# Overview

26 May 2009

# 4 Minutes of Microgravity

- Sensing
- Climaterics
- Vertical Atmospheric Sampling
- Gene Expression
- Fluids
- Physiology
- Emergency Procedures
- Countermeasures
- Cardiovascular Deconditioning
- Workforce Development
- Resistive Exercise Devices
- Inner Ear Neural Signal
- Dust Particle Agglomeration
- Metal Alloy Phase Separation
- Glovebox Investigations
- Combustion
- IR and NIR Optics
- Technology Testing
- STEM Education

# 4 Minutes of Microgravity

QuickTime™ and a
decompressor
are needed to see this picture.

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**Testing**

**Emergency Procedures**

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**1-G**

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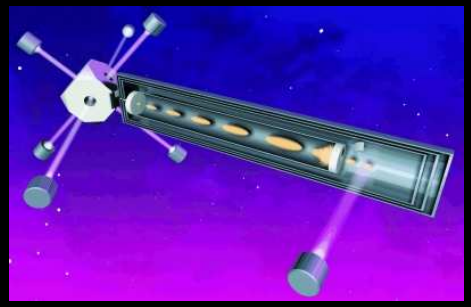
decompressor
are needed to see this picture.

**Technology Development**

**Science**

# NASA's Human Suborbital Flight Program

## Research Opportunities*



- Earth System Science
- Human Physiology
- Biotech
- Fundamental Physics
- Helioscience
- Astrobiology
- Materials Science
- Observational Science
- Technology Demonstrations
- Accretion, gene expression, enzyme activity, whole organism response to µg, atmospheric vertical sampling, fluid mechanics, small body observations, muscle cell culture matrixing (MCCM), personal resistive training devices, alloy multiphase separation, particle agglomeration, basic physics, student programs…

* Some of the areas suggested by the science community through formal and informal interaction, including RFI's, workshops, invited talks, meetings and conversations.

# NASA's Human Suborbital Flight Program

## Research Opportunities

- Earth System Science
  - Direct atmospheric sampling at high altitudes on regular, responsive, frequent, and global basis

- Fundamental Physics
  - Particle agglomeration
  - Fluid dynamics
- Helioscience
  - Observe solar storms

# NASA's Human Suborbital Flight Program

## Research Opportunities

- Biotech
  - Interest from medical and other commercial bioproduct development entities
  - First opportunity to document genomic precursors that initiate the unique biology seen in microgravity

- Human Physiology
  - Gather human physiological response data to µg and transitions from various g loads during ascent and descent
  - Determine effects on a broader (and predictably less fit) talent pool
  - Study effect of radiation on human physiology
  - Study pulmonary response to lunar dust

# NASA's Human Suborbital Flight Program

## Research Opportunities

- Astrobiology
  - Evidence exists that both microbes and DNA survive at the edges of space
  - Potentially relevant to research on climate change, origin of life, and search for extraterrestrial life
- Materials science
  - Observe how complex multi-phase systems or multi-metal alloys behave differently in µg
  - Commercial applications
- Observational Science
  - Opportunistic astronomical observation
- Technology Development and Testing

# NASA's Human Suborbital Flight Program

## Features

- Non-astronaut investigators conduct their own hands-on research (passenger cost estimated at $200K for the ride based on advertised figure by Virgin Galactic) as well as autonomous studies (launch cost estimated at $50K-$100K based on advertised estimate by XCOR, SpaceX).
- Access to unique regions of the atmosphere for Earth Sciences and Astrobiology
- Access to nominal 3-4 minutes of microgravity for laboratory sciences especially biosciences and materials sciences
- Ability to test and demonstrate technologies in flight environment can move innovation through the "Valley of Death" (TRL 4-7) and lower the risk for incorporation into new missions.
- Recovery of payload
- Frequent flights allow iteration and learning
- Class D hardware

## Human Suborbital Flight Program

# Platform Comparisons

| | Sounding Rockets | Commercial Suborbital | Parabolic Flights |
|---|---|---|---|
| **Cost** | $0.5 M - $1.2M | $200K | $8K |
| **Time in Microgravity (Continuous)** | 20 minutes | 4 minutes | 23 seconds |
| **Quality of Microgravity** | High | High | Comparatively Low |
| **Launch Frequency** | Once every 6 months | Multiple flights per day possible | Multiple flights per day possible |
| **Maximum g-Loading** | 20 g | 2 Š 4 g | 2 Š 4 g |
| **Human Tended Science** | No | Yes | Yes |

Comparing commercial suborbital research platforms with two other microgravity research platforms

## Human Suborbital Flight Program

# Platform Comparisons

| PLATFORM | Drop Towers | Sounding Rocket | High Alt. Balloon | KC 135 | Suborbital Commercial |
|---|---|---|---|---|---|
| T/µg | 5-10sec. | 20 min. | ø | 23 sec. | 4 min. |
| Robotic/ Hands on | Robotic only | Robotic only | Robotic only | Hands-on and robotic | Hands-on and robotic |
| Mass | 455 kg | required | 500-1000 kg | option | 20-100kg |
| Volume | 1 x 1.6 m | required | 900-1000 kg | option | option |
| Altitude | 150 m | 50 km-1500 km | 45-50 km | 35 k ft | 325 k ft |
| Cost | Variable | $.5-1.2M | ?? | $100k | $50K-$200k |
| Duration | 12 sec. | 25min. | 20-25 hr. | Hr. | 20 min. |
| g experienced | 35-65 g | 20 g | 1-1.5 g | 2-4 g | 2-4 g |
| Payload recovery | option | option | option | Yes | Yes |
| Frequency/ Opportunity | 1/mo. | 1/ 6mo. | option | Yes | 1/week |
| Science options | Primarily Preliminary tests | Re-entry technologies/ robust payloads | Atmospheric tests | Ultra short duration µg | Wide variety of options |

# NASA's Human Suborbital Flight Program

## Challenges

- New territory in regulatory and liability policy
  - Determine appropriate regulatory environment
  - Determine appropriate liability environment
  - Determine NASA processes for determining safety approvals when NASA provided people will fly
- Providers are not available now
  - Chicken and egg problem for platforms and payloads
  - Many research areas require accommodation (external mounts, air sampling, optical windows, launch on demand, etc.)
  - Costs are projections only and depend critically on leveraging an unproven commercial market (not unlike ELVs)
- Different NASA users have different "business models" for selecting science investigations

# NASA's Human Suborbital Flight Program

## Benefits

- Through a user-focused program, NASA-sponsored researchers, engineers, technologists and educators would be able to conduct hands-on activities in near-space for the first time.
- This new environment provides several technical benefits to NASA
  - Reducing the risk for use of new technologies in future missions
  - Exploring novel environments to make new discoveries
  - Access to 3-4 minutes of microgravity for discovery and testing
  - Routine recovery of payload
  - Frequent flights
- Provides new options for career development and public engagement
  - Inspiring new careers in aerospace,
  - Training the workforce of the future,
  - Providing a competitive edge for the new commercial space industry
  - Creating greater excitement in the space program
- Provides a competitive edge for U.S. commercial space industry