CubeSats / Small Sats 2

Lessons learned from National Science Foundation Ideas Lab on Cutting-edge CubeSat Technology

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Outline

- Heliophysyics and Space Weather
- CubeSat Constellation/Swarms for Science
  - Multipoint measurements
  - Global coverage
- NSF Ideas Lab: Thinking out of the Box
  - Innovative mission concept
- Benefits to the space physics community
Heliophysics Science

- Study of the effects of the Sun on the solar system
- Earth’s magnetosphere/plasmasphere
- Earth’s ionosphere/thermosphere

Space weather

- Energetic particles
- Damages to spacecraft electronics
- GPS signal scintillation
- Loss of communication and navigation
- Power grid
From NASA website
Constellation (Global Coverage)

- **Multi-point measurements**
  - Remove spatial-temporal ambiguity

- **In-situ measurements** of plasma density, temperature, drift, electric field, magnetic field

- **Remote-sensing measurements**
  - Indirect measurements
  - Integrated quantities
  - Tomographic reconstruction
  - Total electron content (TEC) from GPS phase delays from two frequencies
    \[
    \text{TEC} \propto \int N(z)dz
    \]
  - Volume emission rate (VER) from upper atmospheric emissions at different bands (such as Oxygen 1356 A)
    \[
    \text{VER} \propto \int N^2(z)dz
    \]
NSF Ideas Lab: Cross-cutting Initiative in CubeSat Innovations

- Constellation of 10 to 100 spacecraft to enable critical measurements for space science and space weather
  - Science, Miniaturized instrument technology
  - Communication, Propulsion, Power systems, Guidance and Control
  - Systems engineering
- One-week workshop
- Experts from various disciplines
- Various activities (teaming up)
- WBGI: “Would Be Great If … ”
Thermosphere Electrodynamic Testbed using Reconfigurable Intelligent Swarm (TETRIS)

- Total of seven WBGIs presented at the end
- Four concepts invited to submit full proposals
- WBGI: S/C could go down to 100 km and come back

Science questions:
- What is the driving mechanism for the observed global decline in the lower thermosphere density?
- What is the role of lower thermosphere density gradients and equatorial electrojets in formation of plasma instabilities?
Lessons Learned

- CubeSats as low-cost missions are excellent platforms for
  - Implementing high-impact/innovative concepts
  - Increase TRL level of instruments
  - Partnering with different institutions (universities, research institutes, industry, etc..)

- Hands-on training opportunities for students and early-career professionals to develop:
  - Leadership
  - Scientific
  - Engineering
  - Project management skills

- Recognized by NASA Science Mission Directorate (National address by Dr. Thomas Zurbuchen)