Space Life Sciences Missions
In Next-Gen Suborbital Science

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Blue Origin
Virgin Galactic
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</table>
X-Prize Private Suborbital Flight Competition: 2004
X-Prize Private Suborbital Flight Competition: 2004
SpaceshipOne’s Successor: SpaceshipTwo: 2008
Spaceship Two Development: 2009

### Technical Information

**Launch Thrust: 8000 kN** - 14000 Newtons

**Max Altitude:**
- 30,000 ft / 9km
- 326,000 ft / 100km
- 361,000 ft / 110km
- 70,000 ft / 21.5km

**Mission Points:**
1. **Launch from Mothership to Mach 4.**
2. **326,000 ft / 100km:** Kármán Line; Passengers become astronauts.
3. **361,000 ft / 110km:** Maximum altitude. Wings feather after rocket burn.
4. **Re-entry initiated.**
5. **70,000 ft / 21.5km:** Wings de-feather for the glide home.

**Galactic**
Spaceship Two Development: 2009

Spaceship Two Begins Test Flights Early Next Year and Commercial Ops the following year.

Seat Prices for Early Commercial Ops are $200K.
And Virgin’s SpaceShip Has Some Competition: from Blue Origin
Blue Origin is an aerospace company building a suborbital vehicle for research and space tourism.

Blue Origin is based in Kent, Washington.
Blue Origin is developing *New Shepard* to routinely fly multiple astronauts into suborbital space at competitive prices.
Some New Shepard Capabilities

<table>
<thead>
<tr>
<th>Attribute</th>
<th>New Shepard Vehicle Capability</th>
</tr>
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<tbody>
<tr>
<td>Crew/Payload Capacity</td>
<td>3 or more astronauts and/or racks</td>
</tr>
<tr>
<td>Experiment Mass</td>
<td>120 kg per position</td>
</tr>
<tr>
<td>Windows</td>
<td>One per crew position</td>
</tr>
<tr>
<td>Power</td>
<td>28 VDC provided</td>
</tr>
<tr>
<td>In-Flight Communications</td>
<td>Recorded voice, &amp; low-data rate link for experiment TM/control</td>
</tr>
<tr>
<td>Data Recording</td>
<td>Post-flight download of trajectory measurements</td>
</tr>
<tr>
<td>Microgravity Levels</td>
<td>&lt;0.003 Gs in Coast</td>
</tr>
<tr>
<td>Pointing Accuracy</td>
<td>±5° per axis during coast</td>
</tr>
<tr>
<td>Turning Capability</td>
<td>Yes</td>
</tr>
</tbody>
</table>
And Virgin and Blue Origin have competition too.

From Newspace Companies Like:

- Armadillo Aerospace
- XCOR
- Masten Space Systems
All scientific, engineering, and other technical R&D activities applicable to commercial suborbital space flight vehicles.

And all education and public outreach activities applicable to commercial suborbital space flight vehicles.
Unique Features of Next-Gen Suborbital Research

- **Frequent Access to Space at Low Cost**
  - 10x the microgravity time of Zero-G aircraft, and 100x cleaner microgravity environment.
  - Direct access to the “ignorosphere.”
  - Hundreds to thousands of seats flown each year.
Fewer constraints on, and Gentler Rides for Payloads

- Fly off the shelf laboratory equipment.
- Fly researchers with their payloads.
- Fly larger payloads than can be flown inside Shuttle or ISS.
- Simple, fast safety/integration processes, Like zero-G aircraft instead of Shuttle/ISS.
Flexible Operations

- Worldwide launch basing.
- Ability to launch at specific times coincident with phenomenology, in synch with classes, in sync with circadian rhythms, etc.
- Rapid access to samples, test subjects, etc. post-flight
These Attributes Make the REM Market Rich With Applications

- In Life Sciences
- In Instrument Test & Demonstration
- In Atmospheric Science
- In Earth Science & Oceanography
- In Space Physics
- In Astronomy & Solar Physics
- In Microgravity R&D
- In Education, Training, & Public Outreach
Only relatively small numbers of tourists (hundreds) have paid $200K to fly.

But $200K is cheap for governments and industry space research programs.

There are over 190 nations on Earth, and virtually all can afford a rem program that spurs national pride, research, & education at $200K per flight. (Even Aruba can now have a human space flight program!)

Unlike tourists who buy 1 or 2 tickets, research programs buy dozens to hundreds, and then come back for more, year after year.

The estimated REM market over 5 years is many, many thousands of seats.
What traditional SLS research can be supplemented in a useful way with short observations?

What might suborbital vehicle owners and operators want to know about the effects of their vehicles?

Who else might be interested in this data?
What applications exist, given the 10x Longer Time constants over parabolic flights, E.g., for:

- Vestibular and sensori-motor responses
- Lung deposition of particulates
- Acute cellular responses
- Fertilization and early development

What applications Exist to Study Initial responses to micro-g exposure, for:

- Fluid shifts
- Motion sickness
- Pharmacokinetics
What research can be uniquely enabled by

- Multiple flights of the same individual
- Multiple flights of the same hardware
- Very high Population Ns
- Higher g exposure
- Upper atmospheric radiation exposure
- Large Cabin Volumes
- Ability to Fly Diverse Animal Models
What research can be uniquely enabled by?

- Young subjects
- Elderly subjects
- Subjects with a variety of health ailments
- Blind subjects
- Labrynthine-deficient subjects
- Quadriplegics
- Non-human primates
- Various Frequent Flyer Populations
What Apps Exist For:

- Operations training
- Procedures Development
  - Airway management
  - Diagnostic ultrasound
  - Emergency & invasive procedures
  - Disorientation recovery

What Apps Exist For:

- Access to g-transitions
- Ability to launch in sync with circadian rhythms, other time points
- Rapid access in- and post-flight
- Possible ability to manipulate cabin Temp, pressure, composition, etc.
Boulder, Colorado; 18–20 February 2010
Objectives:

- Educate 250+ researchers across 9 relevant REM fields;
- Demonstrate interest in REM to Government agencies, suborbital providers, press, & policy makers.

Organizing Institutions: SwRI, USRA, CSF

Venue: Boulder, CO; 18-20 Feb 2010

Format: 2.5 days, plenary overview & parallel technical sessions

Sponsors: SwRI, USRA, ULA, NASTAR,...
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<thead>
<tr>
<th>Day/Segment</th>
<th>Session (Proposed Chair)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/Morning</td>
<td>Opening Plenary (Stern &amp; Colwell)</td>
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<tr>
<td>1/Afternoon</td>
<td>Space Life Sciences (Wagner &amp; Shelhamer)</td>
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<tr>
<td>1/Afternoon</td>
<td>Space Grant REM Competition</td>
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<tr>
<td>1/Afternoon</td>
<td>Planetary and Astrophysical Science (Durda)</td>
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<tr>
<td>1/Evening</td>
<td>Evening Public Lecture (Durda)</td>
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<tr>
<td>2/Morning</td>
<td>Atmospheric Science (Summers)</td>
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<tr>
<td>2/Morning</td>
<td>Microgravity Physics (Collicott)</td>
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<tr>
<td>2/Morning</td>
<td>Technology Applications &amp; Payloads (Miles)</td>
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<tr>
<td>2/Afternoon</td>
<td>EPO (Grinspoon)</td>
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<tr>
<td>2/Afternoon</td>
<td>Miscellaneous/Other (Pojman)</td>
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<tr>
<td>2/Afternoon</td>
<td>Ionosphere/Aurora (Englert)</td>
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<tr>
<td>3/Morning</td>
<td>Closing Plenary (Sirangelo)</td>
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SRC Meeting Milestones

- First announcement posted: Sep 2009
- Abstract deadline: Nov 2009
- Abstracts to program committee: Nov 2009
- Final text & session assignments due: Dec 2009
- Final announcement posted: Dec 2009
- Pre-registration deadline: Jan 2010

http://www.lpi.usra.edu/meetings/nsrc2010/