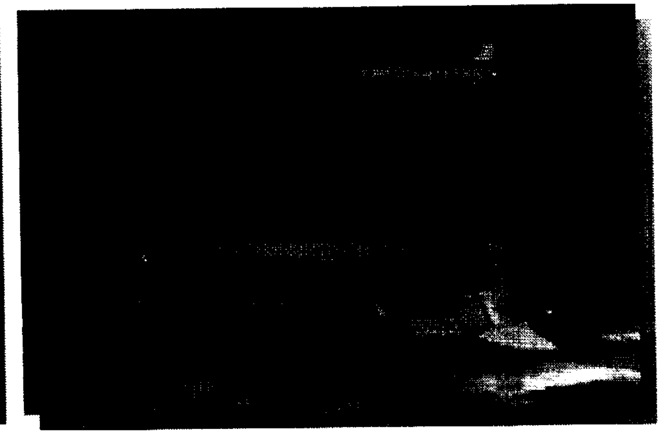
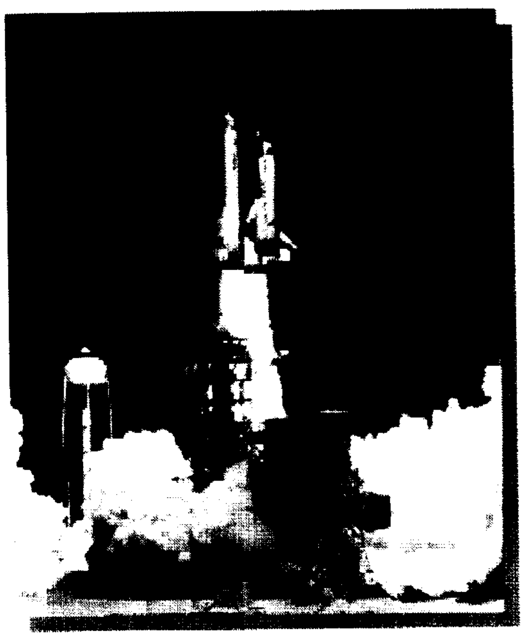
Enclosure (1)

Reusable First Stage Evolutionary Shuttle Upgrade

Reusable First Stage

Evolutionary Shuttle Upgrade





Presented at
Space Shuttle Development Conference
NASA Ames Research Center
July 30, 1999

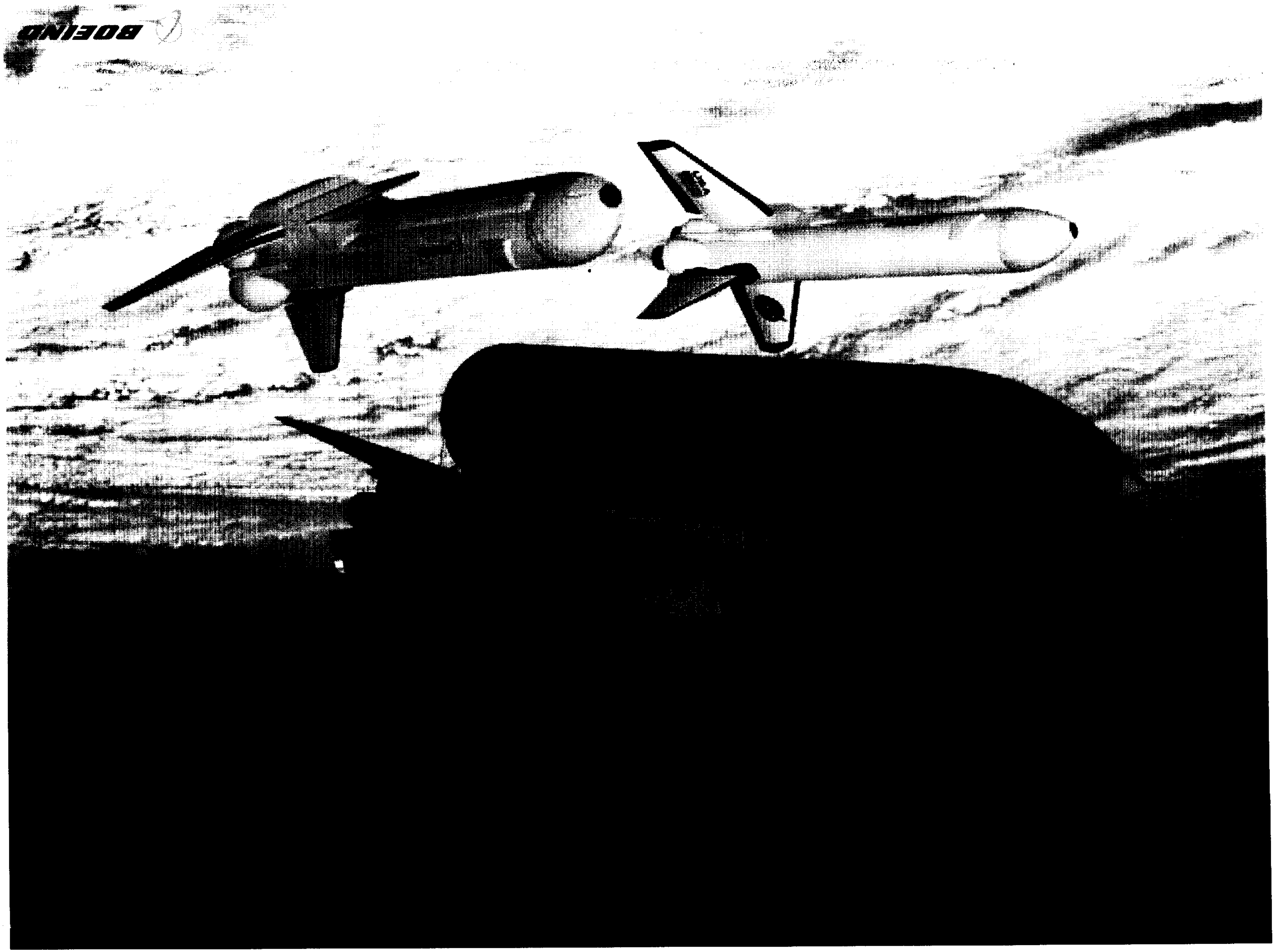
Tom Hamilton
RFS Project Manager

Tom Healy
RLV Chief Engineer

Boeing

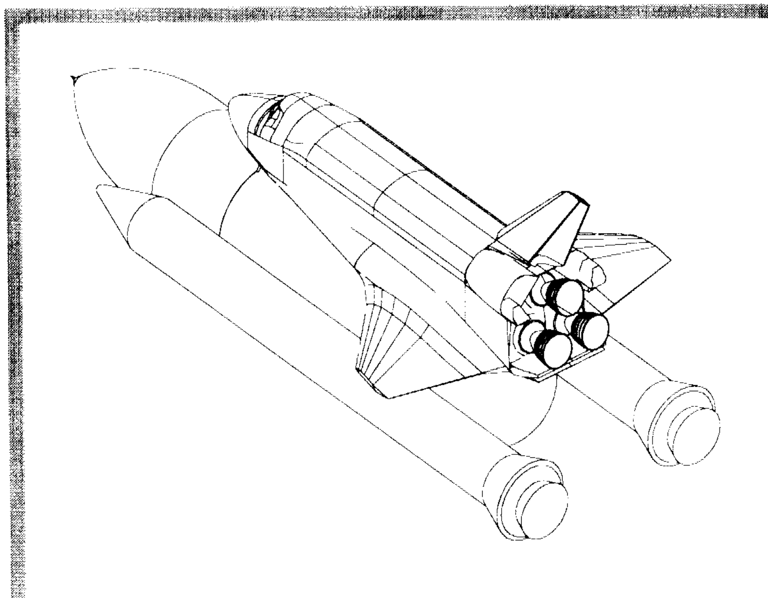
LOCKHEED MARTIN

BOEING

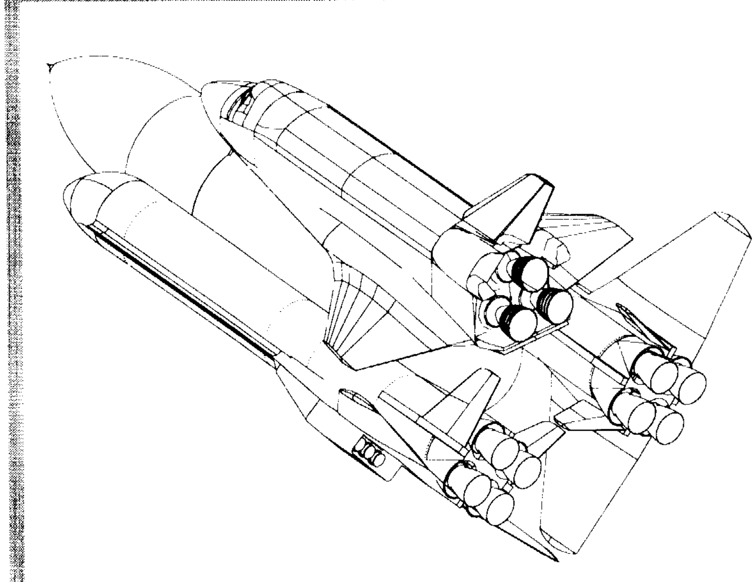


What Is The Reusable First Stage ?

A first stage reusable booster with a Liquid Propulsion System that replaces the Shuttle Solid Rocket Motors



Shuttle with SRB's



Shuttle with RFS's

Key Characteristics of the RFS / Shuttle

- Completely reusable
- Autonomous fly back and landing
- Liquid oxygen and kerosene propellants
- Mission completion with one engine out
- Eliminates RTLS or TAL for intact abort
- No new technology breakthroughs required

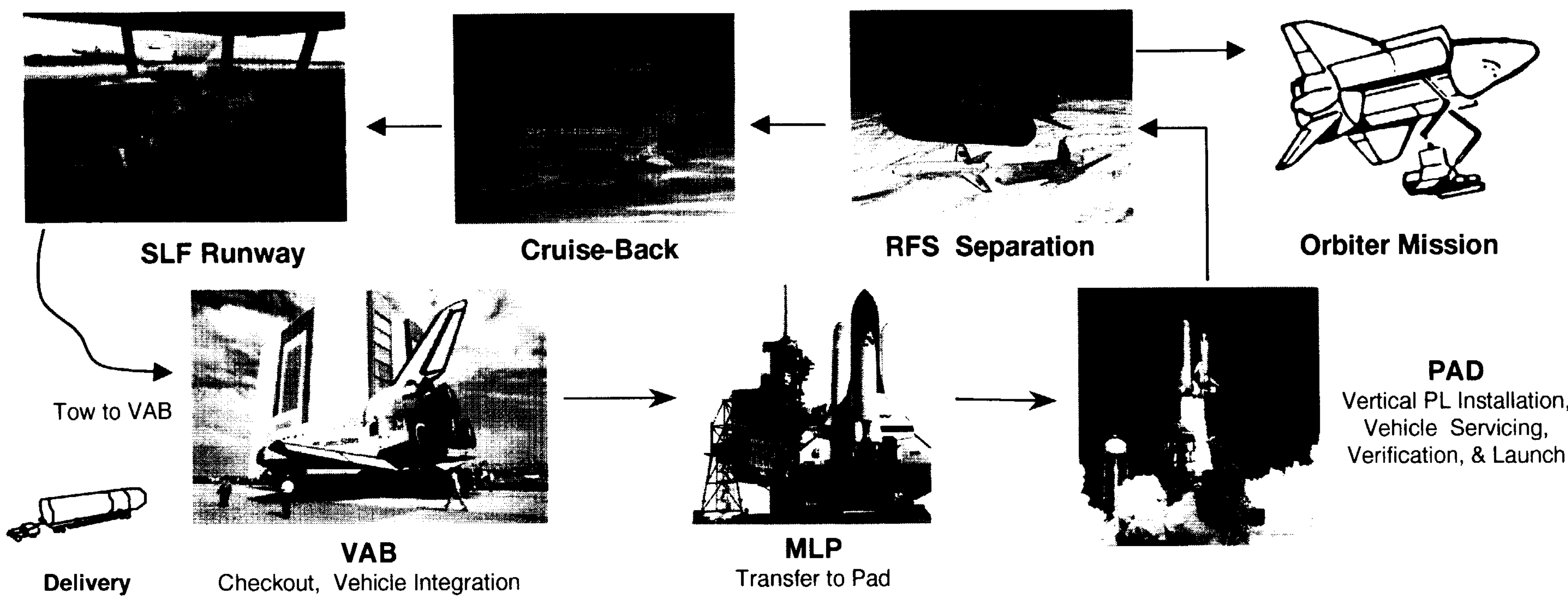
Improved Safety is a Key Focus of RFS

- <u>Mission Success & Safe Return</u>
  - Full mission objectives with single Booster Main Engine (BME) out
  - Eliminates RTLS <u>or</u> TAL for single SSME failure - reduces risk for intact aborts
  - RFS enables abort capability during 1st stage flight due to BME throttling (new capability)
  - Eliminates SSME throttle bucket
  - Lower catastrophic failure ratios
  - Booster system verification before flight
- <u>Environmental & Handling Hazards</u>
  - Eliminates hazardous SRB handling, post-retrieval clean-up and reduces manufacturing process sensitivity
  - Eliminates sea & rail operations and attendant hazards
  - Reduces rocket plume environmental impact

Improved Reliability is Inherent in Improved Safety

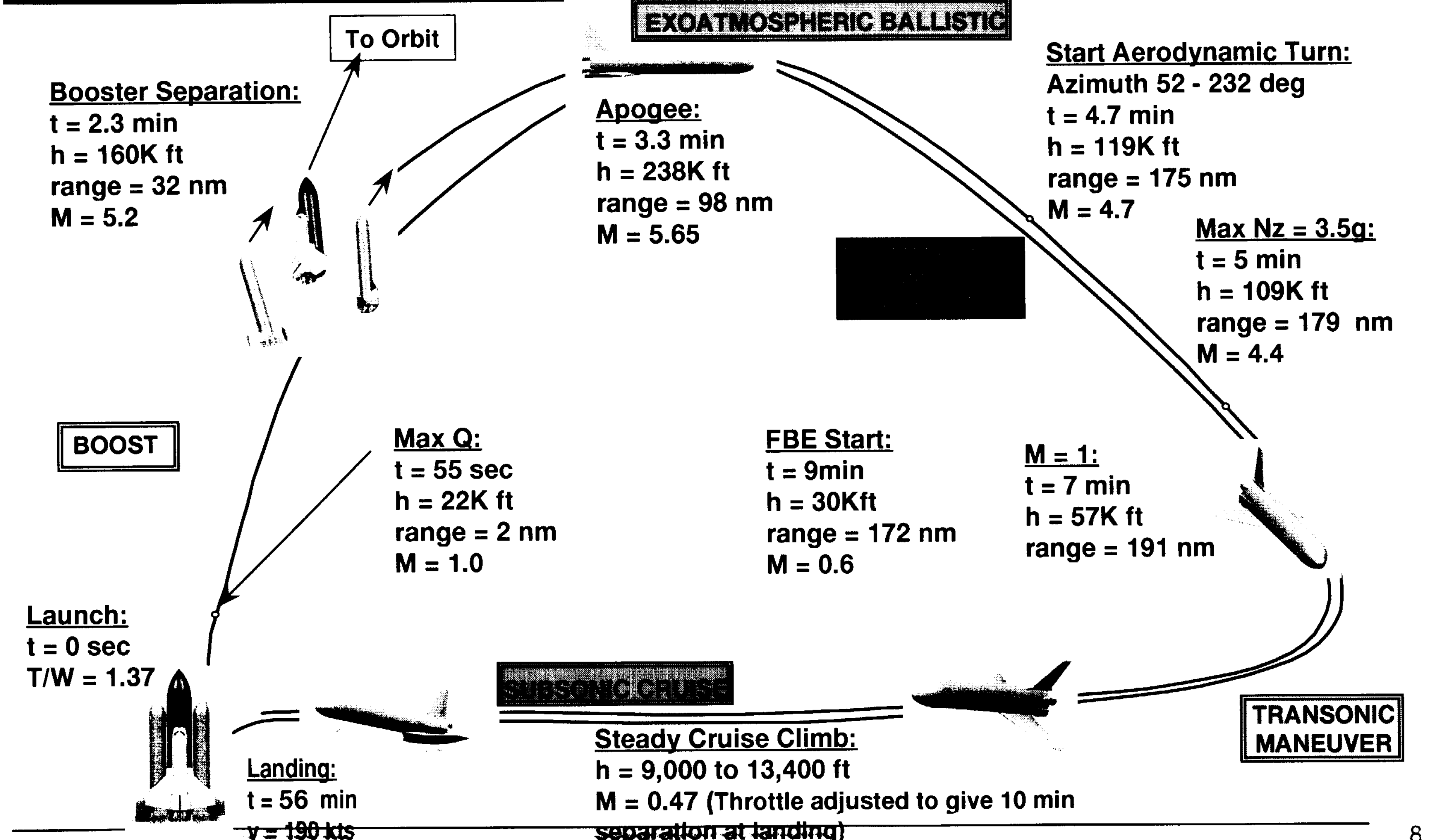
- All subsystems have a minimum of fail-safe system operation during all flight phases
  - Avionics are fail op / fail op/ fail safe
- Demonstrate robust BME margins - nominal ops at 75% rated power
- IVHM & Informed Maintenance data base builds with continued reuse
- Pre-delivery tests of engines / components
- Booster system verification before flight
- Verification of health status engines prior to launch commit
- In-flight health monitoring acts on off nominal performance

Flight Operations Similar to SRB/Shuttle, Except for Fly-Back

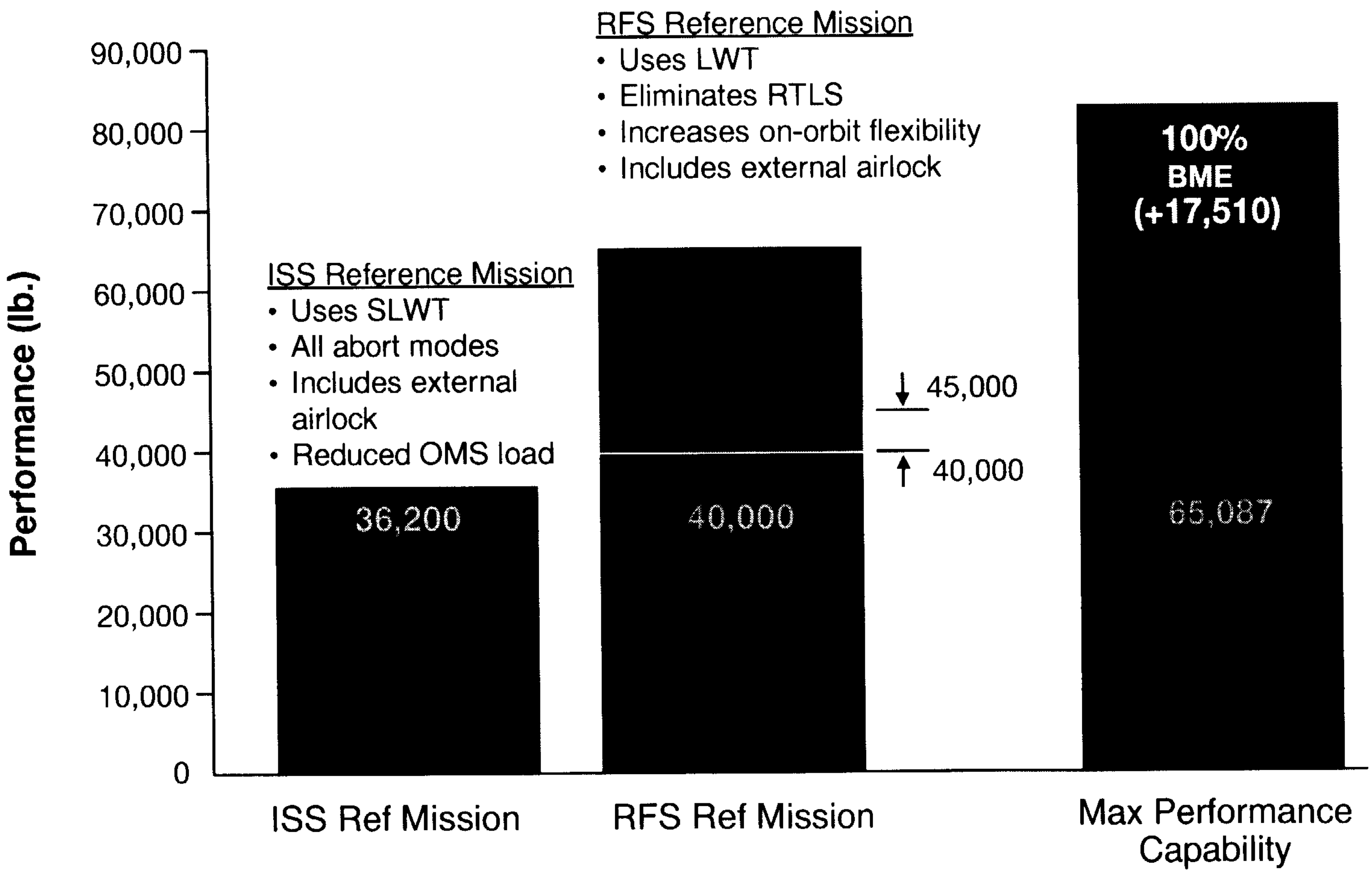


- KSC Lessons learned inputs utilized to design out operations cost drivers
- Fully coupled to CLCS and Logistics Management Systems at KSC
- All land-based operations with no ocean recovery
- Stand-alone horizontal processing using Intelligent Maintenance Management
- Short turn around time line - 24 shifts to process all RFS elements
- Modular component R&R with off-line repairs

The RFS / Shuttle Flies in Five Different Flight Regimes



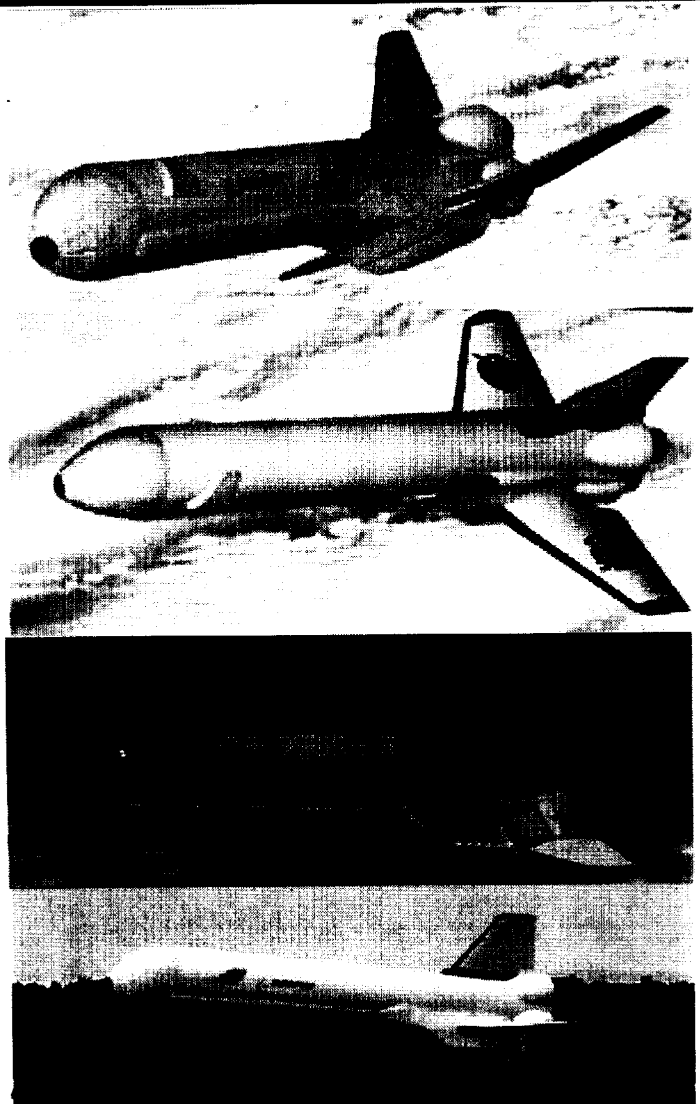
RFS / Shuttle Offers Increased Performance Potential



LOCKHEED MARTIN

BOEING

The Boeing RFS Configuration - A Low Risk, High Performance Design

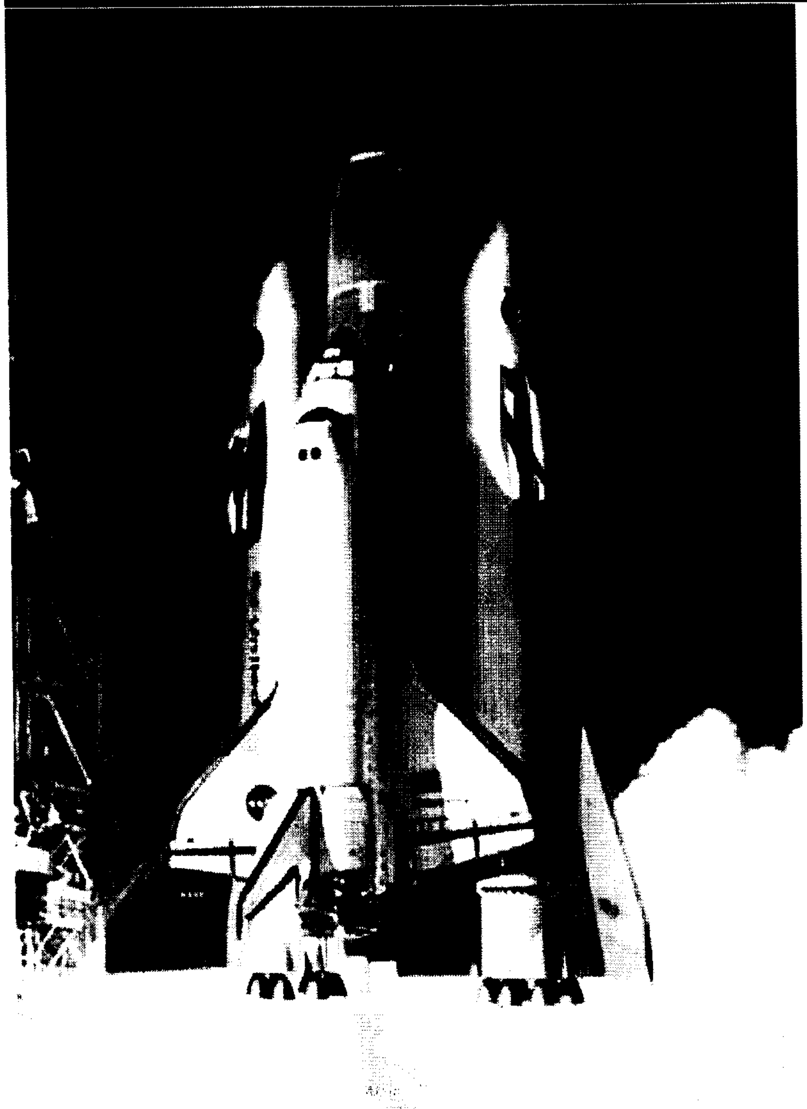


- 16 1/2 ft core diameter
- 152 ft length / 82 ft span
- 204K lb dry weight, 1.4M lb GLOW
- LOX/kerosene propellants
- Delta wing, 35° LE sweep
  - Wing optimized for subsonic cruise
  - Deployable fixed canards (subsonic trim)
- Single tail, all-moveable
- Four nacelle mounted FBE's (two candidates)
  - Lower losses / Improved maintenance
- Four BME's (four candidates)
- All Aluminum structure baseline
  - Integral tanks derived from Delta IV
- B-1 nose gear / 757 main gears
- Integrated VHM / Informed maintenance

BOEING


BOEING

The Lockheed-Martin RFS is Also a Low Risk, High Performance Configuration



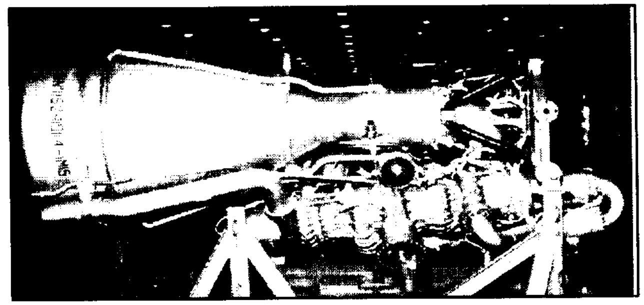
- 17 ft core diameter
- 152 ft length / 75 ft span
- 201K lb dry weight, 1.5M LB GLOW
- LOX/RP-1 propellants
- Delta wing, 50° LE sweep - optimized for flying qualities
- Forward canards to reduce trim drag
- Single tail, all-moveable
- Four forward mounted FBE's (two candidates)
- Four BME's (four candidates)
- Mixed Aluminum & Composite structure
- Integrated VHM / Informed Maintenance
- Orbiter landing gear components

LOCKHEED MARTIN

LOCKHEED MARTIN

Booster Main Engine Candidates

Aerojet AJ26-58
Modified from Existing NK-33



Pratt & Whitney RD-180S
Modified From Existing RD-180

Aerojet AJ-800
Derived from NK-33

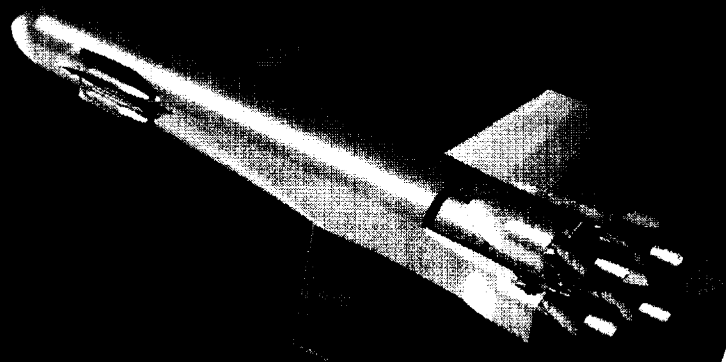
Rocketdyne RS-76
New

Oxygen rich, staged combustion cycle provides clean, dry rocket engines for rapid turn around

Candidate BME Packaging

- All BME's have competitive performance
- All candidate BME's can be packaged in the RFS configurationswith minor differences

RD-180
AJ-26-58 Similar

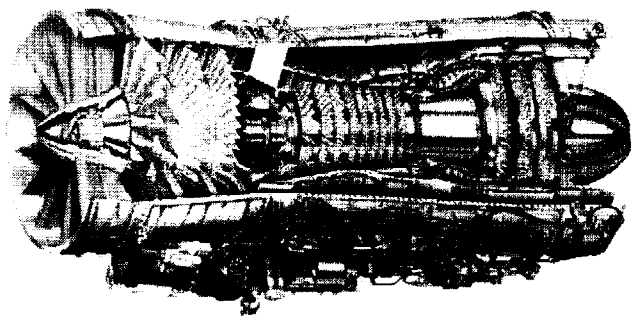


AJ-800

RS-76

Fly Back Engine Candidates

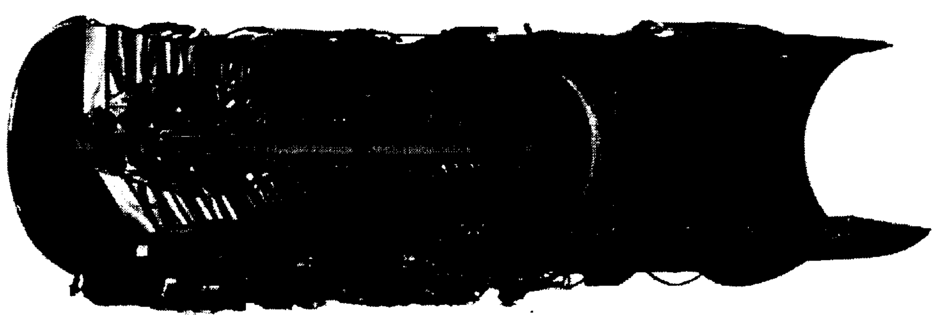
General Electric F118 Derivative



20K lbf Thrust Class

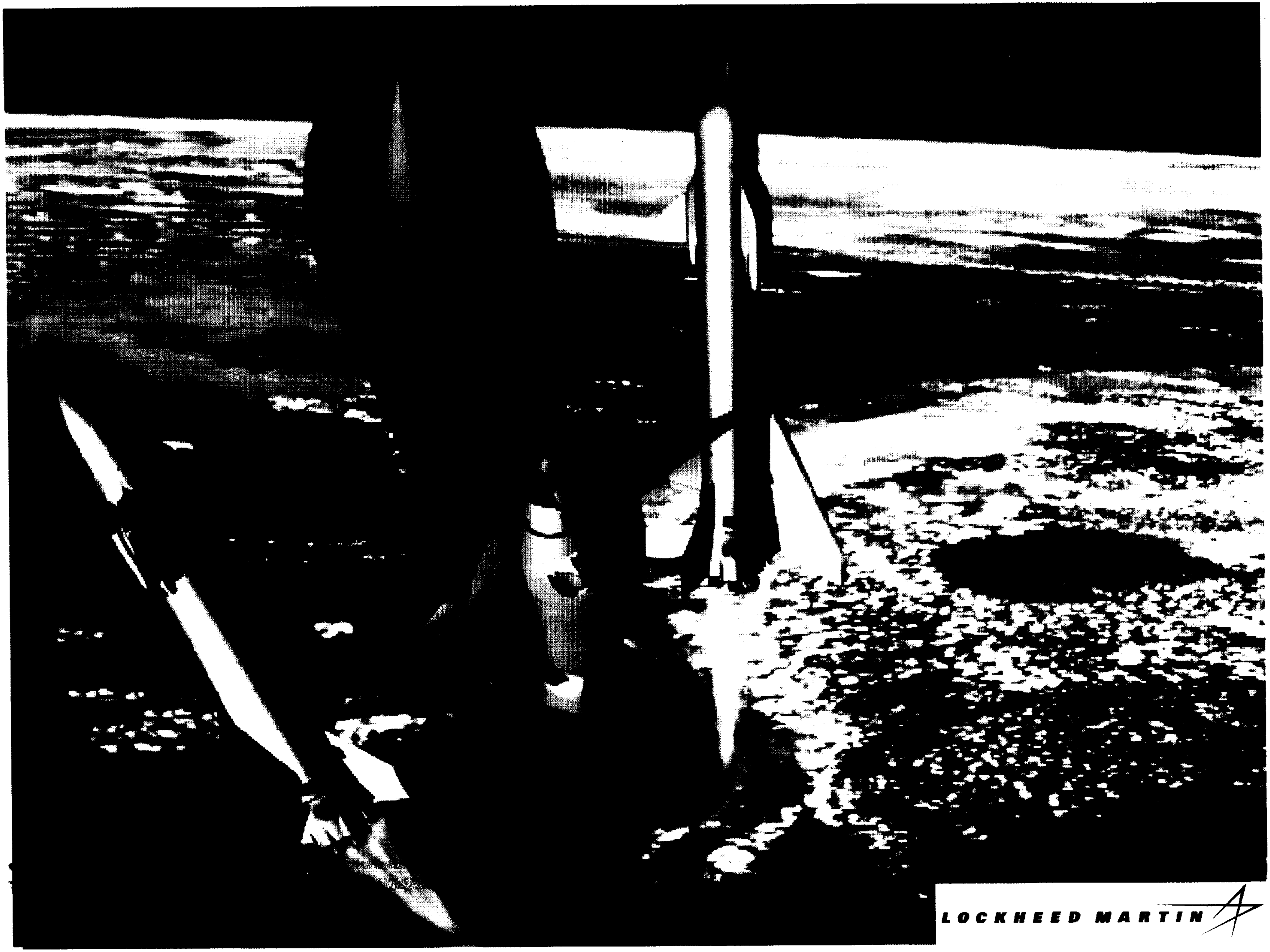
Used on B-2 & U-2 aircraft

Pratt & Whitney F100-PW-229A Derivative



20 K lbf Thrust Class

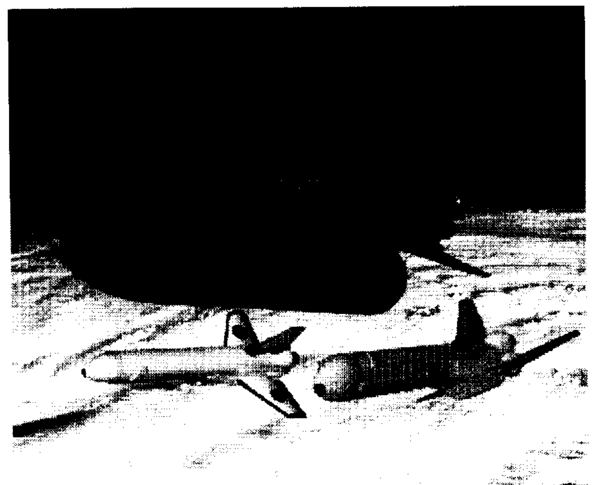
Planned for F15 & F-16 aircraft


LOCKHEED MARTIN

RFS Offers Significant Benefits to Shuttle

Safety

- Eliminates RTLS <u>or</u> TAL for single SSME failure
- Full mission objectives with single Booster Main Engine (BME) out
- Booster system verification before flight
- Eliminates hazardous SRB handling and reduces manufacturing process sensitivity



Mission Effectiveness

- Increases launch flexibility
- Increases mission completion probability
- Enables standard missions
  - Reduce flight-to-flight analysis/reconfiguration
  - Orbiter standard consumable loads

System Performance

- Increases payloads to all planned orbits
  - 45K to ISS (limited by Orbiter down-weight)
  - Polar capability from KSC
- Potential DOD / Commercial applications
- Environmentally friendly

System Cost

- Reduces annual operations by $400M + (@ 7-8 Flights per year)
  - SRB hardware deletion
  - SRB processing elimination
  - Reduced mission operations

In Summary ....

Concepts
are
Feasible

Benefits
are
Significant

Potential for
alternate
applications