ICBM Derived Small Lift Vehicles: Past, Present, and Future

Will Emmer
Capt Joel Freyenhagen
Capt Gene Hockenberry
Lt Jeremy Geiger

Rocket Systems Launch Program (RSLP)
SMC Space Development and Test Wing

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Launch Vehicle Contracts

Orbital Sub-orbital Program (OSP-2)

- Minotaur I
- Minotaur II
- Minotaur III
- Minotaur IV
- Minotaur V

Sounding Rocket Program (SRP-2)

* No Pre-set Configurations

Responsive Small Spacelift (RSS)

- Raptor 1
- Raptor 2
- Falcon 1
### Past and Present Minotaur Missions

<table>
<thead>
<tr>
<th>Minotaur I</th>
<th>Minotaur II</th>
<th>Minotaur I</th>
<th>Minotaur II</th>
<th>Minotaur II</th>
<th>Minotaur II</th>
<th>Minotaur I</th>
<th>Minotaur I</th>
<th>Minotaur I</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAWSAT</td>
<td>TLV-Demo</td>
<td>MightySat</td>
<td>IFT-7/TLV-1</td>
<td>IFT-8/TLV-2</td>
<td>IFT-9/TLV-3</td>
<td>XSS-11</td>
<td>STP-R1</td>
<td>COSMIC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minotaur I+</th>
<th>Minotaur IV+</th>
<th>Minotaur I</th>
<th>Minotaur IV</th>
<th>Minotaur IV</th>
<th>Minotaur IV</th>
<th>Minotaur IV</th>
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</thead>
<tbody>
<tr>
<td>TacSat-2</td>
<td>TLV-5</td>
<td>NFIRE</td>
<td>TLV-7</td>
<td>TLV-8</td>
<td>TacSat-3</td>
<td>SBSS</td>
</tr>
</tbody>
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Minotaur IV Growth Options

**Minotaur IV**
- 3 Axis Stabilized
- S4 Orion 38

**Minotaur IV+**
- 3 Axis Stabilized
- S4 Star 48V

**Minotaur V**
- 3 Axis Stabilized
- S4 Star 48V
- S5 Star 37FMV

**Minotaur V Spin Stabilized**
- S4 Star 48V
- S5 Star 37FM
- S6 Star 27
Responsive vs Low Cost Launch

- Will a Responsive Launch System actually provide Lower Cost Launch?
  - Responsive Launch will most likely be designed to support surge operations
  - Routine Training missions could provide today’s need for small launch vehicles, without any cost savings

- Will Demand for Small launch Vehicles increase in the near term?
  - Launch Rates won’t increase dramatically unless a new “killer app” is discovered
  - Reducing Launch Vehicle costs 50% wouldn’t significantly increase the number of launches
Improving Access to Space

- Revolutionary vs Evolutionary Launch Vehicle Development
  - Propulsion is only one part of the overall launch vehicle system
    - Propulsion alone is not the silver bullet to reduce cost
  - Today’s Systems need to be able to Evolve for tomorrow’s requirements

- Launch Vehicle Technology Demonstration Gap
  - Testing is extremely difficult, costly and not forgiving to any failure
  - Flying secondary experiments and having dedicated demonstration missions are critical
Minotaur Vehicle Evolution

Heritage
- MM II
- Pegasus
- Taurus

Integration
- Minotaur I
- Minotaur II

Payoffs
- OBV
- MT III/IV
- Raptor I

Demonstrated Technologies
- OO SW
- SIGI
- GPS/MT
- TDRSS

Technologies
- Large Fairing
- SoftRide
- MPA
- Low Cost CLA
**Technology Insertion Example**

**Space Integrated GPS INS (SIGI) Navigator**

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Demonstration</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>QRLV-1 TLV-1</td>
<td>QRLV-2</td>
<td>All Orbital LVs (TLV-4)</td>
</tr>
<tr>
<td>SIGI flew as a secondary experiment</td>
<td>SIGI flew as primary nav on low fidelity mission</td>
<td>SIGI is now a highly capable low risk navigator</td>
</tr>
</tbody>
</table>
Current Technology Demonstrations

- GPS Metric Tracking
- TDRSS (LCT2)
- SoftRide
- Multi Payload Adapters
- Large Fairing

Patented Design
Future Technologies

- **Rapid Safety Analysis**
  - Reduce the time and cost to understand and meet safety requirements
- **Automated Flight Software/GN&C**
  - Reduce the time and cost to build mission unique data
- **Automated Built in Test and GSE**
  - Reduce the time and manpower to check out the vehicle
- **Automated Coupled Loads Analysis**
  - Give Spacecraft a better tool to design with in order to survive their own environmental testing and then launch
Space Based Launch Range

- **Ku Band Low Cost TDRSS Transceiver**
  - Provides for full LV Telemetry Bandwidth
  - Antenna Development is Critical

- **Autonomous Flight Safety System (AFSS)**
Summary

- **How Do We Reduce Cost Now?**
  - Buy 3-5 Vehicles at once
  - Bring only your real requirements not desires

- **How Do We Provide Responsiveness Now?**
  - Don’t use responsiveness to cover poor planning
    - Close planning with the LV will always be required
    - Invest in key Long Lead hardware and analysis

- **How Do We Make Vehicles More Responsive in the Future?**
  - Demonstrate the technologies needed today
  - Set clear requirements for what they will need to do
    - Limit the problem

- **How Do We Make Vehicles Cheaper in the Future?**
  - We need a real market for Small LVs
  - Simplify/Clarify the requirements that they will have to meet
    - Primarily Range and Spacecraft Interfaces