A large, stylized graphic on the left side of the slide. It features a globe with a grid of latitude and longitude lines. From the top of the globe, several sharp, elongated lines radiate outwards, resembling a starburst or a rocket's exhaust plume.

Magellan / Bristol Suborbital Rocket Capabilities



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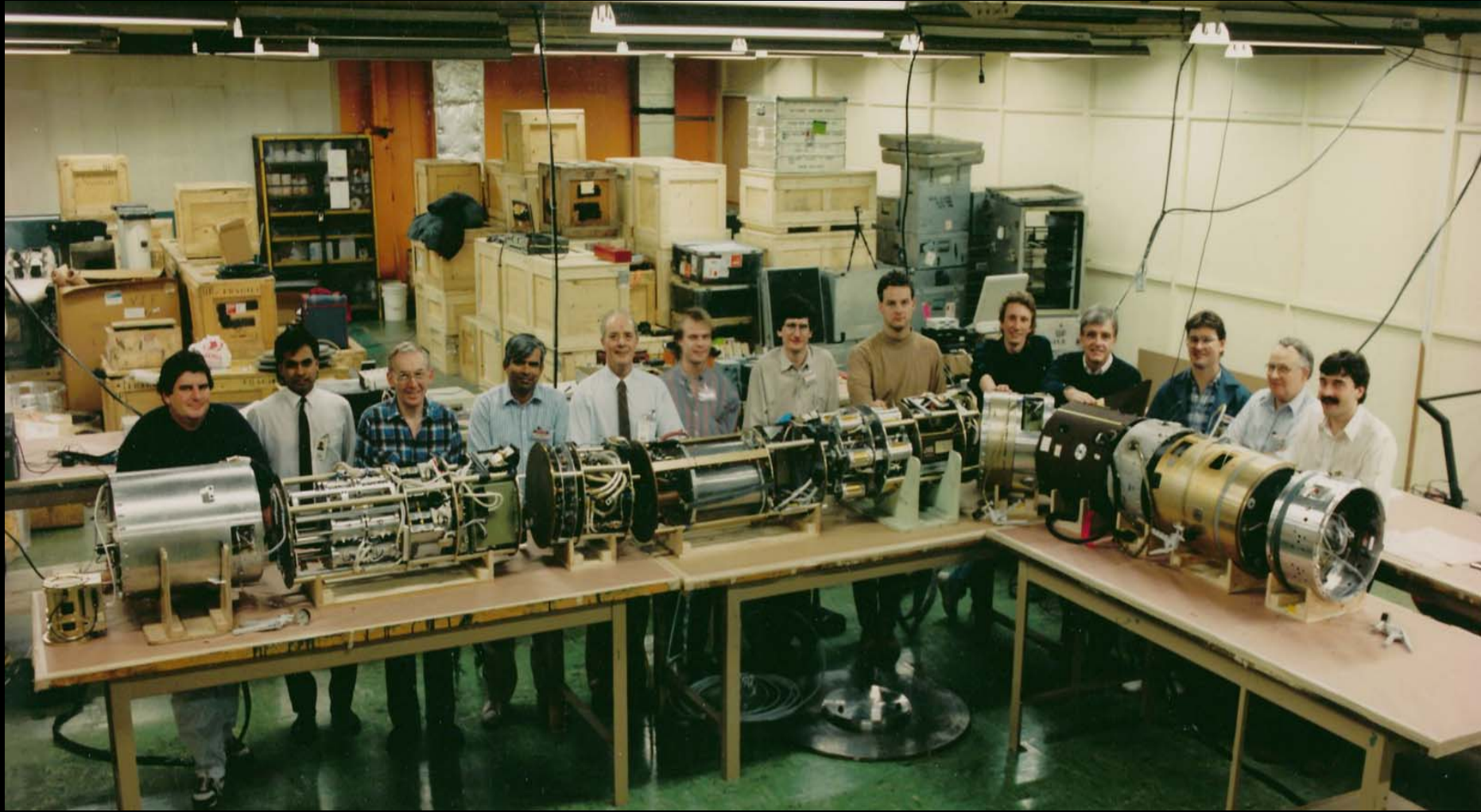
Background

- Bristol designs and manufactures the Black Brant sounding rocket, including the rocket motor(s) and associated hardware components.
- Bristol has also built more than 130 Black Brant payloads over the 50 years of Black Brant history.
- Bristol can provide all levels of support for a sounding rocket mission, from simple provision of the motors to full mission prime activities.
- Bristol also designed and builds the Excalibur motor which supports a smaller sounding rocket.
- Bristol has other rocket motors in production which could be adapted for mini-sounding rockets (CRV7, CL289)



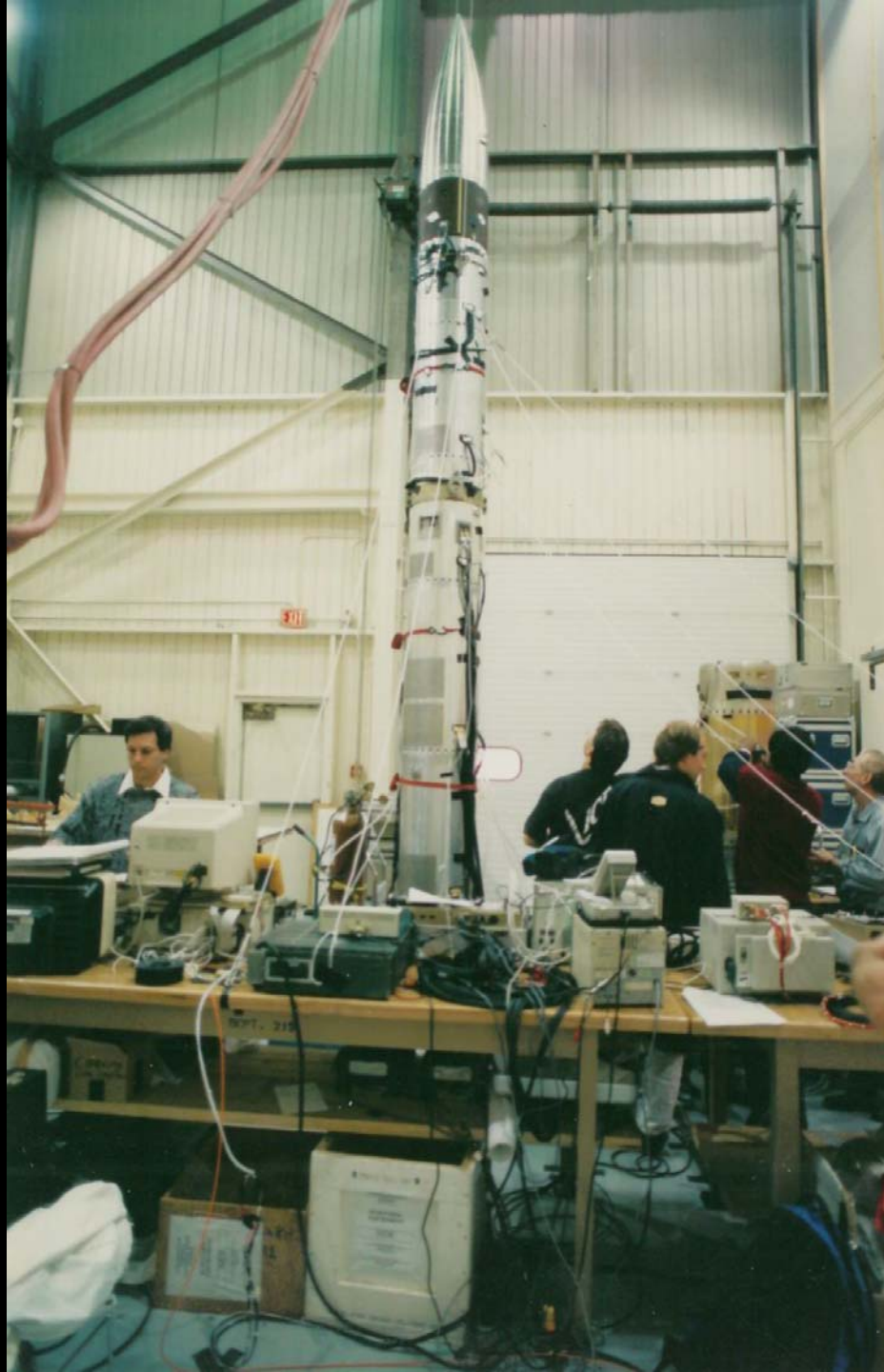
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CSAR-1



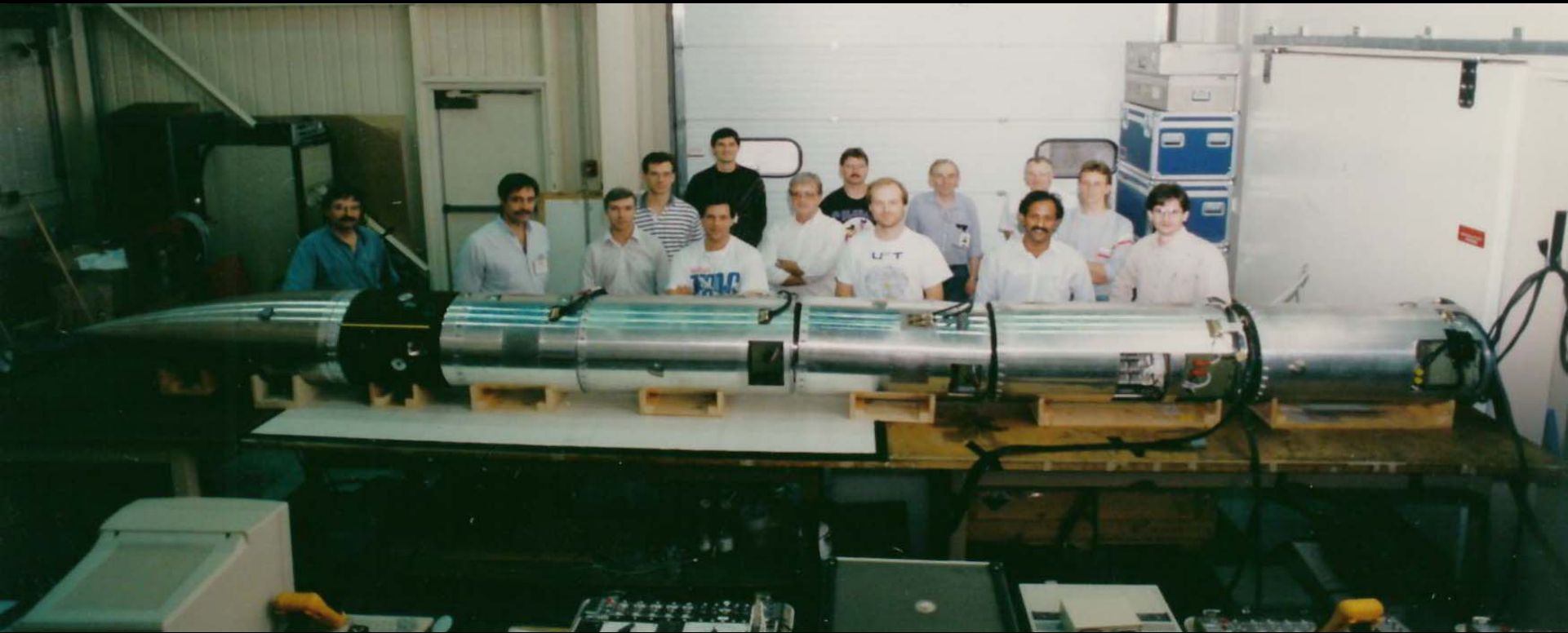
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CSAR-1



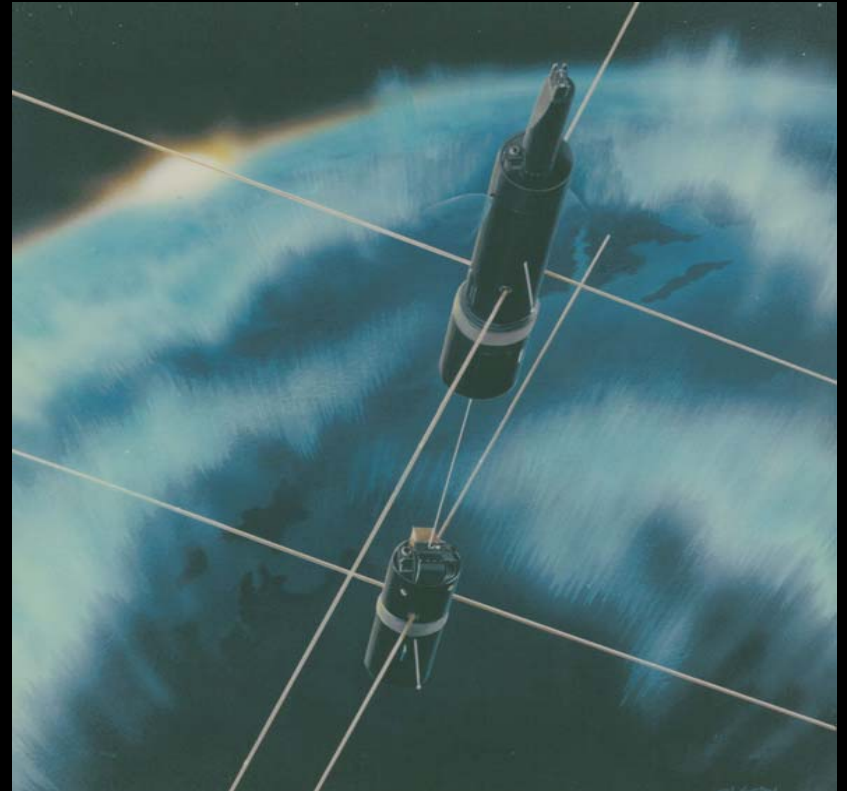
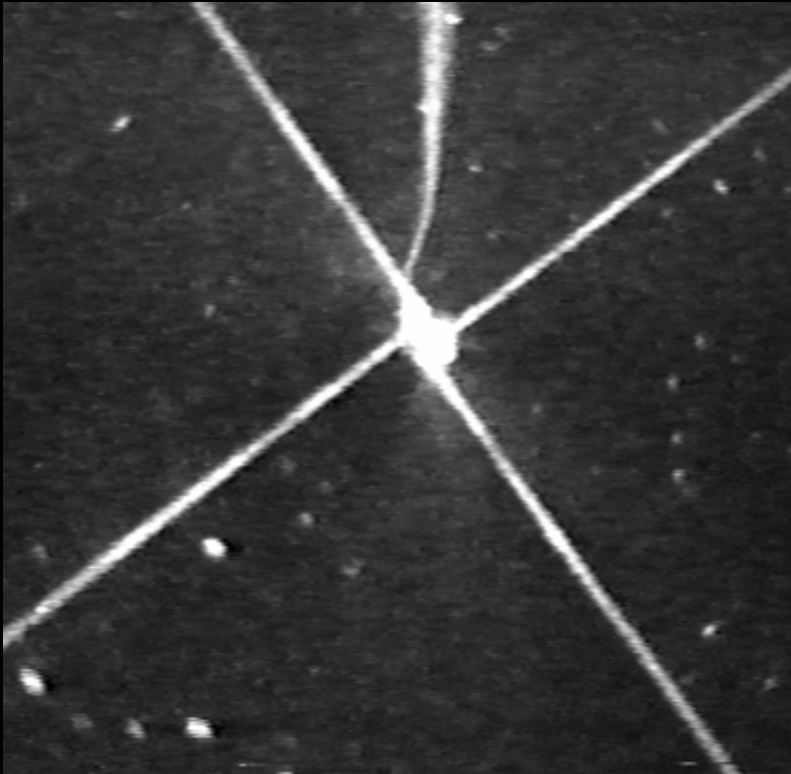
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CSAR-2



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OEDIPUS-A and OEDIPUS-C



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GEMINI



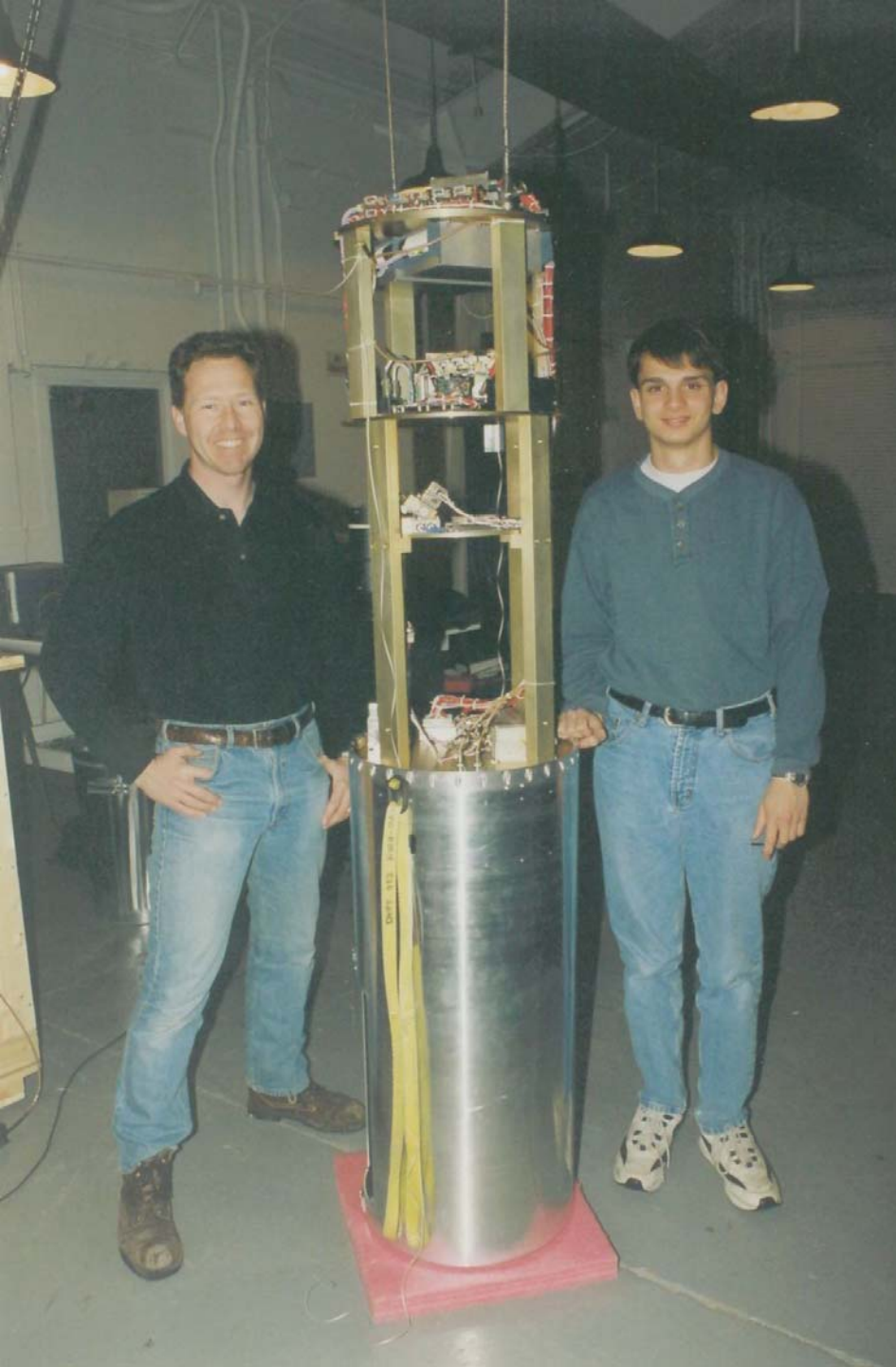
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GEMINI



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ACTIVE



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A E R O S P A C E

ACTIVE



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GEODESIC



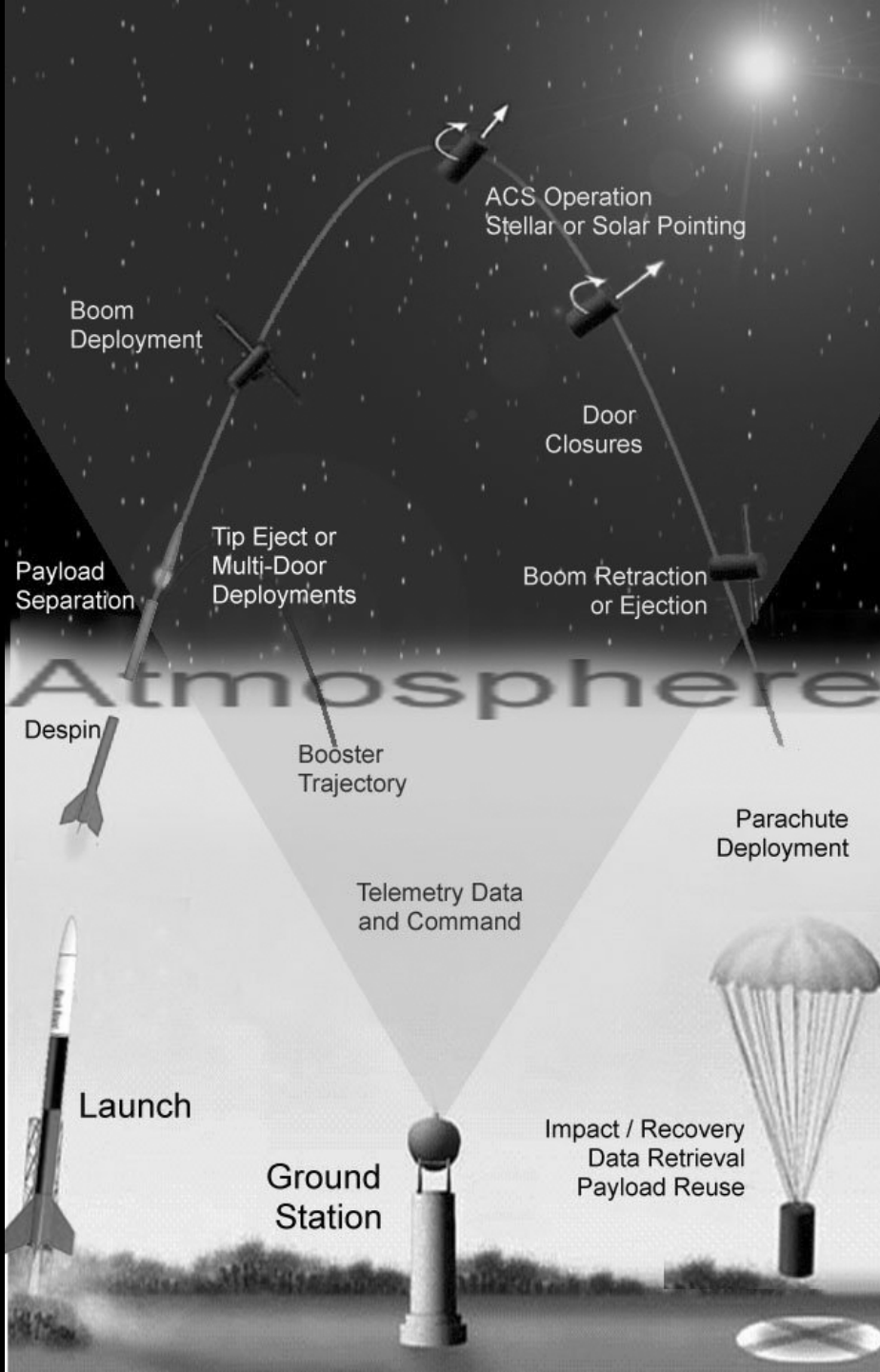
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GEODESIC



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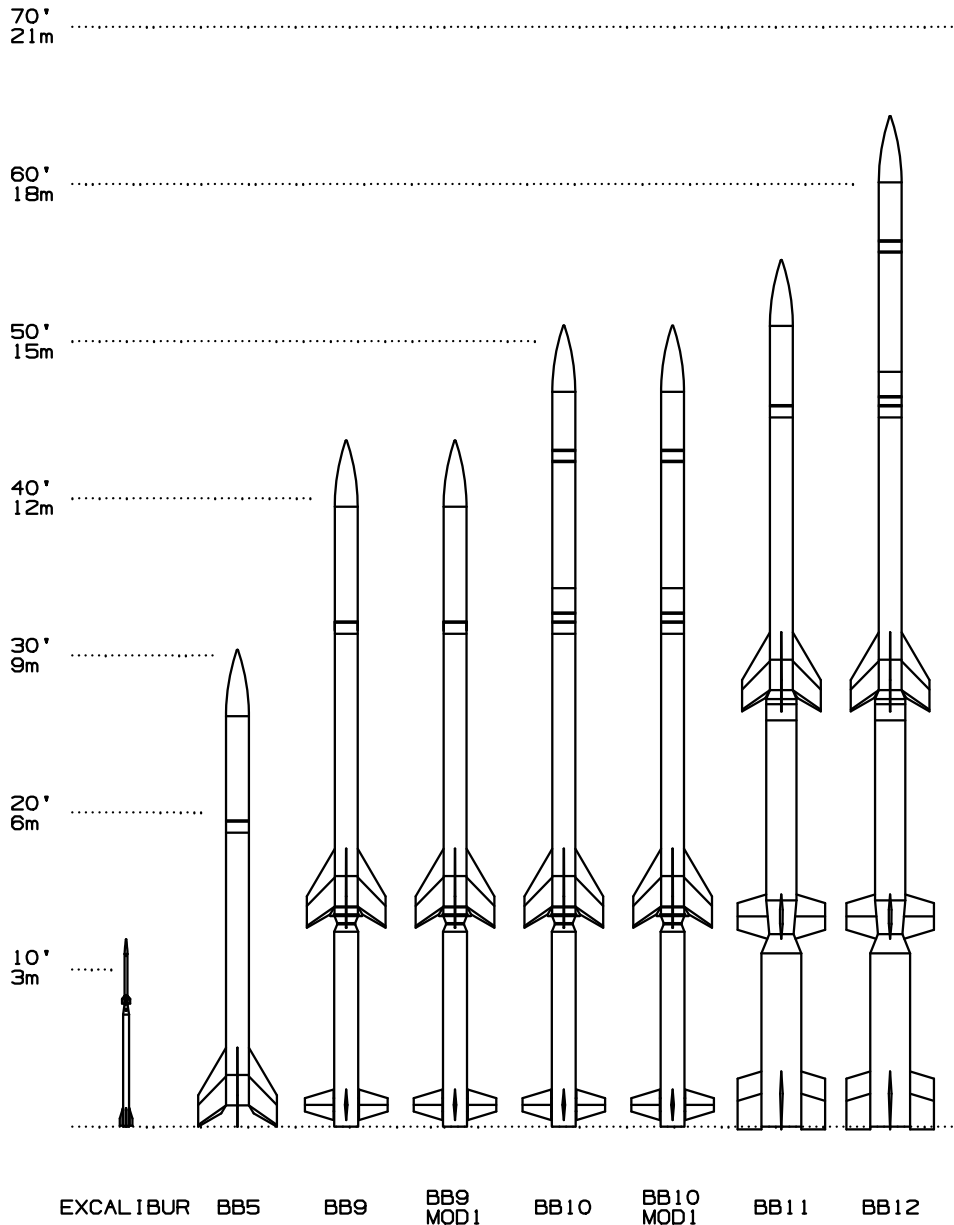


Anatomy of a Sounding Rocket Trajectory



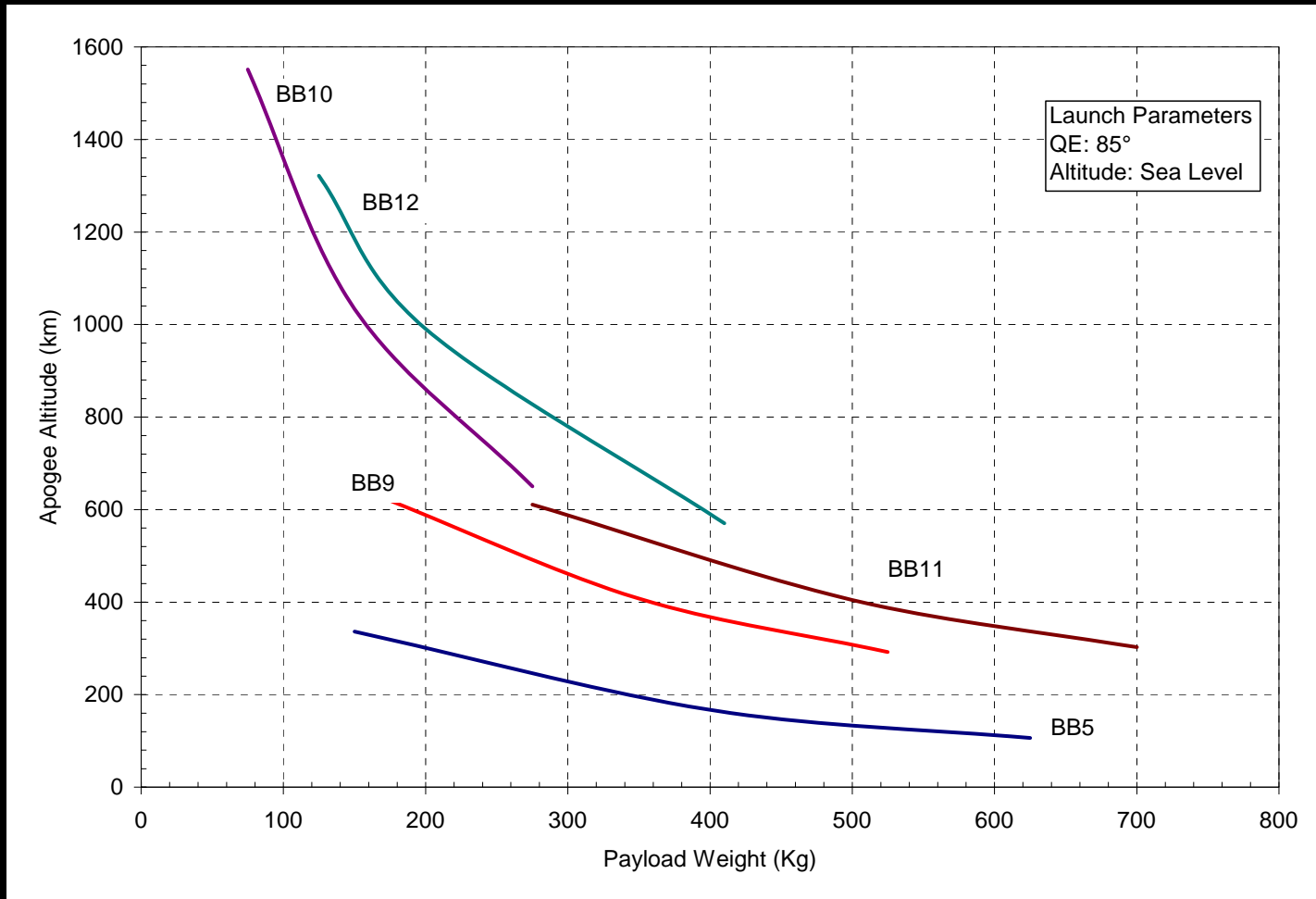
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Black Brant Family

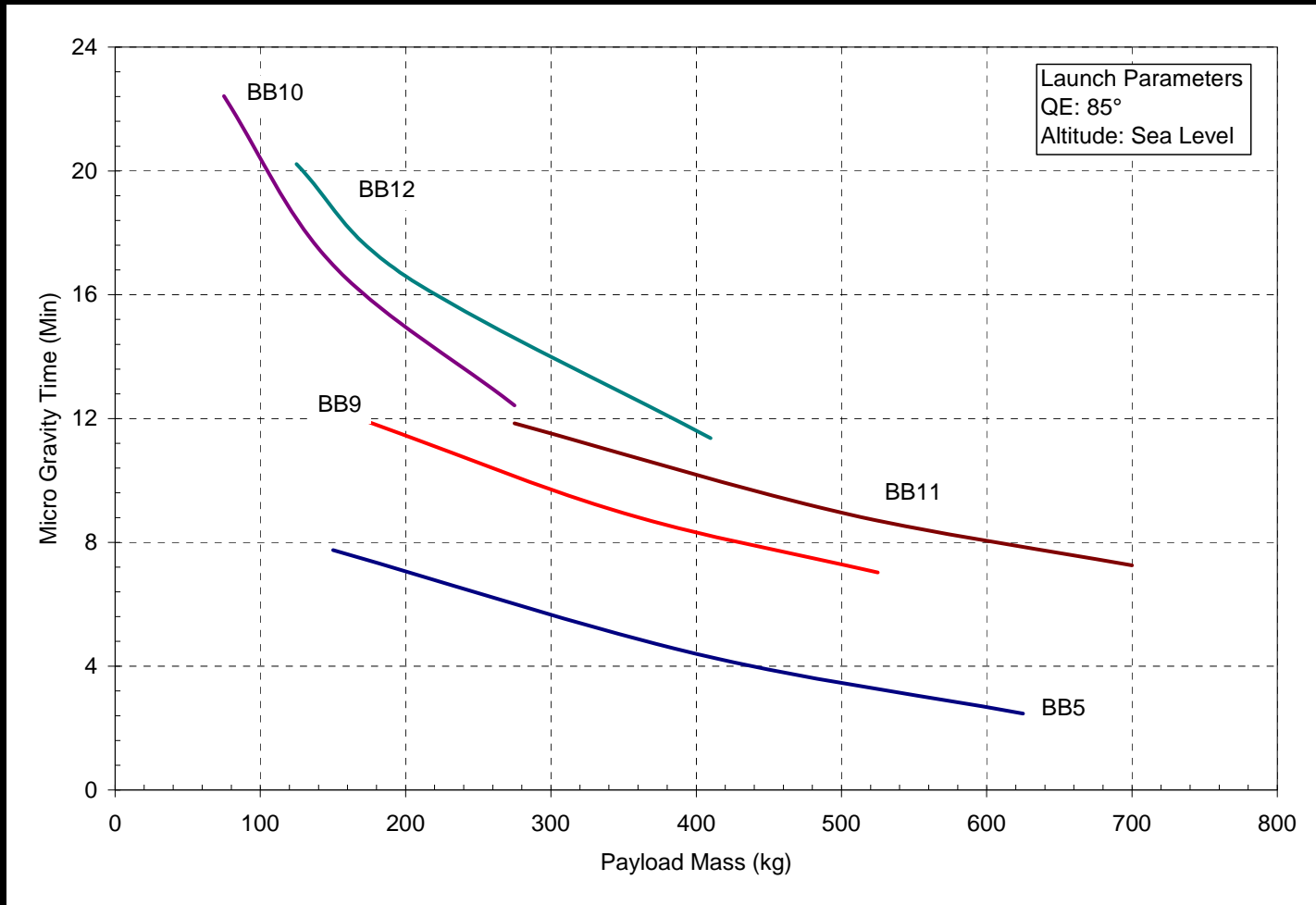


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How High?



How Long?

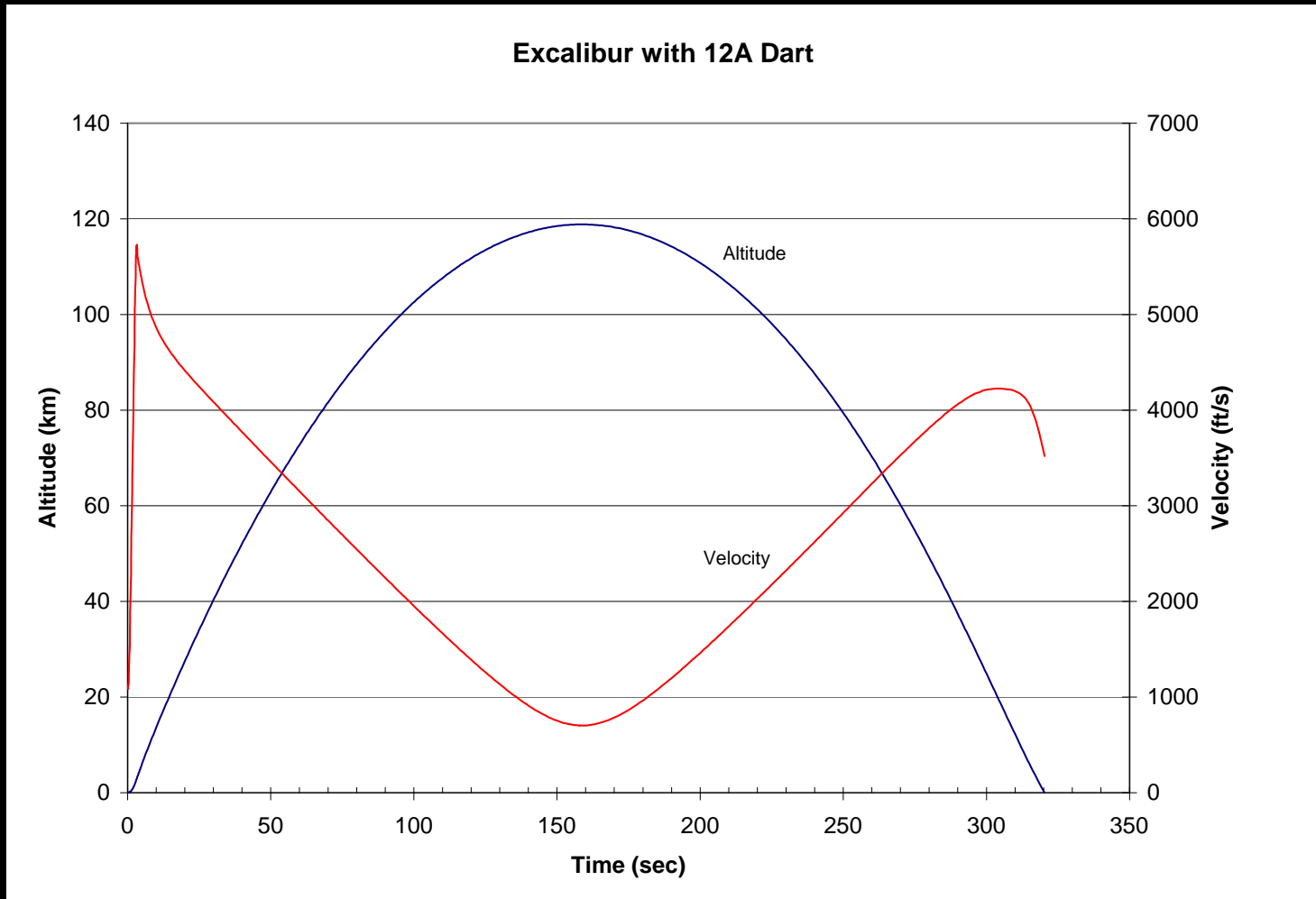


Excalibur



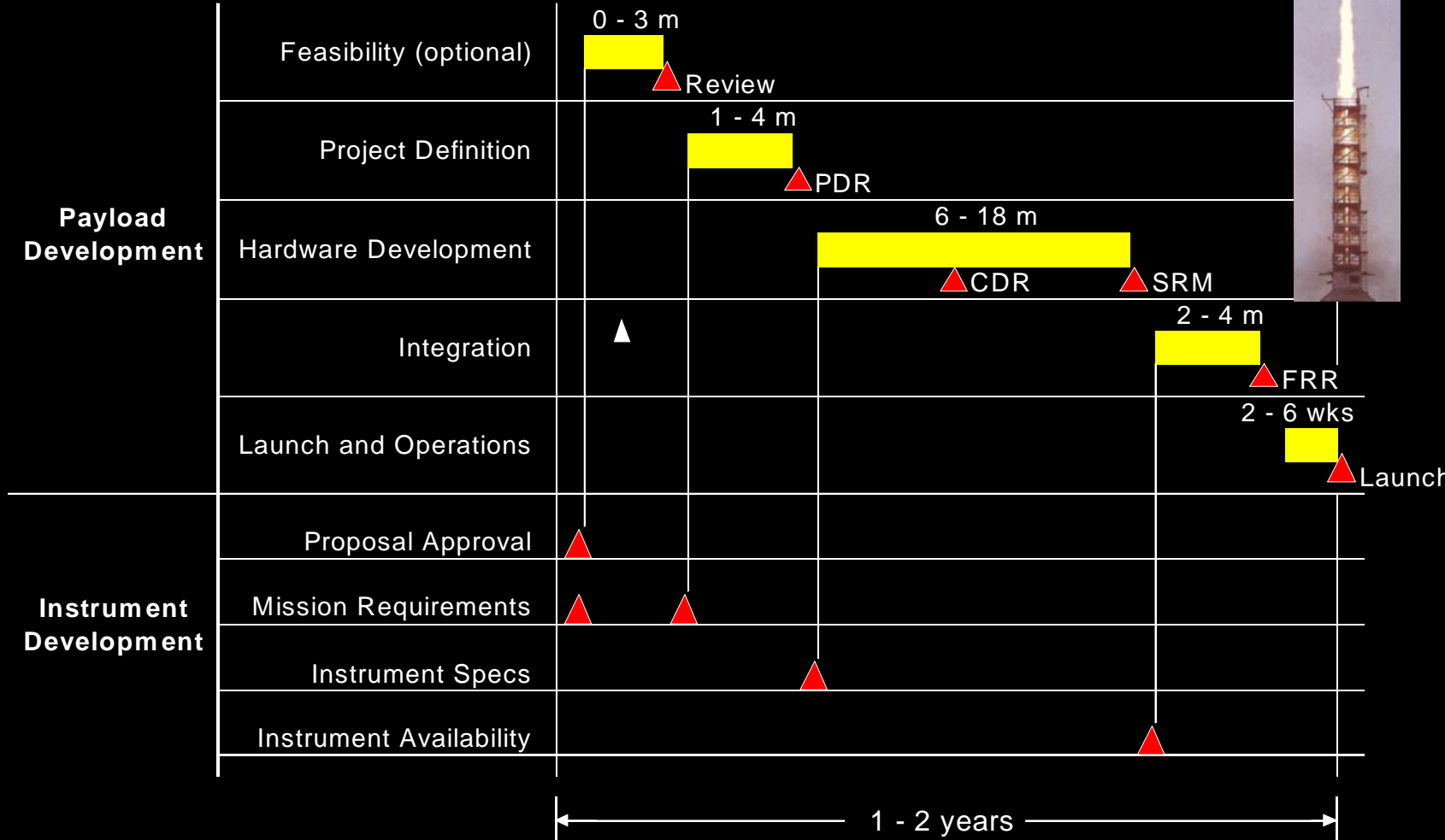
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Excalibur Performance



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Typical Suborbital Project Concept to Launch



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Mission Activities Previously Undertaken by Bristol

- Work with the mission science team to **define the requirements** of the vehicle and payload support systems that will meet the science team suborbital mission objectives
- **Define interfaces** from payload support systems to payload
- Develop **new support systems** as necessary to fill in gaps when off the shelf support systems do not fully meet the mission objectives.
- **Perform vehicle flight dynamics analysis** to support vehicle design considerations
- Conduct the **mission integration and test activity**, including launch range vehicle integration
- Provide mission **liaison to the launch range** to assess range launch support capabilities and range safety requirements
- Collect, process and distribute **post-flight data**



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Launch Sites



- North America

- WSMR
- PFRR
- WFF
- Churchill
- remote sites

- Major International

- Andoya, Norway
- Esrange, Sweden



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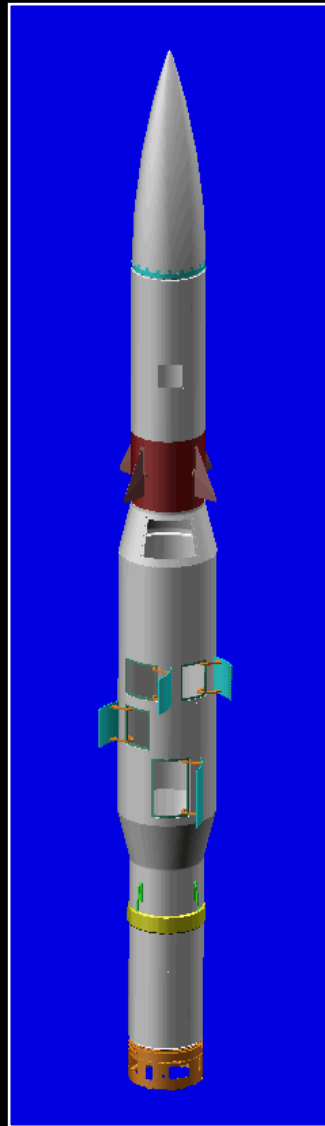
Rocket Payload Capabilities

- data acquisition and telemetry
- sequencing
- power
- tracking
- environmental testing
- recovery
- attitude / rate control
- Others as required

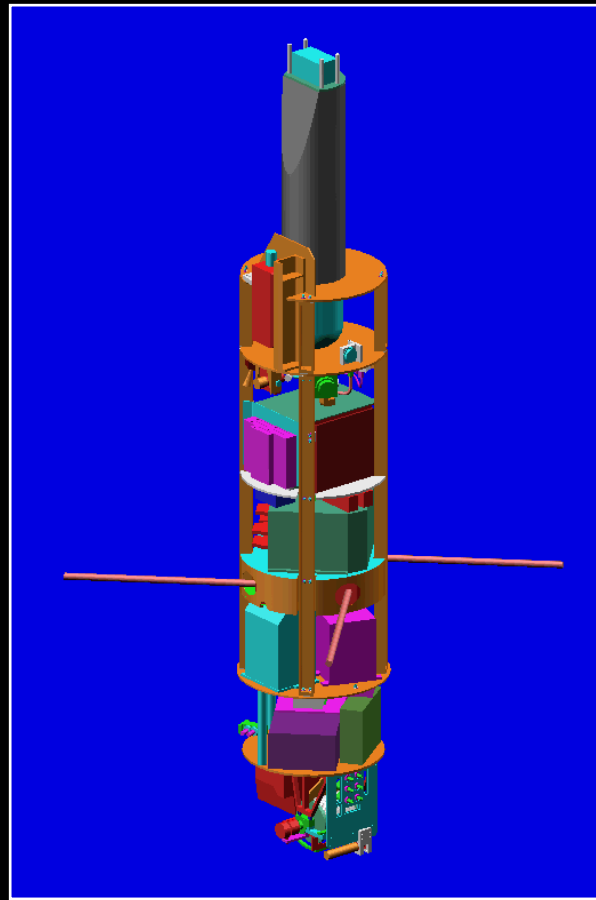


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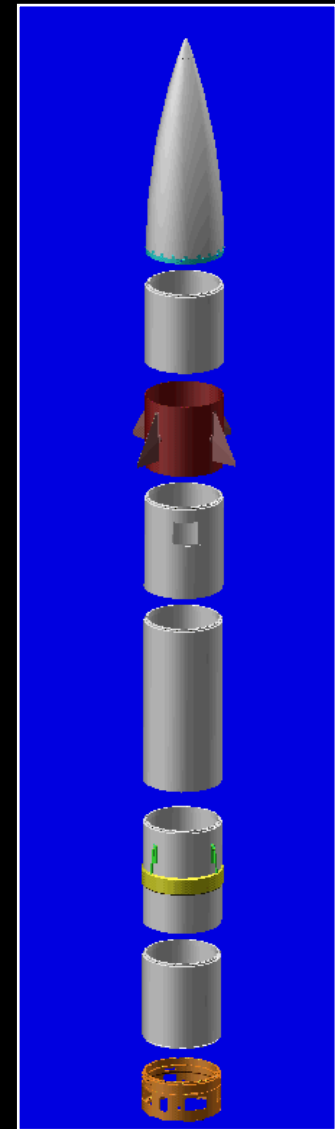
Typical Payloads



Doors, bulbous section, upleg guidance



Integrated instrument bus



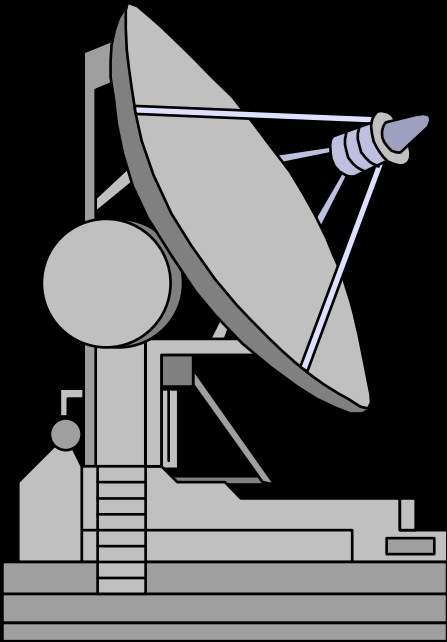
Modular buildup



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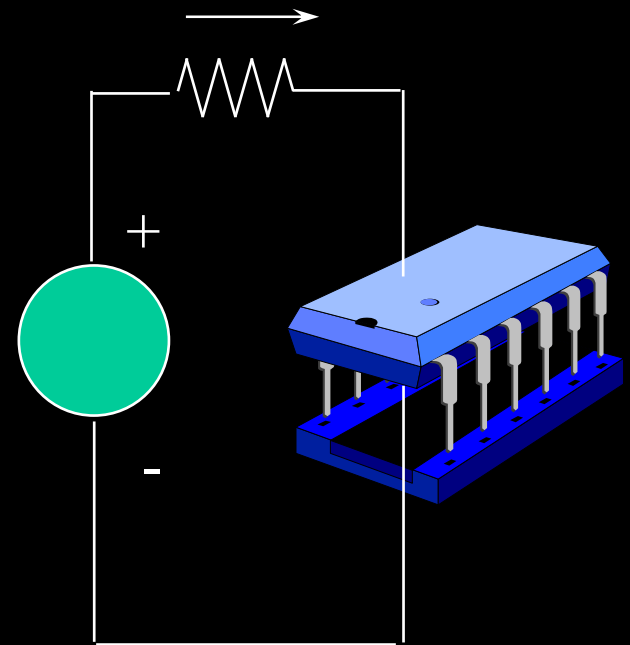
Tracking

- Radar Tracking
 - skin
 - transponder
 - not available everywhere
- TRADAT
 - closed loop ranging
 - TM antenna pointing
 - up to 0.1 km positional accuracy
- GPS
 - < 100 meters



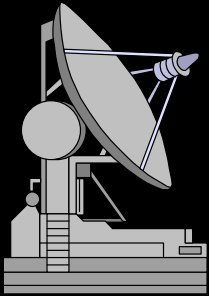
Power

- bus normally provides all power
- battery based system
- standard +ve and -ve buses, shared, +28V, -18V
- full protection, instrument to instrument
- special requirements;
 - low bus noise, dedicated sources
 - high power requirements; 15kW

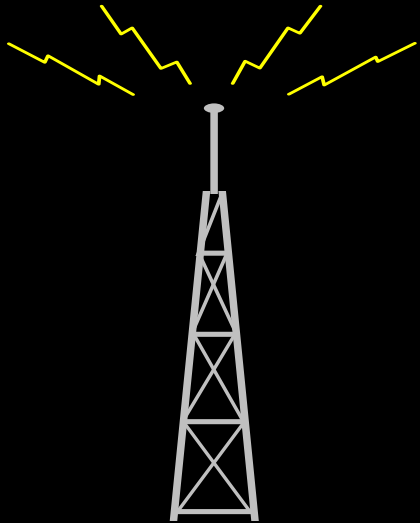


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Real-time Monitoring & Control



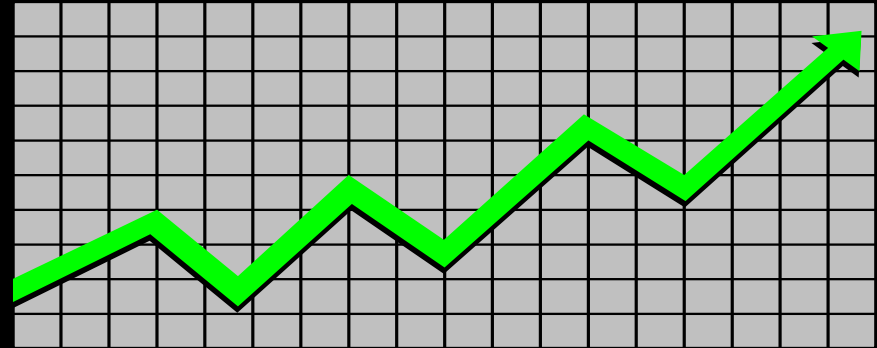
- payload pointing, corrections
- instrument mode control
- instrument sensitivity control
- charge detonation (Waterhole)
- trajectory event initiation



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Diagnostics

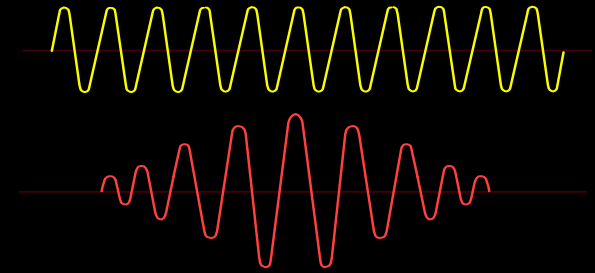
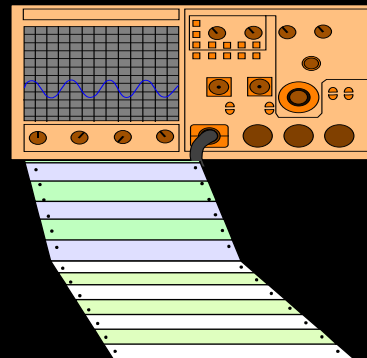
- accelerations
- vibrations
- temperatures
- full payload support system diagnostics
- support for instrument diagnostics
- full vehicle diagnostics



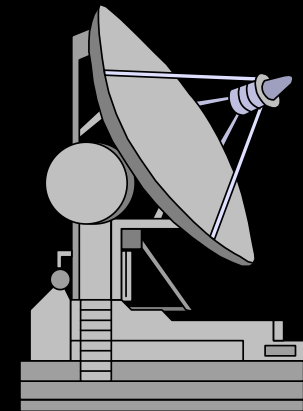
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Data Acquisition and Telemetry

- Data rates to 10 Mbps
- Composite PCM downlinks
 - Analog data interface
 - Serial digital interface
 - Parallel digital interface
 - Counters
- Dedicated PCM links for instruments



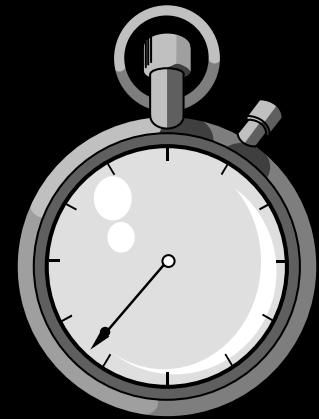
- TV links
- FM/FM multiplex systems
- Onboard data storage (recovered payloads)
- Multiple TM downlinks (5)



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Sequencing/Control

- centralized instrument and bus control, some autonomy
- time based events
- redundant implementation
- vehicle control, pyrotechnics
- IMU based control, altitude
- uplink control



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STARS

Payload Controller
-Software
-Timers

Power Interfaces
- control, distribution,
monitoring of external
power/battery



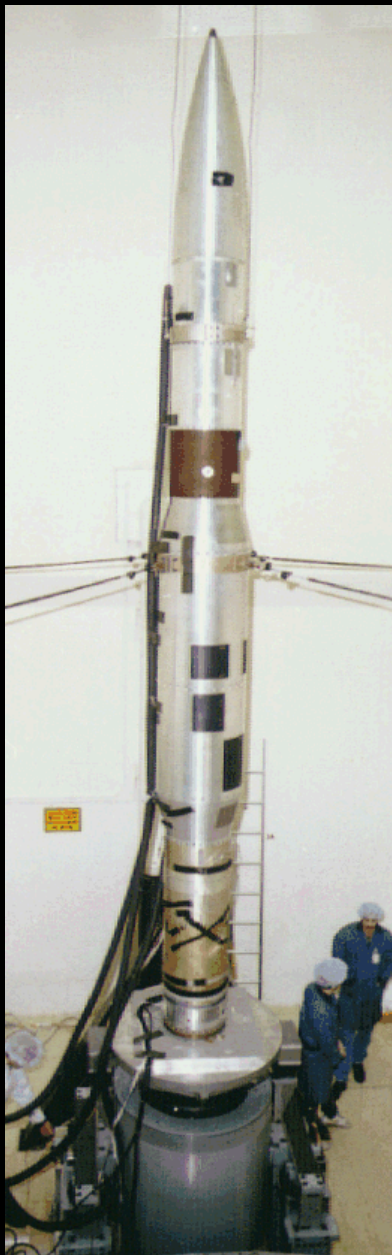
Diagnostics
-Accelerometers
-Magnetometers
-Thermistors
-Microswitches
-GPS interface

Power Switches

Pyro Switches



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Environment

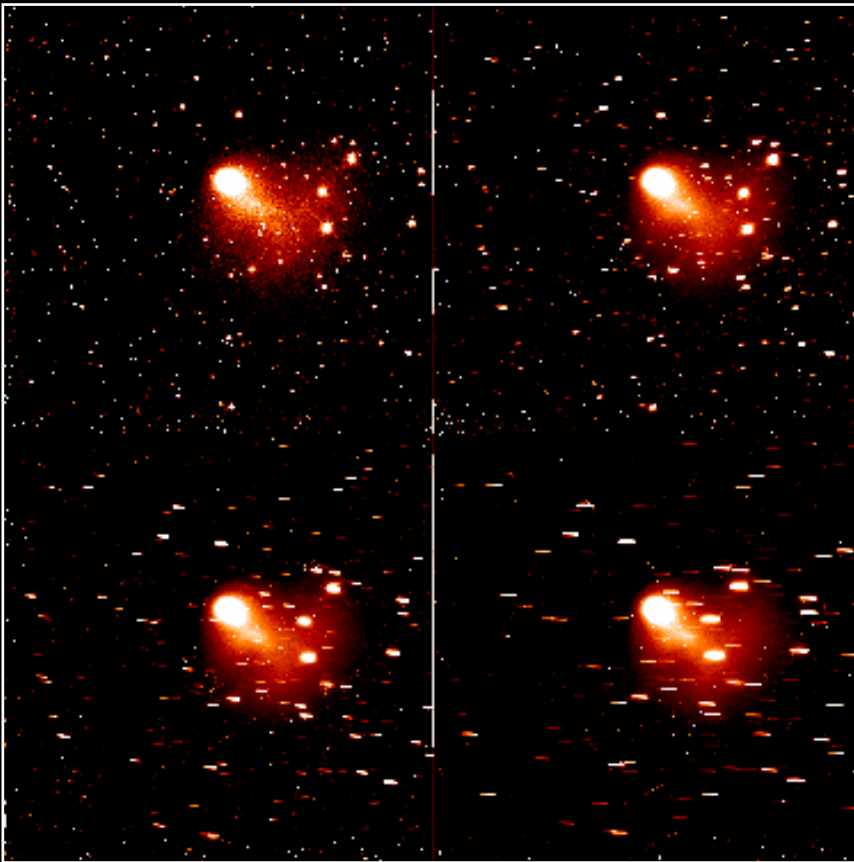
	Environment*	Test Specs
Vibration	0.5 - 6.0 grms	12.7 grms
Temperature	$\pm 10^{\circ}\text{C}$ max	0 - 60°C
Acceleration	-3 to +23g	25g , 3 axis
Vacuum	$>10^{-6}$ torr	10^{-6} torr
Shock	<25 g	50 g , 11 ms

* Environment is very dependent on payload structural design and on location in the payload.



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Established Capabilities Pointing Systems



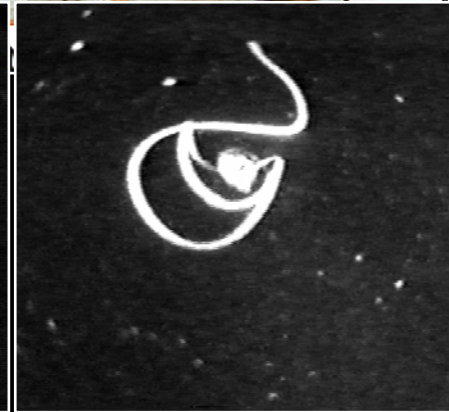
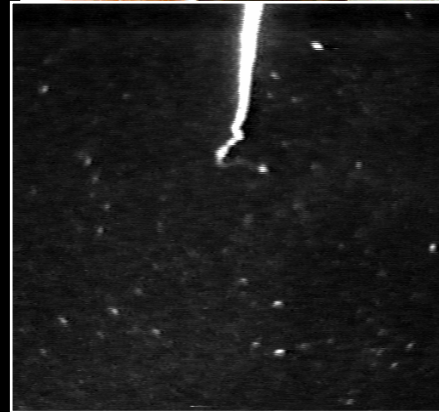
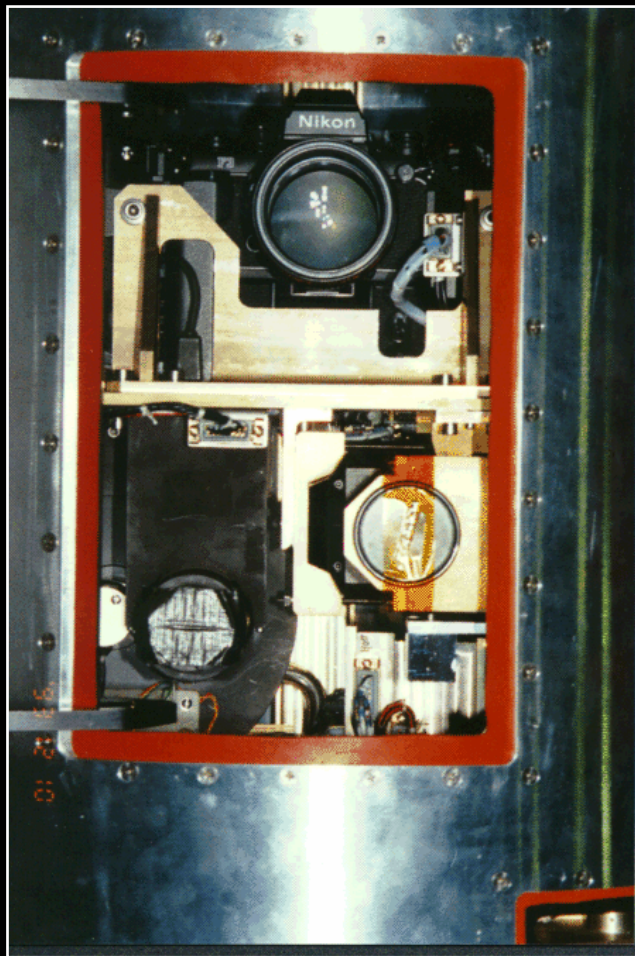
- Inertial pointing
 - - <1 deg
- Magnetic pointing
 - < 1 deg
- Solar pointing
 - arc minute
- Stellar pointing
 - arc second



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Established Capabilities

Cameras, Attitude Determination

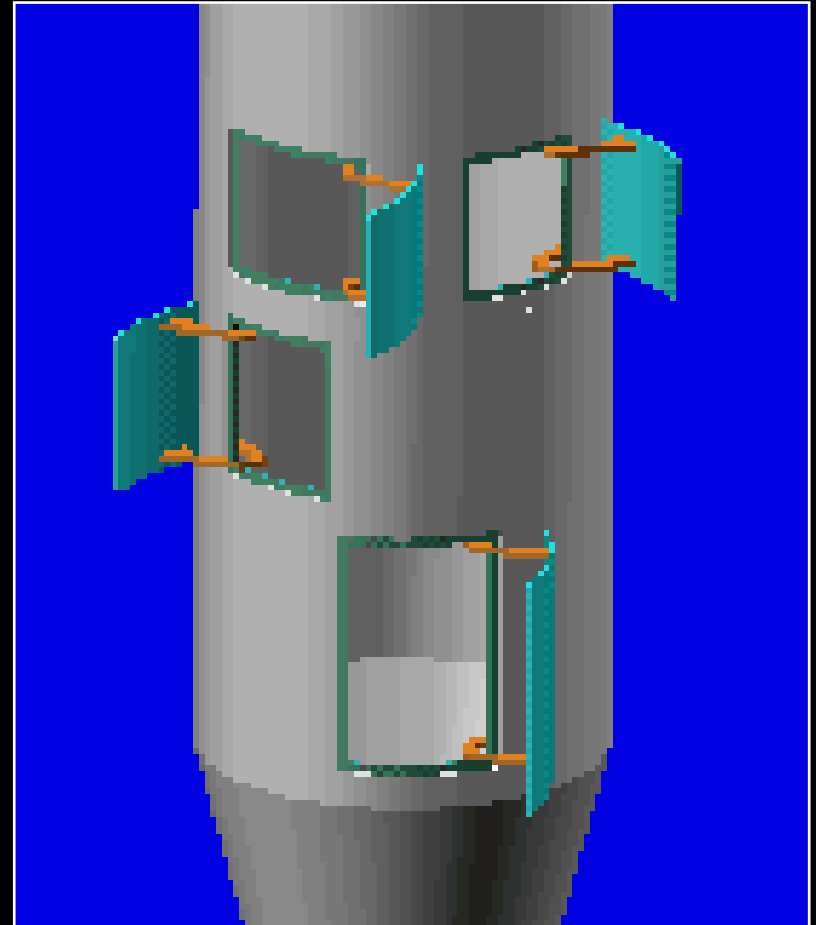


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Established Capabilities

Doors; Re-closable & Deploying

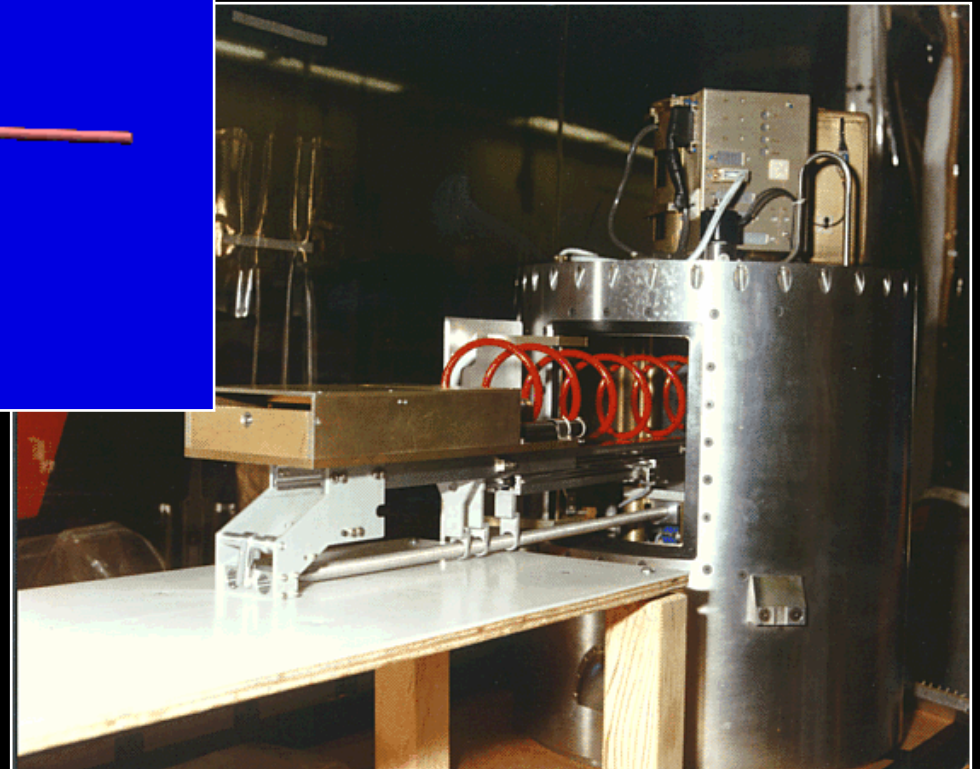
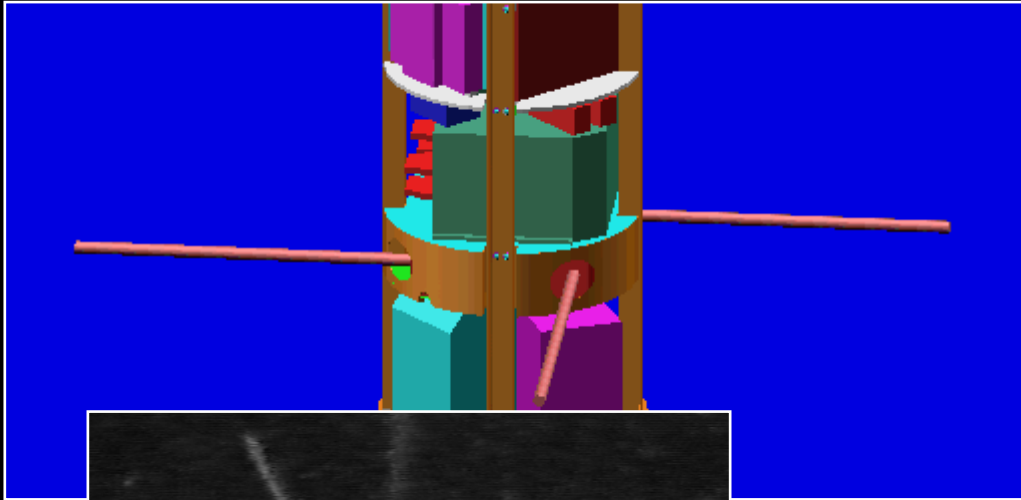
- boom deployments
- instrument viewing ports
- dust tight
- re-entry protection
- recovery protection, payload cleanliness



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Established Capabilities

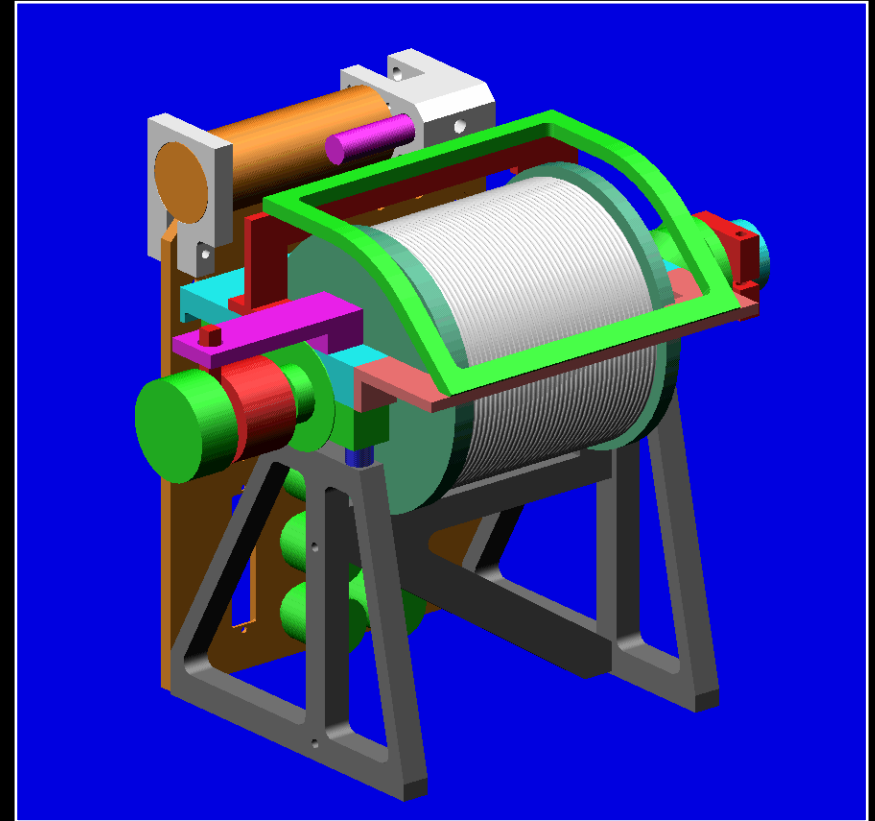
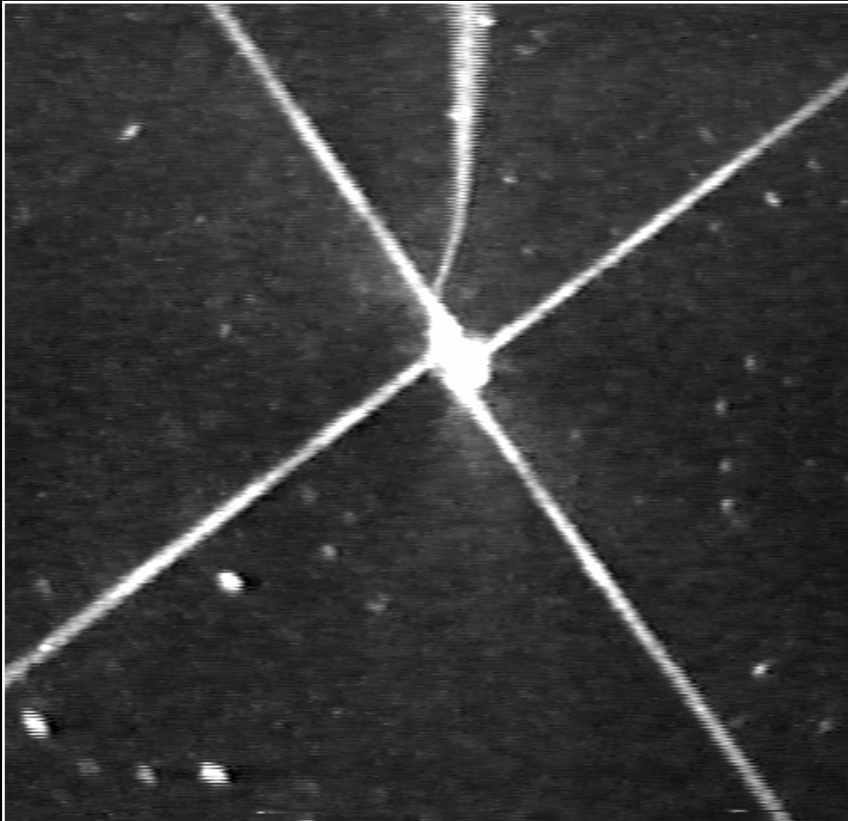
Booms



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Established Capabilities

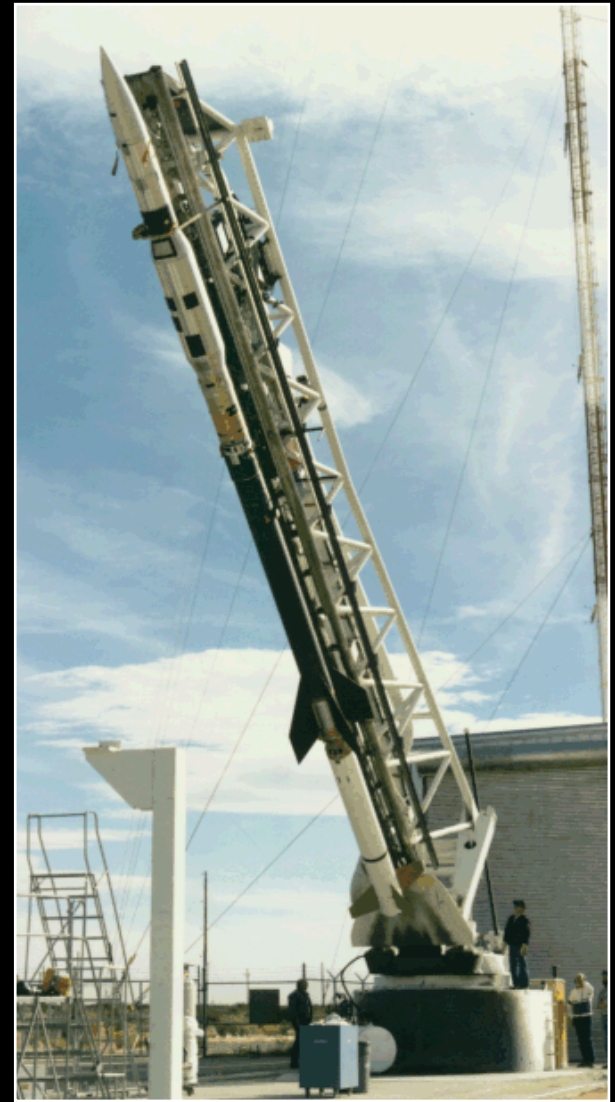
Tethers



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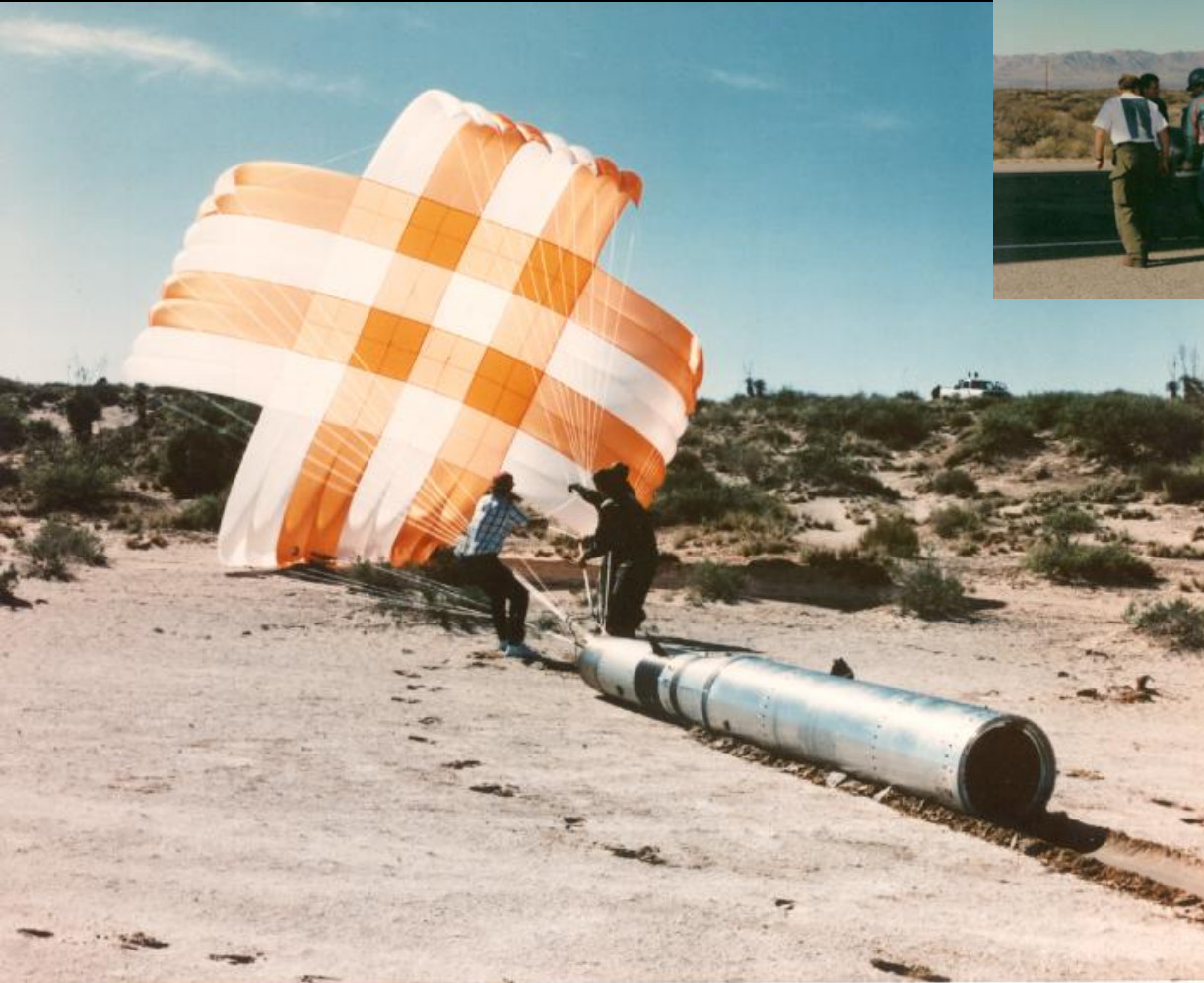
Established Capabilities

Bulbous payloads



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Established Capabilities - Recovery



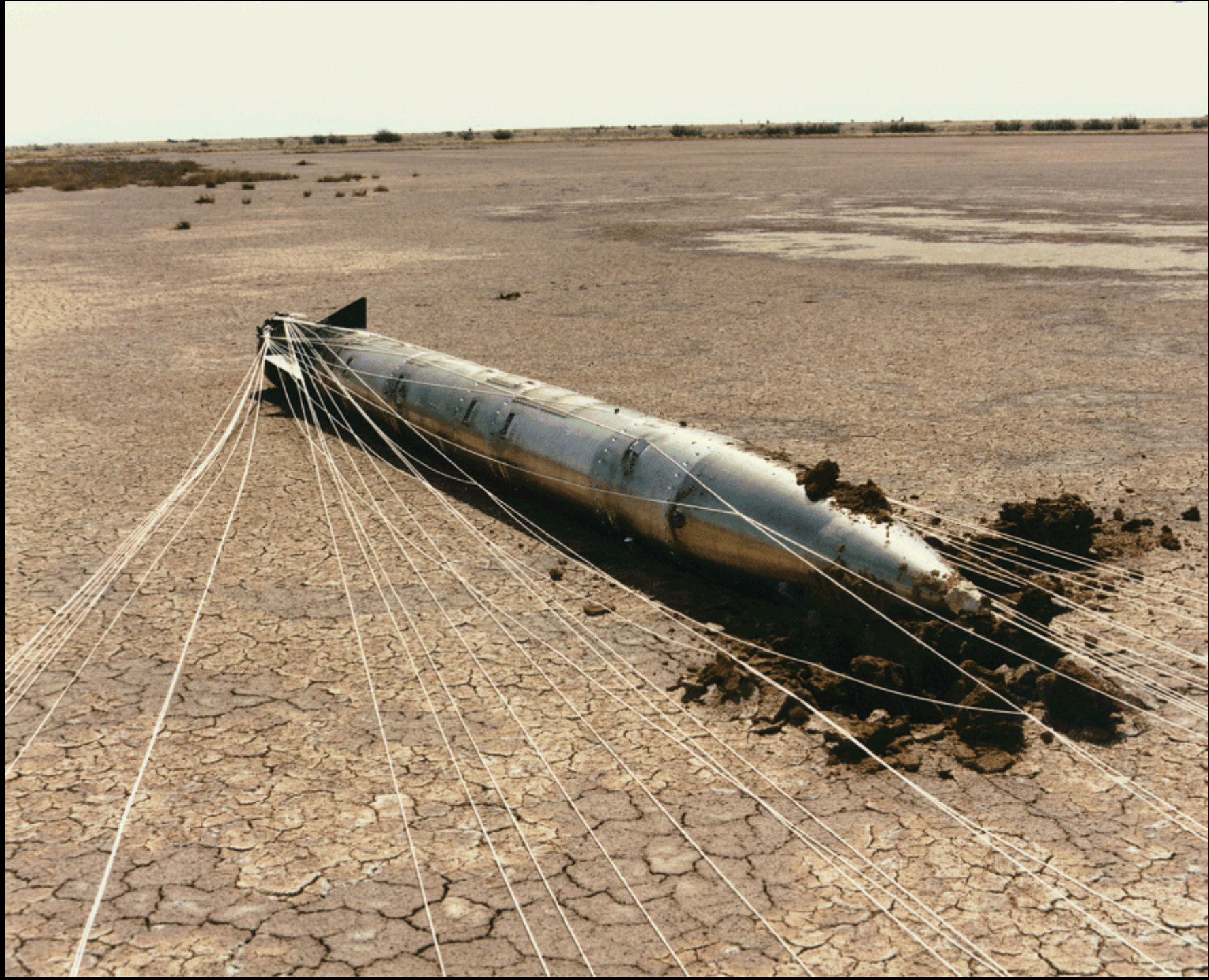
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Established Capabilities

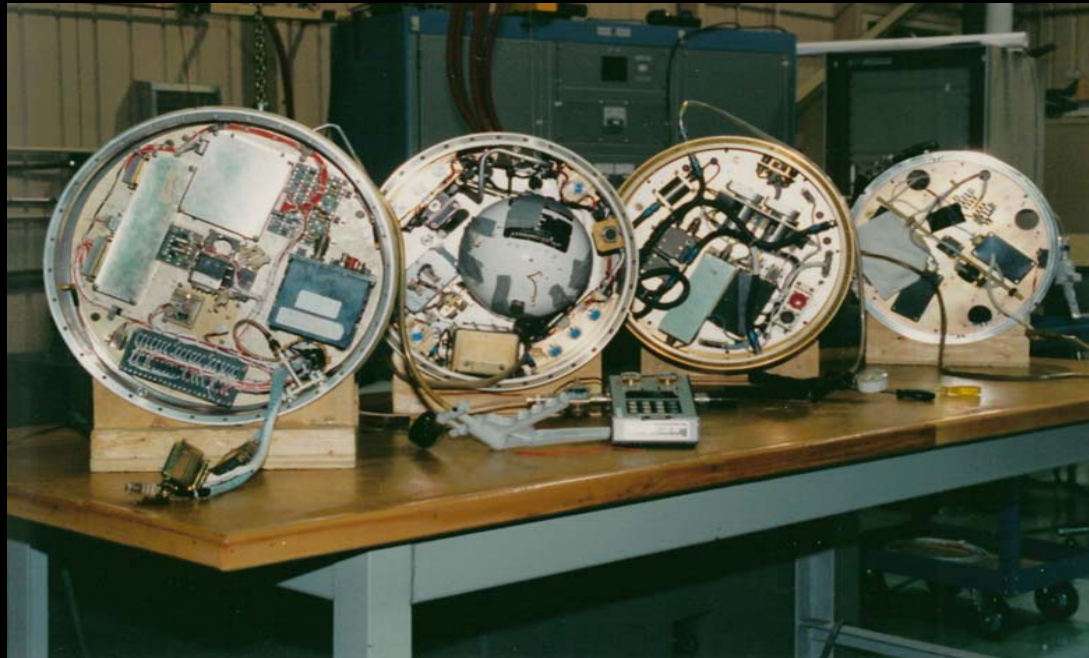
Impact protection



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Payload Support Components



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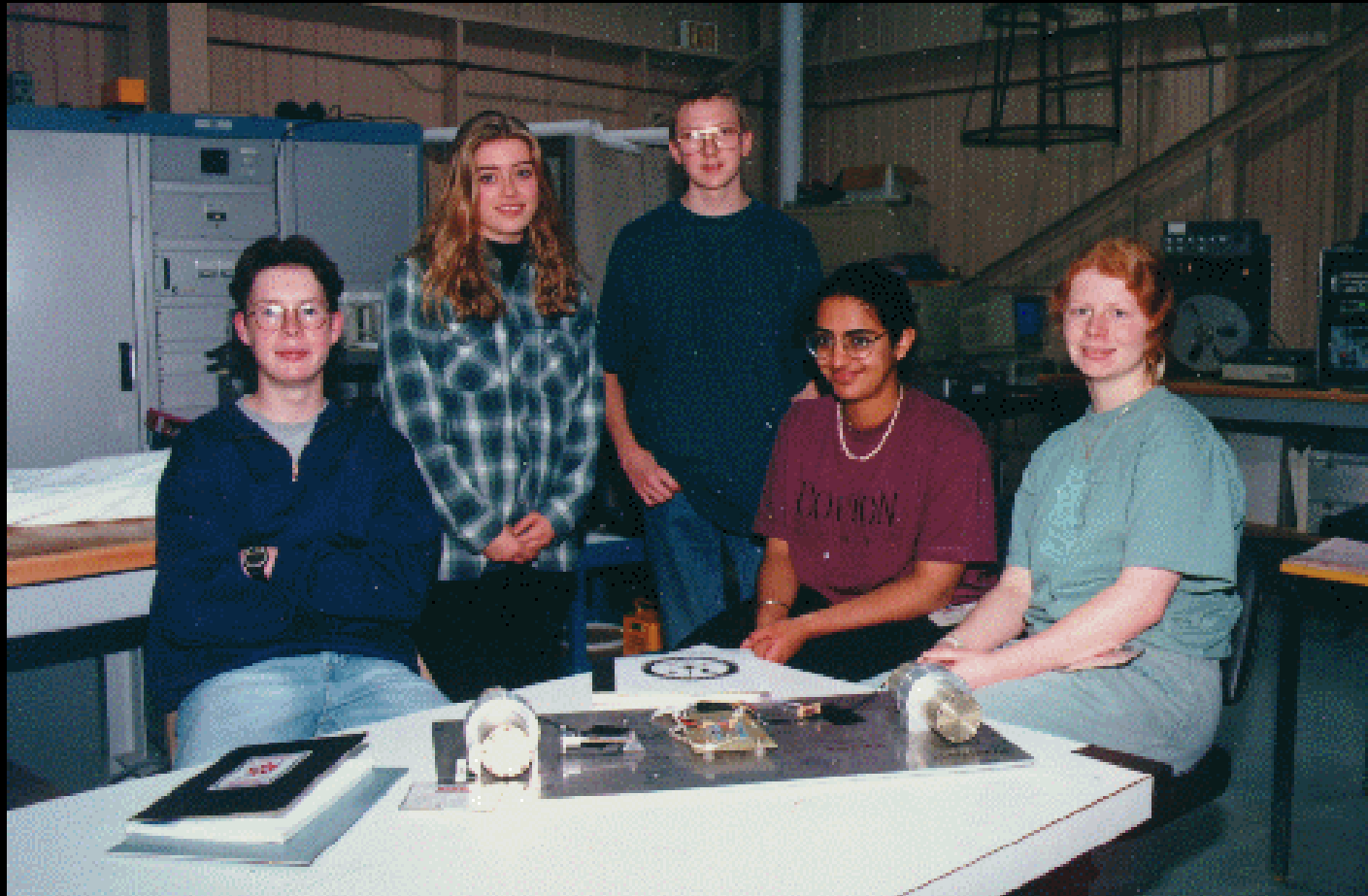
Payload Support – ACS/RCS/Guidance

- Saab S-19 system used when required for upleg
- Previously procured exoatmospheric ACS/RCS systems from US, now have developed capability in-house via satellite programs



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Student participation



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Parting Thoughts...

- Sounding rockets come in a variety of shapes and sizes
- Budgets influenced not only by size of rocket
 - Complexity of payload
 - Standardized equipment
 - Repetition
 - PA approach
- If \$5M gets a 500 kg BB9 payload to 250 km; then
 - \$10K / kg to DESIGN, BUILD, TEST and FLY
- Shared missions have to go both ways...
- Infrastructure largely exists in Canada
- Bristol supports small payload program at CSA
 - Commercial benefit
 - Staff development



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