

SS - Chapter 11.4 / 1.11.16

2017

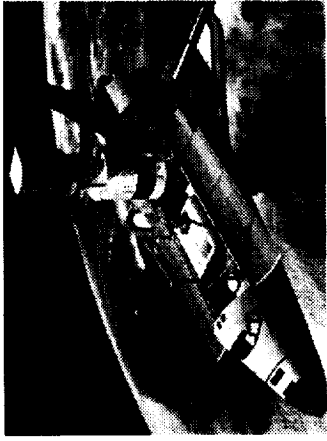
2nd Generation RLV Plans

Dan Dumbacher

Agenda

- Heritage and Background
- Goals and Schedule
- Program Requirements and Organization
- Technology Drivers and Interfaces
- Acquisition Strategy and Planning
- Status and Summary

Generations of Reusable Launch Vehicles



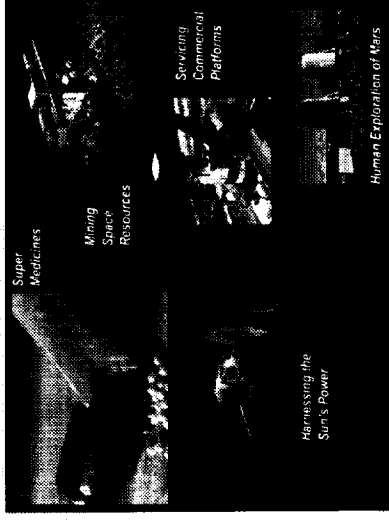
Today: Space Shuttle

- ◆ 1st Generation RLV
- ◆ Orbital Scientific Platform
- ◆ Satellite Retrieval and Repair
- ◆ Satellite Deployment



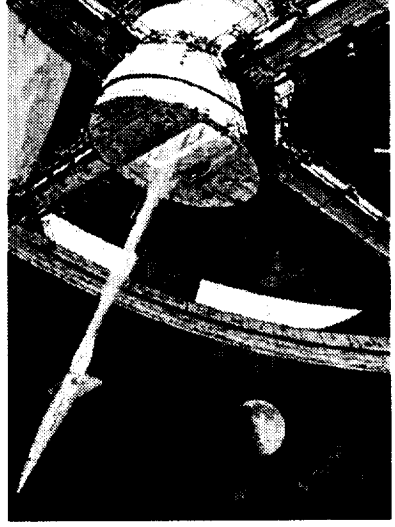
2010: 2nd Generation RLV

- ◆ Space Transportation
- ◆ Rendezvous, Docking, Crew Transfer
- ◆ Other on-orbit operations
- ◆ ISS, Orbital Scientific Platform
- ◆ 10x Cheaper
- ◆ 100x Safer



2025: 3rd Generation RLV


- ◆ New Markets Enabled
- ◆ Multiple Platforms / Destinations
- ◆ 100x Cheaper
- ◆ 10,000x Safer



2040: 4th Generation RLV

- ◆ Routine Passenger Space Travel
- ◆ 1,000x Cheaper
- ◆ 20,000x Safer

Foundation Studies and Plans

- **STAS - Space Transportation Architecture Studies**
 - **Focused Industry and In-House Studies of Space Transportation requirements, architecture options and preliminary risk reduction**
 - Phase I - Aug - Sept '98 - Initial requirements definition
 - Phase II - Sept '98 - Feb 99 - Initial architecture options
 - Phase III - July '99 - Dec '99 - Requirements and architecture refinement , technology prioritization
 - Phase IIIB - Dec '99 - July '00 - System engineering process definition, technical risk reduction plan
- **ISTP - Integrated Space Transportation Plan**
 - **Annual effort to integrate NASA plans and resource requirements for:**
 - Space Shuttle safety upgrades and on-going programs
 - Crew Transfer/Return Vehicle
 - 2nd Generation RLV and NASA Unique systems
 - Alternate Access to Space Station
 - 3rd Generation RLV and In-Space Transportation
- **SLI - Space Launch Initiative**  **2nd Generation RLV Program**
 - **Systems Engineering and Requirements Definition**
 - **2nd Generation RLV Competition and Risk Reduction**
 - **NASA Unique systems**
 - **Alternate Access to Space Station**

Integrated Space Transportation Plan



2nd GEN

Ensure continued safe access to space through Space Shuttle Safety Upgrades until a replacement alternative has been demonstrated

Invest in technical and programmatic Risk Reduction activities, driven by industry needs, to enable full-scale development of commercially-competitive, privately owned and operated, Earth-to-orbit (ETO) reusable launch vehicles (RLVs) by 2005.



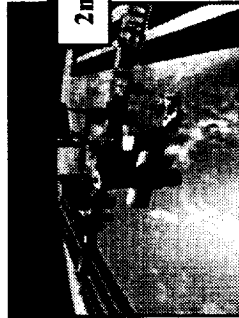
2nd GEN

Develop an integrated architecture with systems that build on commercial ETO launch vehicles to meet NASA-Unique requirements that cannot be economically served by commercial vehicles alone.



2nd GEN

Enable procurements of near-term, launch services for select International Space Station needs on Existing and Emergent Commercial Launch Vehicles.



Secure safe, reliable and cost-effective access to space in the far-term through investments in 3rd-Generation RLV Technologies for ETO and in-space applications

Space Launch Initiative Goals

The goal of this Space Launch Initiative is for NASA to meet its future space flight needs, including human access to space, using commercial launch vehicles that will improve safety and reliability and reduce cost.

Safety Goal - *Improve safety to better than 1 in 10,000 Loss of Crew*
Cost Goal - *Reduce mission cost to \$1000/lb*

Four principles exist:

Commercial Convergence – flying on privately owned and operated launch vehicles;

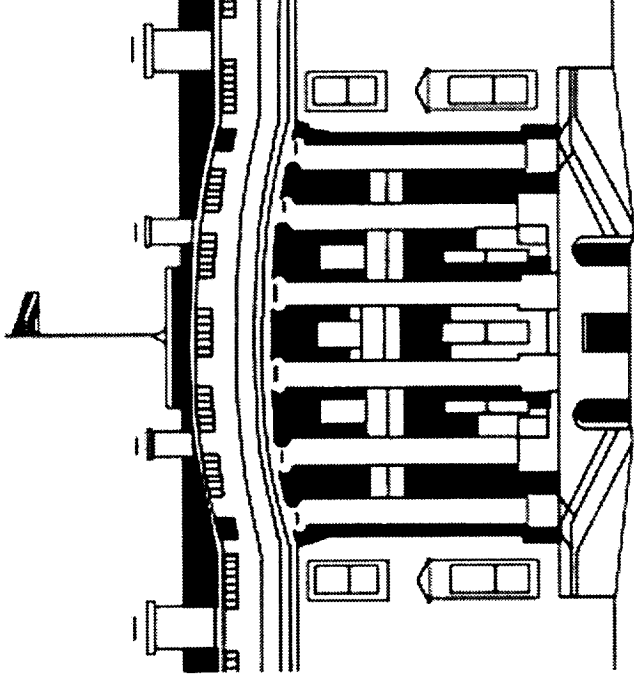
Competition – bringing innovation and new ideas to bear;

Assured Access – ensuring alternate means of getting to space despite launch mishaps;

The Ability to Evolve – adding new capabilities affordably as new mission needs emerge.

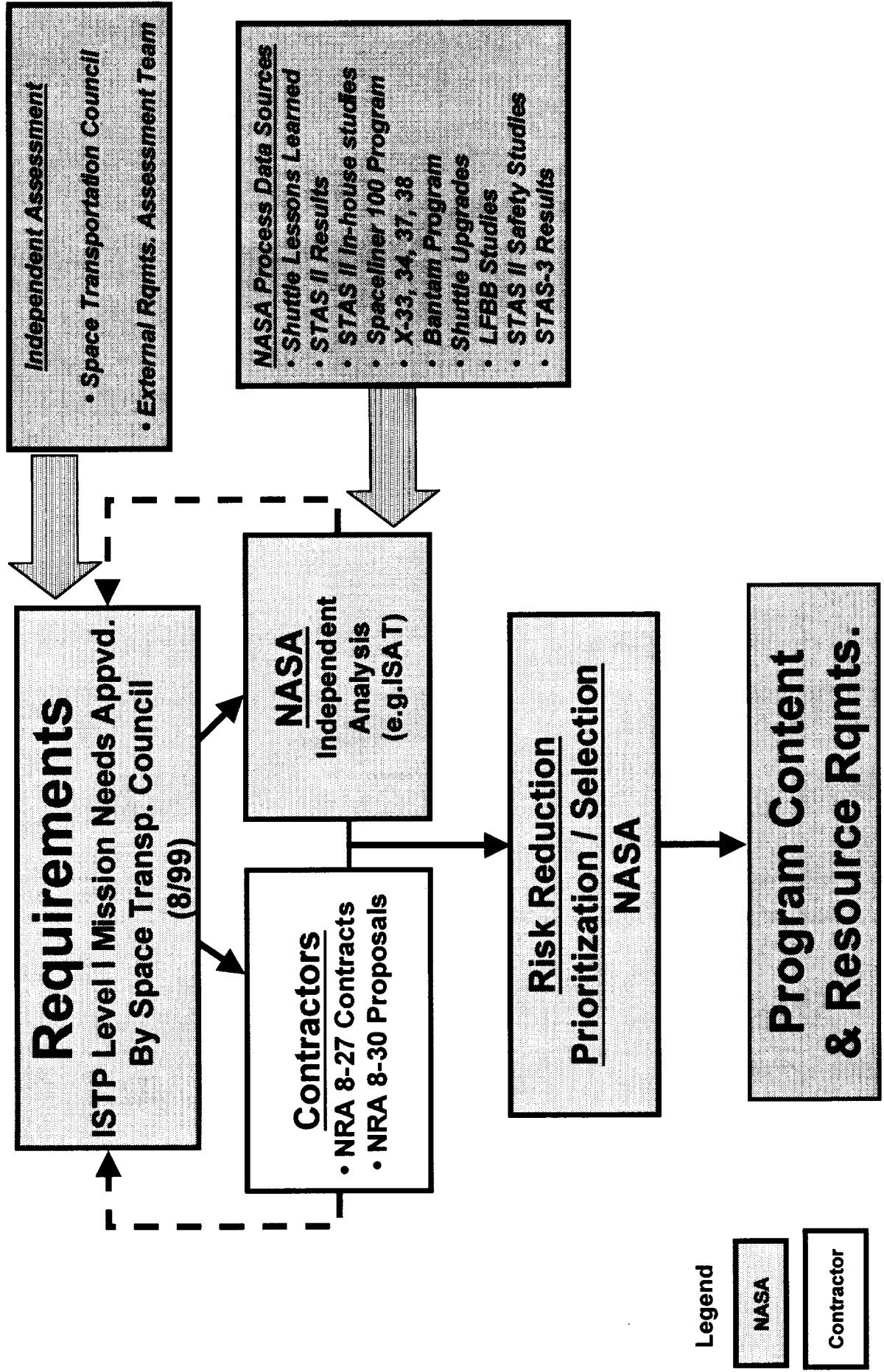
National Endeavor

“The Space Launch Initiative is an extremely ambitious undertaking. If successful – and I’m confident it will be – it will dramatically alter the economics of space launch. I believe that this Space Launch Initiative could ultimately have as profound an impact on space exploration and space commerce as anything our nation has ever attempted.”

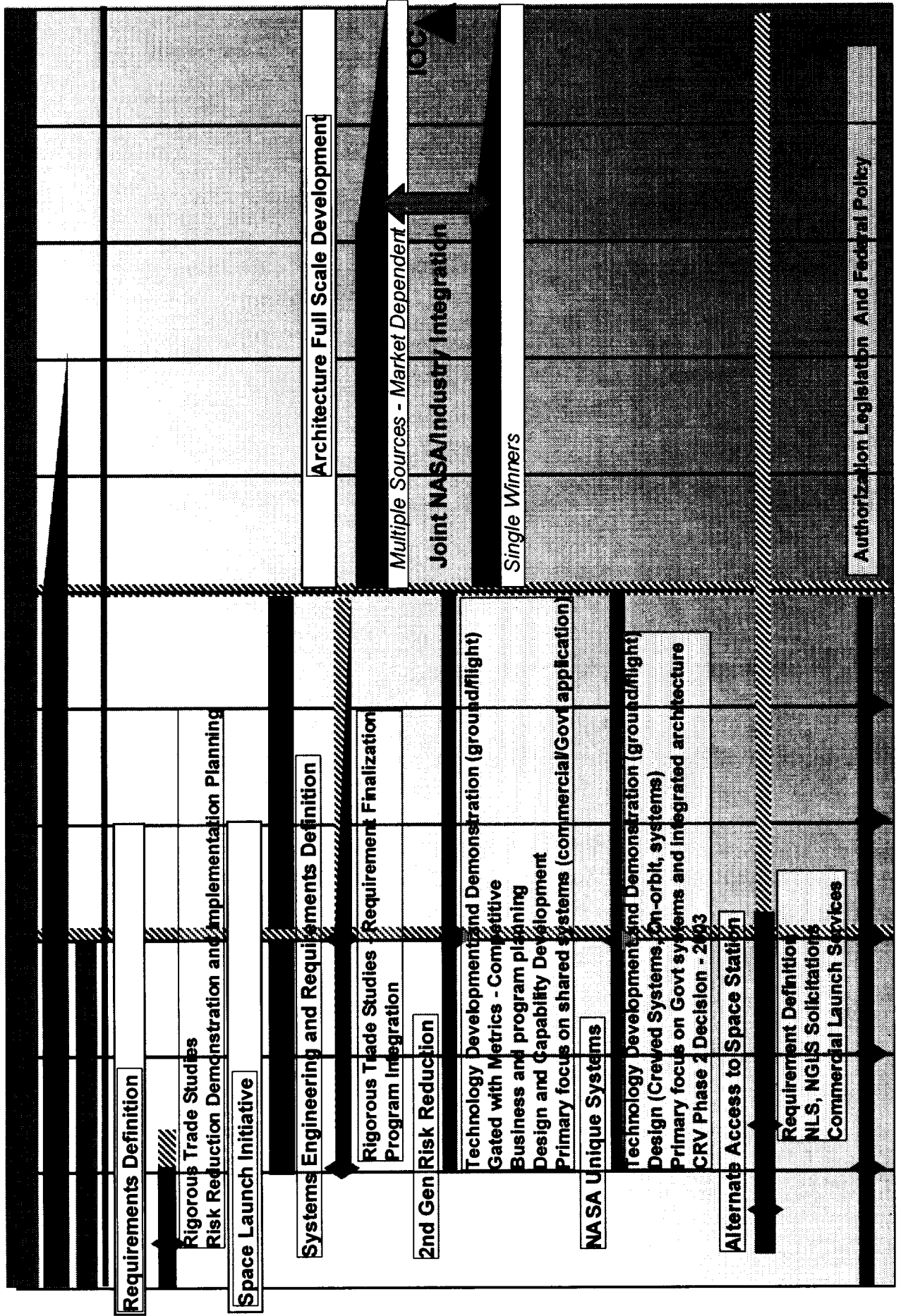


Dr. Neal Lane
Assistant to the President
for Science and Technology

2nd Gen Program Planning Process



2nd Generation Program Plan

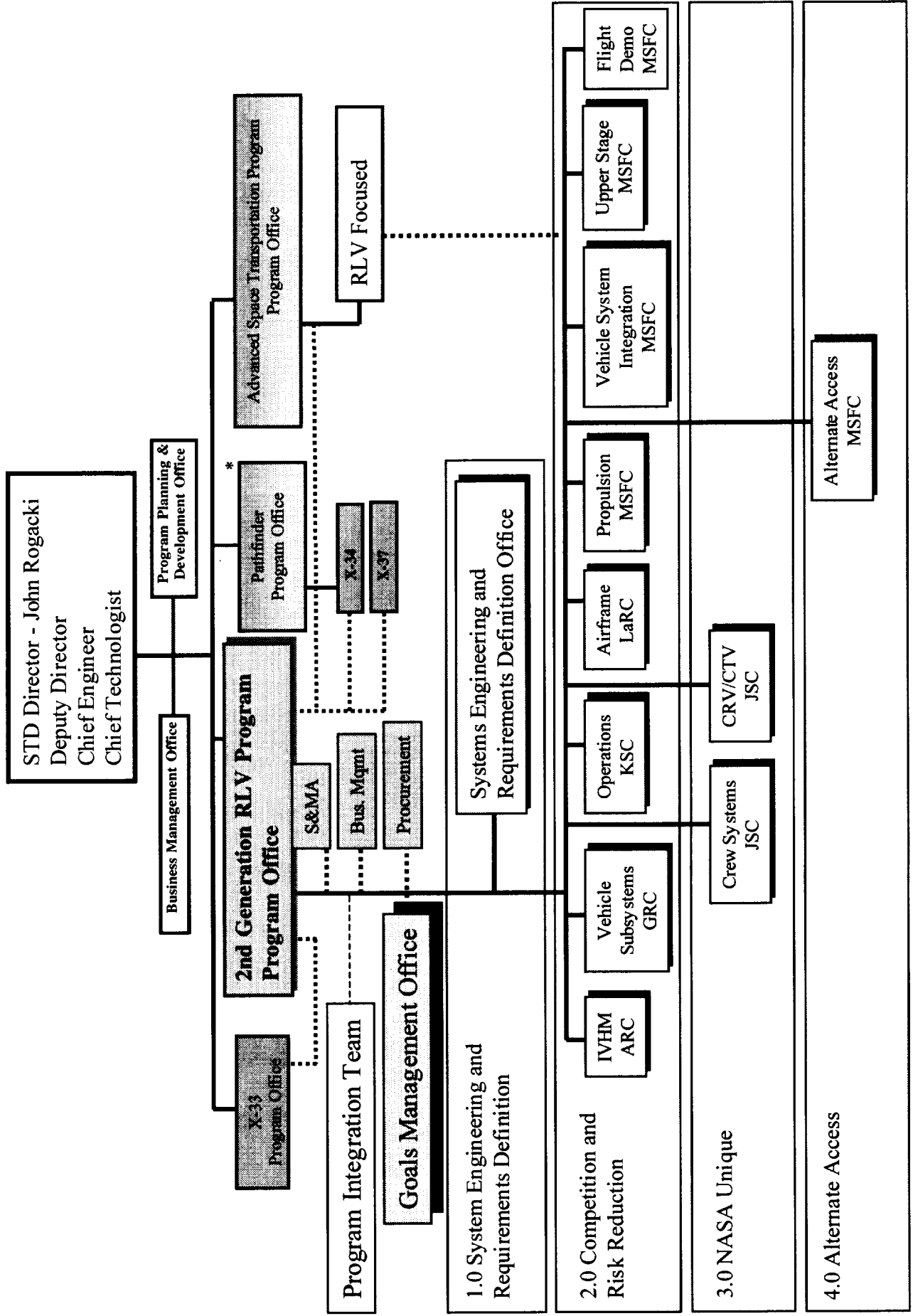


2nd Generation RLV Objectives

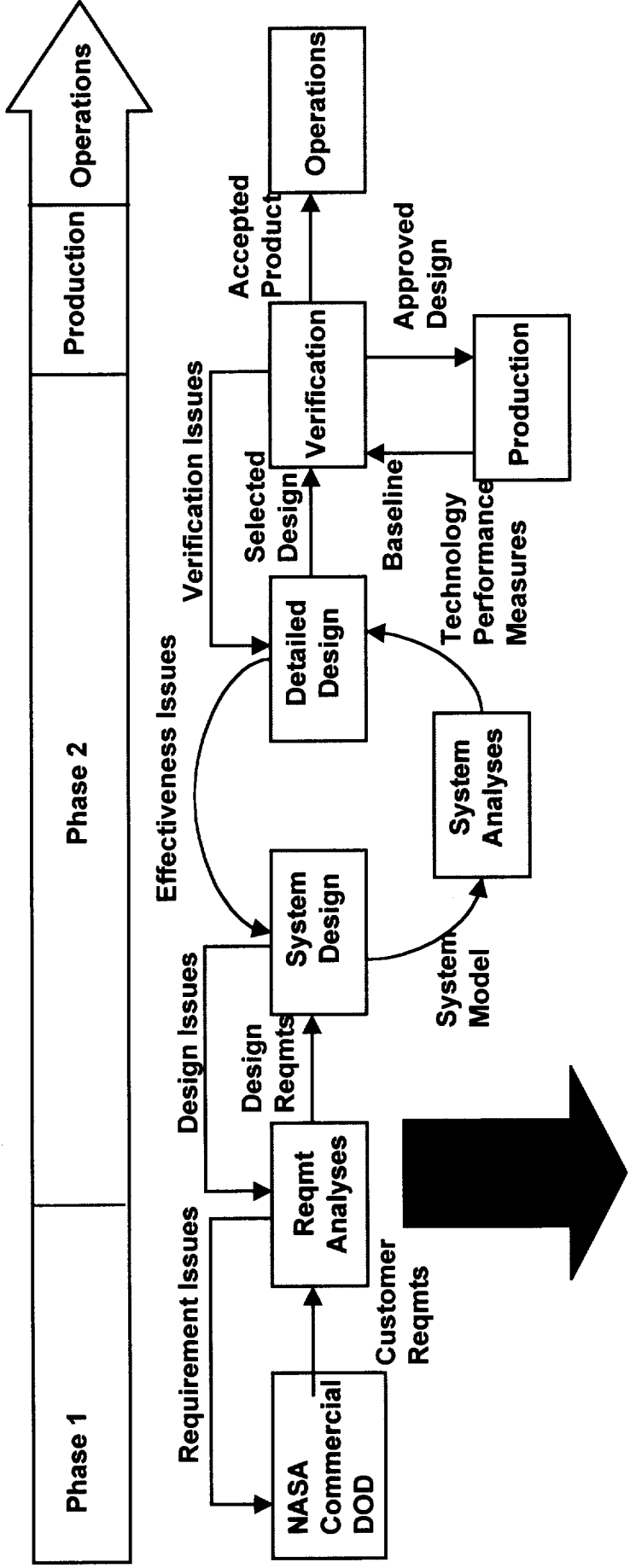
What 2nd Gen RLV must accomplish to meet our Goals

Objectives	Success Criteria	Date	Approach
A. Converge National Needs – Industry, NASA, and DOD	U.S. Transportation Needs Document Approved by Space Transportation Council	Baseline is August 1999 and updated annually	Initiated for ISTP with annual updates from systems engineering process
B. Provide an architecture requirement set derived from converged needs for industry competition	2nd Generation RLV System Requirements Database Approved by Space Transportation Council	Preliminary in August 2000 and updated annually	Initiated for ISTP with annual updates from systems engineering process
C. Develop systems engineering processes and tools, and connect goals to risk reduction Investments	Risk Reduction Investment Strategies documented in project plans Tools developed and validated. Knowledge base developed.	Initial - August 2000 with periodic updates 2002 2005	Implement rigorous systems engineering process (Utilizing tools developed by ISE, Design for Safety Initiative, etc) Initiated with NRA 8-27
D. Abate business and technical risks through defined risk reduction activities	Architecture definition at a minimum of a PDR level. Government / Industry full-scale development contracts initiated.	2005	In-house/ contractor led advanced development and technology demonstrations, including ground and flight, complete
E. Architectural decision made to safely meet unique NASA needs	CRV/CCTV Decision complete. NASA unique architecture elements identified and in development	2002 2005	NASA unique requirements identified in Obj. A & B, risk reduction investments from Obj. D
F. Enable alternative Space Station re-supply	Launch service agreement(s) in place and enabling activities complete	2002-2005	Perform initial studies to define activities. Develop and implement activities jointly between Code M and Code R

2nd Generation RLV Program Office Structure



Requirements Drives the Process

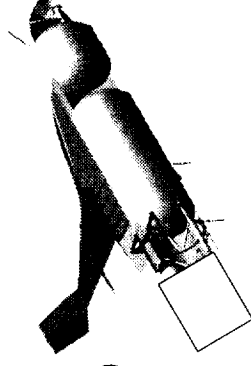
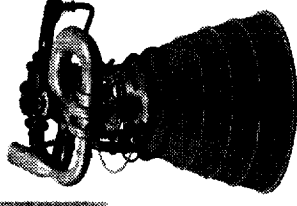
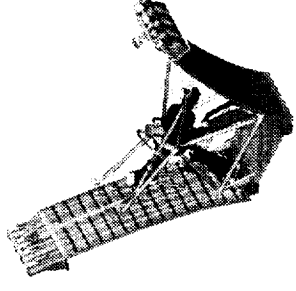


- Safety**
- Reliability**
- Affordability** → Refine for Commercial Convergence
- Mission Performance** → Define Priority Risk Reduction Needs
- Define Scale, Fidelity, Test Environment for Tech Demos
- Enable Full Scale Development With 20% Margin

Independent Assessment / Space Transportation Council Review
Include Shuttle Lessons Learned / Business Case Closure

Significant 2nd Technology Drivers

- **Crew Escape and Survival**
 - Detection, separation, ascent/descent
- **Operable, Long-life H₂/O₂ and RP/O₂ Engines**
 - 100 mission life, 50 missions to overhaul
- **Long life, lightweight integrated airframe**
 - Critical integrated cycle testing (500 missions)
- **Advanced TPS, IVHM, and Operations**
 - Quick turn vehicle with intelligent data analysis

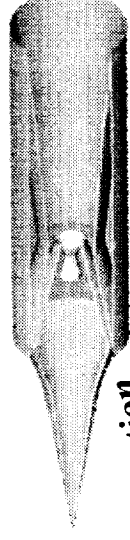


• **Ejector Ramjet**

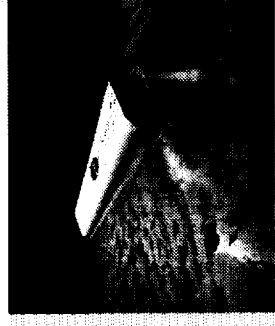
- Improved performance margin

• **SHARP Leading Edges**

- Global crossrange from orbit



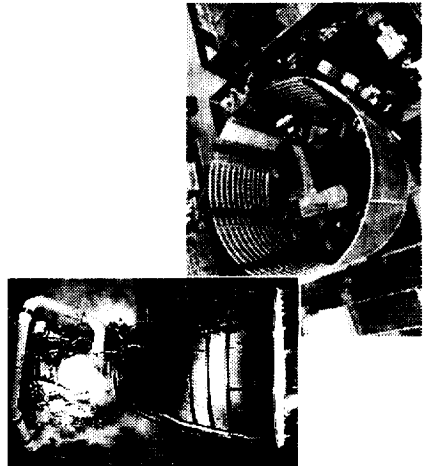
Edge for 2nd Generation



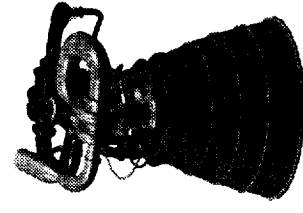
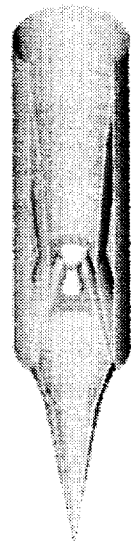
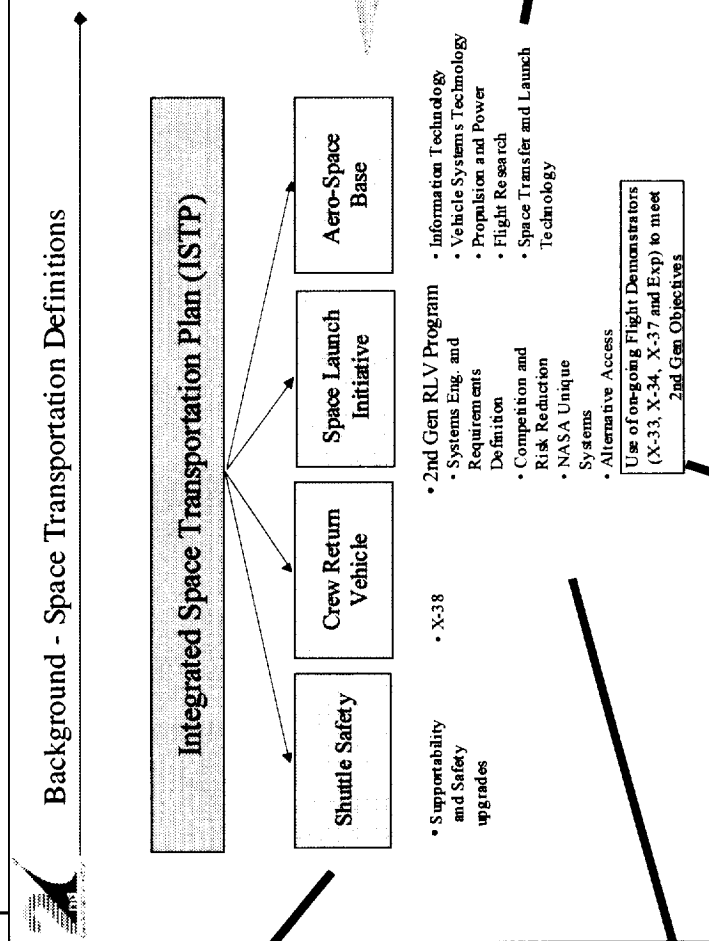
Cutting

2nd Gen RLV Relation to Other Programs

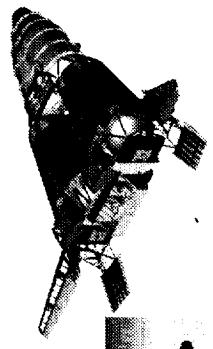
2nd Generation RLV coordinates investments with:
 Shuttle
 X-Vehicles
 ASTP
 Air Force



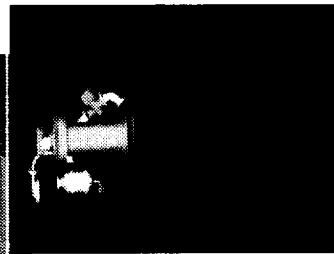
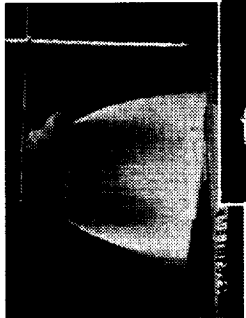
Shuttle Up-Grades



3rd Generation Technology



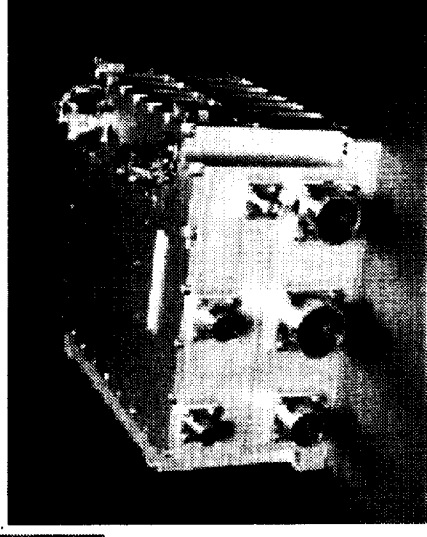
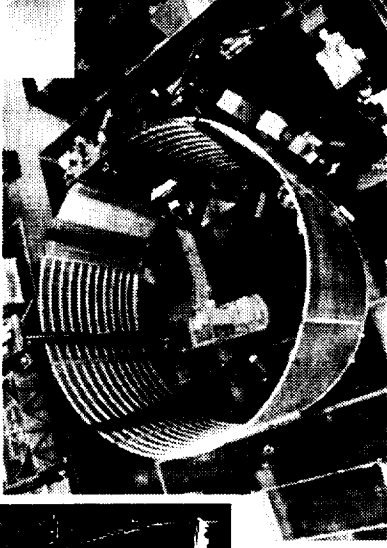
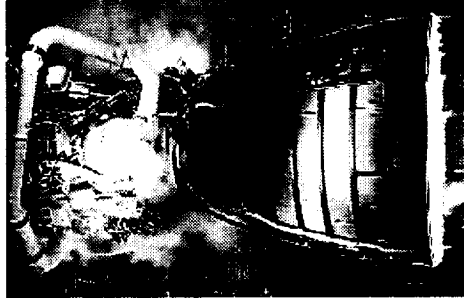
X-Vehicles



DOD Technologies

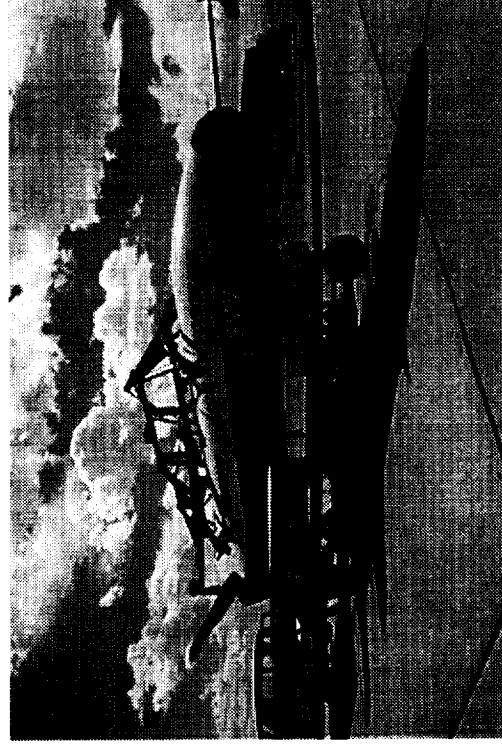
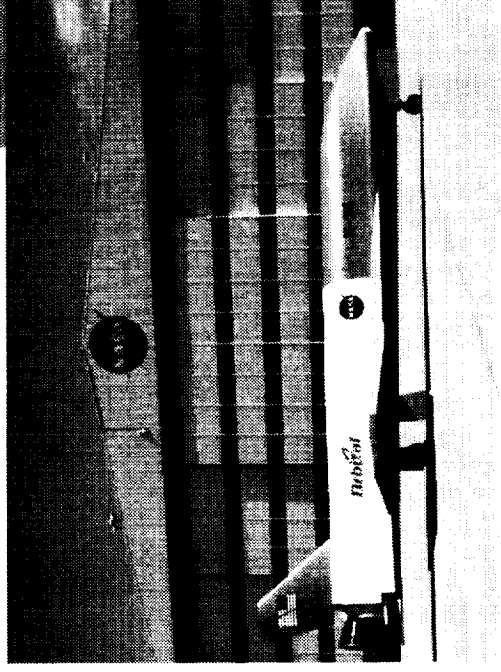
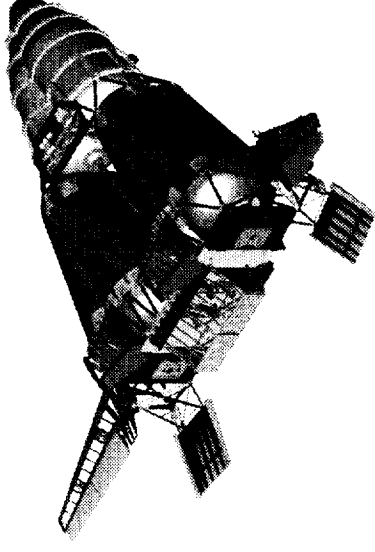
Space Shuttle Upgrades

- **Cooperation with the Space Shuttle Upgrades program is required to:**
 - Coordinate technology activities
 - Avoid duplication of effort
 - Consider application of Second Generation technologies to future Space Shuttle upgrades and the evolved Space Shuttle

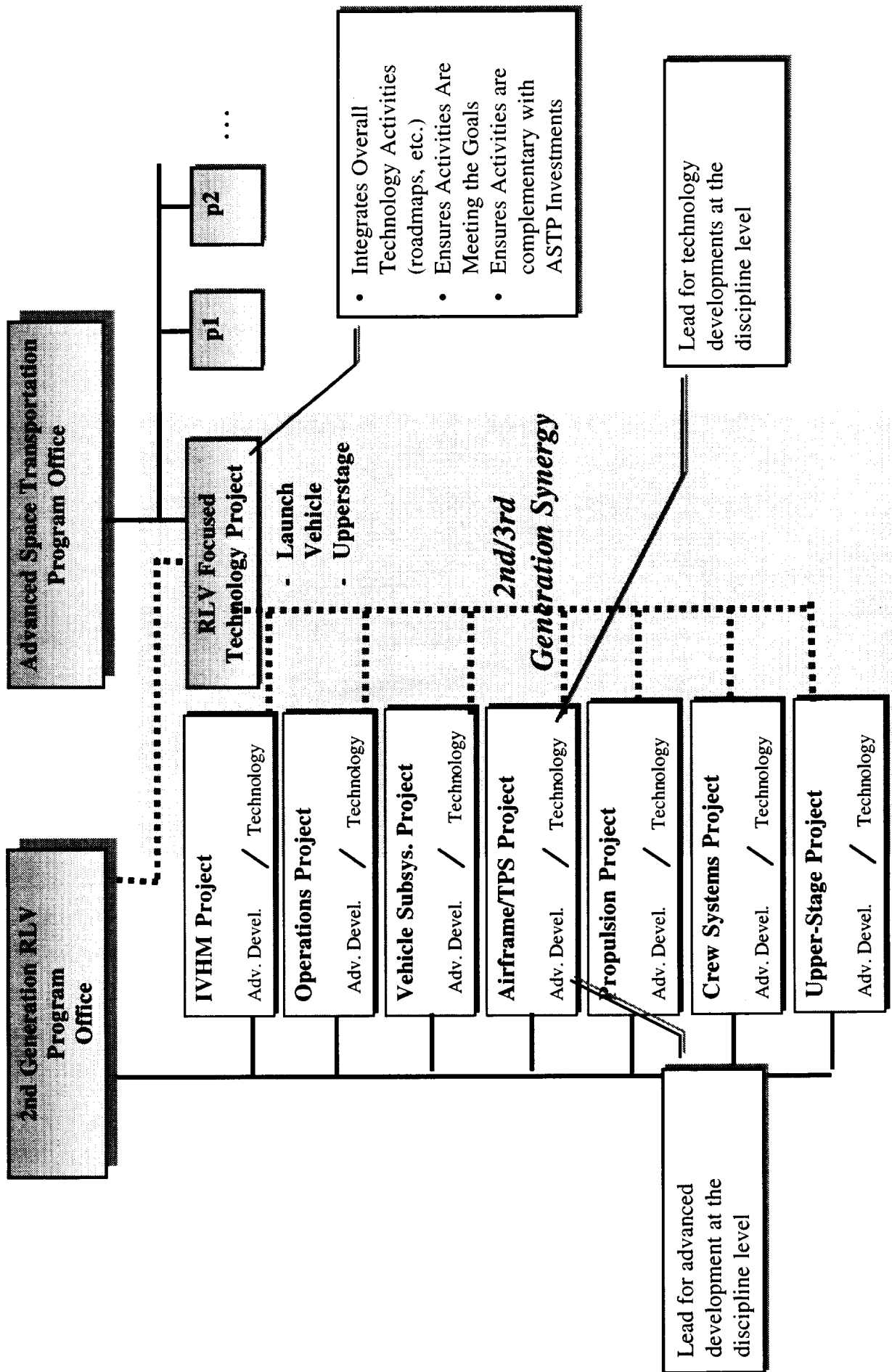


X - Vehicles

- The 2nd Generation Program is linked to the success of the current X-Vehicle programs
- The current investment in X vehicles offers a unique opportunity to reduce risk through flight test
- The future use of the current X-vehicles and other flight vehicles is dependent upon selection within the competitive process

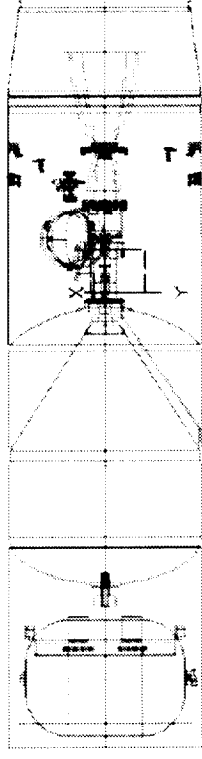
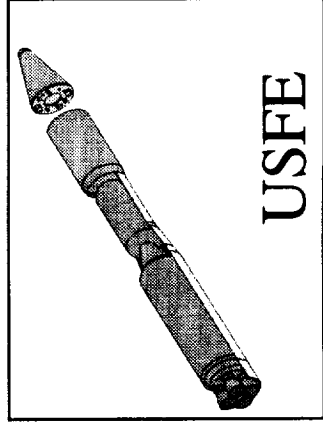
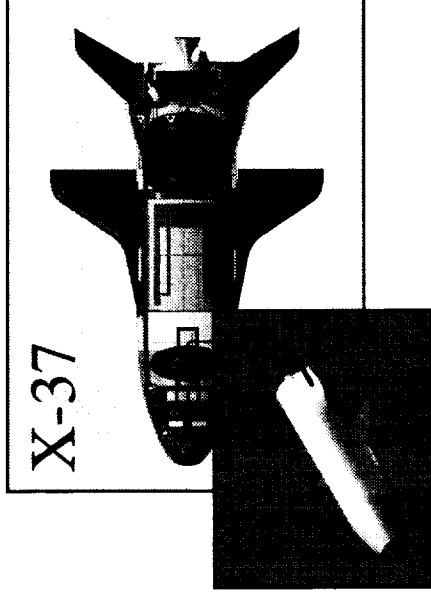
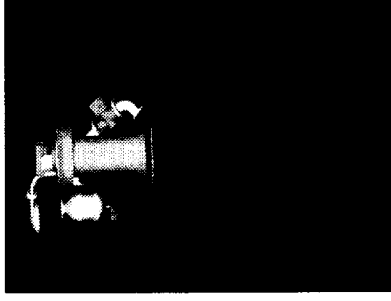
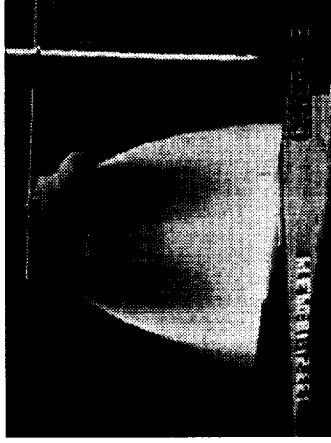


2nd/3rd Synergy Management Structure



Joint Air Force/NASA Efforts

- 2nd Generation Program is coordinating its risk reduction investments with ongoing Air Force Space Transportation investments.
- 2nd Generation Program will leverage/continue already initiated joint AF/NASA efforts including IPD, X-37, USFE, Advanced Peroxide Propulsion and MWG.



Total Program Acquisition Strategy

- Overall acquisition strategy will be in 2 major competitive phases
 - **Phase I (FY00 - 02)** develops architectures through System Requirements Definition and initiates risk reduction activities.
 - NRA8-27 converges and refines top level requirements, develops process and tools and defines risk reduction priorities.
 - NRA8-30, a single NASA Research Announcement seeking competitive systems engineering and risk reduction activities conceived by the offerors, in multiple areas of program interest (e.g. propulsion, airframe)
 - **Phase II (FY03 - 05)** focuses on architecture design and advanced technology development
 - Anticipate RFP(s) for the focused architecture design and Advanced Technology development activities
 - **Phases have decision gates** for program / project updates based on systems engineering results and Agency management milestones (e.g. Space Transportation Council, Non-advocate Review)
- In-House Risk Reduction Task
 - Cross cutting risk reduction - available to all concepts with no proprietary issues
 - Develops in-house “Smart Buyers”.
 - A second cycle will be implemented to fill risk reduction gaps.
- Alternate Access will be addressed separately based on study results from current contracts

Total Program Acquisition Needs

- Support a **decision for commitment to full scale development** of the RLV architecture that meets NASA's goals (target date is 2005)
 - Industry teams to define an RLV architecture life cycle implementation with emphasis on Full Scale Development (FSD) technical and business metrics.
 - Rigorous system engineering, detailed trade studies, and risk reduction activity leading to concept design with acceptable technical and investment risks.
 - Business analysis must be supported with appropriate parameter identification and metric evaluation and show closure.
- **Maintain competition** and encourage solicitation of all good ideas.
 - Established Aerospace Companies
 - Emerging Aerospace Companies
 - Stand-alone Technologies from Companies not providing a system level architecture
- Resulting awards will provide appropriate Government insight to ensure successful development of the 2nd Gen RLV.
- Resulting awards will provide appropriate options to facilitate adjustments after major program “**Decision Gates**”.
 - NAR recommendations
 - Systems Requirement Review
 - Commitment to Full Scale Development (FSD)

In-House Led Activities

High Priority / Schedule Critical Activities

Activities required for 2nd Gen based on STAS 3B / ISTP

Activities best performed by NASA / Gov't (expertise, data sharing, etc.)

Activities industry may not propose & must be initiated ASAP to support 2005

- Systems Engineering and requirements
 - Systems Analysis Tool Development
 - Probabilistic Risk Assessment
 - ORM & S/C Database Enhancements
 - Uncertainty Analysis and Design
 - Commercial Cargo System Modeling Task
- Propulsion
 - Full-flow staged combustion injectors
 - Lox / H2 Combustion devices test bed
 - Turbomachinery technology demonstrator
- Airframe
 - Integrated Aerothermal and Structural-Thermal Analysis
 - Stage Separation and Ascent Aerothermodynamics
 - Materials and Advanced Manufacturing: Permeability Resistance
 - Lightweight, Informed, Micrometeoroid Resistant Ceramic TPS for Leading Edge and Acreage Applications
- Crew Systems
 - Cockpit Architecture Roadmap Team
- Operations
 - Advanced mission planning / ops w/ MOD
 - Future Launch vehicle Umbilical Development
 - Satellite Telemetry Acquisition and Range Study (STARS) and Space-Based Range Safety System
- Vehicle Subsystems
 - Proton Exchange Membrane Fuel Cell (PEMFC) Power Plant Development
- Integrated Vehicle Health Management
 - IVHM Architecture Roadmap Team
- Flight Mechanics
 - Robust Integration Technology and test bed for RLV Navigation Systems
 - Natural Atmospheric Environment Technology Development

Recent Accomplishments

- Successfully completed Program Readiness Review (May 17, 2000)
 - First major milestone required by 7120.5A
 - “Program Formulation” until Non-advocate Review in June 2001
- Systems Engineering
 - Completed STAS 3B Final Reviews
 - Top level rqmts. input provided to NASA
 - All potential vehicle concepts are being assessed (e.g. Shuttle derived, new design) to meet NASA rqmts.
 - Industry top priorities remain main propulsion, airframe / cryotanks, TPS
 - Initiated further mission needs refinement and trade studies via NRA 8-27 contracts
 - Mid-term reports conducted week of Sept. 26-28, 2000
 - Final reports - Jan 31, 2001
 - CTV / CRV Planning on-going w/ JSC, LaRC, ARC, MSFC
- Acquisition strategy developed
 - Alternate Access study contracts in place
 - NASA led technology development tasks reviewed and selected, downstream selections will be based on contractor input via NRA 8-30
 - NRA 8-30
 - Pre-meeting w/ HQ Code H, G,R, & M held August 25, 2000
 - Acquisition strategy meeting held at HQ Sept. 11, 2000
 - Draft NRA released on September 21, Final to be released October 10
- External requirements assessment team formulated
 - Required skill areas (Shuttle / RLV experience, investment experience) identified, potential team members in work

Summary

- ◆ **Systems Engineering in work based on Space Transportation Council approved mission needs.**
- ◆ **Program Planning and Implementation continuing w/ broad Agency and Industry Participation**
 - ◆ **NRA 8-27 for requirements and tools development on-going**
 - ◆ **NASA In-House Development Tasks selected and set to begin**
 - ◆ **Draft NRA 8-30 for systems engineering and risk reduction activities on street with bidders conference planned for 10/13**
- ◆ **Alternate Access study contracts to develop concepts and requirements for emerging launch systems to support ISS are in place**
- ◆ **Looking forward to continuing to work with Industry to achieve the Nation's goal of developing the next generation Reusable Launch Vehicle**