Five Segment RSRB Feasibility Status

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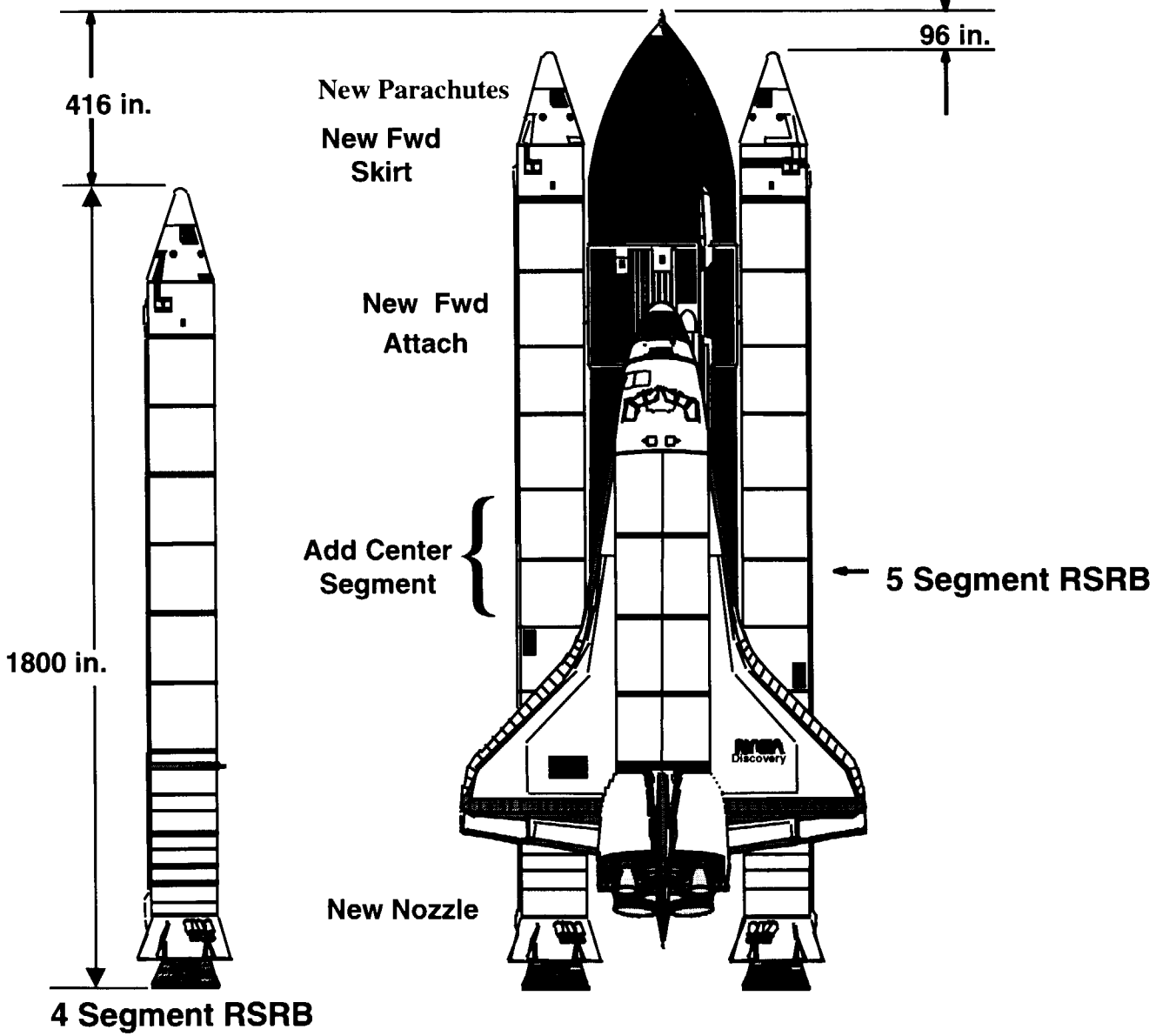
Shuttle Upgrade Conference
Ames Research Center
30 July 1999

Five Segment Booster(FSB) Objective

- Provide low cost, low risk approach to increase reliability and safety of Shuttle system

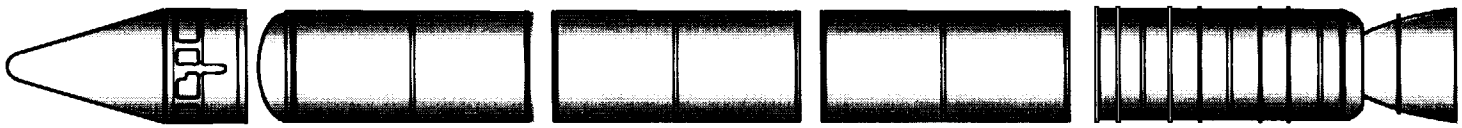
STS Booster Upgrade Requirements

- Safety/Reliability Improvement
  - FSB reliability > RSRB reliability
  - Enhance abort modes
- Increased System Capability
  - Performance improvement to ISS
  - Provide increased payload capability to other orbits
- Reduce Costs
  - Decrease operations costs
- Low Development Risk

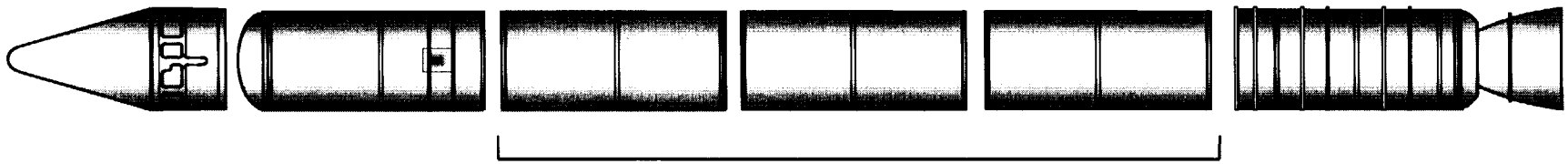

96 in.
416 in.
New Parachutes
New Fwd Skirt
New Fwd Attach
Add Center Segment
5 Segment RSRB
1800 in.
New Nozzle
4 Segment RSRB

5 Segment RSRB Design Summary

4-SEGMENT



5-SEGMENT



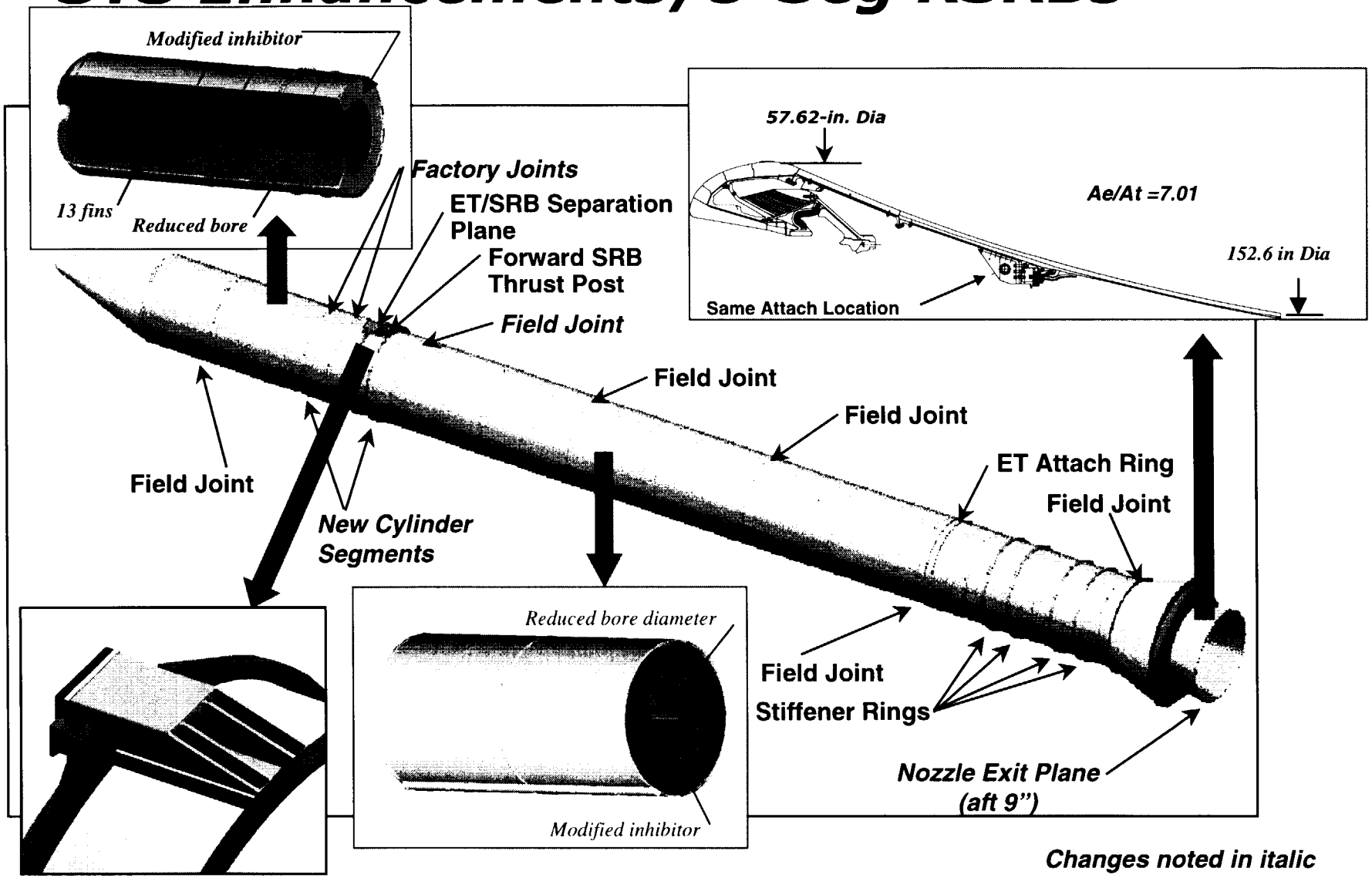
- Same frustum & BSMs
- New forward skirt (-26")
- New medium wt parachutes

- New attach case segments
- Increased segment length(26")
- Grain/inhibitor modification
- Reduced bore diameter(4")
- Reduced burn rate
- Insulation modification
- System tunnel modification

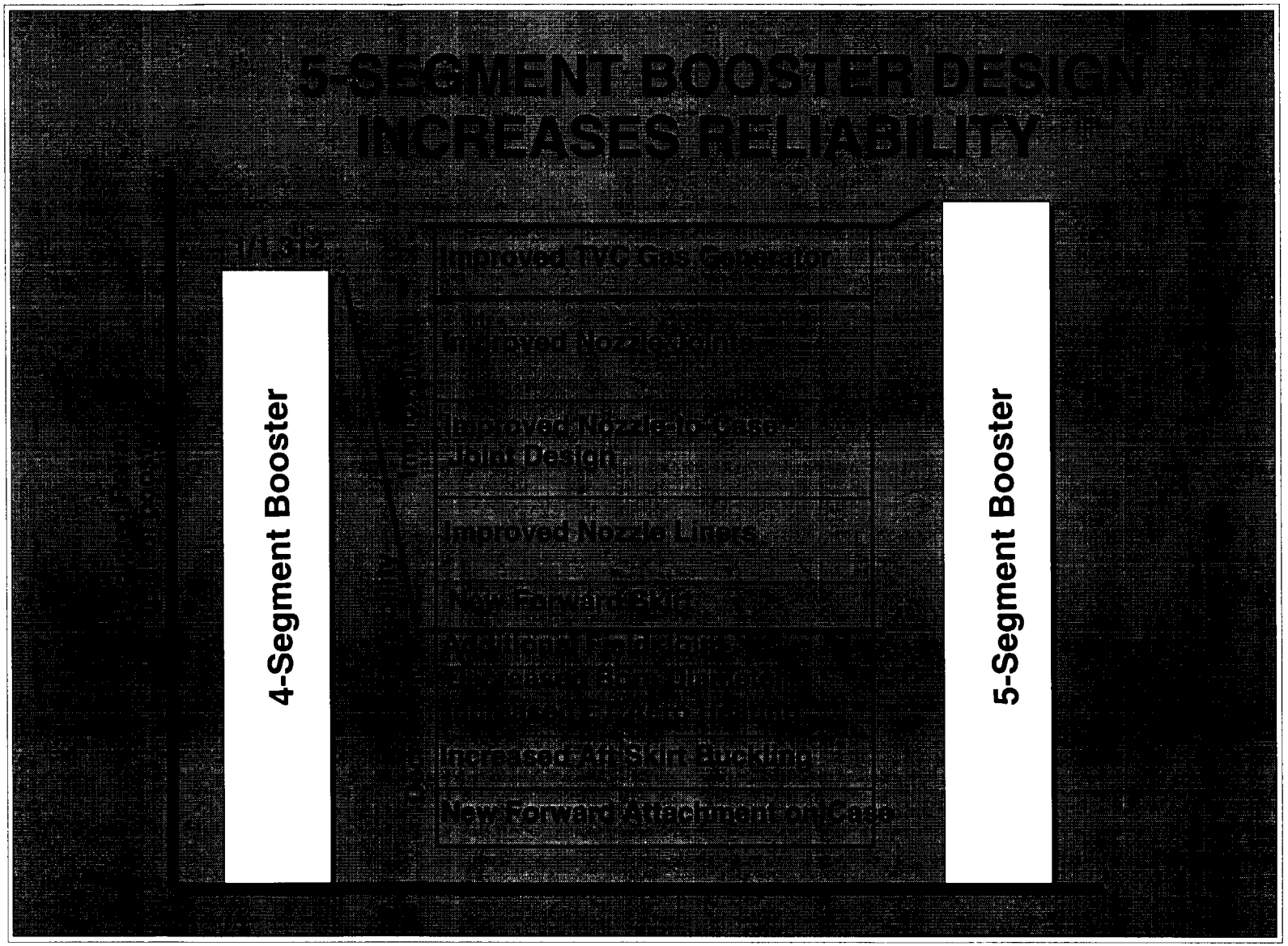
- Added center segment
- Insulation modification
- Reduced burn rate
- Modified inhibitor height
- Reduced bore diameter (4") w/lead-in chamfers

- Standard weight stiffeners
- Added stiffener ring
- New nozzle
- Increase nozzle length
- Insulation modification
- Reduced burn rate

STS Enhancements/5-Seg RSRBs

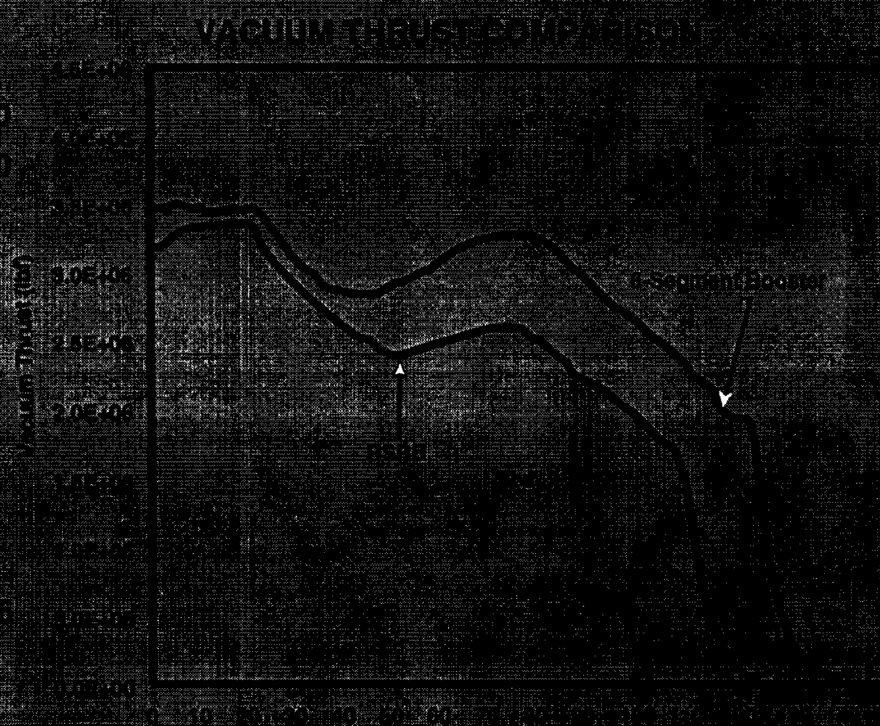


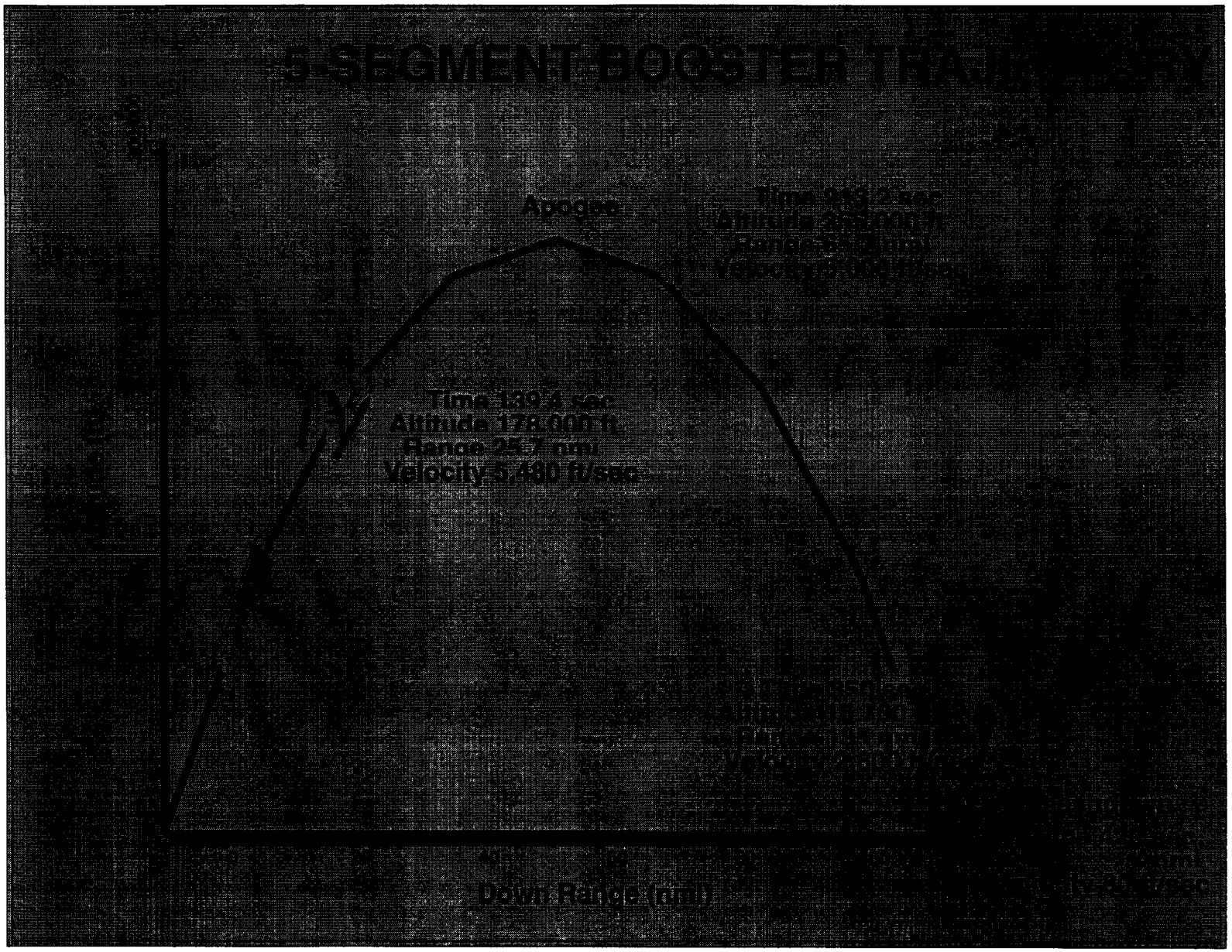
Changes noted in italic


5-SEGMENT BOOSTER DESIGN INCREASES RELIABILITY
4-Segment Booster
5-Segment Booster

5-SEGMENT DESIGN PERFORMANCE

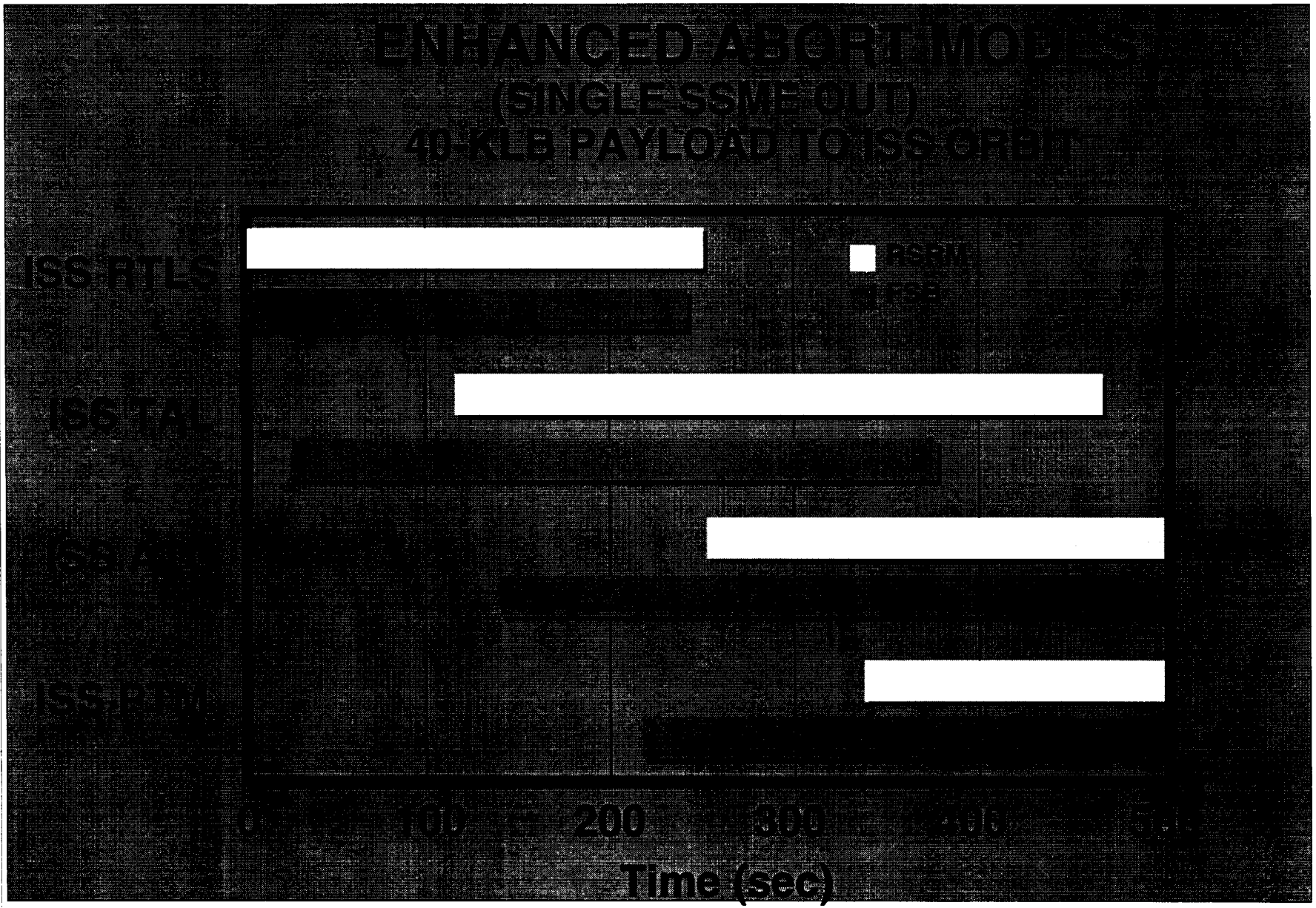
	5 Segment	RSRB
Total Impulse (Mlbf-sec)	[illegible]	286.3
Max Thrust (lb)	3,487,300	3,331,400
[illegible]	[illegible]	2,395,000
Average Pressure (psia)	622	625
MEOP (psia)	1,016	1,016
Vacuum Isp (sec)	266.4	268.0
Action Time (sec)	138.4	123.7
Burn Rate (in/sec)	0.343	0.368
[illegible]	[illegible]	7.72
[illegible]	[illegible]	53.86
[illegible]	[illegible]	1.56
Propellant Weight (lb)	[illegible]	1,105,546
Motor Burnout Weight (lb)	[illegible]	149,725
Booster Inert Weight (lb)	[illegible]	43,408




5-SEGMENT BOOSTER TRAJECTORY
Apogee
Time 139.4 sec
Altitude 178,000 ft
Range 25.7 nmi
Velocity 5,480 ft/sec
Down Range (nmi)

FSB Capability Improvement

- **FSB Design Features**
  - Add center segment
  - Increase forward segment 26 in.
  - Decrease propellant bore diameter 4 in.
  - Increase nozzle length (~9 in) and exit diameter (3 in)
  - Larger diameter medium wt. Parachutes
  - Shorter Lt. Wt. forward skirt
- **Performance Constraints**
  - Maximum Dynamic Pressure 730psf
  - Maximum Acceleration during SRB 2.7 g
- **Equivalent ISS Payload Capability - 60,500 lbm**
  - Orbiter ISS Payload increased to 40,000 lbm
  - Improved abort mode capability


ENHANCED ABORT MODES
(SINGLE SSME OUT)
40-KLB PAYLOAD TO ISS ORBIT
ISS RTLS
ISS TAL
ISS PERI
RSRM
FSE
100
200
300
Time (sec)

ET Impacts

- **No change to aft interface**

- **Increased loads on forward interface**
  - Maximum acceleration increased from 2.4 to 2.7 g
  - Pre-Phase A data indicates minimal structural impact
    - 2.7 g maximum acceleration will be confirmed in this study

- **Protuberance and thermal environments remain to be defined and assessed**
  - Stagnation heat load ~50% greater than current
    - Additional TPS will be required

Load increases are manageable with minimal weight penalty

Launch Site Assessment

FACILITY MODIFICATIONS

VAB

- MODIFICATION OF SRB ACCESS PLATFORMS
- ADDITION OF SRB ACCESS PLATFORMS

PADs

- MODIFICATION OF GOX VENT ARM
- MODIFICATION OF SRB FWD ACCESS PLATFORMS
- POTENTIAL MODIFICATION OF H2 VENT UMBILICAL

MLPs

- MODIFICATION OF SRB T-0 UMBILICAL
- POTENTIAL MODIFICATION OF SRB HOLD POSTS

HANGER AF

- ADDITIONAL SRB RAIL DOLLIES
- MODIFICATION OF SRB RETRIEVAL OPERATIONS (DIVER OPERATIONS)

LCC

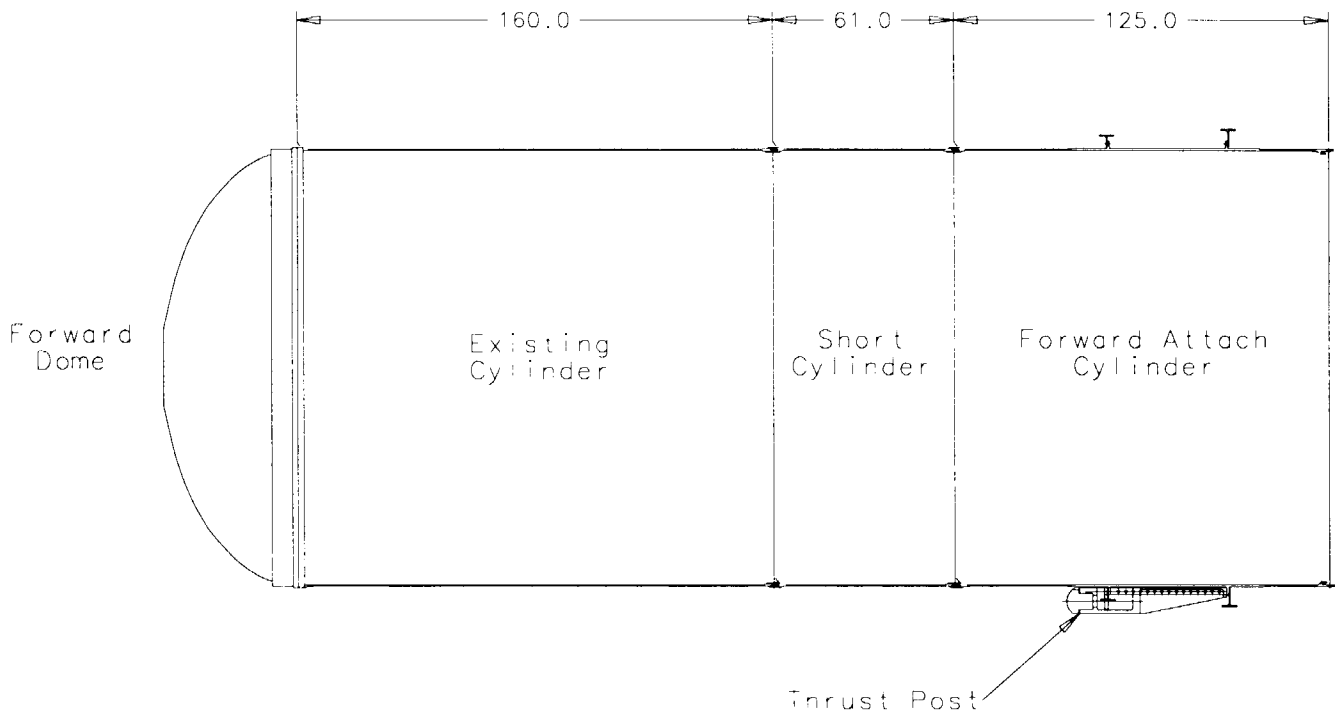
- UPDATE LPS SOFTWARE

Conclusion

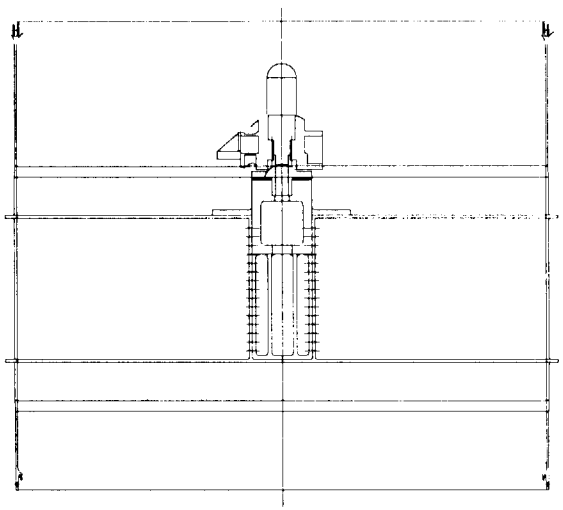
- **FSB will be safer and more reliable than current RSRB**
- **Increased capability from FSB enables improved flight safety during boost phase**
  - Reduced risk for SSME-out abort modes
  - Increased performance will enable Orbiter upgrades for increased crew survivability and still meet ISS commitments
- **Improved performance increases payload capability to ISS and other orbits**
- **FSB offers low cost, low risk approach to gain safety and performance enhancements**

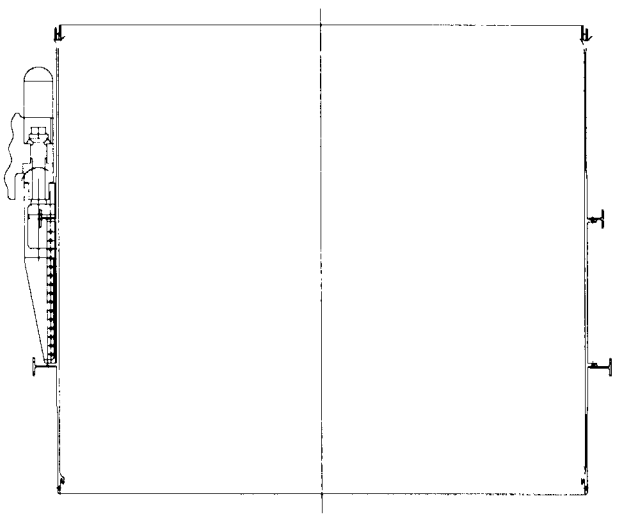
Backup Charts

Forward Segment



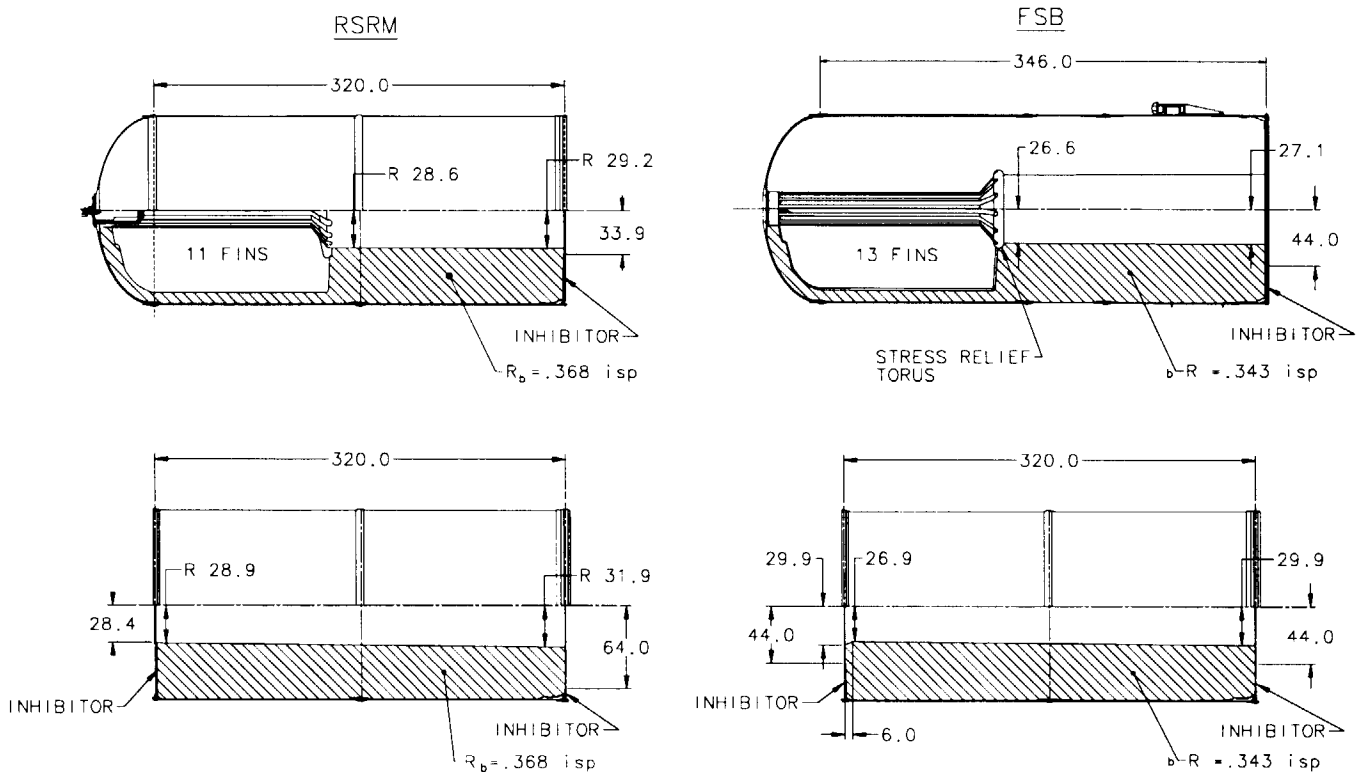
Forward Attach





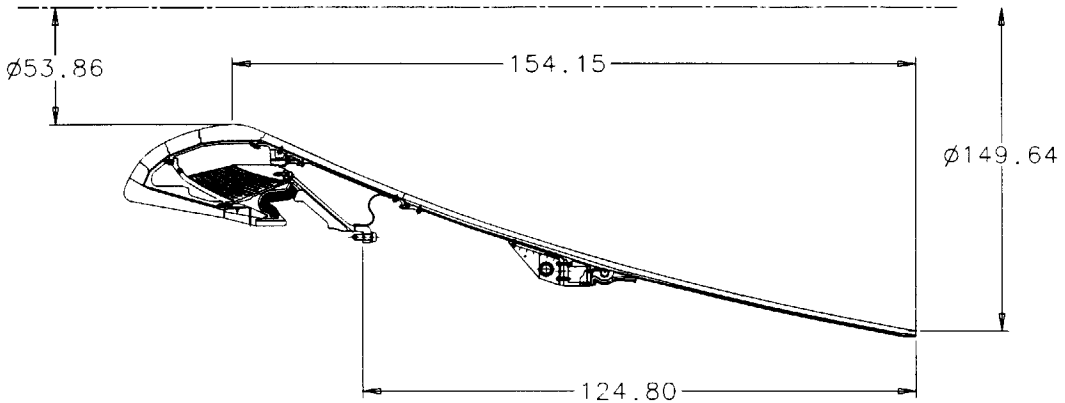
FSB Grain Design

GRAIN DESIGN



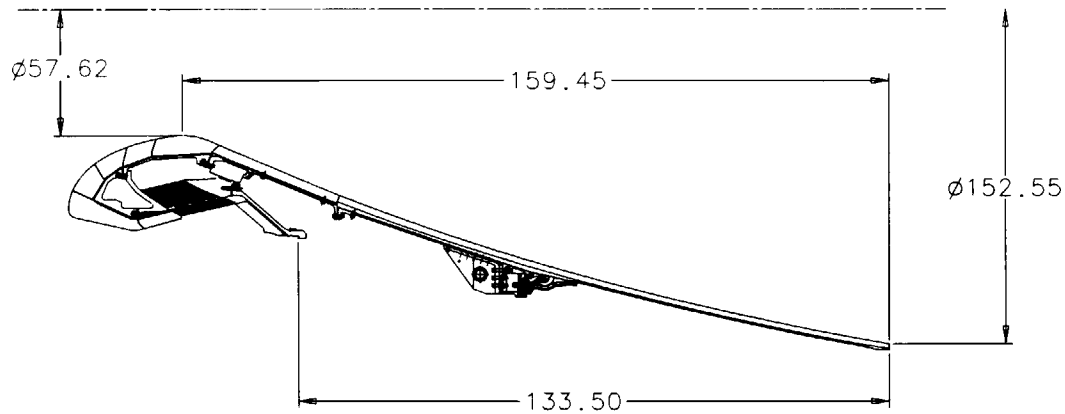
RSRM NOZZLE

$A_e/A_t = 7.72$

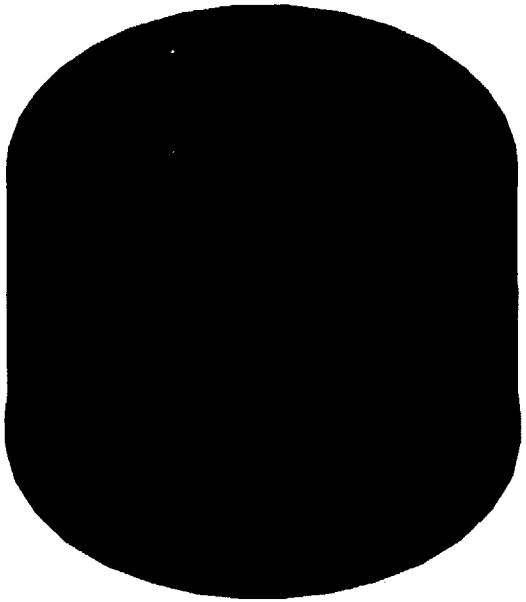


FSB NOZZLE

$A_e/A_t = 7.01$



FSB Forward Skirt



- Skeletal structure with internal stiffening ring/avionics interface
- Longitudinal beams oriented to each parachute riser fitting
- Length reduction =/> 26 inches
- Skin panels optimized for weight
- Weldment assembly
- Fwd and Aft ICD's unchanged
- Material: AL2219