Magellan / Bristol
Suborbital Rocket
Capabilities
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)
CSAR-1
CSAR-2
OEDIPUS-A and OEDIPUS-C
GEODESIC
GEODESIC
How High?

Launch Parameters
QE: 85°
Altitude: Sea Level
How Long?

![Graph showing payload mass vs. microgravity time for different launch parameters]

Launch Parameters
- QE: 85°
- Altitude: Sea Level

Payload Mass (kg)
- BB10
- BB12
- BB9
- BB11
- BB5
Excalibur
Excalibur Performance

Excalibur with 12A Dart

Altitude vs. Time

Velocity vs. Time

Time (sec)

Altitude (km)

Velocity (ft/s)

Excalibur with 12A Dart

Altitude

Velocity
Typical Suborbital Project
Concept to Launch

<table>
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<th>Phase</th>
<th>Duration</th>
<th>Details</th>
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<td>Feasibility (optional)</td>
<td>0 - 3 m</td>
<td>Review</td>
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<tr>
<td>Project Definition</td>
<td>1 - 4 m</td>
<td>PDR</td>
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<td>6 - 18 m</td>
<td>CDR, SRM</td>
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<td>Instrument Availability</td>
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1 - 2 years
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.
Launch Sites

- North America
  - WSMR
  - PFRR
  - WFF
  - Churchill
  - remote sites

- Major International
  - Andoya, Norway
  - Esrange, Sweden
Rocket Payload Capabilities

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

- Doors, bulbous section, upleg guidance
- Integrated instrument bus
- Modular buildup
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
Real-time Monitoring & Control

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

- accelerations
- vibrations
- temperatures
- full payload support system diagnostics
- support for instrument diagnostics
- full vehicle diagnostics
Data Acquisition and Telemetery

- 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)
Sequencing/Control

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

<table>
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<tr>
<th>Environment*</th>
<th>Test Specs</th>
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<tbody>
<tr>
<td>Vibration</td>
<td>0.5 - 6.0 grms</td>
</tr>
<tr>
<td>Temperature</td>
<td>± 10°C max</td>
</tr>
<tr>
<td>Acceleration</td>
<td>-3 to +23g</td>
</tr>
<tr>
<td>Vacuum</td>
<td>&gt;10⁻⁶ torr</td>
</tr>
<tr>
<td>Shock</td>
<td>&lt;25 g</td>
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* Environment is very dependent on payload structural design and on location in the payload.
Established Capabilities
Pointing Systems

- Inertial pointing
  - $< 1 \, \text{deg}$
- Magnetic pointing
  - $< 1 \, \text{deg}$
- Solar pointing
  - arc minute
- Stellar pointing
  - arc second
Established Capabilities
Cameras, Attitude Determination
Established Capabilities
Doors; Re-closable & Deploying

- boom deployments
- instrument viewing ports
- dust tight
- re-entry protection
- recovery protection, payload cleanliness
Established Capabilities
Booms
Established Capabilities
Tethers
Established Capabilities
Bulbous payloads
Established Capabilities - Recovery
Established Capabilities
Impact protection
Payload Support Components
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
Student participation
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