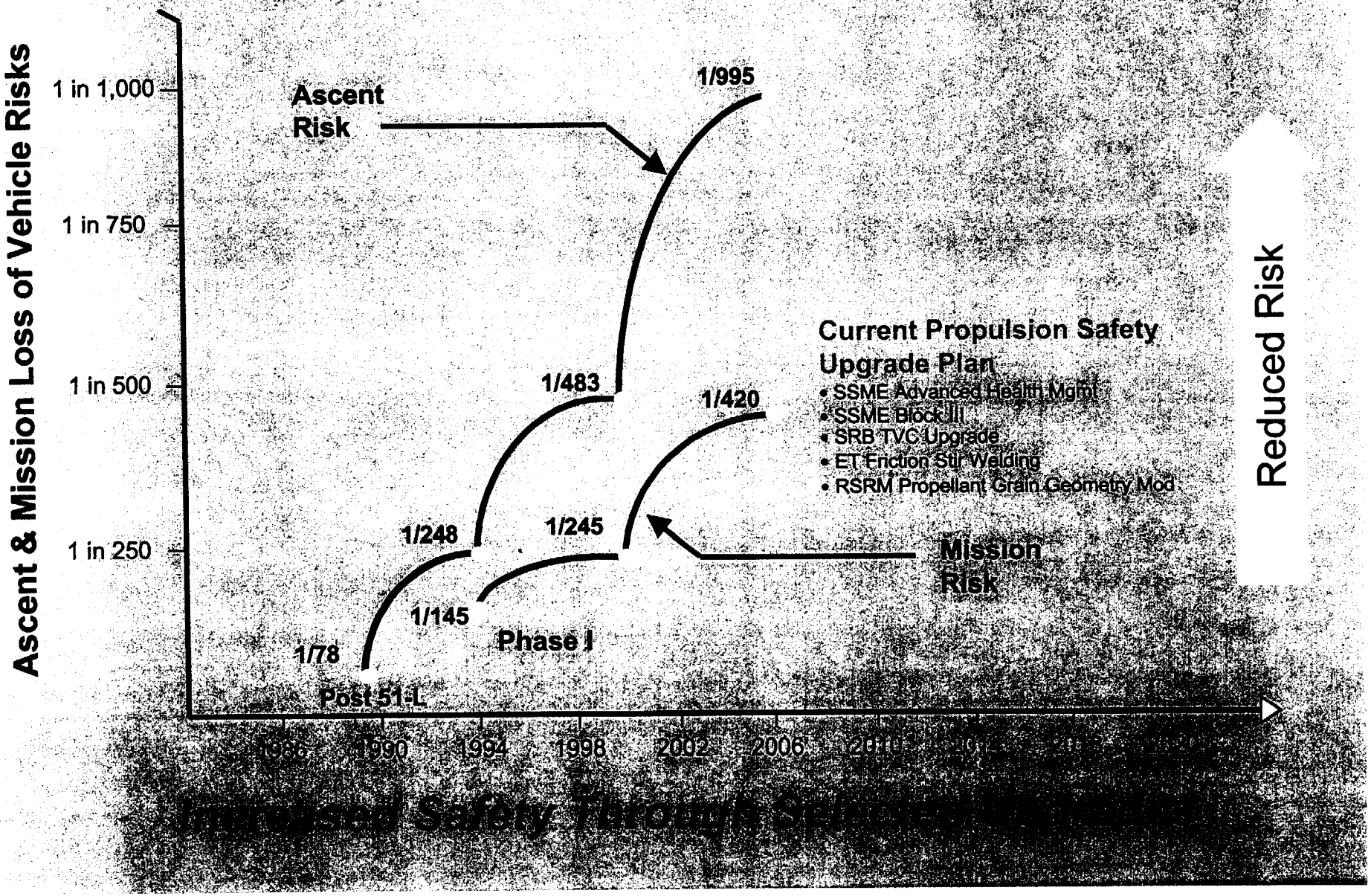
- Propellant Grain Geometry

Solid Rocket Booster

- Advanced Thrust Vector Control

Safety Benefit of Planned Shuttle Upgrades

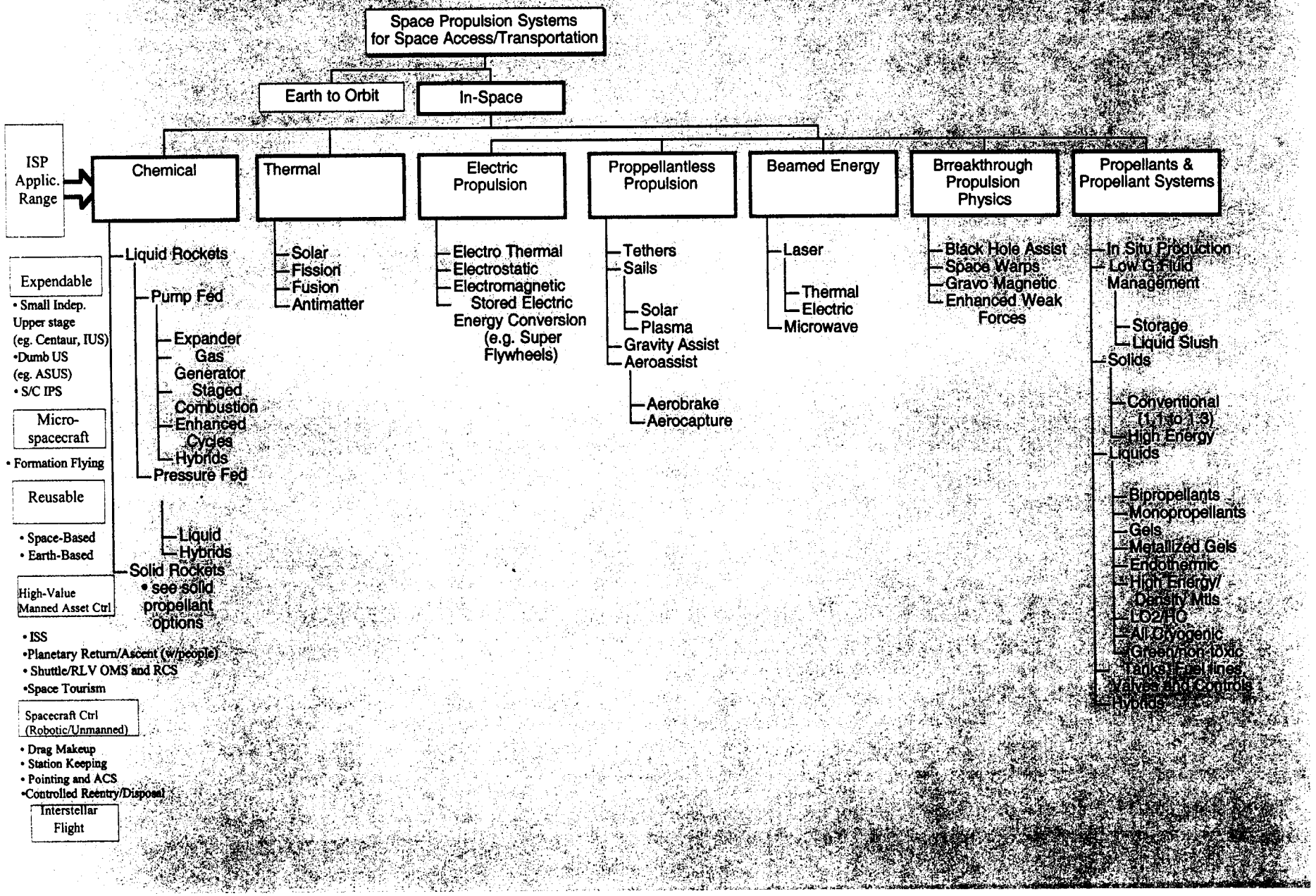
Marshall Space Flight Center



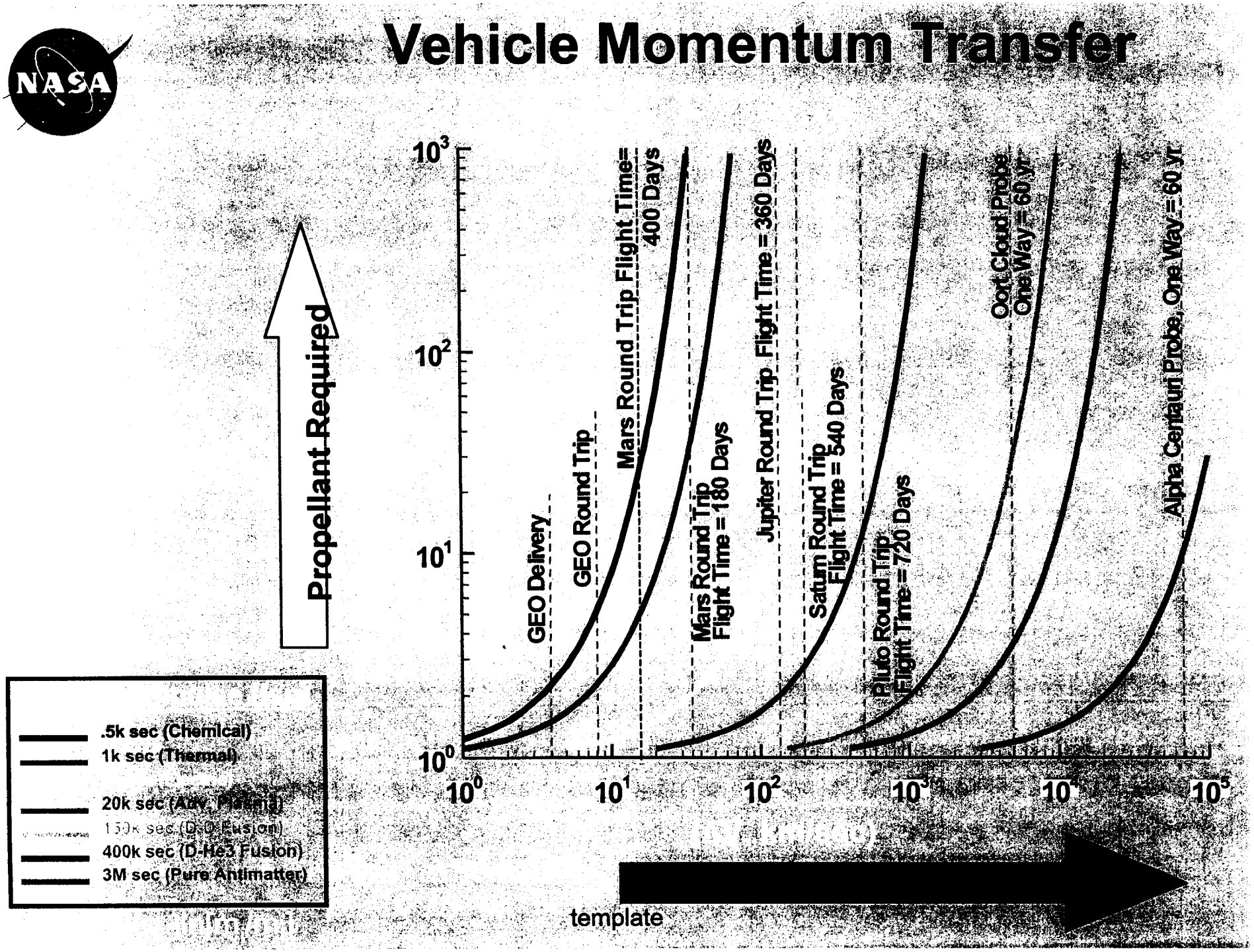
Increased Safety Through Shuttle

In-Space Propulsion Systems

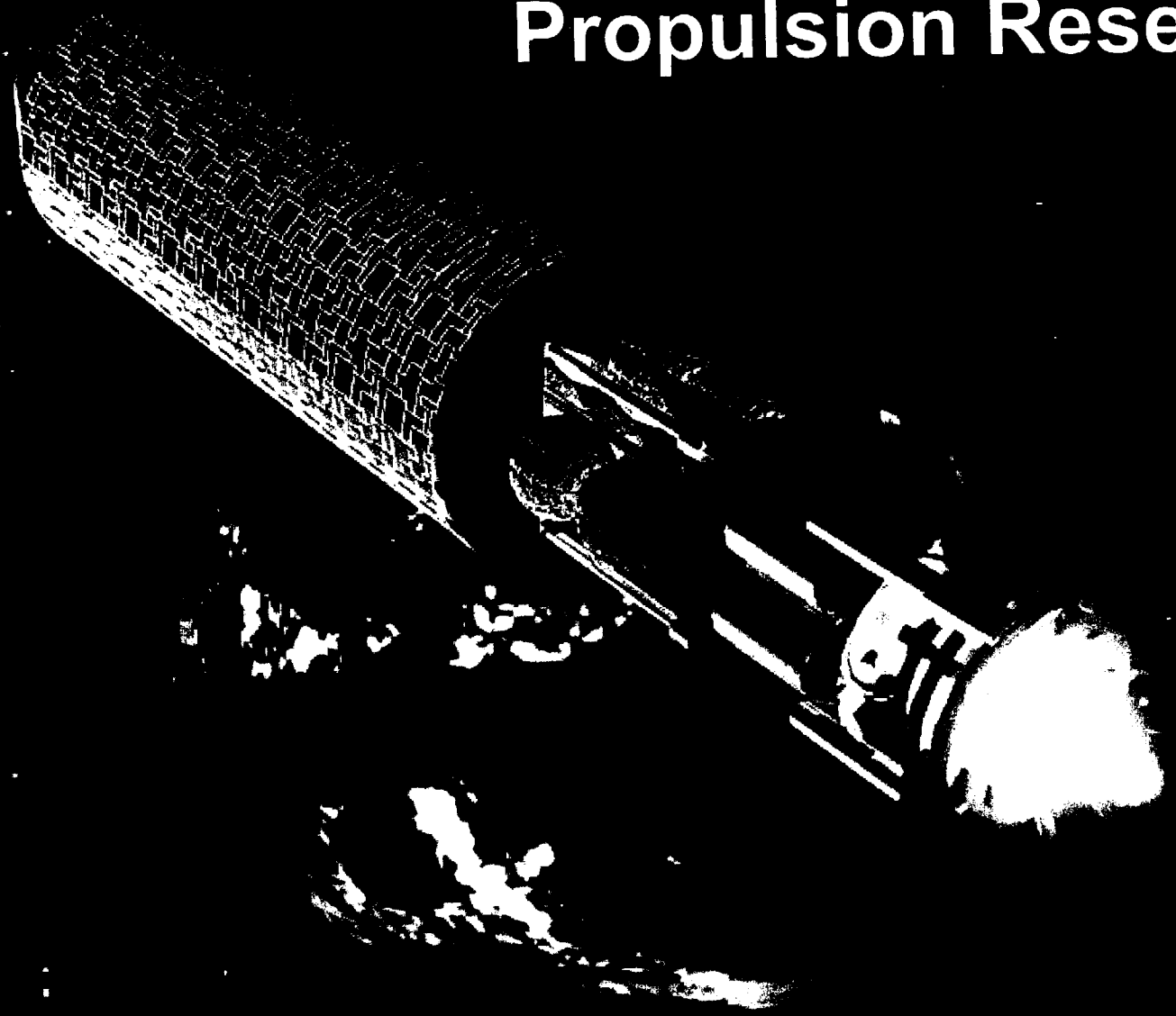
Marshall Space Flight Center



Vehicle Momentum Transfer



Propulsion Research Center



NASA George C. Marshall Space Flight Center

Develop and maintain NASA's role in space propulsion, enabling the exploration and development of space while dramatically increasing program and mission safety and reliability and reducing overall cost.

Initiatives

In-Space Propulsion

Fusion

High Density

Sails

Tethers

Solar Thermal

Plasma

Ionized

Electric

Electromagnetic

ProSeds

Electro-Magnetic

Hall Thruster

Earth-to-Orbit Propulsion

PDRE Proof of Concept

Rocket-Based Combined Cycle

H2O2/JP 140s Firing

Hydrogen Peroxide Storable

MagLev

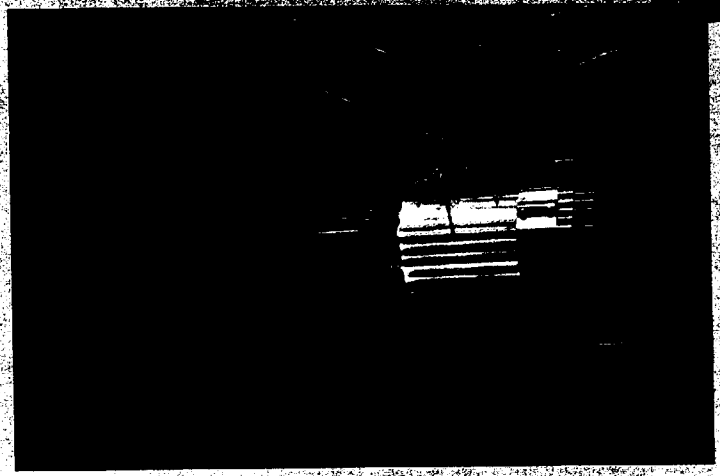
Simple Injector

Pintle 650K 5s Firing

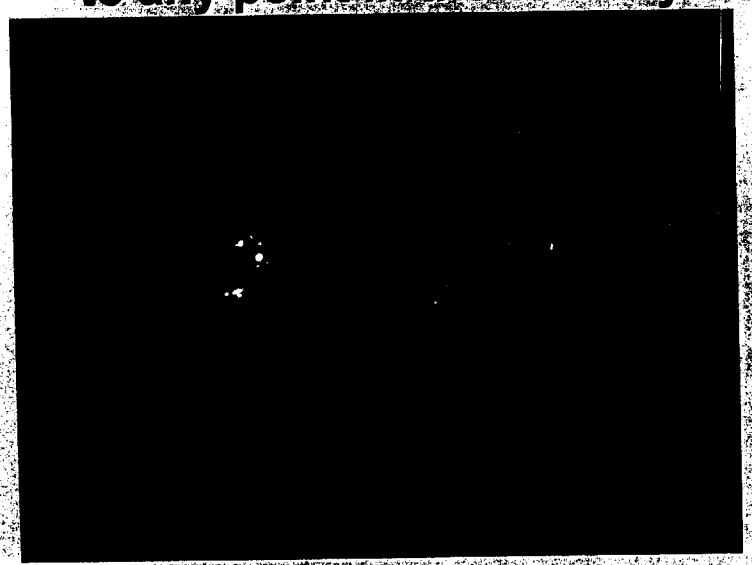
Space Fission Propulsion

Objective

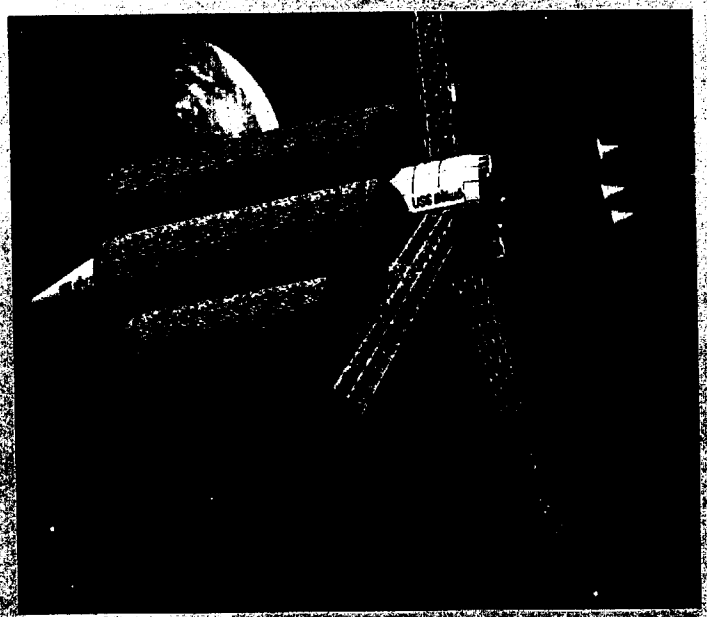
- Develop a safe, near-term, affordable fission propulsion system for use on advanced robotic missions.
- Use experience gained from Phase 1 fission systems to develop very high performance space fission propulsion systems.
- Enable safe, rapid, affordable access to any point in the solar system.



SAFE-30 Full-core Primary Heat Transport Test



Coupled SAFE-30 / Stirling Engine Test

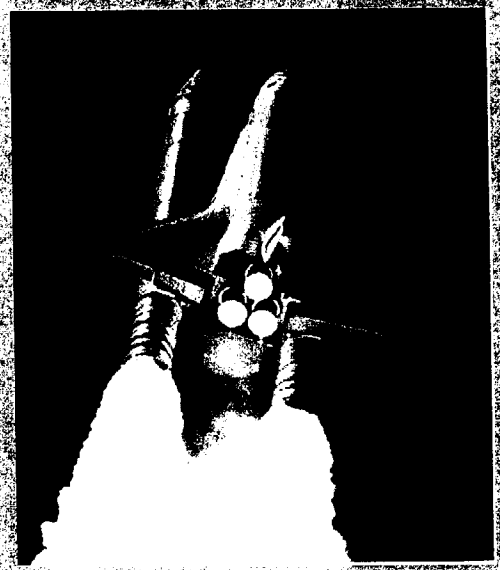


Potential Phase 2 Space Fission Propulsion

template

MSFC's important role

Marshall Space Flight Center

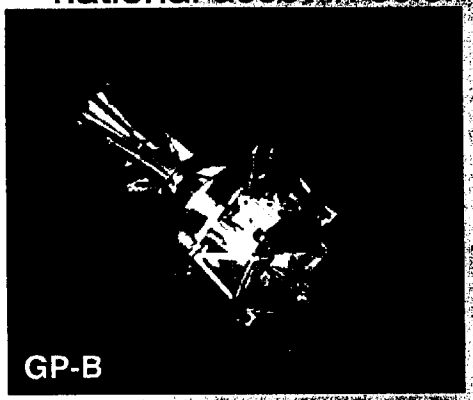


Marshall Space Flight Center is a leader in space propulsion and transportation systems.

Propulsion Research Center supports MSFC leadership role by conducting scientific and engineering research leading to advanced propulsion technologies and improvements to existing propulsion systems.

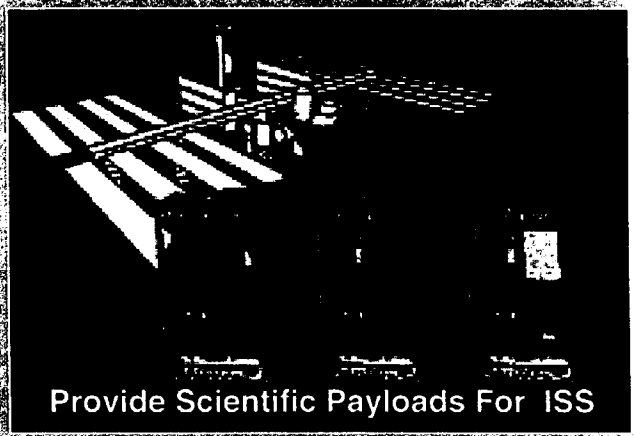
Science Directorate: We generate and communicate knowledge of Microgravity Science, Earth and Space Science, and Space Optics Technology. Our vision is to become a laboratory seen by NASA and other agencies as essential to their missions, and to become a national asset in science and technology education.

We operate the National Space Science and Technology Center as a research institute with Government, corporate, and academic researchers working side by side...a new way to do science!

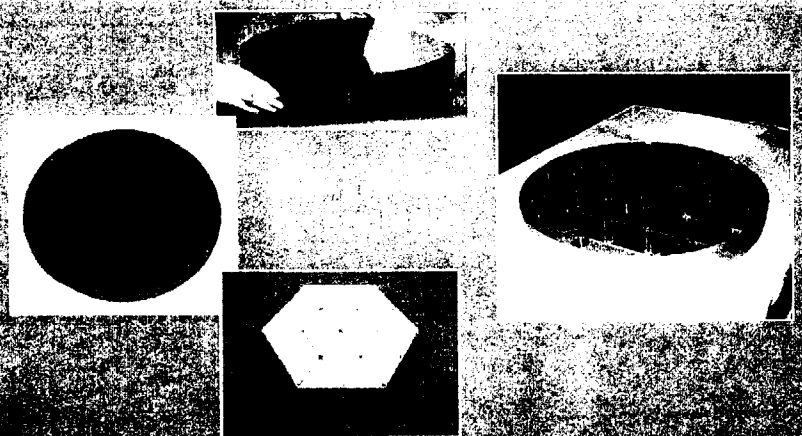

GP-B


Chandra


NSSTC

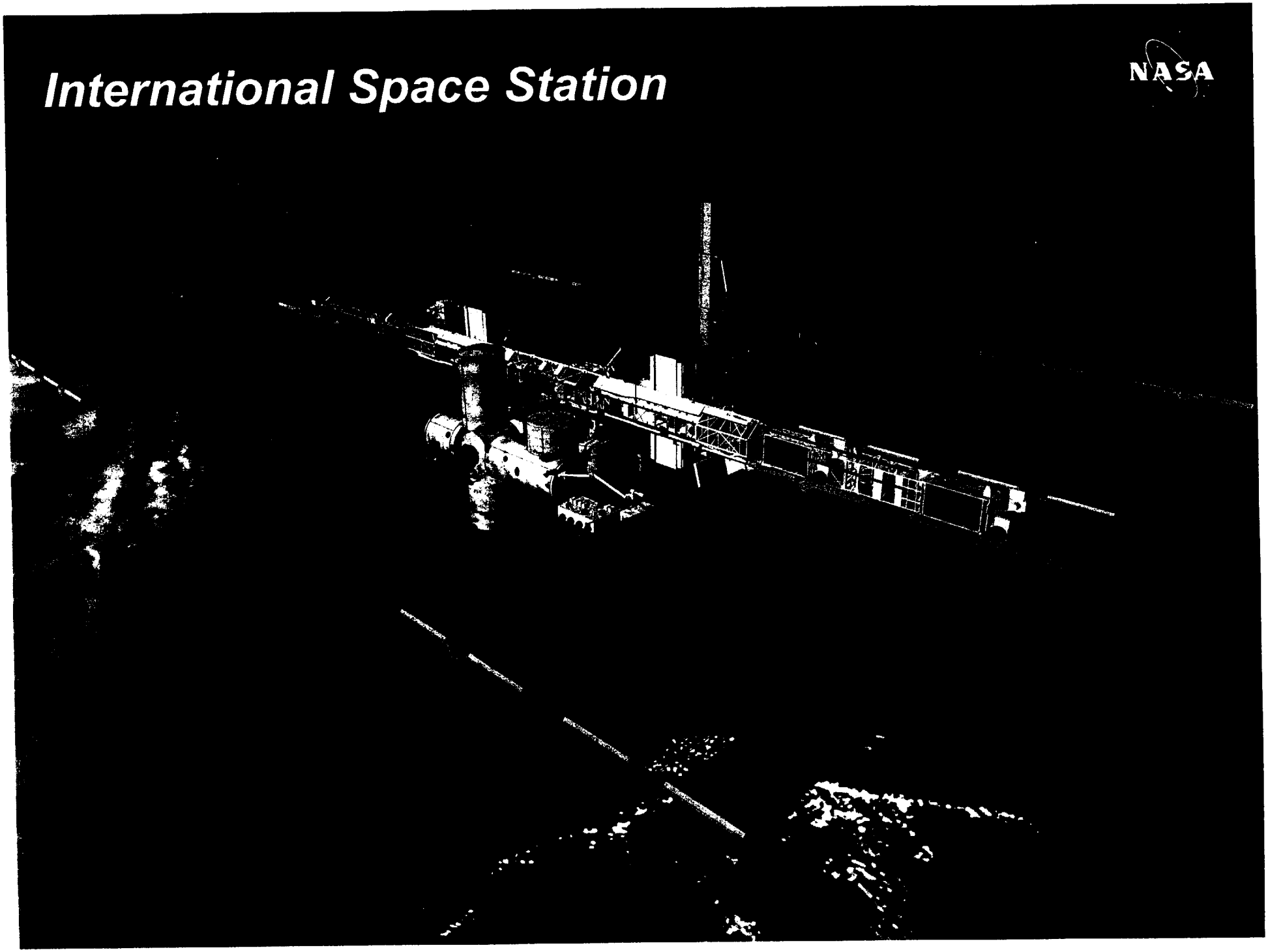

Provide Scientific Payloads For ISS


Space Product Development



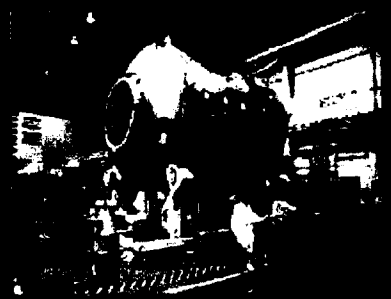
Perform Global Climate and Hydrology Studies

International Space Station



Marshall's Role in the *International Space Station*

Construction

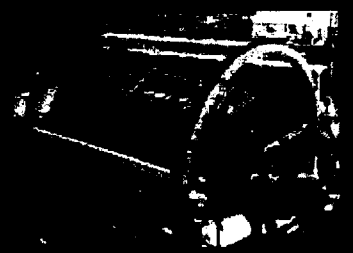


Nodes 2 and 3
Project Management

Vehicle Engineering,
Manufacturing, and
Test Support

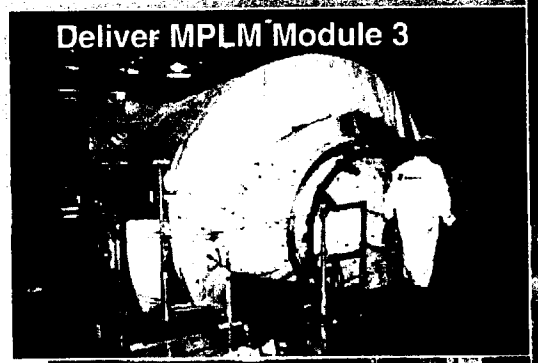
Life Support Systems
Development for Water
Reclamation and Oxygen
Generation

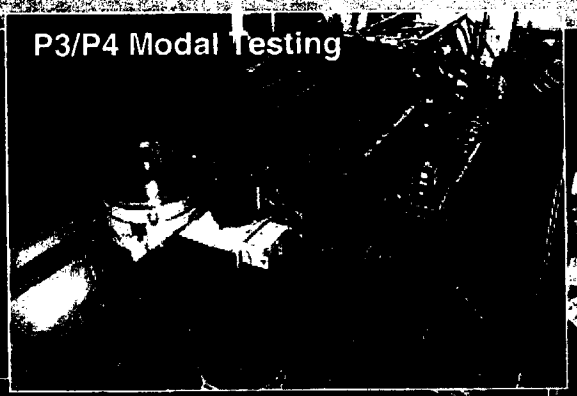
Spacelab Pallets
for Assembly
Transportation

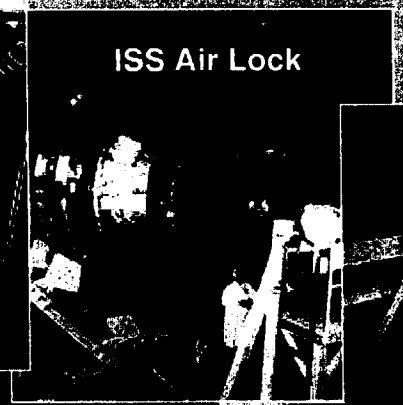


Multipurpose
Logistics Module
Project Engineering

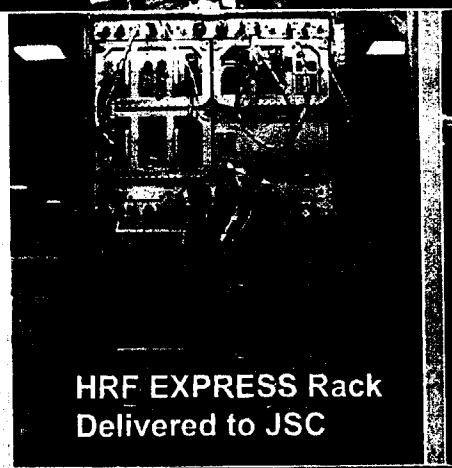
International Space Station Support


Deliver MPLM Module 3

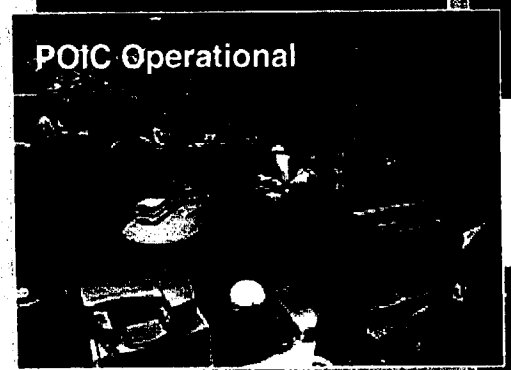

P3/P4 Modal Testing

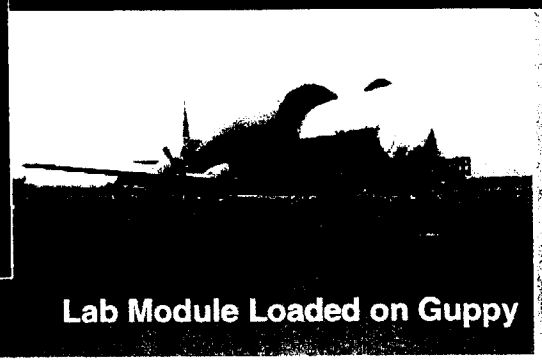

ISS Air Lock


Flight 3A Pallet On-Orbit


HRF EXPRESS Rack
Delivered to JSC

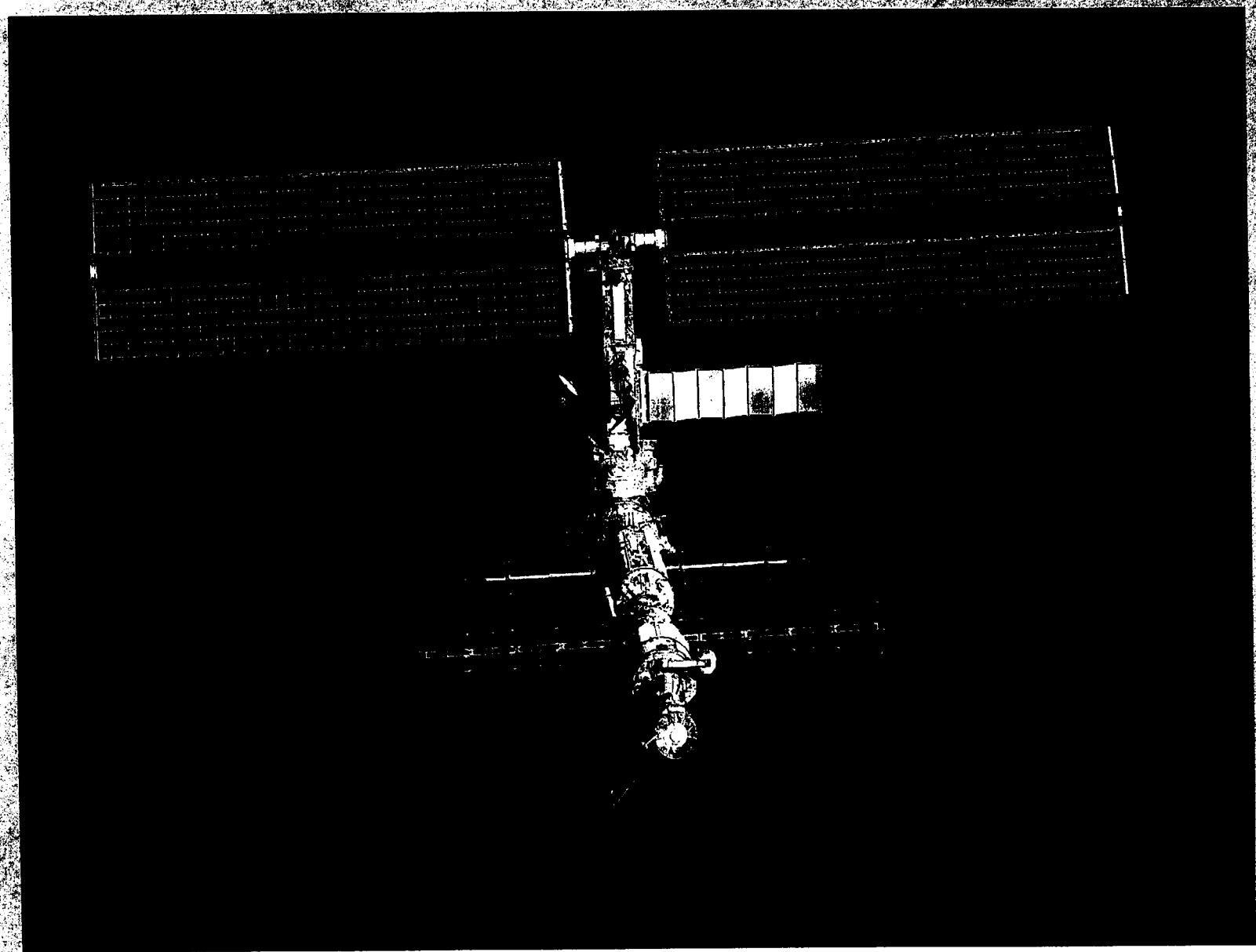

X-38 Deorbit Prop


POIC Operational


Lab Module Loaded on Guppy

International Space Station Metrics

- Deliver the Vapor Compression
  Flight Engineering Unit (FEU)
- Complete the Water Recovery and
  Water Recovery and
- Deliver the Lightweight Flight
  Support Structure and
- Flight Support Equipment
- Complete X-38 Hardware



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ACRONYMS/ABBREVIATIONS

- ACS Attitude Control System
- ASTP Apollo Soyuz Test ASUS
- ATM Apollo Telescope Mount
- BATSE Burst And Transient Source Experiment
- ELV Expendable Launch Vehicle
- E-M ElectroMagnetic
- ET External Tank
- ETO Earth to Orbit
- GEO Geosynchronous Earth Orbit
- HEAO High Energy Astronomy Observatory
- HEDS Human Exploration & Development of Space
- IPS Integrated Propulsion System
- ISP In-Space Propulsion
- ISP Initial Specific Impulse
- ISS International Space Station
- IUS Inertial Upper Stage
- KM Kilometer
- Mag-Lev Magnetic Levitation
- MHD Magnetohydrodynamic
- M-Wave Microwave
- OMS Orbital Maneuvering System
- PAM Payload Assist Module
- PDE Pulse Detonation Engine
- PDRE Pulse Detonation
- ProSeds Propulsive Small Expendable Deployer System
- RBCC Rocket Based Combined Cycle
- RCS Reaction Control System
- RLV Reusable Launch Vehicle
- RSRM Reusable Solid Rocket Motor
- S/C Spacecraft
- S Seconds
- Sec Seconds
- SLI Space Launch Initiative
- SOMTC Space Optics Manufacturing Technology Center
- SRB Solid Rocket Booster
- SSME Space Shuttle Main Engine
- SSTO Single Stage to Orbit
- TBCC Turbine Based Combined Cycle
- TOS Transfer Orbit Stage
- TSS Tethered Satellite System
- TSTO Two Stage to Orbit
- TVC Thrust Vector Control
- US Upper Stage
- V velocity
- W/ with
- Yr Years