13

N91-28207

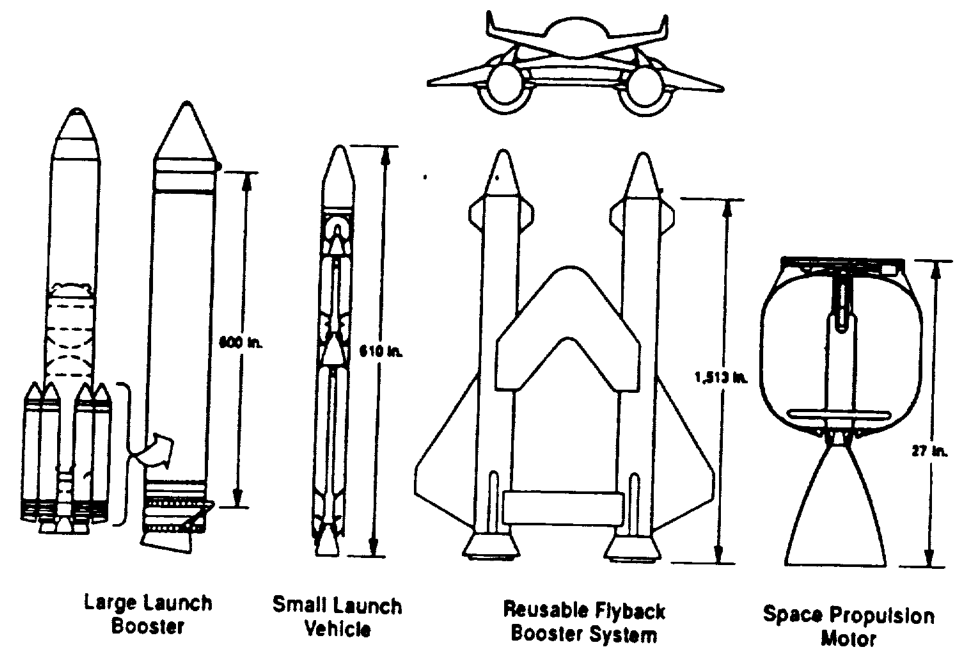
Next Generation Solid Boosters

R. K. Lund

27 June 1990

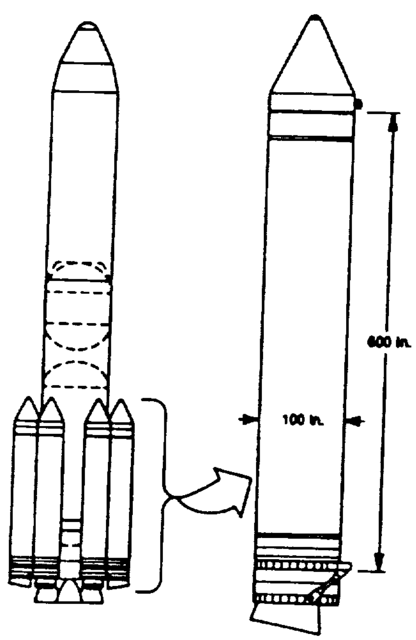
Thiokol CORPORATION

Space Transportation Solid Rocket Motor Systems



Thiokol CORPORATION

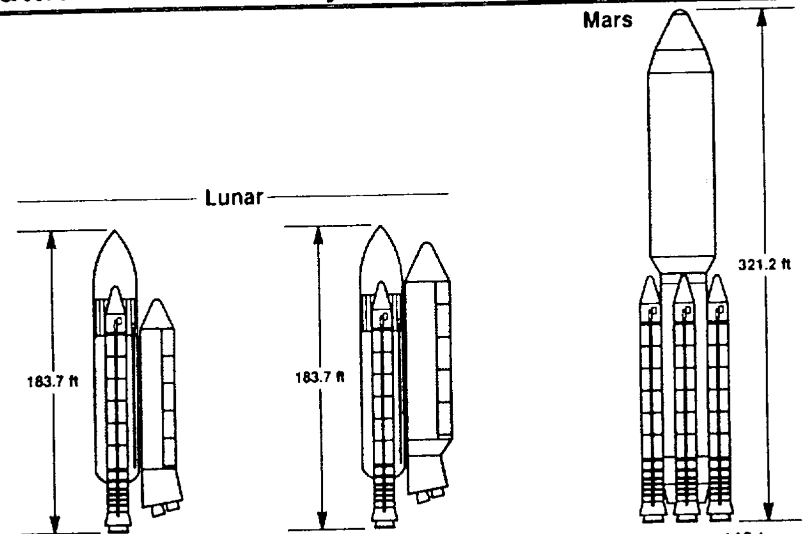
Large Launch Solid Rocket Boosters



- Concept objectives:
  - Reduce booster costs to \$5–6/lbm of booster weight (60% decrease)
  - Increase booster reliability and safety (demonstrate 0.999X reliability/booster)
  - Clean propellant exhaust (no HCl)

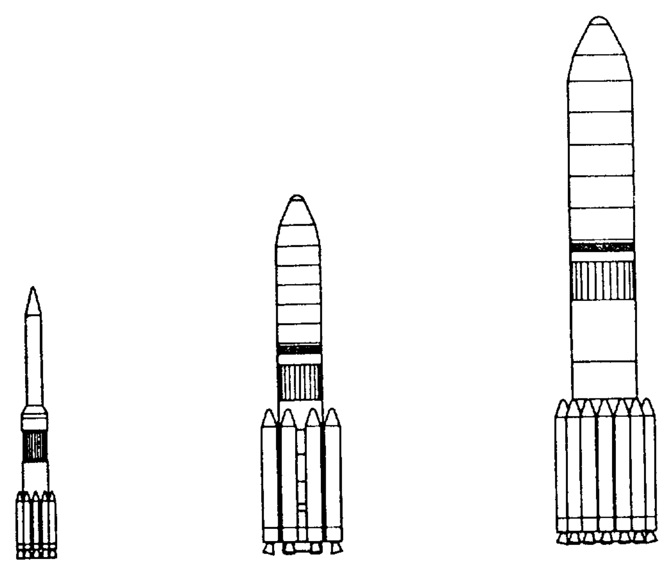
INFORMATION ON THESE PAGES WAS PREPARED TO SUPPORT AN ORAL PRESENTATION AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

Shuttle–Derived Heavy Lift Launch Vehicles



Net Payload	71 t	61 t	140 t
Booster	2 ASRBs	2 ASRBs	4 ASRBs
Core Stage	Standard ET	Standard ET	32.8 ft dia
Core Propulsion	3 SSMEs	3 SSMEs	Recoverable P/A With 5 SSMEs
Payload Envelope	15.1 ft dia/ 82 ft length	24.9 ft dia/ 89.9 ft length	41 ft dia/ 98.4 ft length

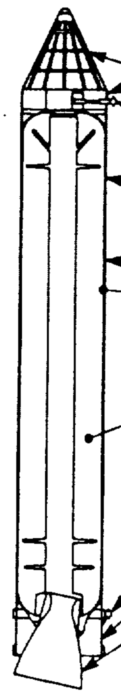
ALS–Derived Heavy Lift Launch Vehicles



Booster Thrust (klb)	8–460	6–600	12–600
Payload (klb)	88	117	250

Thiokol CORPORATION

Enabling Technologies



	Design	Process/Material
System	Reliability Cost	S.A.F.E.R.sm Performance/cost optimization
Nose cone	Stiffened shell	Composite/aluminum
Forward skirt extension	Stiffened shell	Aluminum welded
Forward attach structure	Pivot	Midstrength D6AC
Case/skirts	Monolithic Integral aft dome Symmetric aft opening	Filament wound on "green" insulation Graphite prepreg resin
External insulation		Bonded cork
Internal insulation	Variable thickness Single material Flapless	Kevlar EPDM Strip wrap on mandrel Co-cure with case
Propellant/grain	Slotted CP	Clean exhaust Machined grain Batch or continuous mix Direct bond
Aft attach structure	Aft end thrust reaction truss structure	Midstrength D6AC
Aft skirt extension	Stiffened shell	Aluminum welded or chem-milled
Nozzle	Submerged centerline Canted boss Symmetric nozzle	PAN carbon phenolic Molded
Ignition/ordnance	Pyrogen/laser-initiated igniter Forward dome termination	Tailored clean propellant Shaped charge detach

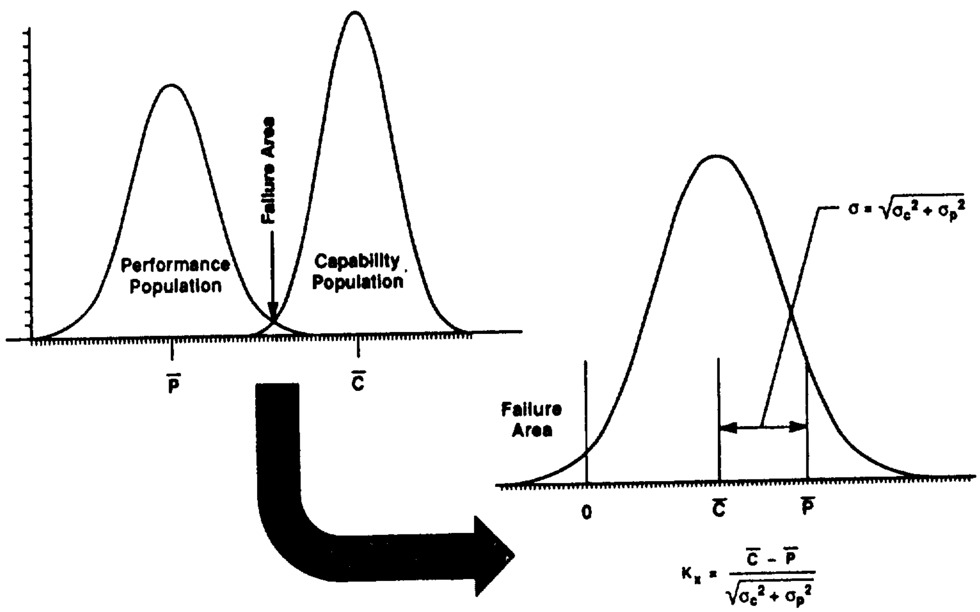
S.A.F.E.R.^{sm} Philosophy

Statistical Analysis for Engineering Reliability

- Link reliability and producibility to affect design
- Conduct design to meet allocated reliability
    - Estimate design reliability based on estimated performance and capability distributions
    - Base capability distribution on historical test data and established requirements
    - Develop approach to estimate performance distribution from standard engineering models
- Link process control variables and key design variables to critical failure modes
- Establish test program to demonstrate reliability (tailor test data to establish capability and performance distributions)

Thiokol CORPORATION

Independent Performance and Capability Distributions Combined Into One Failure Distribution: X=C–P

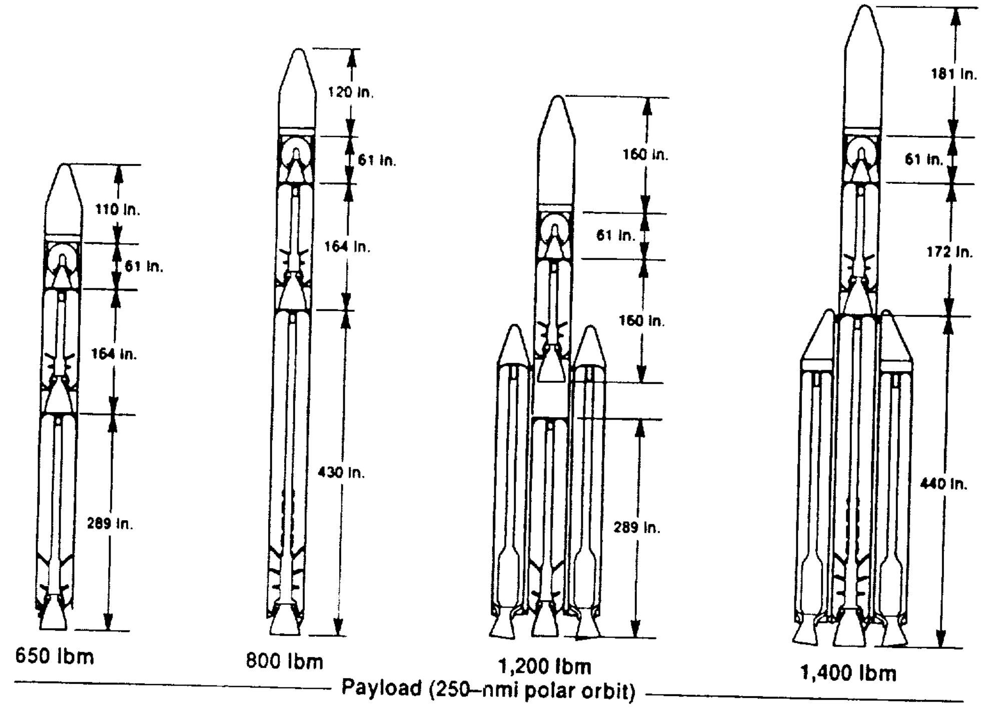


Small Launch Vehicle Concept Objectives

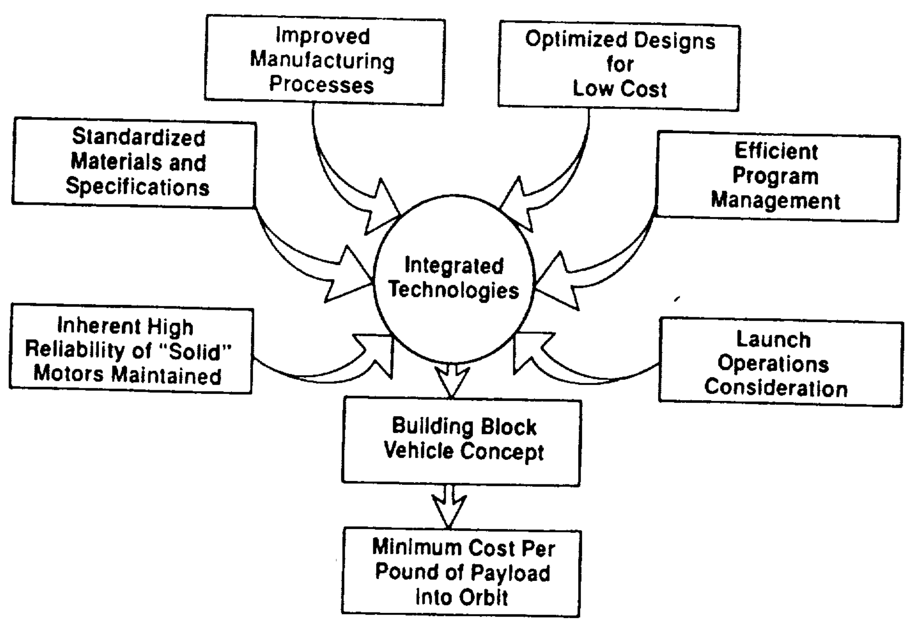
- Provide family of small launch vehicles to increase user flexibility in delivering a broad range of payloads (600 to 2,000 lb) into LEO
  - Remote sensing satellites
  - Communication and scientific research satellites
  - Recoverable capsules for industrial applications
- Retain high reliability of military systems
- Vehicle family based on basic motors (building blocks) derived from current strategic motor systems
- Minimize launch operations relating to vehicle
- Provide resiliency and responsiveness to launch on alert

Thiokol CORPORATION

Small Launch Vehicle Concept

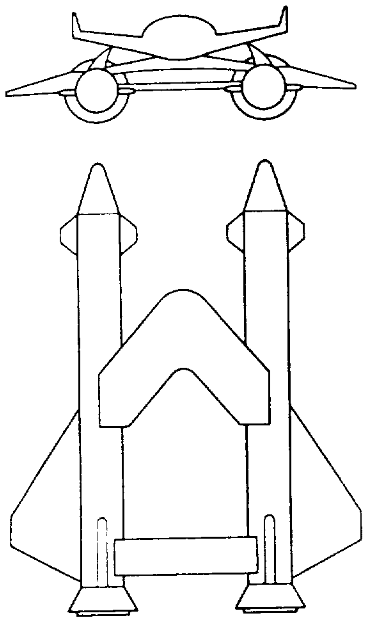


Small Launch Vehicle Enabling Technologies



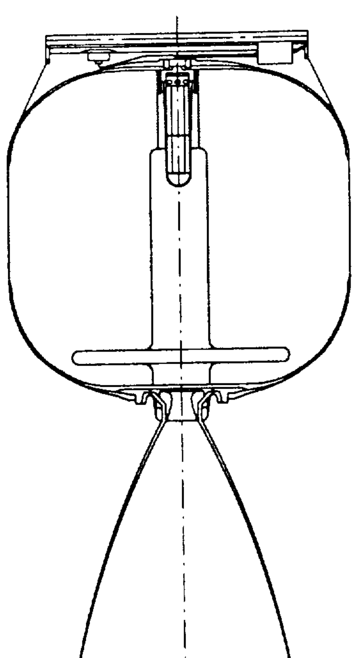
Thiokol CORPORATION

Reusable Flyback Booster System



- Concept objectives:
  - Solid rocket or hybrid propulsion
  - Booster transportation system for manned shuttle II and unmanned cargo carriers
  - Vertical launch, horizontal landing
  - Short turnaround cycle time
  - No preflight assembly required (load fuel and launch)
  - Lower recurring cost
- Enabling technologies:
  - Composite cases, struts, and wings
  - Cartridge–loaded propellant (SRM) or fuel (hybrid) grains
  - Integral removable aft dome/nozzle/skirt for quick fuel loading
  - Quick–change moldable nozzle insert or completely reusable (3–5 flights) advanced ceramic, passively cooled nozzle

High–Performance Solid Motors for Space



- Concept objectives
  - High–performance space propulsion system for:
    - Mars and lunar ascent propulsion
    - Orbit transfer propulsion
  - Long space storage capability
  - High I_{sp} performance
  - High mass fraction performance
- Enabling technologies
  - High–performance beryllium propellants
    - I_{sp} (theoretical) = 360–400 lbf–sec/lbm at 100:1
    - High propellant density (~0.05–0.06 lbm/in.^{3})
  - Braided carbon–carbon exit cone
  - 4D carbon–carbon throat
  - Consumable igniter
  - Laser–diode safe–and–arm device
  - Graphite composite case

Thiokol CORPORATION

Measured Comparison of Be and Al Propellants

Propellant	TP-H-3062	TP-H-1092
Metal fuel	Al	Be
Solids/metal (%)	86/16	86/12
Ballistics (BATES)		
Burn rate, 500 psi (in./sec)	0.246	0.260
Pressure exponent (n)	0.26	0.33
Theoretical I_{sp}, vac, $\epsilon = 50$ (lbf-sec/lbm)	315.50	342.20
Measured I_{sp}, $\epsilon = 50$ (lbf-sec/lbm)	293.00	312.50
Efficiency, η (%)	92.80	91.30

Conclusions

- Solids have multiple uses
  - Boosters
  - Small launch vehicles
  - Flybacks
  - Space transfer motors
- Keys to use
  - "Designed in" reliability
  - Low cost
  - Simplicity

Thiokol CORPORATION

PRESENTATION 1.3.4

ADVANCED LAUNCH SYSTEM