Commercial Suborbital Science Program Workshop

Results

December 2008

Sponsored by NASA and USRA (Universities Space Research Association)

Emerging Commercial Suborbital Science

- Suborbital vehicles under development by emerging commercial companies offer new potential capabilities:
  - High flight rates, with rapid-turnaround and fly-on-demand
  - Lower cost than many existing research methods
  - Research fields include: earth science, heliophysics, planetary sciences, astronomy, microgravity physical sciences, life sciences, aeromedical, and aeronautics
  - Support for both unmanned payloads and human-tended experiments
  - Affordable platform for risk reduction, flight qualification, and raising hardware TRLs
  - Hands-on experience for students and postdocs to build and fly low-cost experiments

- Initial test flights expected in 2010 timeframe

Workshop Objectives

- Two-way conversation between vehicle developers and scientists:
  - **Scientists:** what unique science do these vehicles enable?
  - **Vehicle developers:** how can we best tailor our spacecraft and ground processes to meet scientific needs?
- Workshop in Dec 2008, San Francisco
  - Held in conjunction with American Geophysical Union AGU Fall Meeting
  - Focus on earth science, heliophysics, and planetary sciences

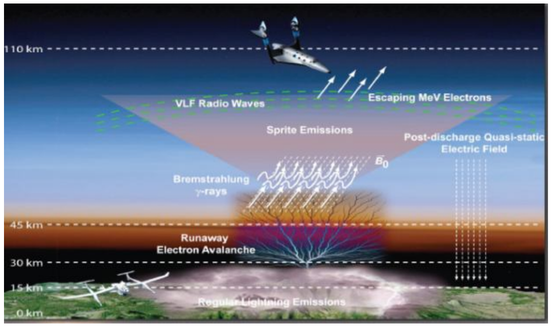
Workshop Program (December 2008)

- **NASA Ames Center Director Pete Worden**
- **Commercial Suborbital Science Program Manager Col. Yvonne Cagle, MD**
- **Service providers**
  - Armadillo Aerospace, Blue Origin, Masten Space Systems, XCOR Aerospace, Virgin Galactic
- **Scientists and End Users**
  - Josh Colwell, Univ. Central Florida
  - Steven Collicott, Purdue Univ.
  - Joe Hill, USRA
  - Doug Rowland, GSFC
  - Craig DeForest, SWRI
- **Breakout Sessions**
  - Two 45-minute breakout sessions
  - Brainstorming in small groups

Earth Science

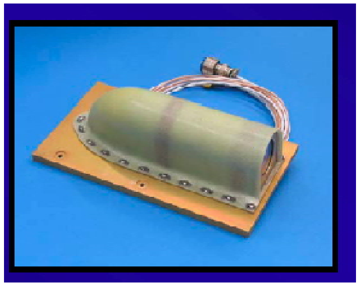
Atmospheric research (turbopause, lower thermosphere)

- **<u>Scientific Questions</u>**
  - What is the impact of chemical transport at the turbopause (95 km) on neutral and ionized species higher up in the lower thermosphere?
  - What is the interplay of dynamic instabilities and turbulent structures at altitudes where uniform atmospheric mixing breaks down?
  - What role do atmospheric gravity waves have in chemical and momentum transport?
- **<u>Why Commercial Suborbital?</u>**
  - Prior in-situ investigations were TOMEX, Coqui Dos, and ETON: Middle Atmosphere is dynamically complicated and models do a poor job of predicting density in this region.
  - Middle Atmosphere climatology difficult to construct based on experiments that occur once every few years.
- **<u>Proposed Approaches</u>**
  - Based on a monolithic Spatial Heterodyne Spectrometer (SHS) – gimbal mounted
  - Sample emissions with high sensitivity, unconstrained data rates, & with frequent opportunities
  - Chemical release: Trimethyl Aluminum (TMA) long used to track winds & turbulence
  - Rocket pod: Sufficient Volume for Spectroscopy (Optical & Mass) & Chemical Release Subsystem

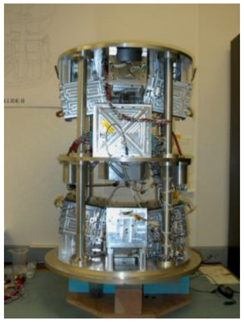


Terrestrial Gamma-ray Flashes (TGFs) – discovered in 1994

- **<u>Scientific Questions:</u>**
  - How can such large numbers of electrons be produced in such a short duration?
  - What are ambient conditions when this occurs?
- **<u>Why Commercial Suborbital?</u>**
  - **M**id-altitude measurements not usually obtainable on SR or Balloon, Altitude profiles available for the first time. Additional features include: frequent measurements; on demand; tailored launch window and flight plan; hand-pick storms.
  - Large payload to low altitudes means 1000x higher fluxes
- **<u>Proposed Approaches</u>**
  - Mass <100 kg, Power ~30 W, Volume: 50x50x30 cm3, 1m for antenna
  - Data: 10 Mbits/sec (recording everything)
  - Accommodation for VLF/HF antenna

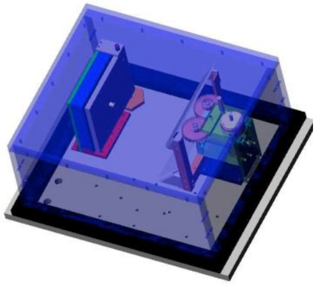


Planetary Science



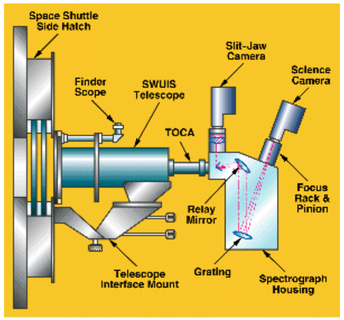
Dust aggregation and condensation in early planetesimals

- **<u>Scientific Questions</u>**: Vary parameters to simulate early solar system aggregation and condensation:
  - Collisions between aggregates
  - Collisions between monomers and aggregates
  - Collisions in presence of low pressure gas flow in microgravity
  - Understand scaling with size
  - Understand scaling with particulate shapes and composition
  - Note: Dynamically cold analogs of the Early Solar System can be found in planetary rings



- **<u>Why Commercial Suborbital?</u>**
  - Microgravity is needed to study this effect because interparticle gravitational forces are negligible, collision speeds are low (10-3 - 10 m/s), looking at formation and disruption of aggregates bound by weak surface forces, very low speed ejecta (less than collision speeds)
  - Airplane parabolas only open part of the parameter space (limited time, large residual accelerations). Parameter space has many dimensions in which results can vary qualitatively.
  - So far threshold only identified for one impactor size and target type. Small ejecta velocities may limit erosion in the protoplanetary disk even in impacts above the threshhold velocity.
- **<u>Proposed Approaches</u>**
  - Device for measuring dust particle ejecta velocities (see images). Low velocity impact experiments into granular material in microgravity conditions.
  - Frequent experiments allow for variation of parameters (see list above)

Heliophysics



UV-compatible optics for heliophysics research

- **<u>Science Questions:</u>**
  - Part A: high frequency waves in the solar chromosphere (10 second period; not observable from the ground due to atmospheric seeing)
  - **Part B:** Doppler shift and rapid dynamics in the solar chromosphere
  - **Part C:** Stereoscopic spectral imaging of the chromosphere (novel spectral technique for extremely high sensitivity to Doppler shift), Detection of UV flashes near umbral dots in sunspots, (with external mount): C IV 155 nm spectral imaging
- **<u>Why Commercial Suborbital?</u>**
  - Similar project has already flown on Space Shuttle; but human-in-the-loop flight opportunities on Shuttle will soon be gone. Shuttle lead times are much higher also.
- **<u>Proposed approaches:</u>**
  - **Overall telescope**
    - Pointed medium-resolution (1-2 arcsec telescope) with one or two stage solar pointing system
    - Long-term mission: proof of new instrument concepts in a seeing-free, UV-accessible environment
  - **Proof of concept flight (part A)**
    - Technical goal: demonstrate UV imaging from the platform
    - Observation: line-wing images of the solar chromosphere in red wing of the Calcium K line (393.7) (0.1 nm passband)
    - Filtergraph imager only - use a Barr high-density interference filter.
    - Can be ready in six months.
  - **Major milestone flight (part B)**
    - Observation: extremely narrowband, scanned filtergraph images in Ca K (393.2 - 393.6 nm; 0.01 nm passband)
    - Method: active pointing with SWOT telescope and limb sensor; rapid spectral scanning with a rocking etalon
    - Ready ~1 year after proof-of-concept flight
  - **Possible future extension missions (part C)**
    - Raising TRL to enable new detectors on orbital missions
    - Your mission here: design an optics add-on module and use the stabilized solar beam.

Additional Enabled Activities

Why Commercial Suborbital?: Take advantage of low cost, rapid turnaround, and frequent flight rate features, as well as exciting, high-profile nature of flights

Goals and Approaches:

- Technology test and risk reduction
  - Low cost flight qualification
  - Iterative approach to experiment design
  - Example: Collicott from Purdue: “[Fluids] experiments and computations to support design of operations for the 2500 liter liquid-He Dewar in Gravity Probe–B satellite.”
- Public visibility for low-cost science
  - Leverage private sector outreach expertise
  - Flights will occur from spaceports across the United States
  - High frequency, rapid turnaround is well suited for public visibility
- Education and Outreach
  - Student-built experiments
  - Participatory activities, streaming video
  - Hands-on training opportunities for small experiment hardware
  - Select teachers for participation