Launch Vehicle for Orbital Missions: COMET

Mr. Deke Slayton
Director
EER Systems
Space Services Division

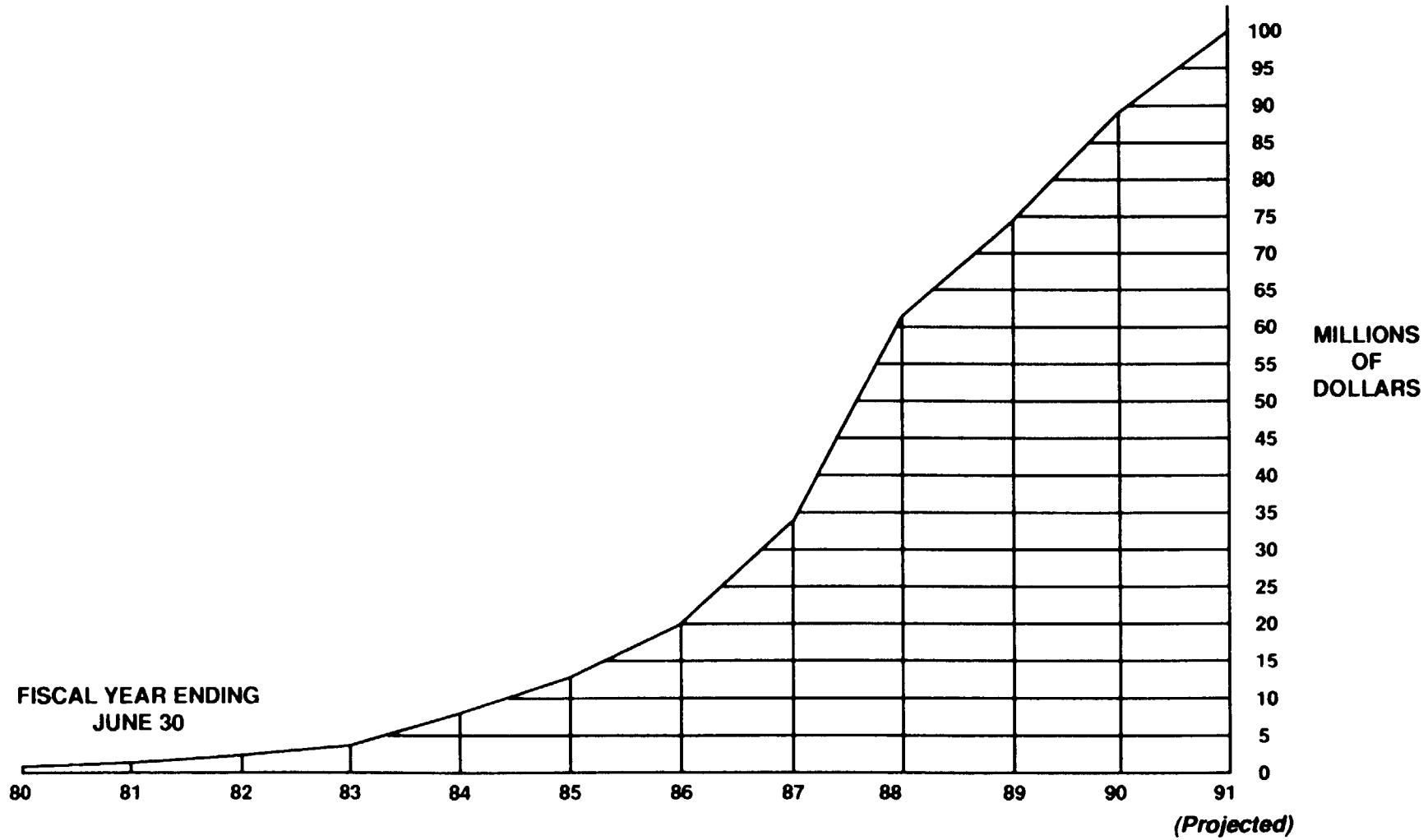
EER Systems Engineering Services and Space Launch Services

May 1991

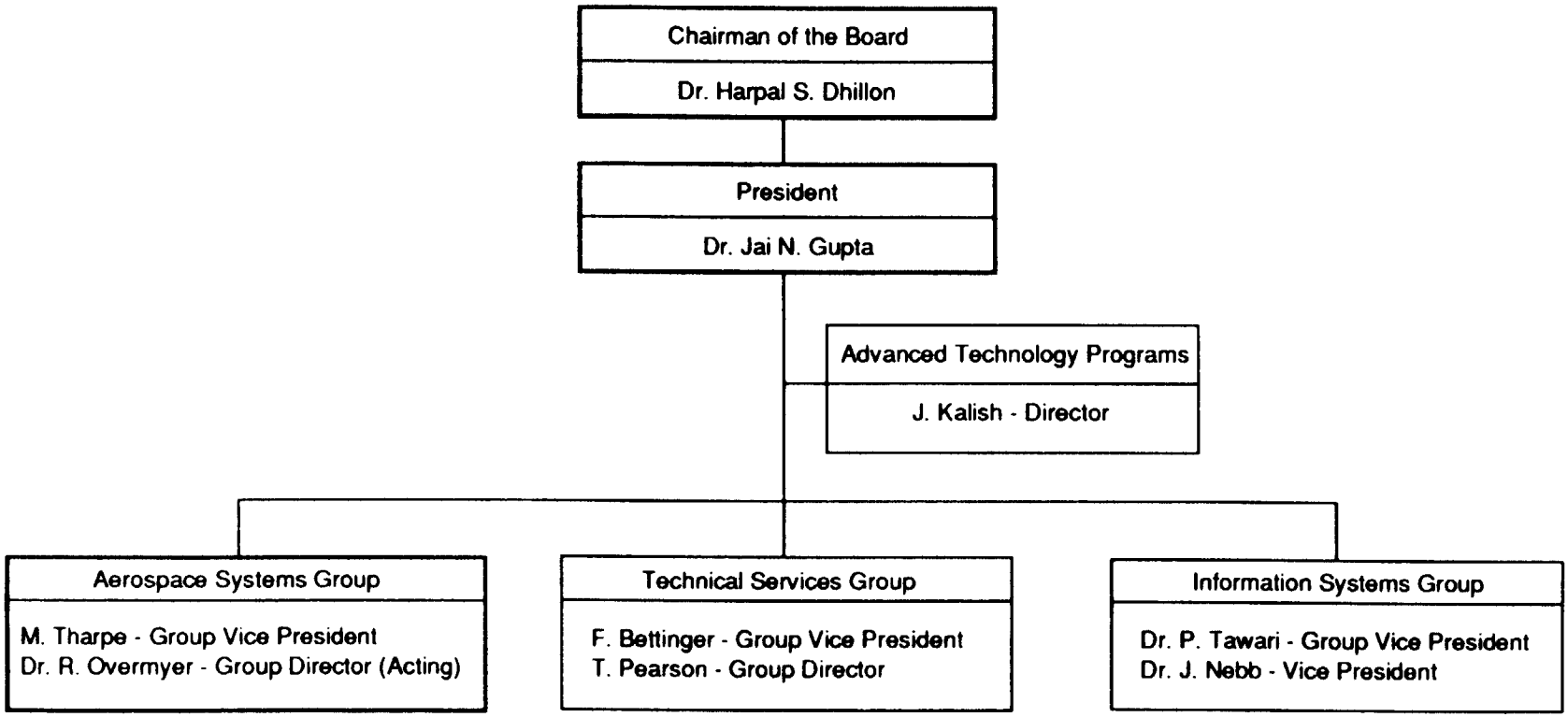
EER SYSTEMS

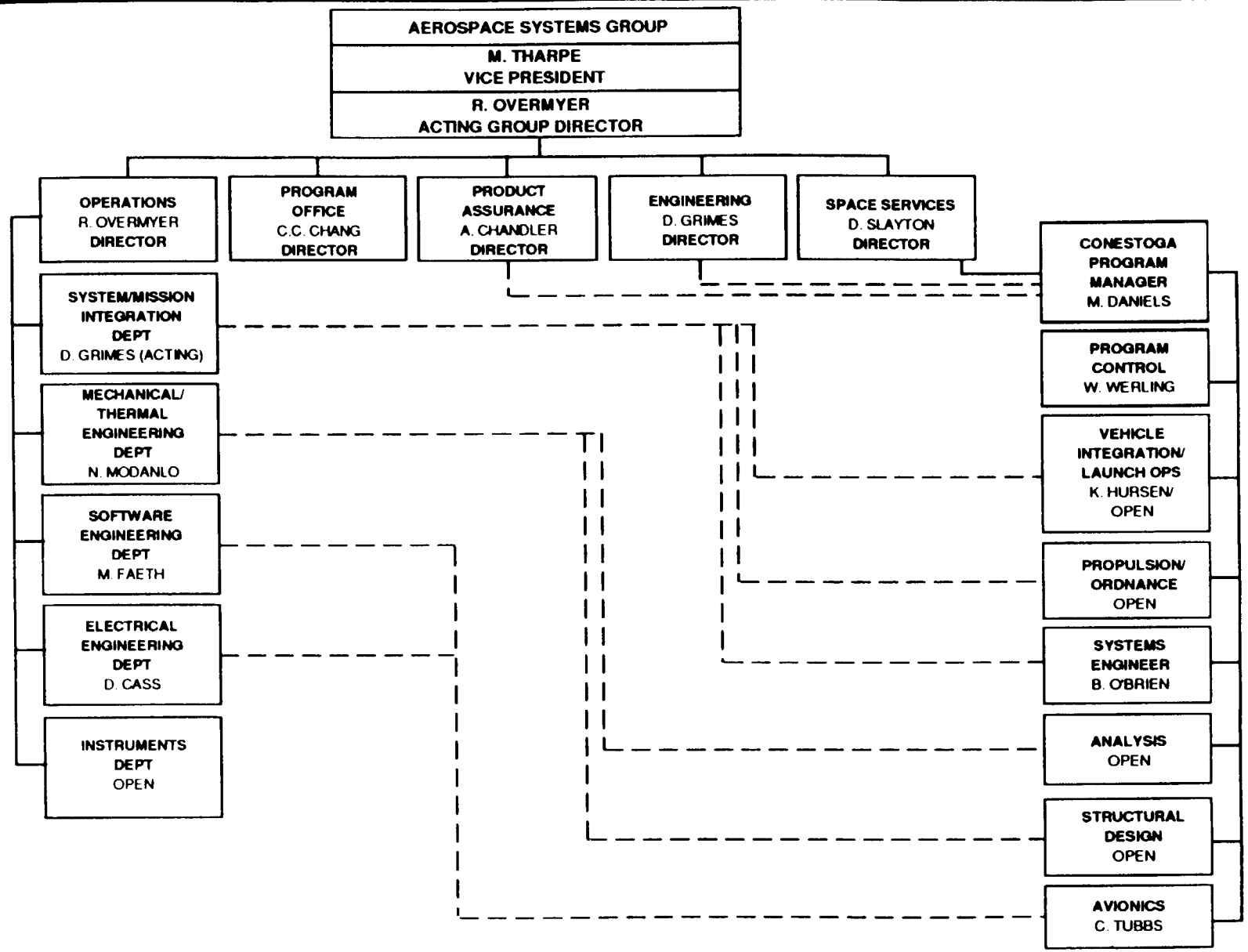
- Company Founded in 1979
- Eleven Years of Steady Growth
- Well Managed and Financially Sound
- Highly Qualified Professional Staff of 850 Individuals
- Providing System Engineering, Development, and Integration Support in the Areas of:
  - Aerospace Flight Systems
  - Information Systems
  - Training Systems

Revenues


100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
MILLIONS
OF
DOLLARS
FISCAL YEAR ENDING
JUNE 30
80
81
82
83
84
85
86
87
88
89
90
91
(Projected)

EER Systems Organization




AEROSPACE SYSTEMS GROUP
M. THARPE
VICE PRESIDENT
R. OVERMYER
ACTING GROUP DIRECTOR
OPERATIONS
R. OVERMYER
DIRECTOR
PROGRAM OFFICE
C.C. CHANG
DIRECTOR
PRODUCT ASSURANCE
A. CHANDLER
DIRECTOR
ENGINEERING
D. GRIMES
DIRECTOR
SPACE SERVICES
D. SLAYTON
DIRECTOR
SYSTEM/MISSION INTEGRATION DEPT
D. GRIMES (ACTING)
MECHANICAL/ THERMAL ENGINEERING DEPT
N. MODANLO
SOFTWARE ENGINEERING DEPT
M. FAETH
ELECTRICAL ENGINEERING DEPT
D. CASS
INSTRUMENTS DEPT
OPEN
CONESTOGA PROGRAM MANAGER
M. DANIELS
PROGRAM CONTROL
W. WERLING
VEHICLE INTEGRATION/ LAUNCH OPS
K. HURSEN/ OPEN
PROPULSION/ ORDNANCE
OPEN
SYSTEMS ENGINEER
B. O'BRIEN
ANALYSIS
OPEN
STRUCTURAL DESIGN
OPEN
AVIONICS
C. TUBBS

Small Orbital/Suborbital Commercial Launch Services

- Launch Vehicle Design, Analysis, and Development
- Launch Vehicle Integration
- Spacecraft to Launch Vehicle Integration and Test
- Launch Services

Small Spacecraft and Suborbital Payloads

- System/Subsystem Design, Analysis, Fabrication, Assembly, Integration and Test
- Ground Support Equipment Development

- Bid USAF STEP as Prime
  - — Designed Small Spacecraft
  - — Made Best and Final
- Bid TOMS Spacecraft With Ball Aerospace
- Bid OCDS (SeaWiFS) Spacecraft With SCI
- Bid NASA/GSFC SELV Launch Services/Did Not Make Cut
- Bid Launch Services for Iridium
- Bid Launch Services for OCDS
- Bid Other Commercial Systems and Launches

Space Services Heritage

- First Private Sector Space Launch in the World
- Marketing Conestogas Internationally Since 1982
- One of the Three Finalists in 1984 DOC Landsat Commercialization RFP
  - — Managed Team of Major Aerospace Companies
  - — Proposed and Sold Conestoga as Launcher
- First DOT Mission Approval – 1985
- $17 Million Invested in Conestoga Designs
- First Agreement to Use U.S. Government Range as a Commercial Launch Site (Wallops, 1986)
- Awarded One of Four DARPA SSLV Contracts – May 1988
- First Commercial Sounding Rocket Launch in U.S., Starfire I Launched March 29, 1989 at WSMR
- Acquired by EER Systems – November 1990
- EER Systems/Space Services Won COMET Competition December 1990
  - — Three Firm Launches: September 1992, August 1994, June 1995
  - — Two Optional Launches: June 1996, June 1997
  - — Launch Specification – 818 kg (1800 lb) in 555 km (300 nmi), 40 Degree Circular Orbit

1982 Launch

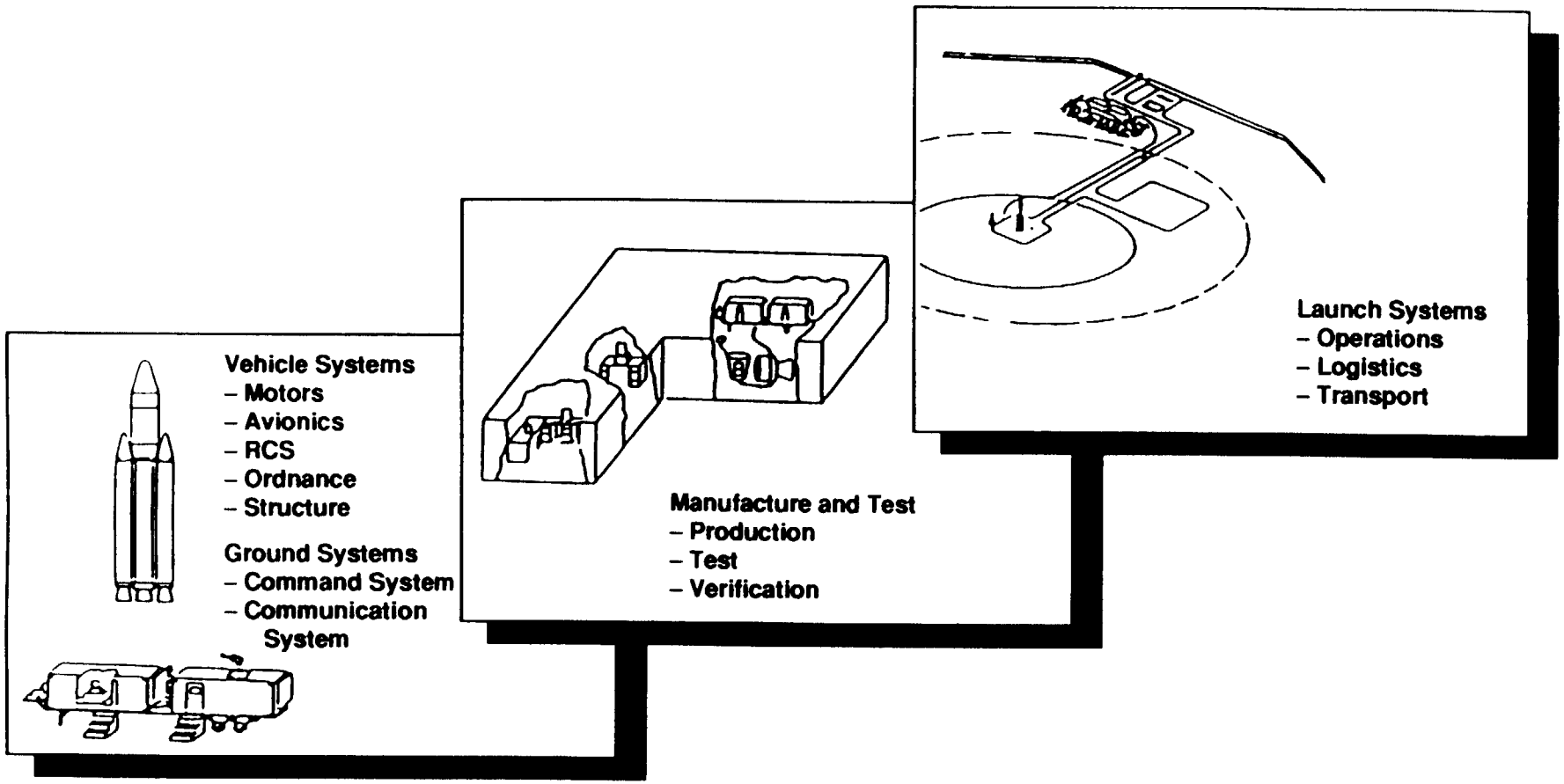
- Ability to Finance in Private Sector
- Ability to Obtain Necessary Government Approvals
- Selected and Managed Contractor Team
- Selected, Surveyed, and Constructed Launch Site
- Maintained an Expedited Schedule
- Established and Implemented Industry Standard
  - — Design Review Procedures
  - — Quality Assurance Procedures
- Maintained Commitment to Excellence
- Performed Own Range Safety
- 100% Successful Demonstration of Company's Launch Concepts
- Demonstrated Ability to Go Orbital

Starfire 1989 Launch

- Acquired DOT Launch License
- Acquired DOT-Required Liability Insurance
- Acquired DOT Authorization for Commercial Shipping of Solid Rocket Motors
- Acquired FCC Approval for Radio Frequency Usage
- Established Government Support Memoranda of Understanding With DOD and NASA
- Established, Integrated, and Managed a Highly Professional Program Engineering and Operations Team
- Conducted Commercial Launch Operations From a DOD Range in Total Compliance With Range Safety, Security, and Operations Requirements
- Conducted Fast-Track, Schedule-Driven, 100% Successful Mission – Launched Ahead of Schedule, 5 Months from Receipt of Contract, and Met All Mission Objectives
- Completed Mission Within Budget on a Fixed Price Contract

- Minimize Development Cost
  - — Flight-Proven Hardware
- Minimize Recurring Cost
  - — Volume Production
  - — Turnkey Commercial Approach
- Maximize Reliability
  - — Proven Components
  - — Experienced Management
  - — Experienced Subcontractors
  - — Mature Reliability and QA

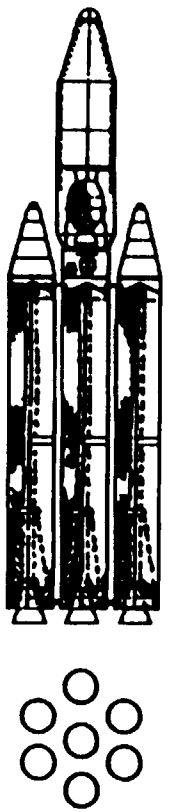
Commercial Launch Services



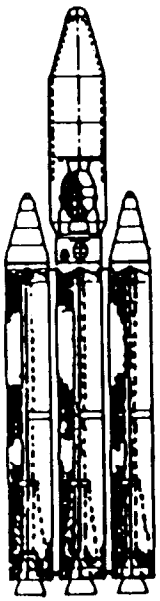
Structure	Avionics	Safety	Software	
Vehicle	Vehicle	Vehicle	Flight	Integrated Test and Verification
Pad	GSE	Ground	Ground	
GSE		Range		

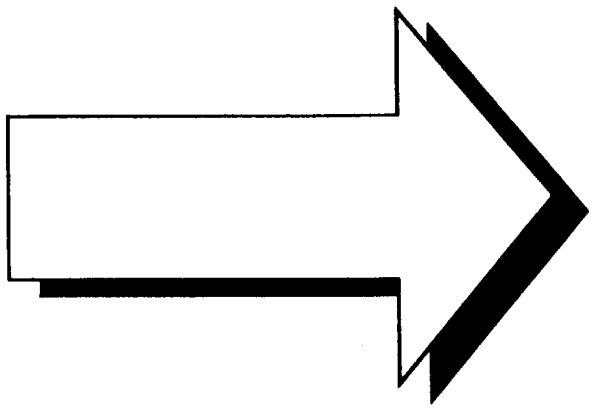
- Fixed Price Option
- Launch Vehicle
- Launch Site and Modifications
- Liability Insurance
- Mission Control
- Mission Planning
- Payload Integration
- Launch Operations
- Range Safety
- Payload Control (Options)
- Postmission Analysis

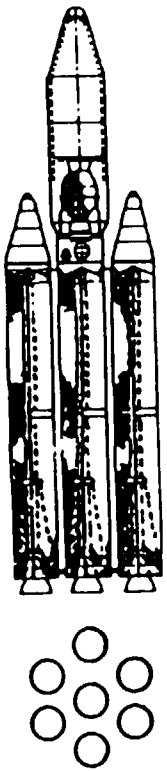
- Utilizes Only Two SRM Types (CASTOR and Star)
- Adaptable to Wide Payload Range
- Yields Volume Production Efficiencies
- Utilizes Modular Elements
- Utilizes Common Hardware
- Requires Only One Interstage for a Variety of Missions
- Minimizes Total Program Costs
- Provides Enhanced Vehicle Stability
- Minimizes Technical Risk
- Minimizes Schedule Risk
- Accommodates Advanced Technology Growth
- Accommodates Performance Growth Easily



Conestoga 421-48 Is a Growth Version of Conestoga 210-48

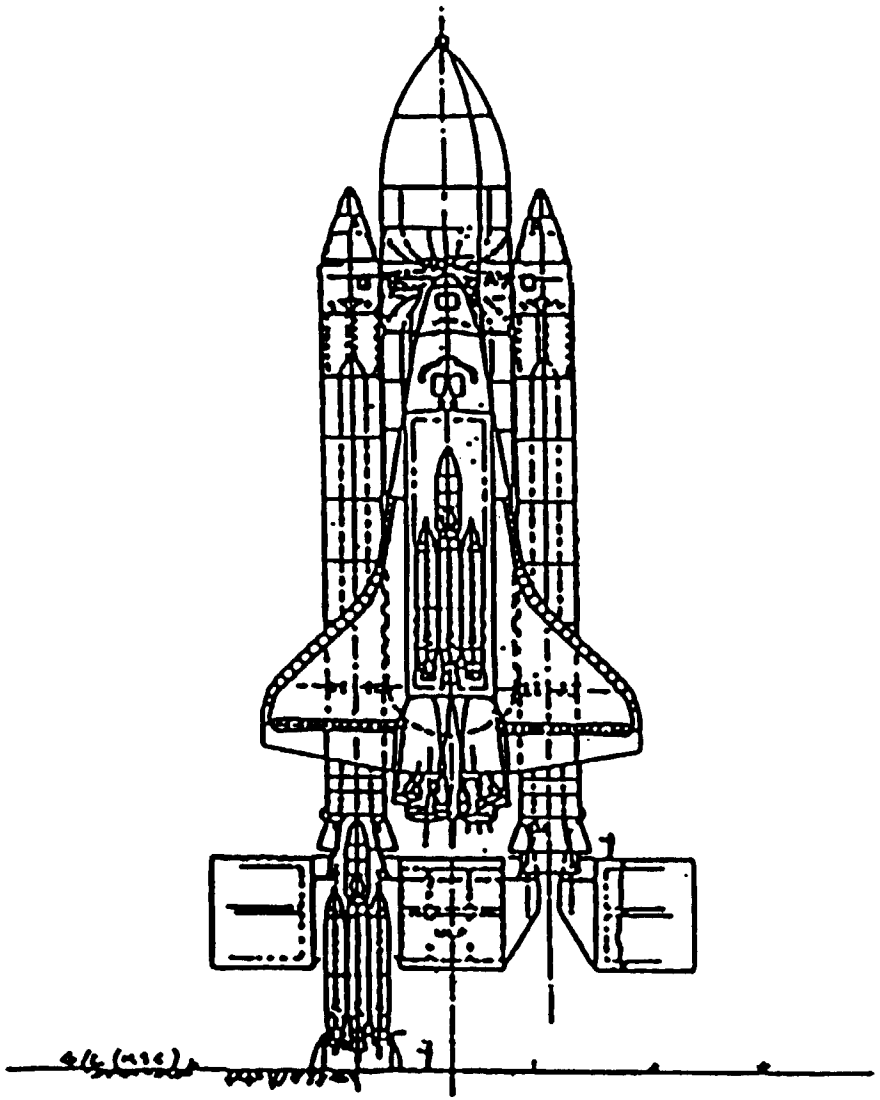




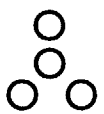
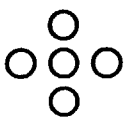
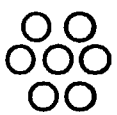


Conestoga 210-48
400 lb
400 nm Polar

Conestoga 421-48
1500 lb
400 nm Polar

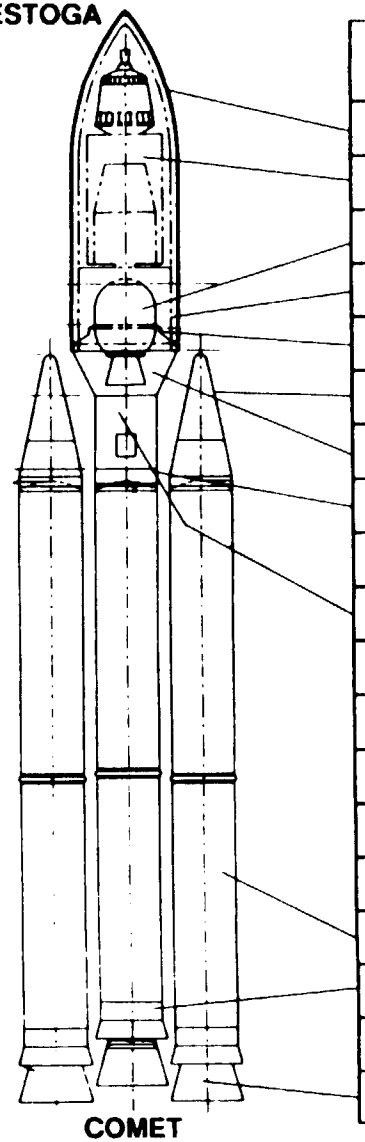


CASTOR IVB-BASED CONESTOGA VEHICLES

	Conestoga 210-48	Conestoga 310-48	Conestoga 221-48	Conestoga 421-48B
				
Payload Weight* to Orbit	**lb (kg)**	**lb (kg)**	**lb (kg)**	**lb (kg)**
200 nm Circ., 37° inclination	650 (295)	1100 (499)	1500 (680)	2800 (1270)
400 nm Circ., 90° inclination	420 (190)	650 (295)	905 (410)	1570 (712)
Geosynchronous Transfer	160 (73)	250 (113)	550 (250)	970 (440)
GEO Orbit (Estimated)	80 (36)	115 (52)	275 (125)	485 (220)
Motor Configuration 10:1 Nozzles				
Stage 1	2-CASTOR IVBs	3-CASTOR IVBs	2-CASTOR IVBs	4-CASTOR IVBs
Stage 2	1-CASTOR IVB	1-CASTOR IVB	2-CASTOR IVBs	2-CASTOR IVBs
Stage 3	1-Star 48B	1-Star 48B	1-CASTOR IVB	1-CASTOR IVB
Stage 4	--	---	1-Star 48B	1-Star 48B

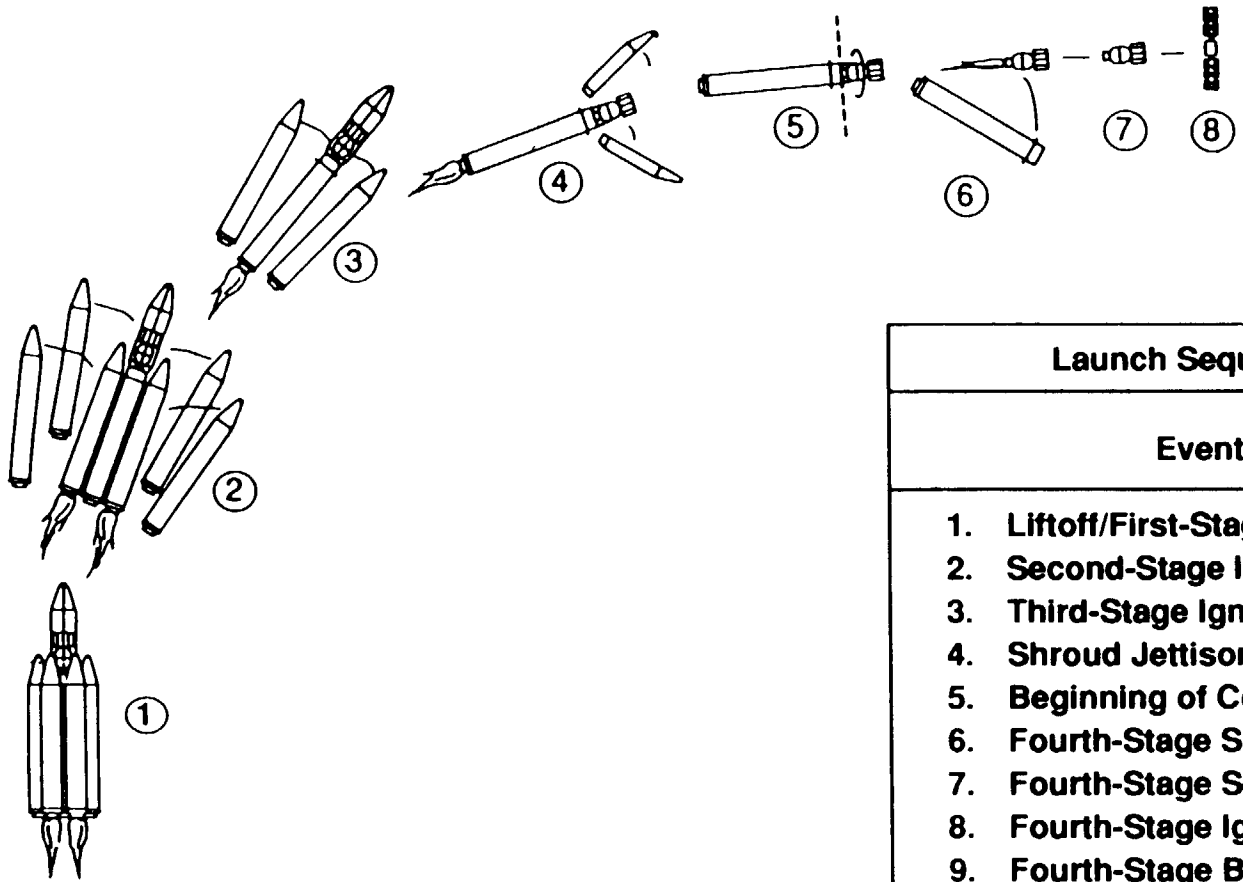
*Spacecraft total weight (GTO figures include apogee kick stage weight)

CONESTOGA



COMET

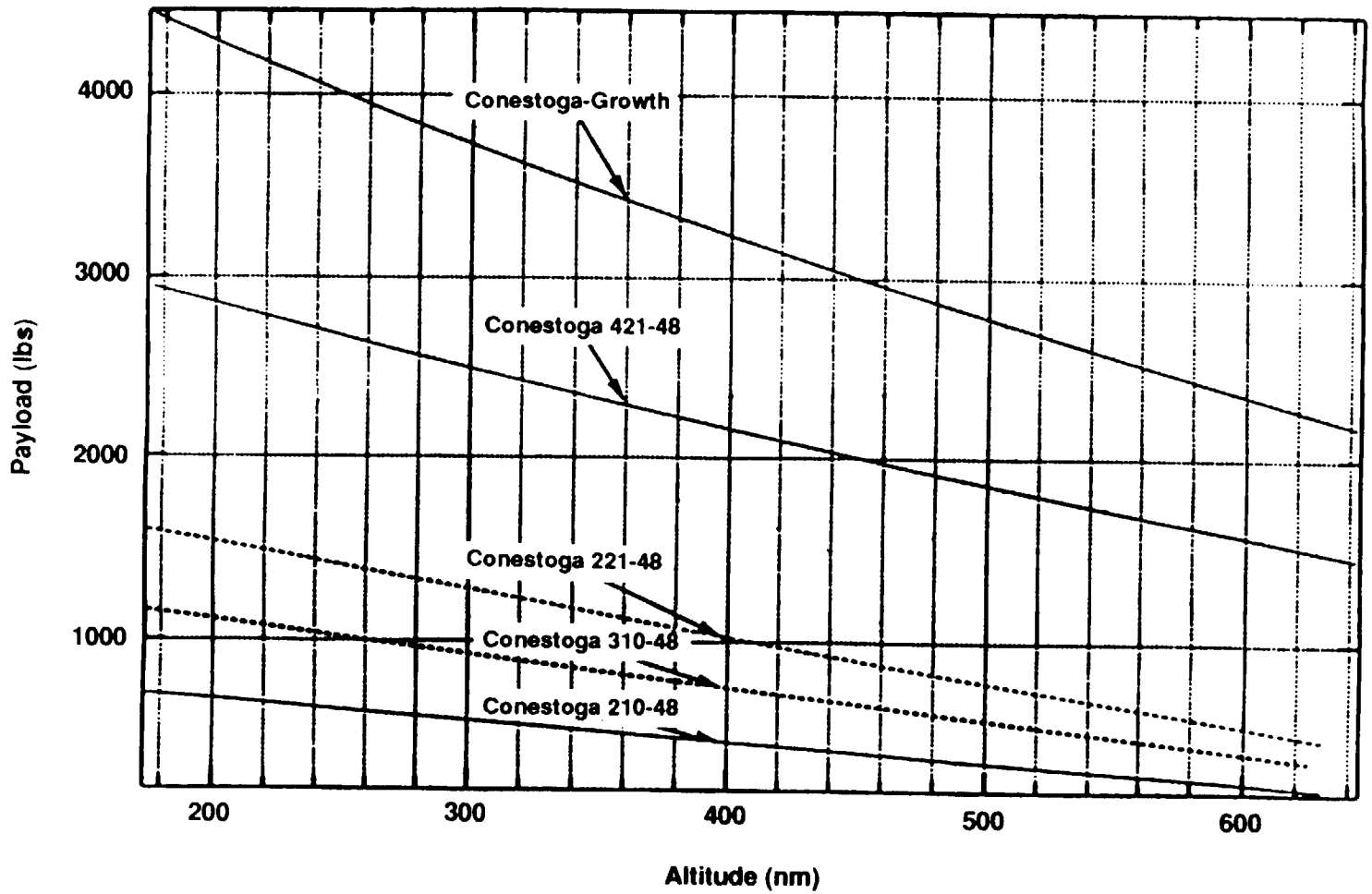
Area/Process	No. / Flt	Responsibility		Remarks
		Design	Manufacture	
Payload Fairing	1	MDSC	MDSSC	Tracor – Alternate
Payload (Various)	1	Customer	Customer	
Star 48 TVC	1	Thiokol	Thiokol	
Star Separation System	1	EER/Tracor	MDSC/Tracor	TVC Star for Future
RCS	1	DSI	DSI	
Nose Cones (Strap On)	6	Thiokol	Thiokol	
Interstage Structure	1	EER	General Dynamics	Tracor – Alternate
Attachment H/W (Upper)	6	MDSC		Thiokol – Alternate
FWD Thrust Ring (Core)	1	EER	General Dynamics	Thiokol – Alternate
Avionics	1	—	—	
Power Dist. System	1	EER	EER	
GN&C (IGU & Control)	1	Canavco	Canavco	
Telemetry System	1	DSI	DSI	
Thrust Termination	8	EER	EER	
Flight Software	1	Intermetrics	Intermetrics	
Castor IVB Motors	7	Thiokol	Thiokol	
Attachment H/W (Lower)	6	MDSC	MDSC	Thiokol – Alternate
Aft Thrust Ring	1	EER	General Dynamics	Thiokol – Alternate
TVA	5	Thiokol	Thiokol	



Launch Sequence of Events	
Event	**Time (sec)**
1. Liftoff/First-Stage Ignition	0
2. Second-Stage Ignition	55
3. Third-Stage Ignition	110
4. Shroud Jettison	120
5. Beginning of Coast Phase	169
6. Fourth-Stage Spin-Stabilized	650
7. Fourth-Stage Separation	655
8. Fourth-Stage Ignition	660
9. Fourth-Stage Burnout	724
10. Payload Separation	729

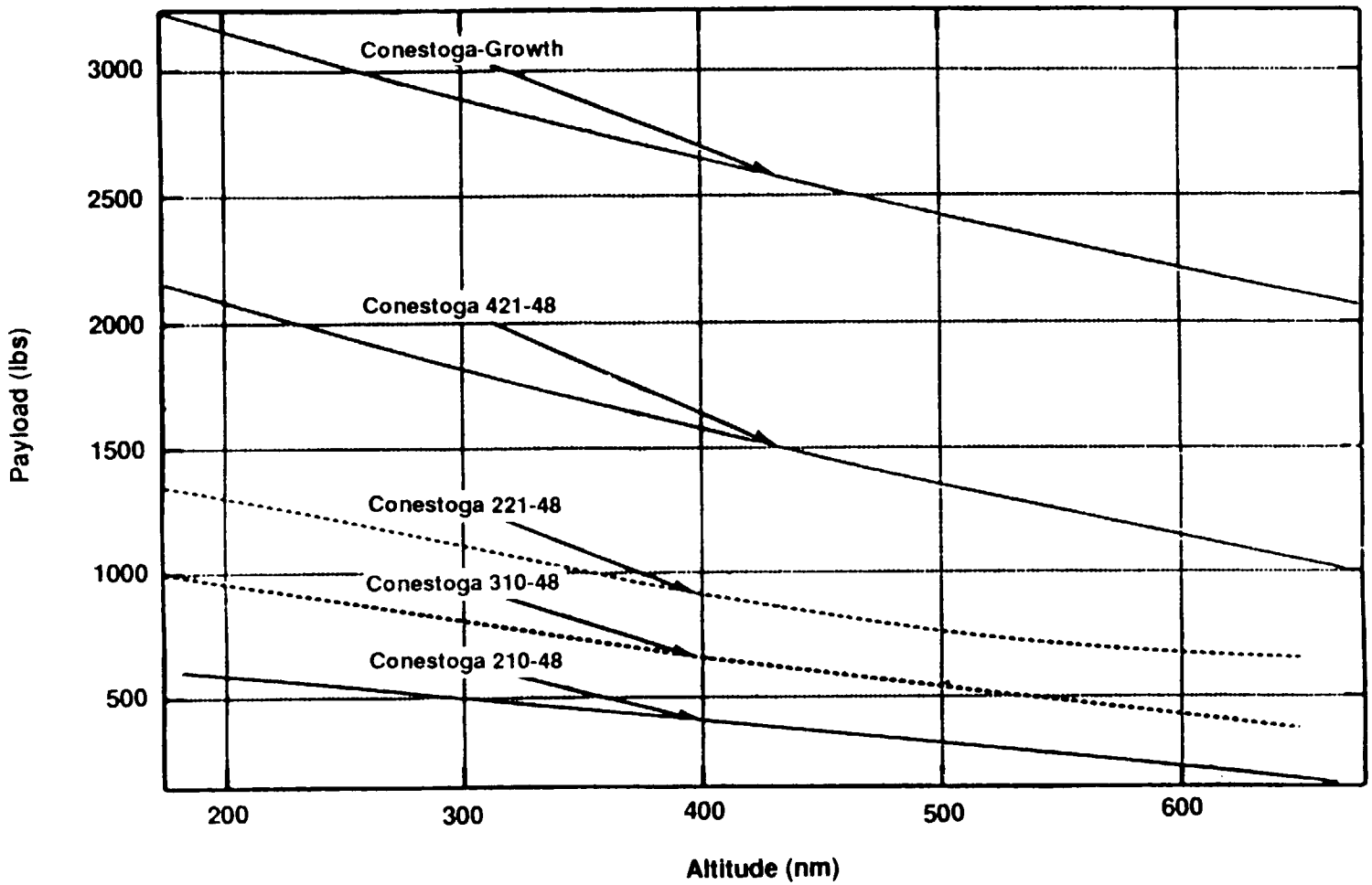
BASELINE VEHICLES

Circular Orbits, 37° Inclination

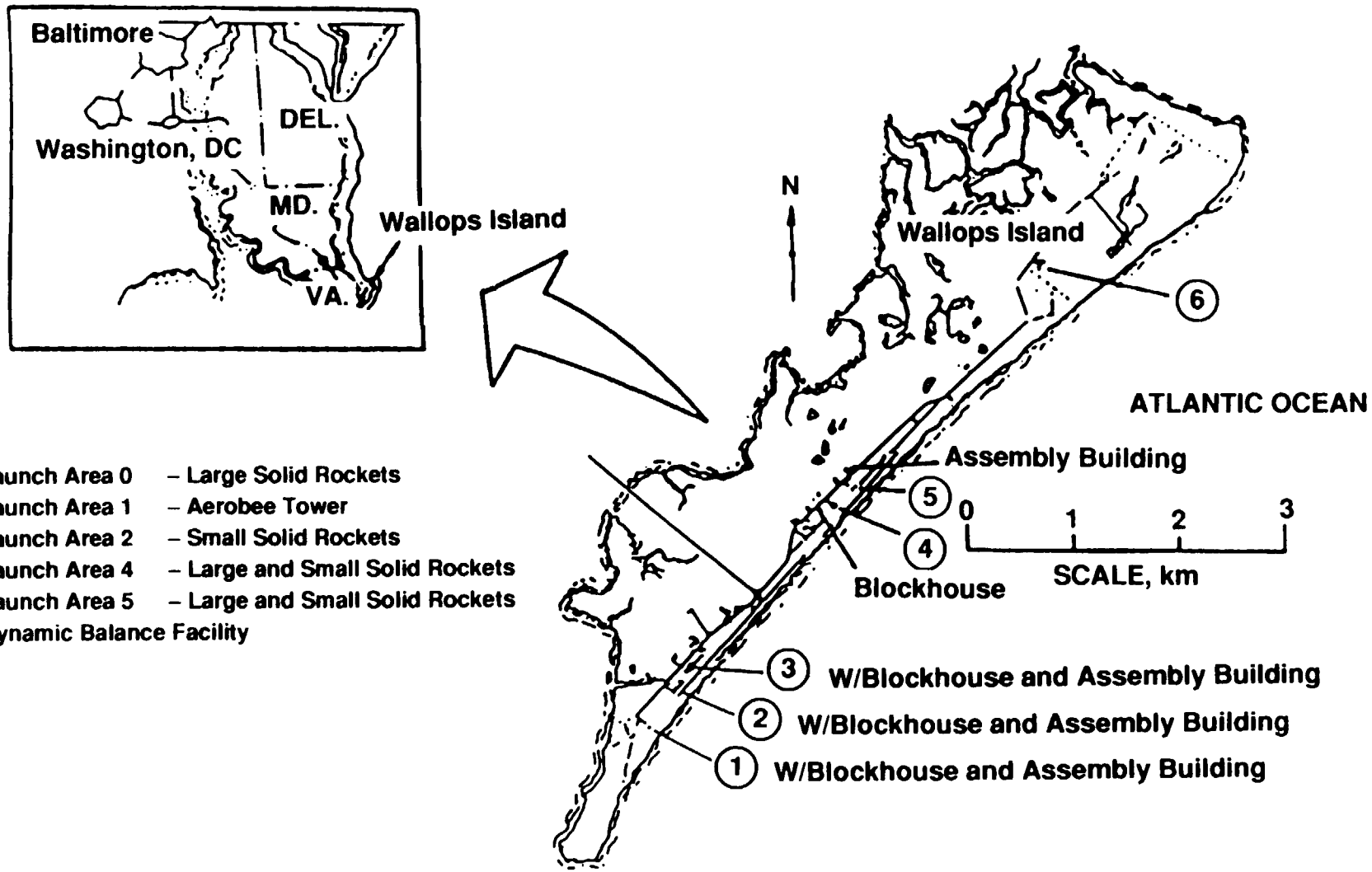


BASELINE VEHICLES

Circular Orbits, 90° Inclination

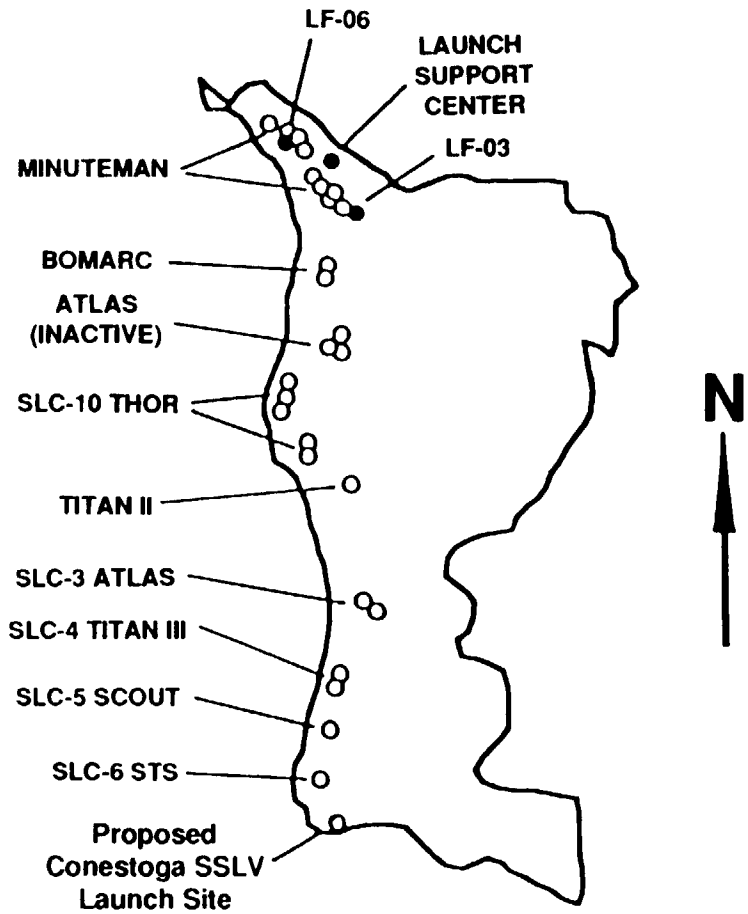


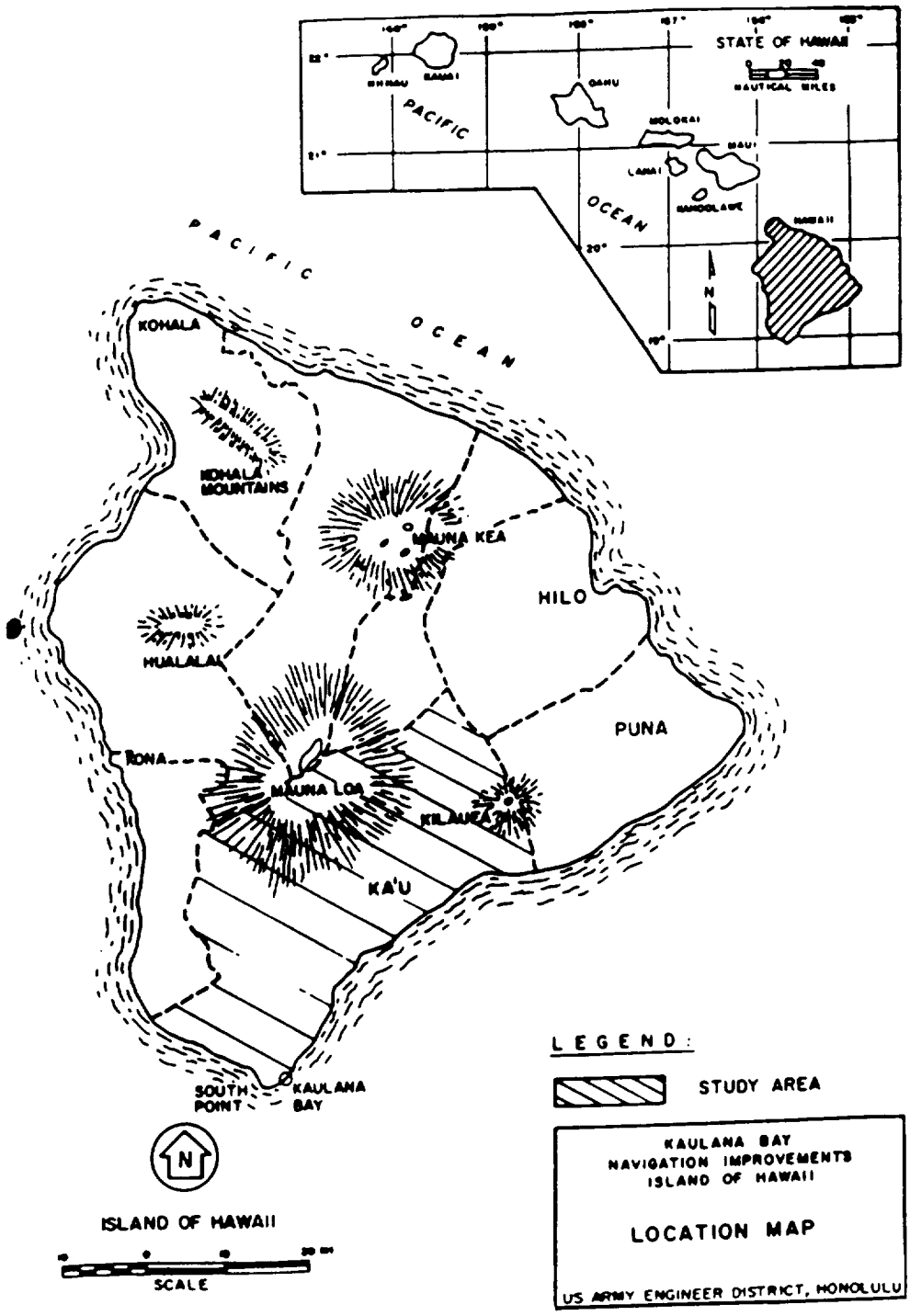
- Government Interagency Interactions With
  - Department of Commerce
  - Department of Defense
  - NASA
  - Department of Transportation
- Launch Site Agreements Exist With
  - Wallops Island, VA
  - White Sands Missile Range, NM
- Negotiating Memoranda Exist With
  - Western Test Range (VAFB, CA)
  - Eastern Test Range (PAFB, FL)
- Preliminary Investigations Regarding
  - Hawaii
  - San Marco Island, Kenya
  - Kourou, French Guinea
- Licenses Obtained for the Consort Starfire Program

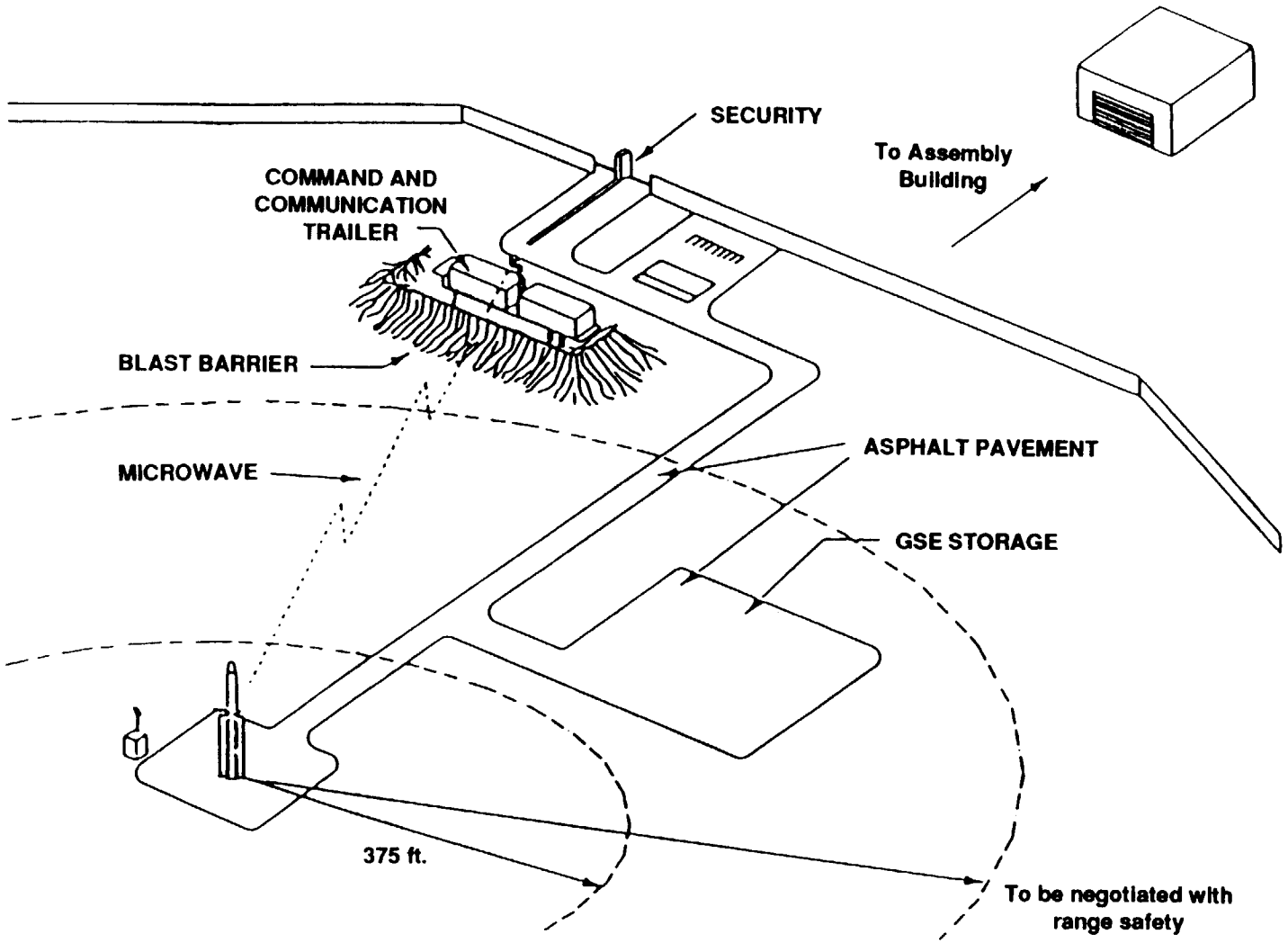


1. Launch Area 0 – Large Solid Rockets
2. Launch Area 1 – Aerobee Tower
3. Launch Area 2 – Small Solid Rockets
4. Launch Area 4 – Large and Small Solid Rockets
5. Launch Area 5 – Large and Small Solid Rockets
6. Dynamic Balance Facility

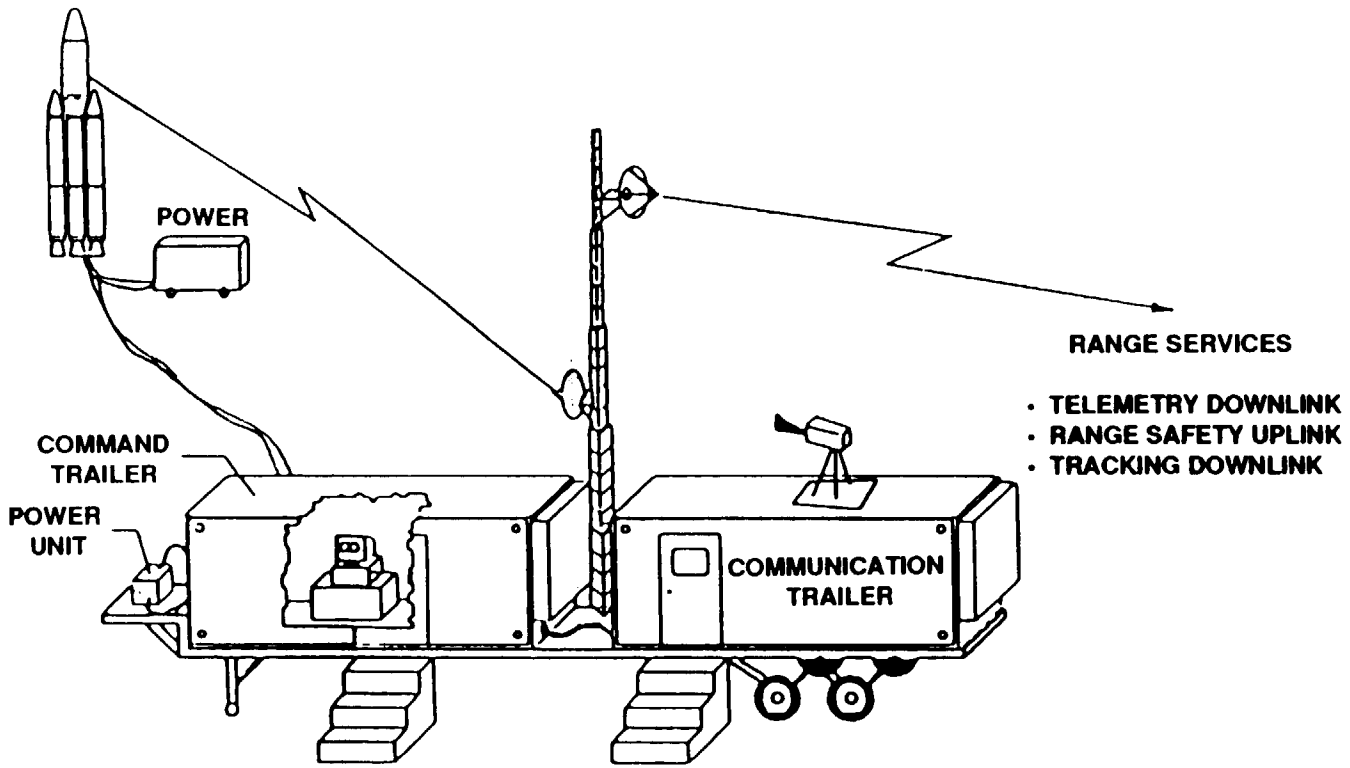
Vandenberg Air Force Base (VAFB)



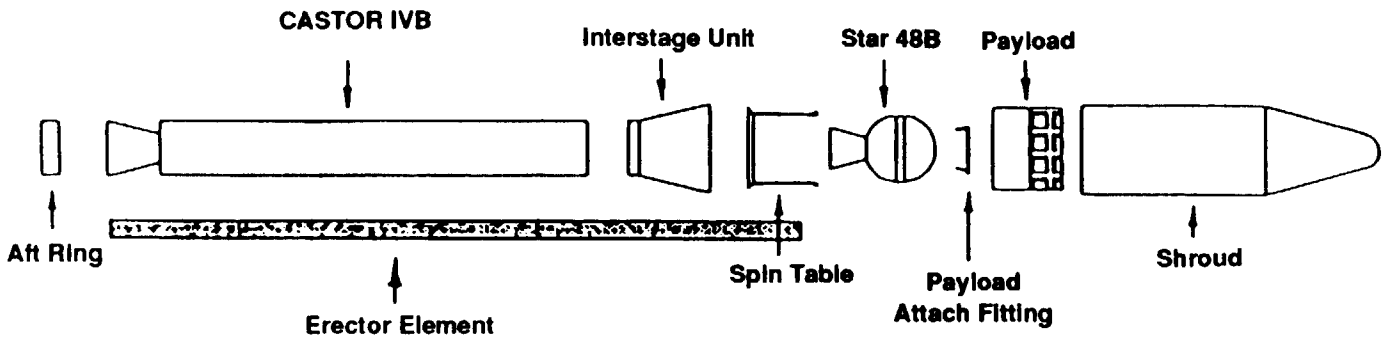

STATE OF HAWAII
NAUTICAL MILES
PACIFIC
OCEAN
OAHU
MOLOKAI
MAUI
LANAI
KAHOOLAWE
HAWAII
N
PACIFIC
OCEAN
KOHALA
KOHALA MOUNTAINS
MAUNA KEA
HILO
HUALALAI
PUNA
KONA
MAUNA LOA
KILAUEA
KA'U
SOUTH POINT
KAULANA BAY
N
ISLAND OF HAWAII
SCALE
LEGEND:
STUDY AREA
KAULANA BAY
NAVIGATION IMPROVEMENTS
ISLAND OF HAWAII
LOCATION MAP
US ARMY ENGINEER DISTRICT, HONOLULU

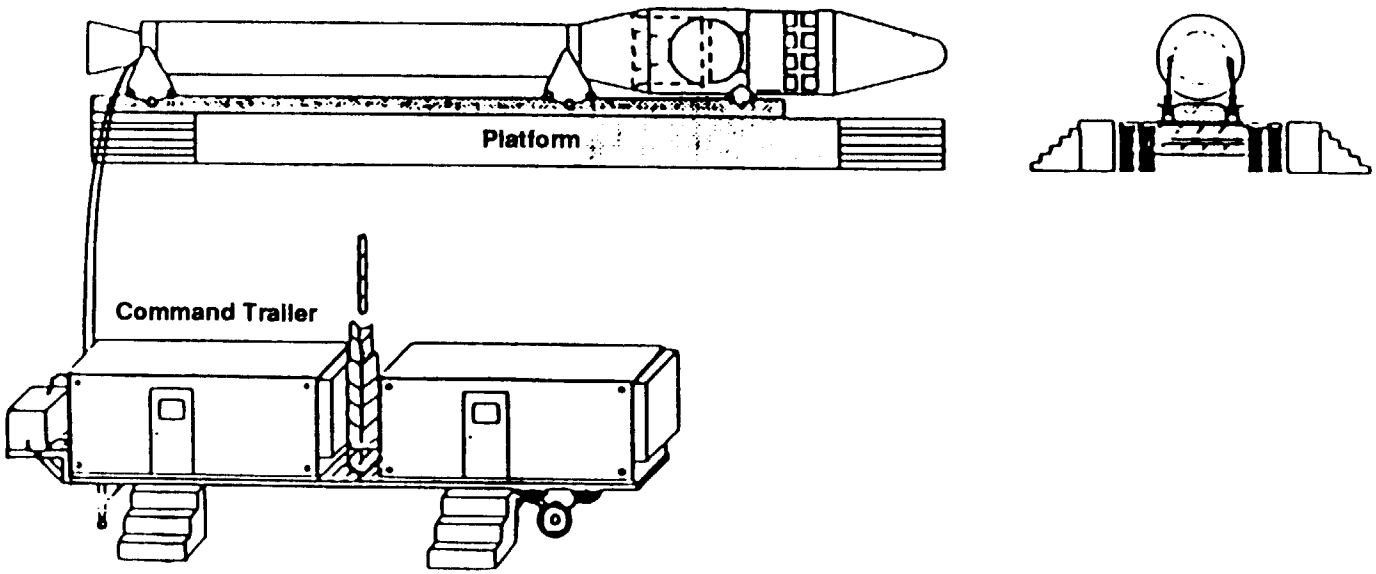

SECURITY
To Assembly Building
COMMAND AND COMMUNICATION TRAILER
BLAST BARRIER
MICROWAVE
ASPHALT PAVEMENT
GSE STORAGE
375 ft.
To be negotiated with range safety

LAUNCH CONTROL SYSTEM

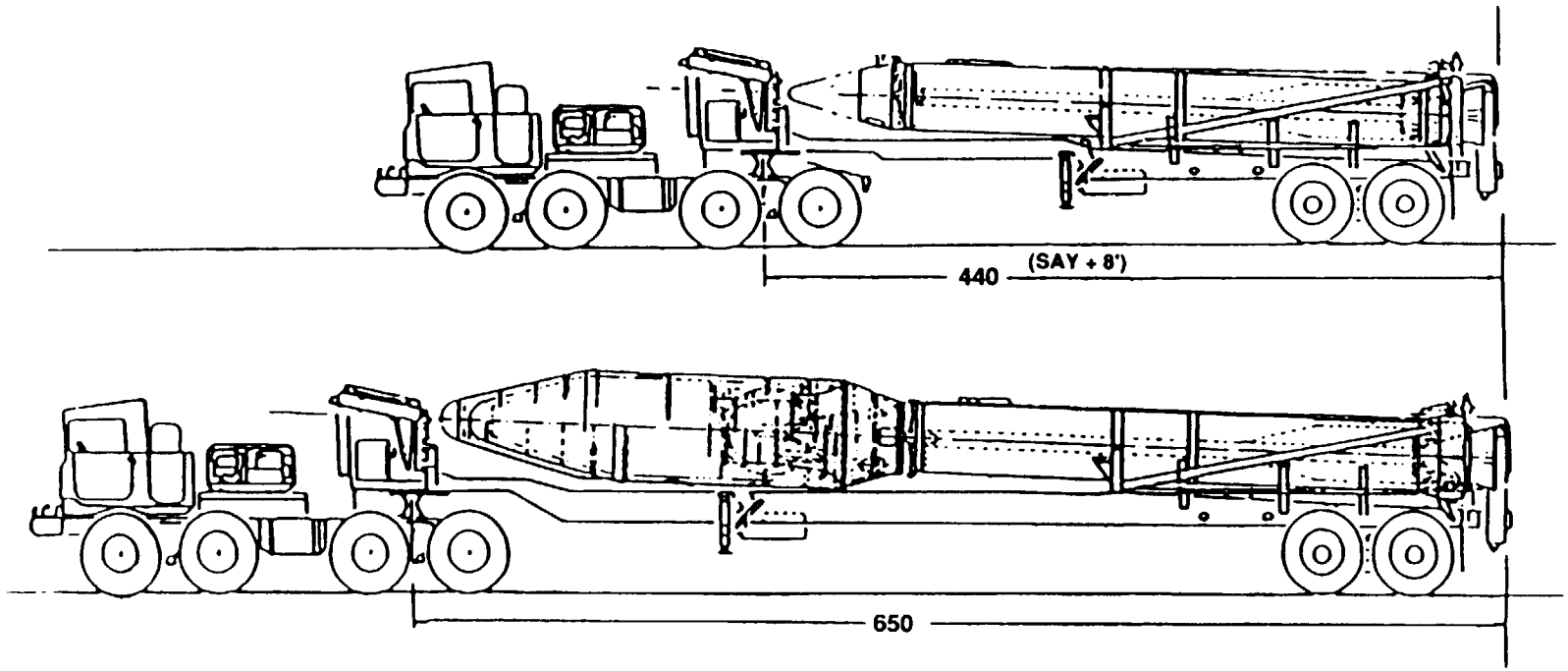


ASSEMBLY CONCEPTS

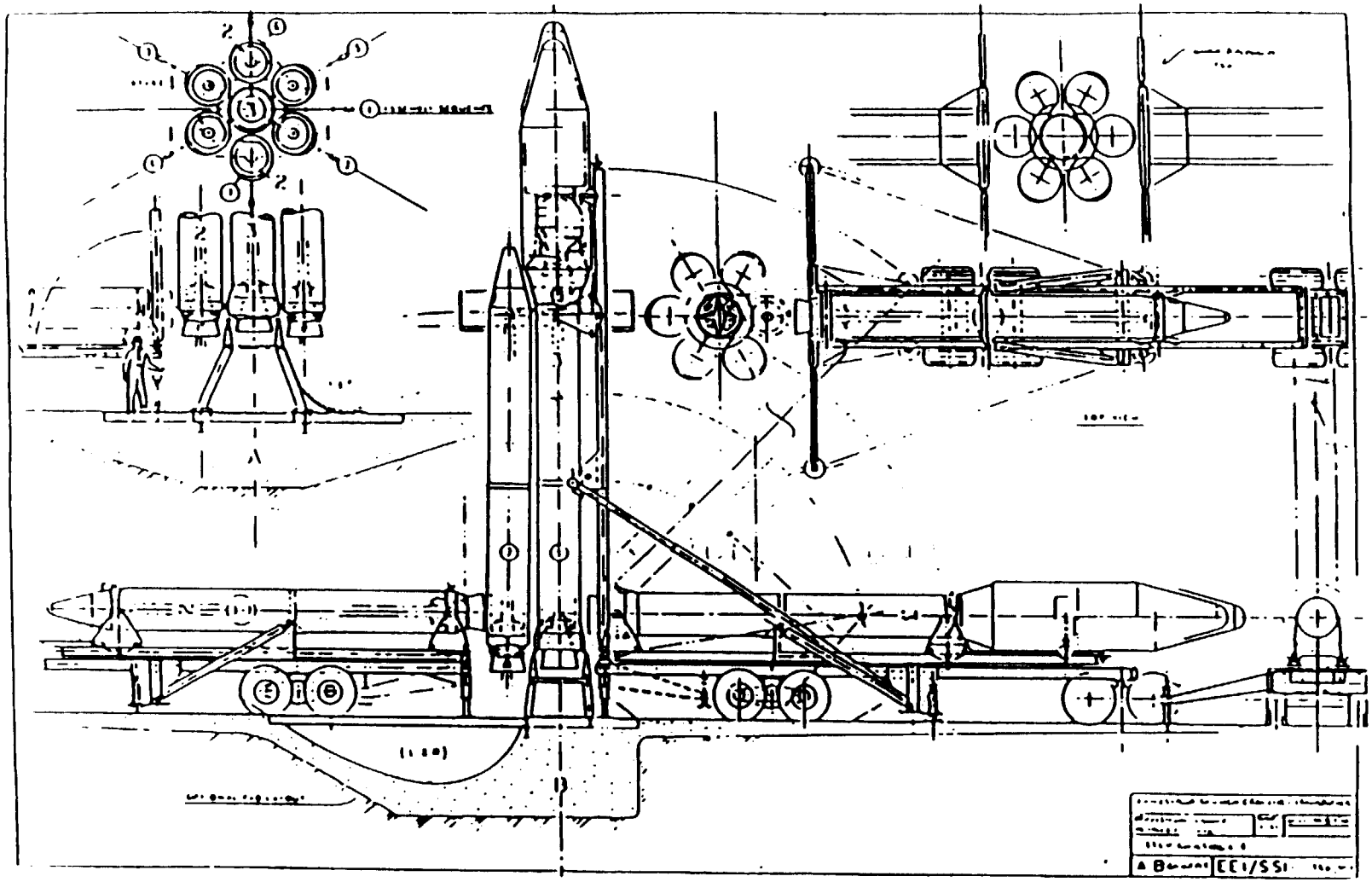




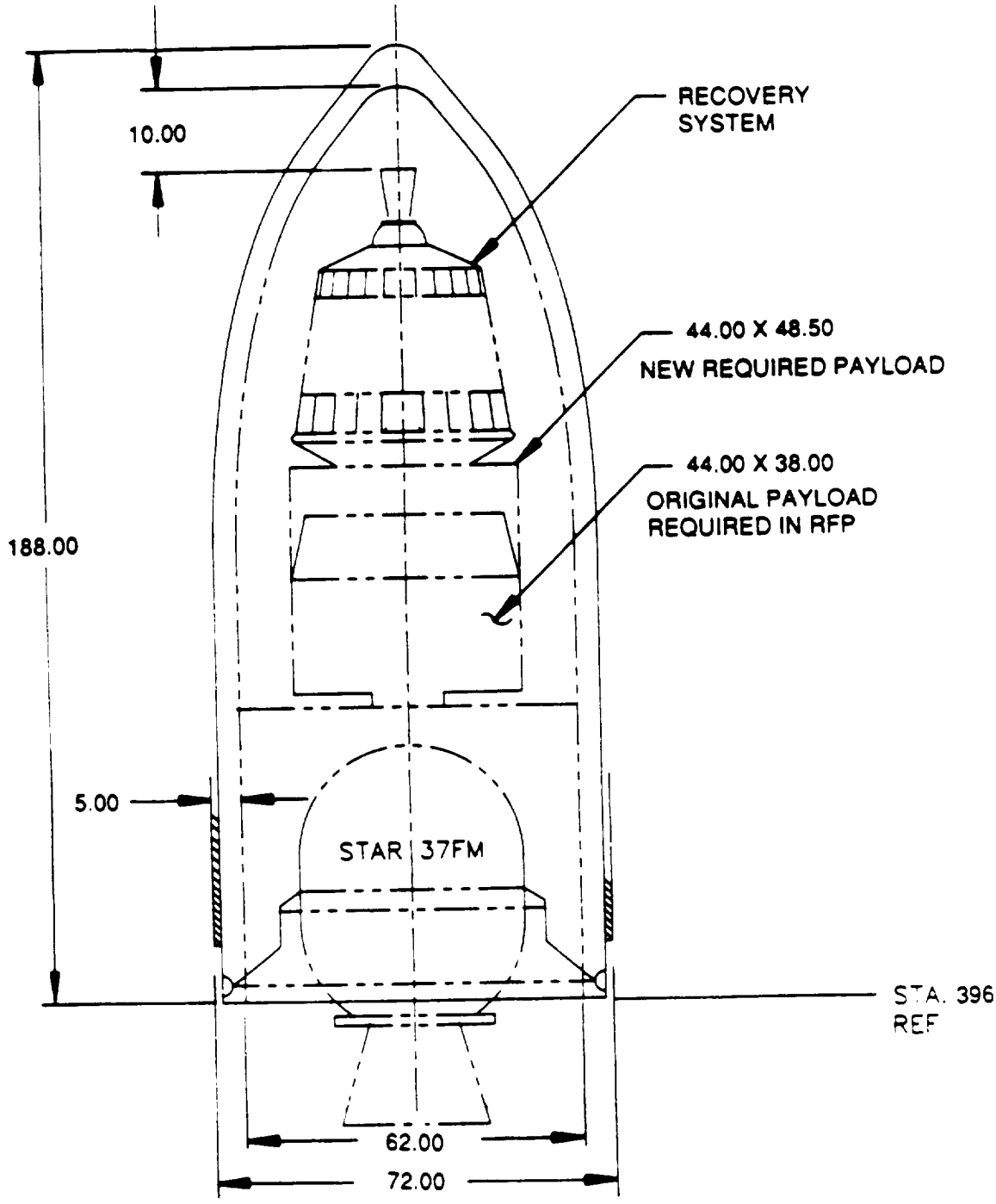
MOVE TO LAUNCH PAD



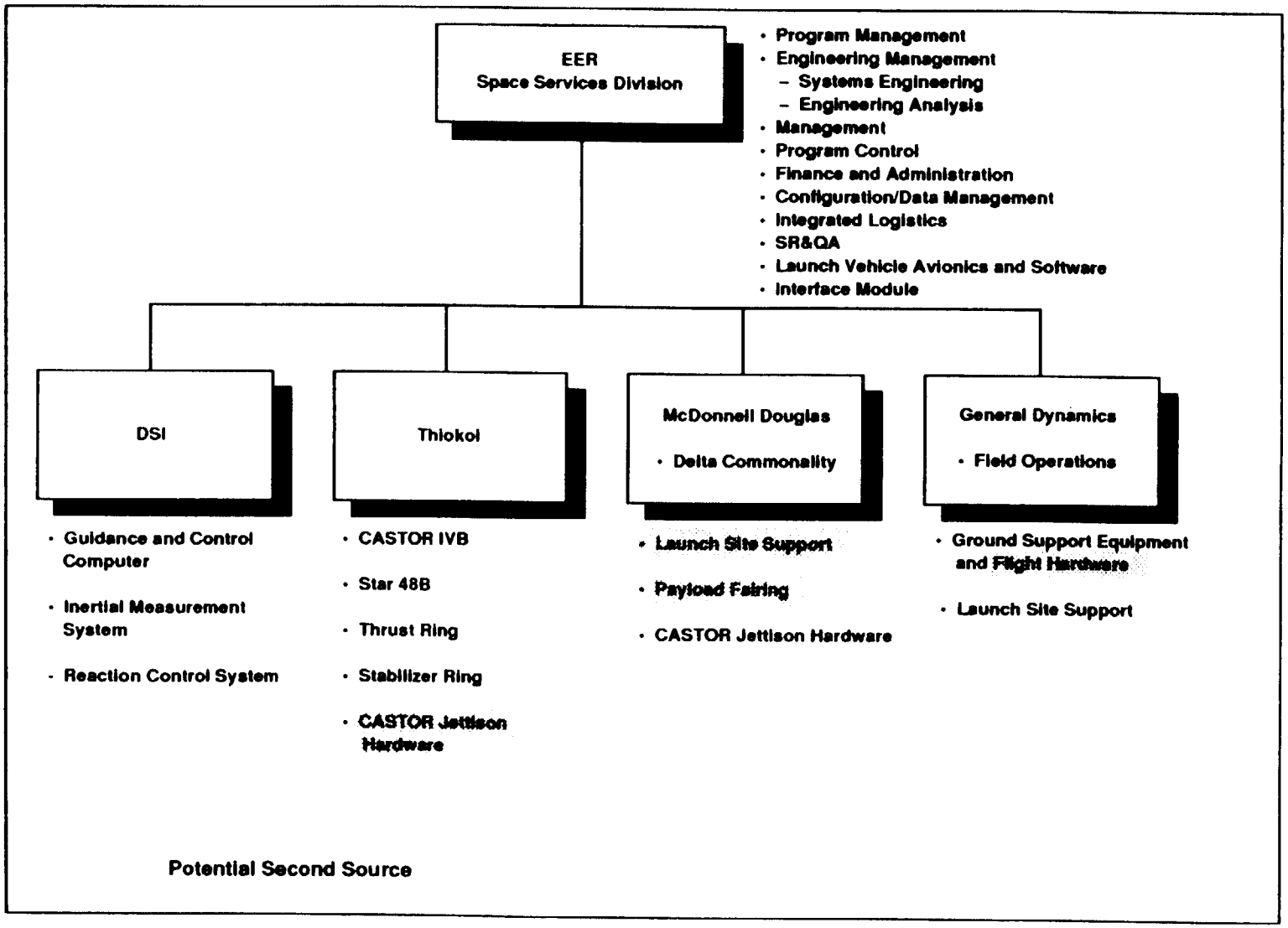
VEHICLE ASSEMBLY CONCEPT



CONESTOGA 421-37FM FAIRING ENVELOPE



Conestoga Team for COMET



- "Managed" Team Approach
- Optimized Flight-Proven Hardware
- Optimized Teaming/Subcontracts
- Minimum Technical Risk
- High Confidence Cost and Schedule
- High Confidence Launch Success Rate
- Range Experienced Operations Personnel
- Flexible Payload Weight/Altitude Range
- Fixed Price Commercial Approach

- Payment Schedule
  - — Cost of Money, Financing Requirement
- Mission and Payload Schedule
  - — Size of Vehicle, Unique Equipment
- Order Volume
  - — Economies of Scale
- Delivery Schedule
  - — Carrying Costs, Long-Lead Orders

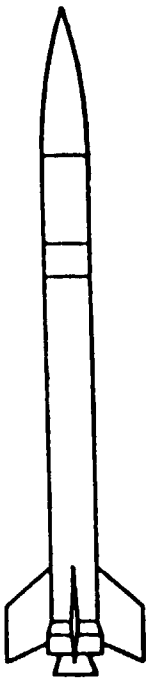
- $17M Invested in Conestoga Pre-COMET by SSI
- $20M Nonreimbursed Nonrecurring Costs Prior to First Flight by EER Systems
- First Flight Costs Far in Excess of Requested Budget
- Fixed Price Contract
- 11 Percent Recovery of Nonrecurring From COMET

Budgetary Concerns

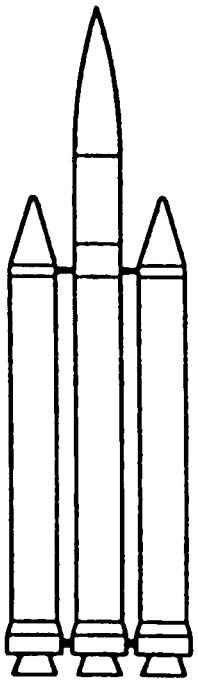
- Estimate 50-100 Percent Increase in Reflight Insurance
- Accelerated Fast Track Schedule
- Continued Pressure to Cut Budget

Starfire Sounding Rockets

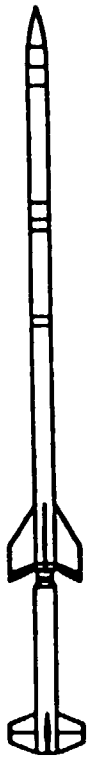
Starfire I



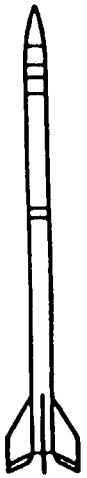
Starfire II



Starfire III

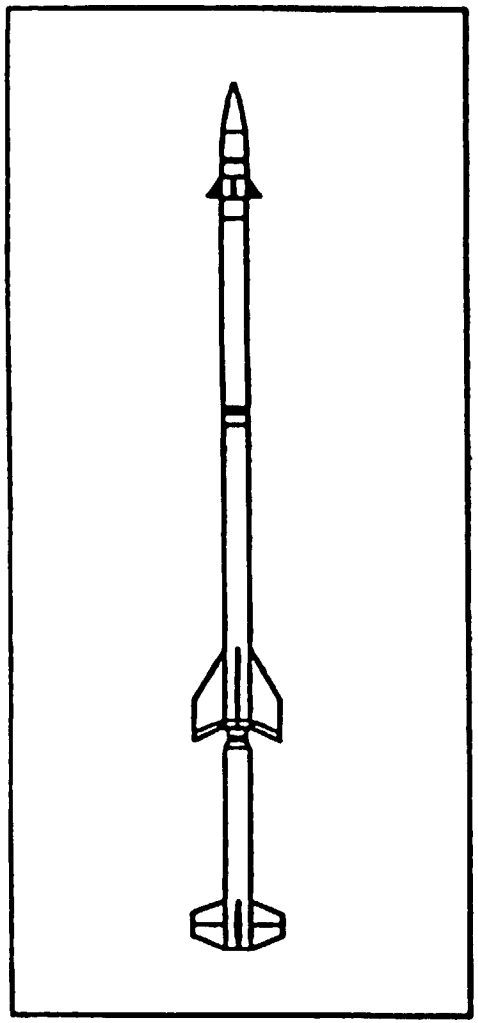


Starfire IV



Starfire V

Starfire I



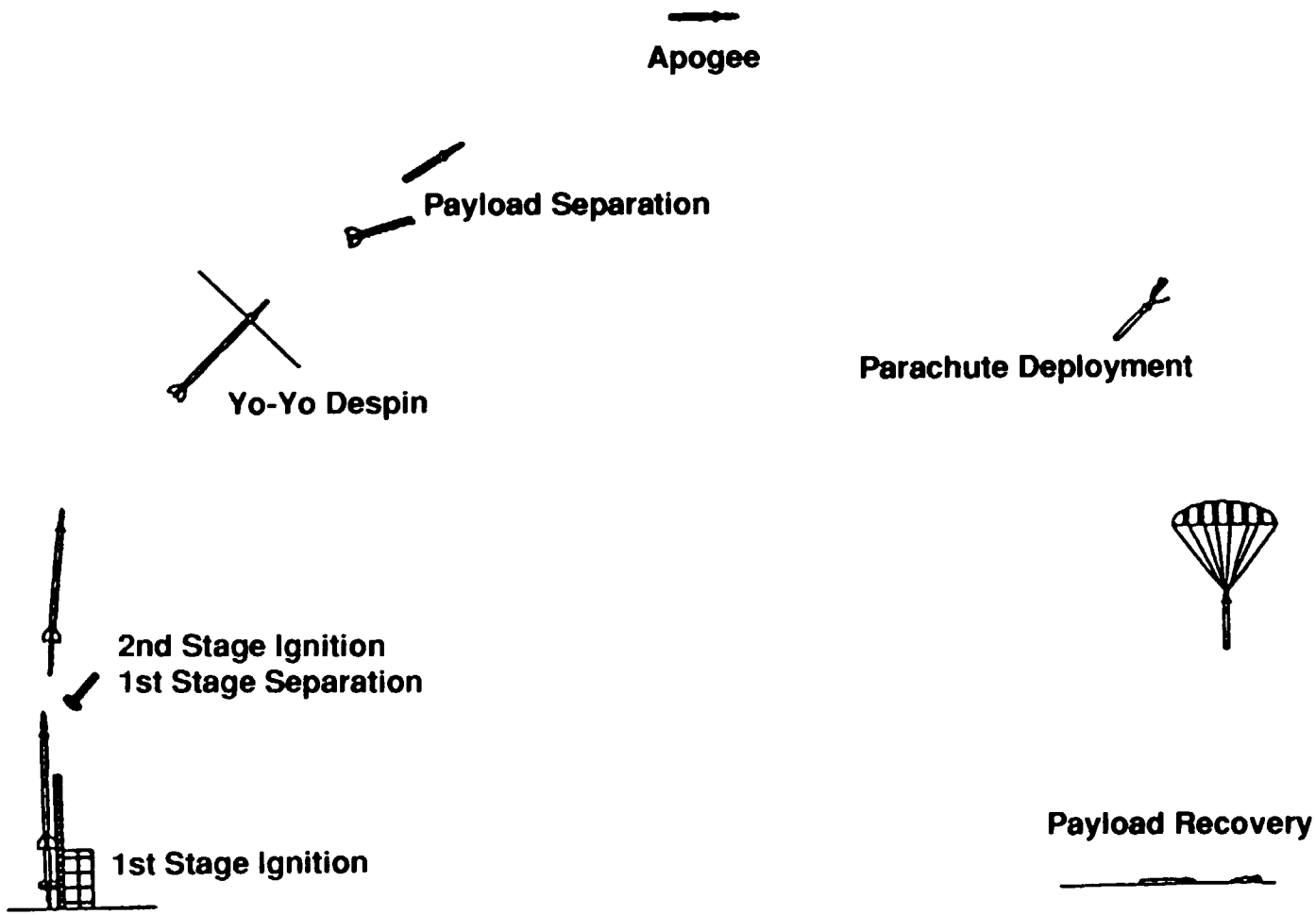
1400 lbs max payload* weight to 126 nm

260 nm max altitude with 600 lb payload

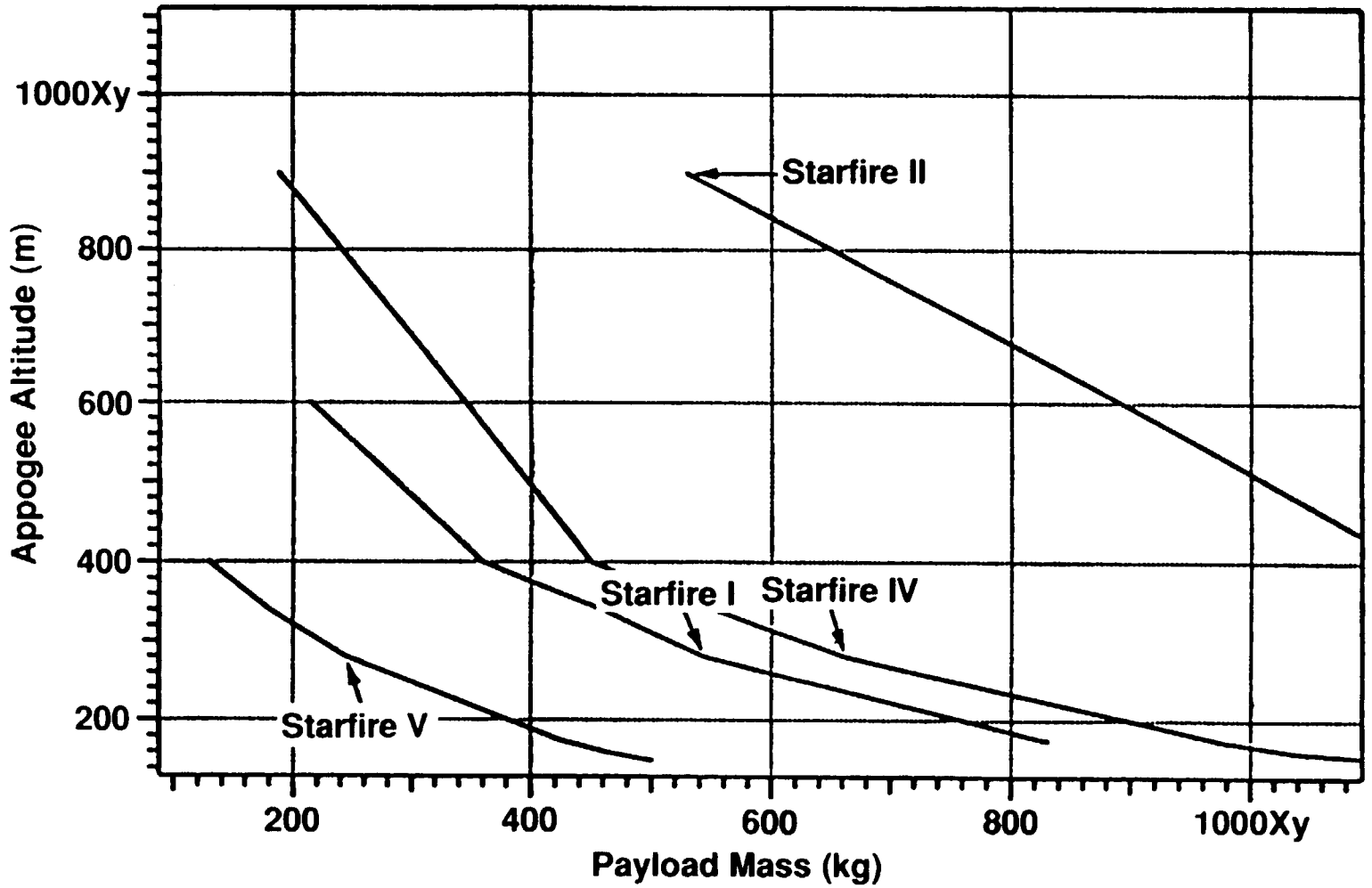
10.8 max G (1000 lb payload)

Configuration: TX 664-4, Black Brant VC (Advanced Terrier-Black Brant)

***Payload is all hardware above Black Brant forward case joint.**


Apogee
Payload Separation
Yo-Yo Despin
Parachute Deployment
2nd Stage Ignition
1st Stage Separation
1st Stage Ignition
Payload Recovery

Standard Sounding Rockey Program
Starfire Vehicle Comparision
Altitude vs. Payload Mass



Summary

- EER Systems Has an Established Systems Engineering Capability Within the Aerospace Industry.
- EER Systems' Aerospace Systems Group Is Committed to Becoming a Leader in Providing Engineering Services and Launch Services in the Small Satellite Market Arena.
- EER Systems' Aerospace Systems Group Is Committed to Providing Small Satellite, Conestoga Launch Vehicle, and Starfire Sounding Rocket Product Lines.
- EER Systems Is Committed to Providing the Required Aerospace Systems Group Resources Needed to Support Commercial Initiatives.