The Application of Small Satellites in Research and Teaching

Charles M Swenson -- Utah State University

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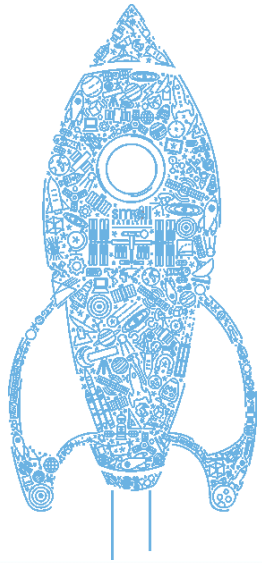
United Nations/Brazil Symposium on Basic Space Technology
"Creating Novel Opportunities with Small Satellite Space Missions"

September 11, 2018 Natal, Brazil

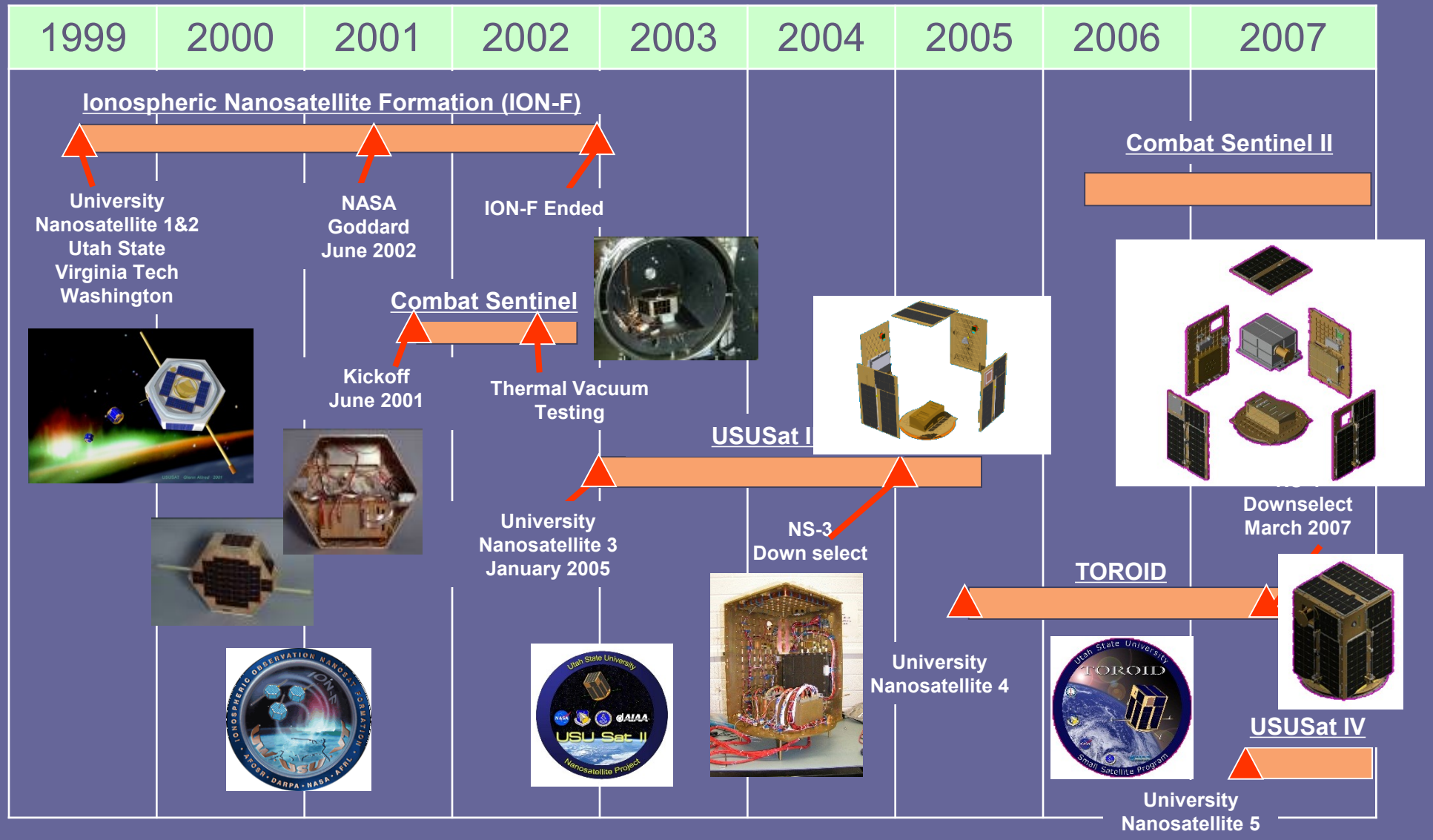
Charles Swenson

- **Professor Utah State University since 1991**
- **Sabbaticals**
  - 2000 to 2001 Aerospace Corporation
  - 2007 to 2008 NASA HQ SMD
  - 2016 to 2017 Aerospace Corporation
- **Research Motivation**
  - "How do we get the simultaneous measurements at multiple locations in the space environment that are needed to understand the physics of the Earth's upper atmosphere?"
  - Plasma and optical instrumentation techniques for space weather
  - Small satellites, CubeSats, and constellations
  - Spacecraft subsystems (systems level)

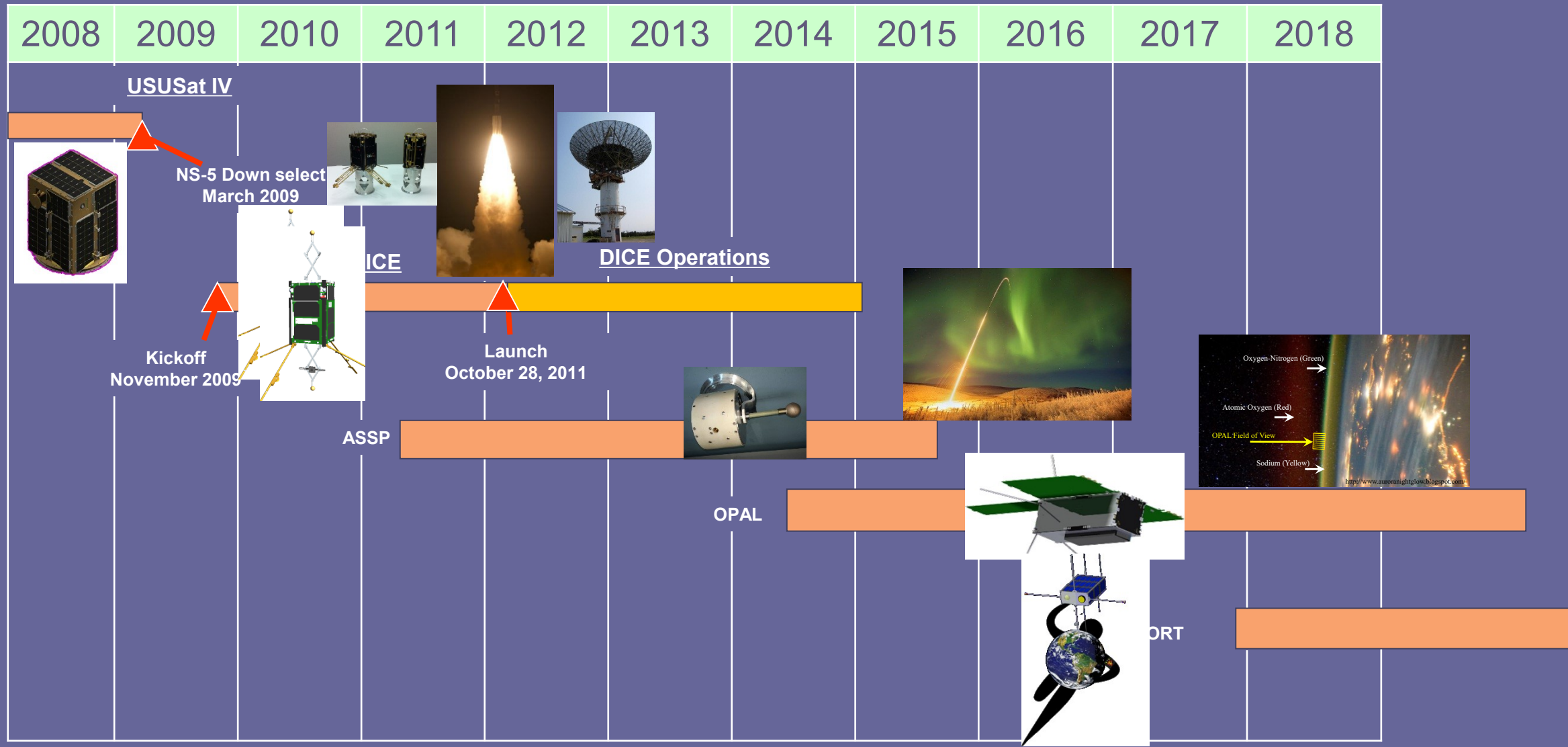
Small Satellite Conference
Associate Chairmain



USU Nanosatellite Programs



USU Nanosatellite Programs



What have I learned with time?

1) It takes a whole team of people to accomplish a space mission.

2) Students are best taught in “real” projects.

3) A single purpose is essential for every space mission.

Brief History of the USU SmallSat Conference

https://www.smallsat.org/

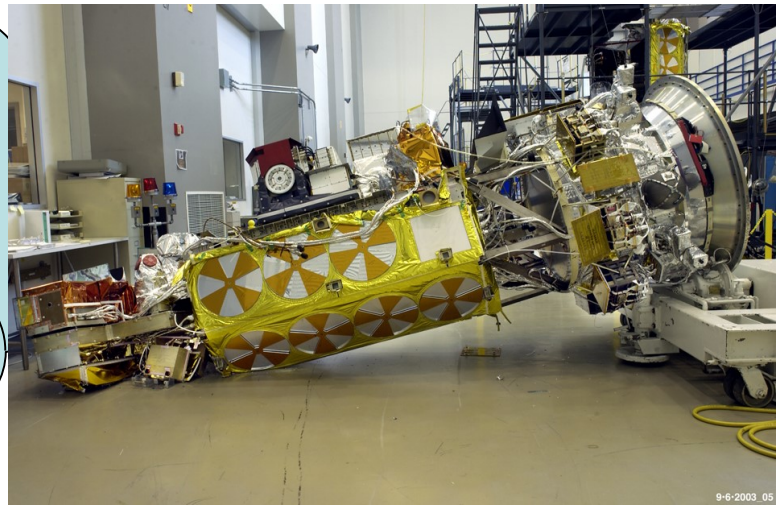
http://digitalcommons.usu.edu/smallsat/

Started in 1986 (33rd year)

The Concept of the Big Satellite BUS

money by putting lots of payloads on the same bus?

Alphabus, ESA

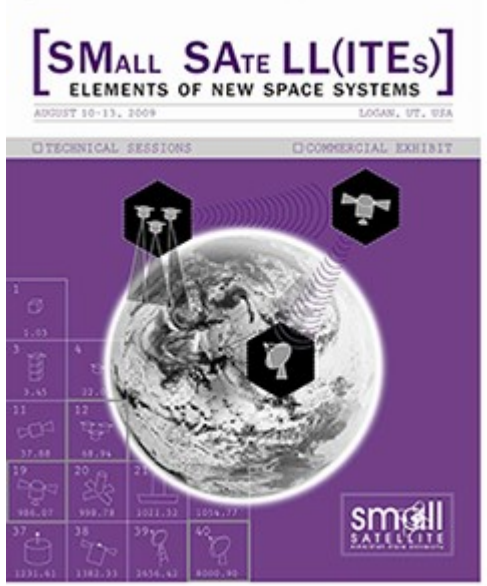


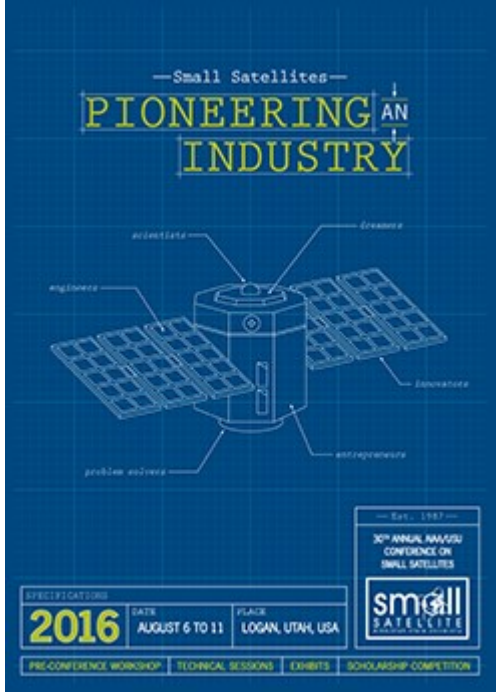
The Motivation For the Small Satellite Community

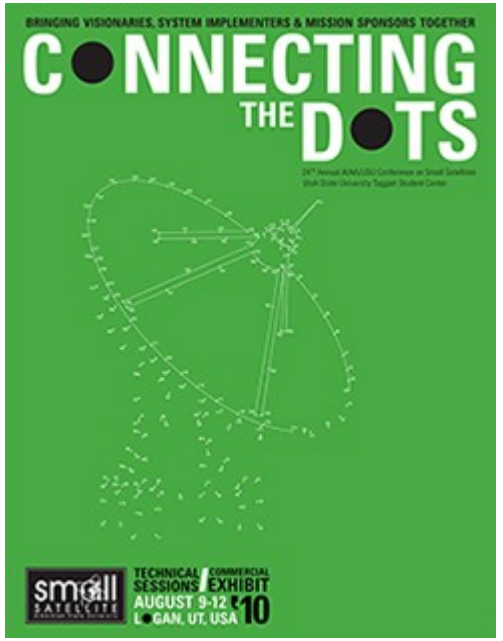
- **Satellites were becoming bigger and more complex**
  - Multiple payloads and multiple purposes
  - Costs were increasing
  - The ability to build such satellites was concentrated in a few organizations
  - Time between launches was increasing.
  - Young people felt shut out of a careers in space.

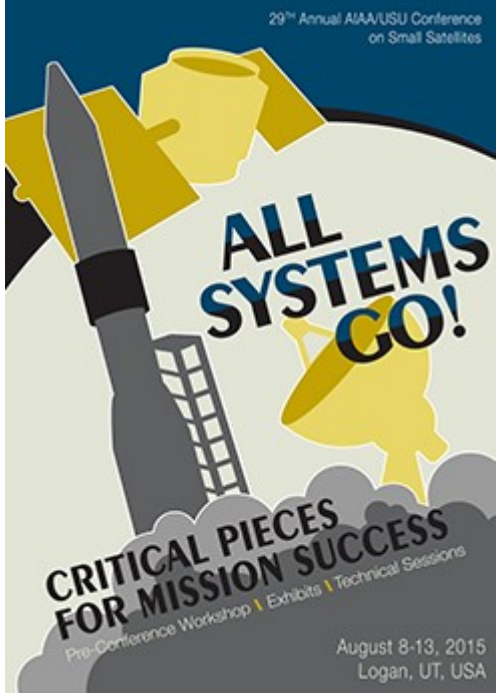
- **There has to be a better way!**

- **1986 the small satellite conference organized to promote smaller less complex satellites. ~50 people attended.**
  - Dr. Frank Redd.


[SMALL SATELL(ITES)]
ELEMENTS OF NEW SPACE SYSTEMS
AUGUST 10-13, 2009
LOGAN, UT, USA
TECHNICAL SESSIONS
COMMERCIAL EXHIBIT
small SATELLITE


Small Satellites
PIONEERING AN INDUSTRY
2016
DATE AUGUST 6 TO 11
PLACE LOGAN, UTAH, USA
small SATELLITE
PRE-CONFERENCE WORKSHOP
TECHNICAL SESSIONS
EXHIBITS
SCHOLARSHIP COMPETITION


BRINGING VISIONARIES, SYSTEM IMPLEMENTERS & MISSION SPONSORS TOGETHER
CONNECTING THE DOTS
small SATELLITE
TECHNICAL SESSIONS
COMMERCIAL EXHIBIT
AUGUST 9-12
LOGAN, UT, USA

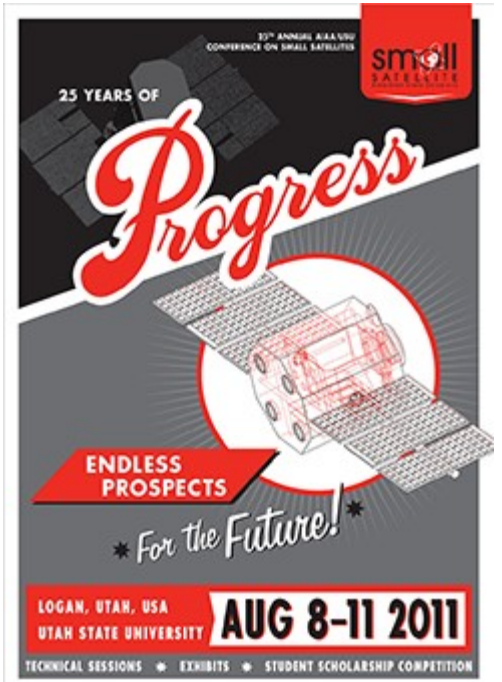

29th Annual AIAA/USU Conference on Small Satellites
ALL SYSTEMS GO!
CRITICAL PIECES FOR MISSION SUCCESS
Pre-Conference Workshop | Exhibits | Technical Sessions
August 8-13, 2015
Logan, UT, USA


small SATELLITE
IT'S THE MISSION THAT MATTERS
TECHNICAL SESSIONS • COMMERCIAL EXHIBIT

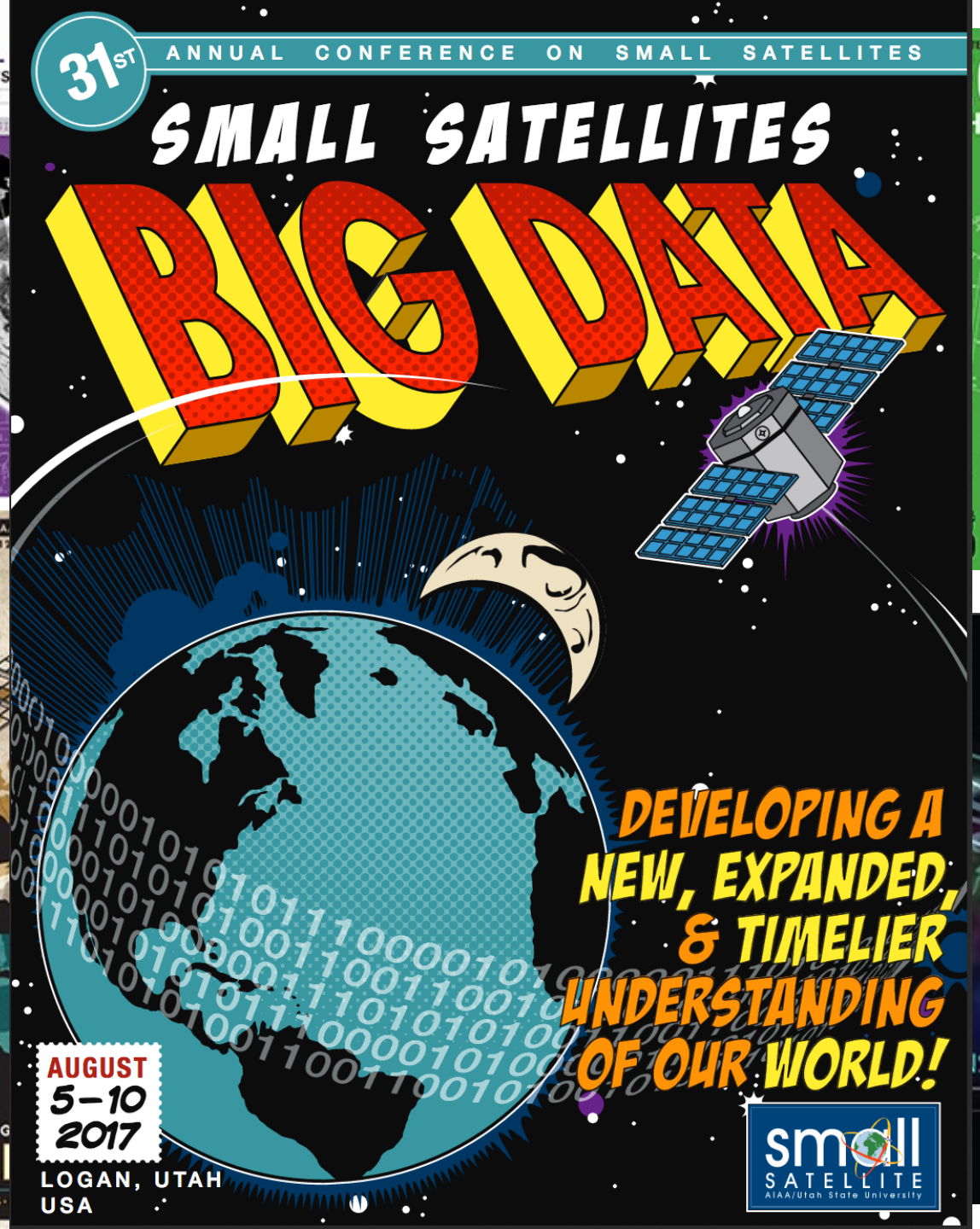

26TH ANNUAL AIAA/USU CONFERENCE ON SMALL SATELLITES
AUGUST 13-16, 2012 • LOGAN, UT, USA • UTAH STATE UNIVERSITY
ENHANCING GLOBAL AWARENESS THROUGH
SMALL SATELLITES
TECHNICAL SESSIONS • EXHIBITS • STUDENT SCHOLARSHIP COMPETITION

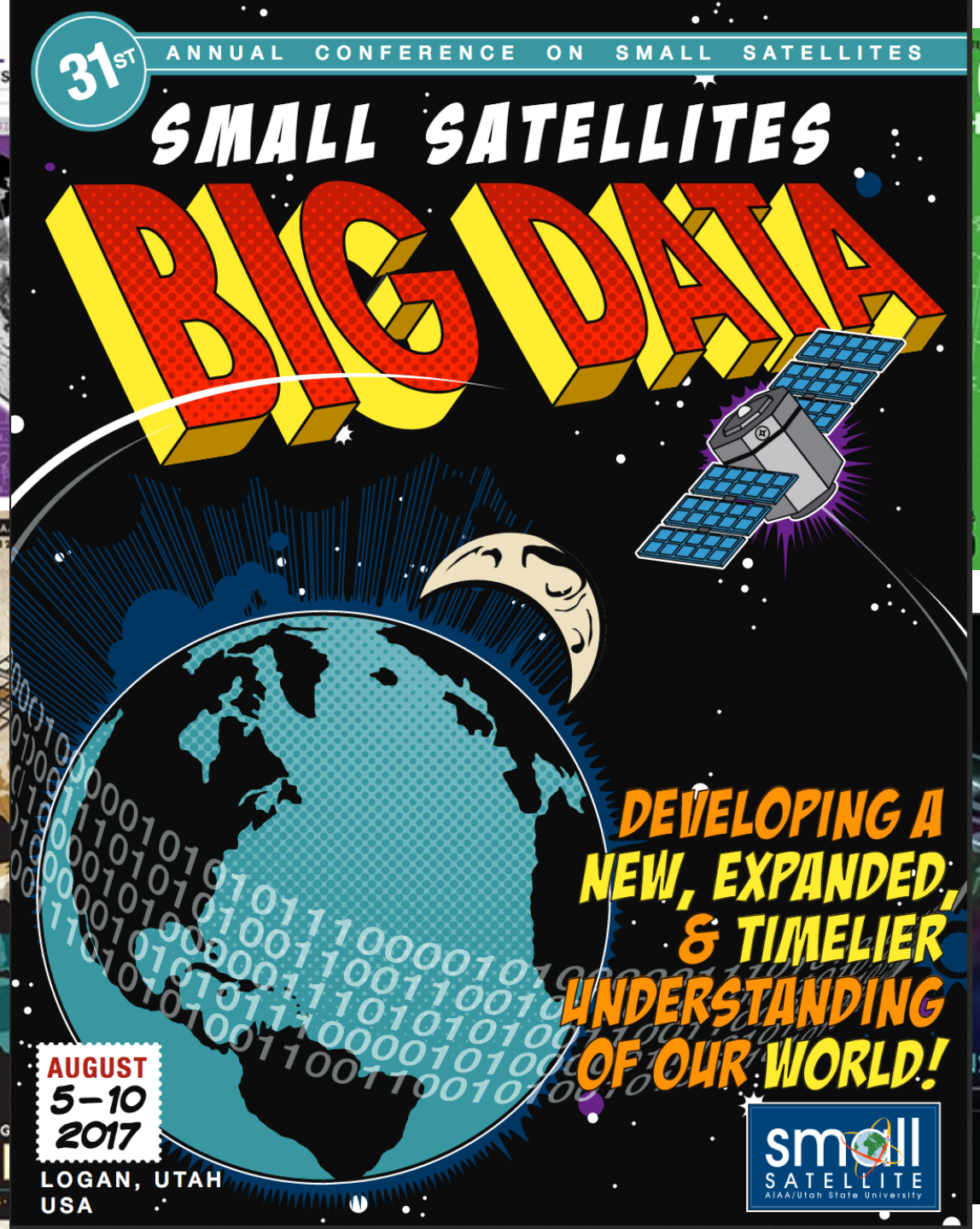

$$$
THE COMMERCE OF $MALL $ATELLITE$
AUG 2-7
2014
LOGAN
UT, USA
small SATELLITE


SMALL SATELLITE CONSTELLATIONS
STRENGTH IN NUMBERS
small SATELLITE


small SATELLITE
25 YEARS OF
Progress
ENDLESS PROSPECTS
For the Future!
LOGAN, UTAH, USA
UTAH STATE UNIVERSITY
AUG 8-11 2011
TECHNICAL SESSIONS • EXHIBITS • STUDENT SCHOLARSHIP COMPETITION


SMALL SATELLITES
BIG BUSINESS
small SATELLITE
TECHNICAL SESSIONS • COMMERCIAL EXHIBIT


31ST
ANNUAL CONFERENCE ON SMALL SATELLITES
SMALL SATELLITES
BIG DATA
DEVELOPING A NEW, EXPANDED, & TIMELIER UNDERSTANDING OF OUR WORLD!
AUGUST 5–10 2017
LOGAN, UTAH USA
small SATELLITE
AIAA/Utah State University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small SATELLITE
AIAA/Utah State University

Small Satellite Conference

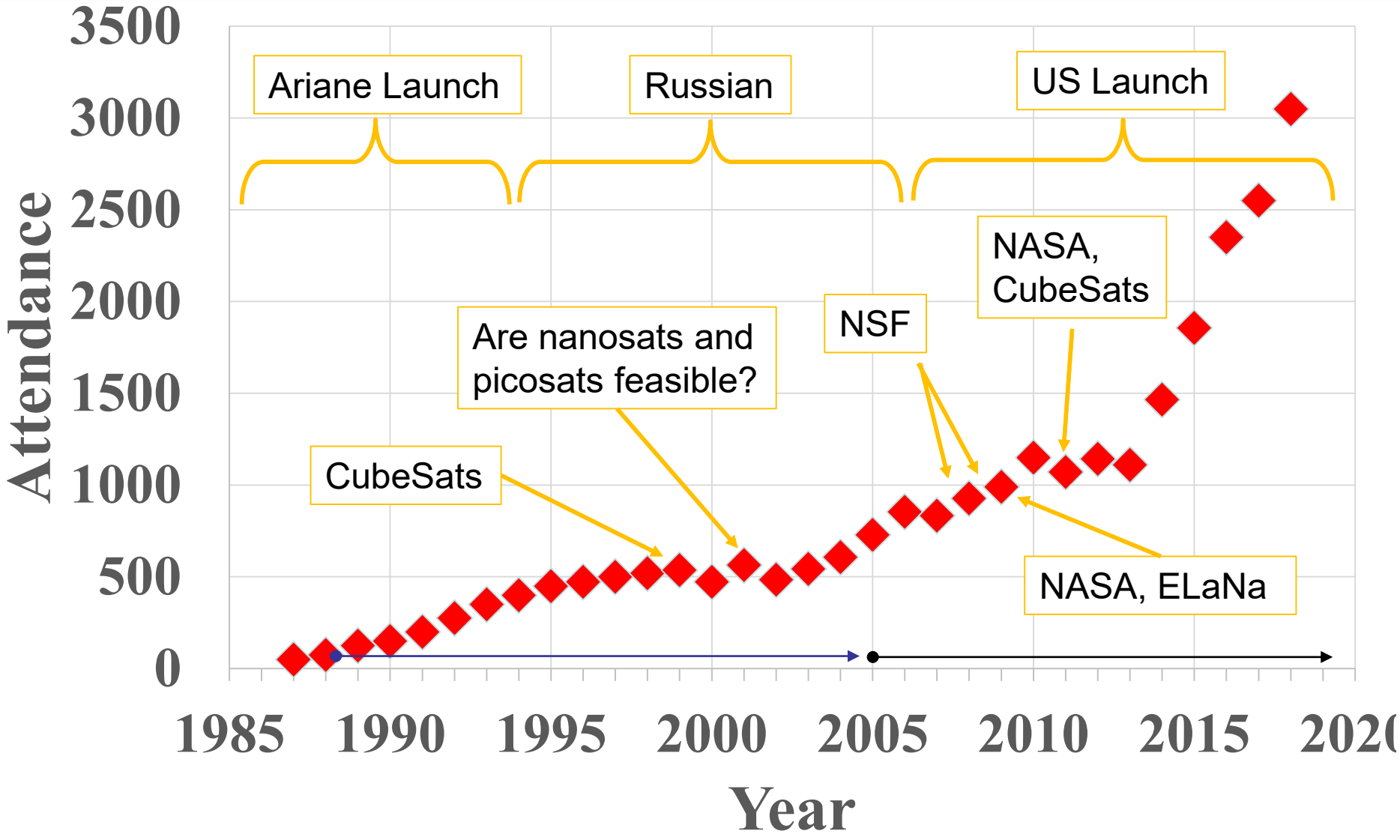
Small Satellite 2016

- 2300 total head count
- 680 organizations
- 140 exhibiting organizations
- 286 Students
- 40 countries represented

Small Satellite 2018

- 3050 total head count
- 900 organizations
- 206 exhibiting organizations
- 313 Students
- 42 countries represented

USU Small Satellite Conference



ARIANE UTILIZATION FOR SECONDARY PAYLOADS

- **BY G.G. Rei baldi etal, SmallSat 1988**
- **ABSTRACT**
  In preparing for the future, the European Space Agency (ESA) has identified a growing shortage of flight opportunities for secondary payloads. This was most directly felt in the execution of the In-Orbit Technology Demonstration Program (TOP), which is aimed at the demonstration of new technologies in orbit, before their application in projects, thereby reducing the overall risk.

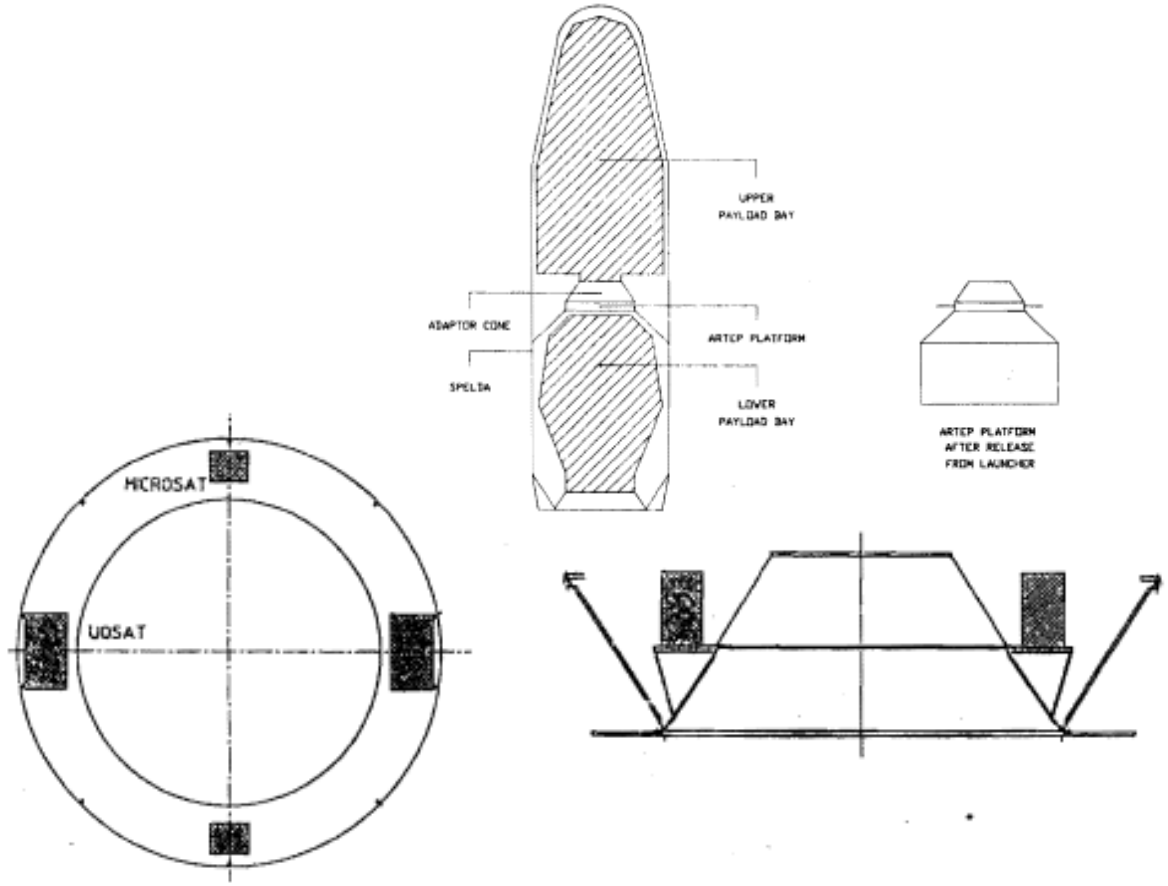
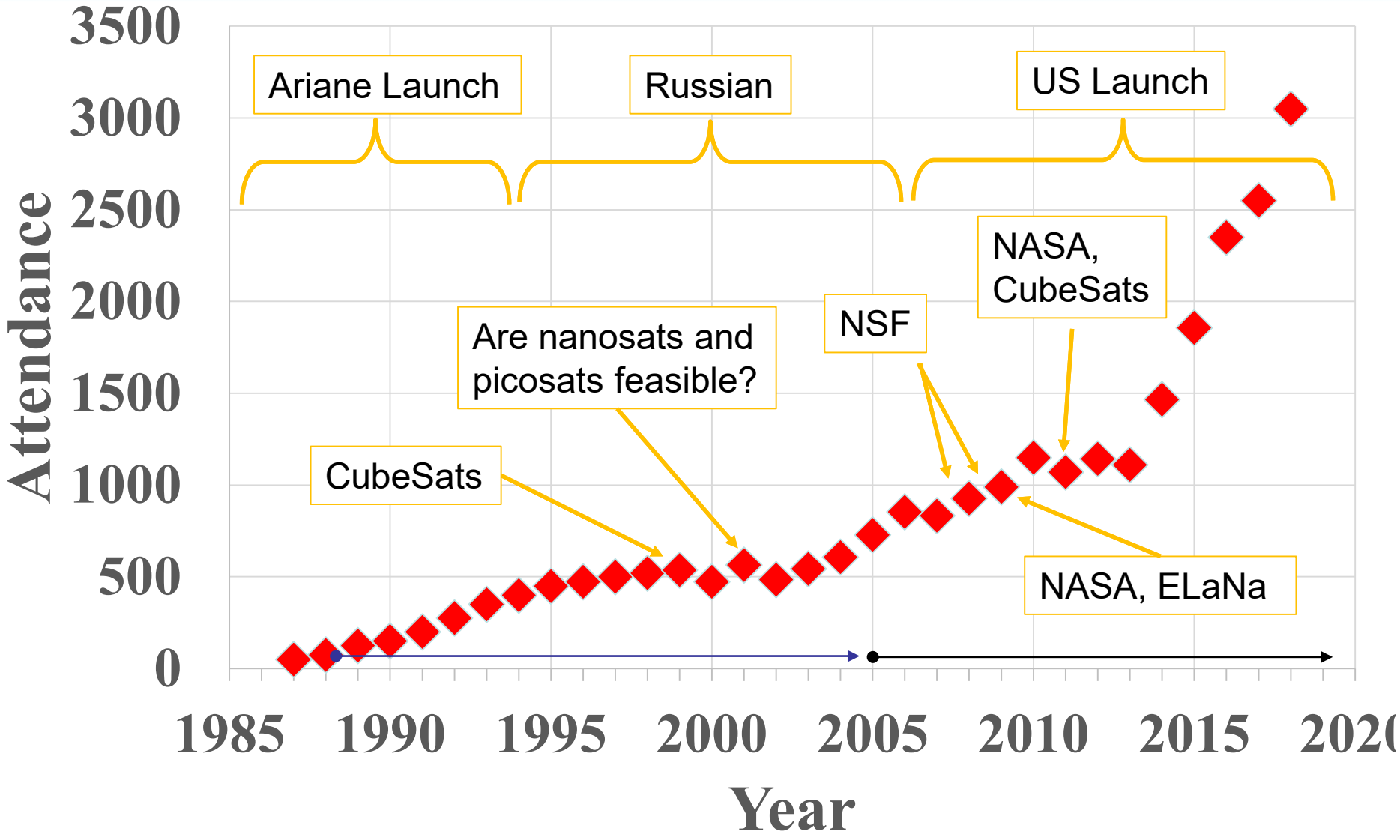


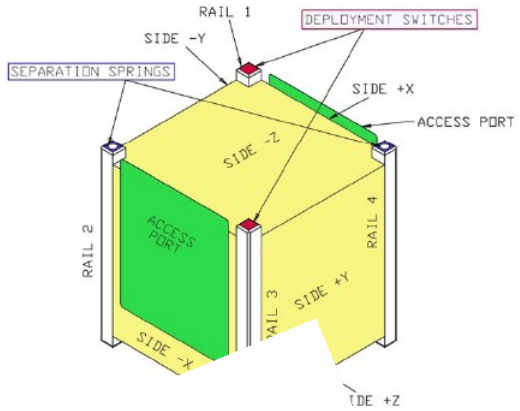
Figure 5 ARIANE Secondary Payload Adapter (ASAP) Mechanical Concept

USU Small Satellite Conference

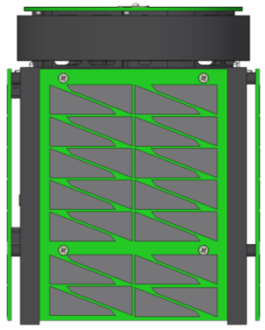


“CubeSat”

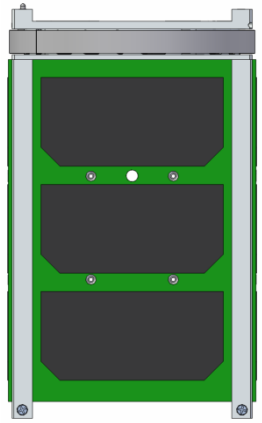
- **Proposed in 1999 by Professor Twiggs, Stanford**



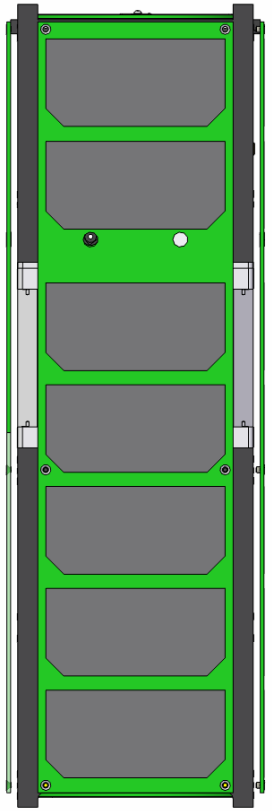
1-U

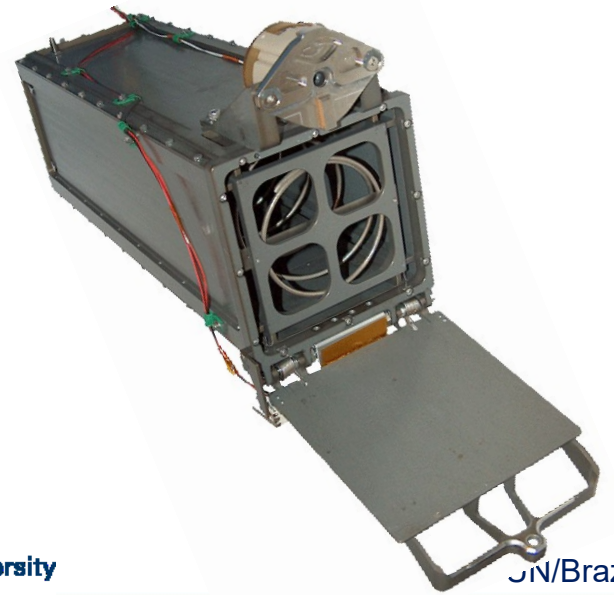


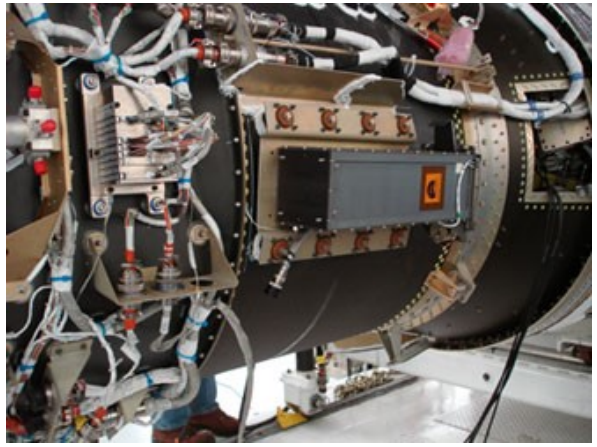
1.5-U



3-U







Cubesats: Change of mindset

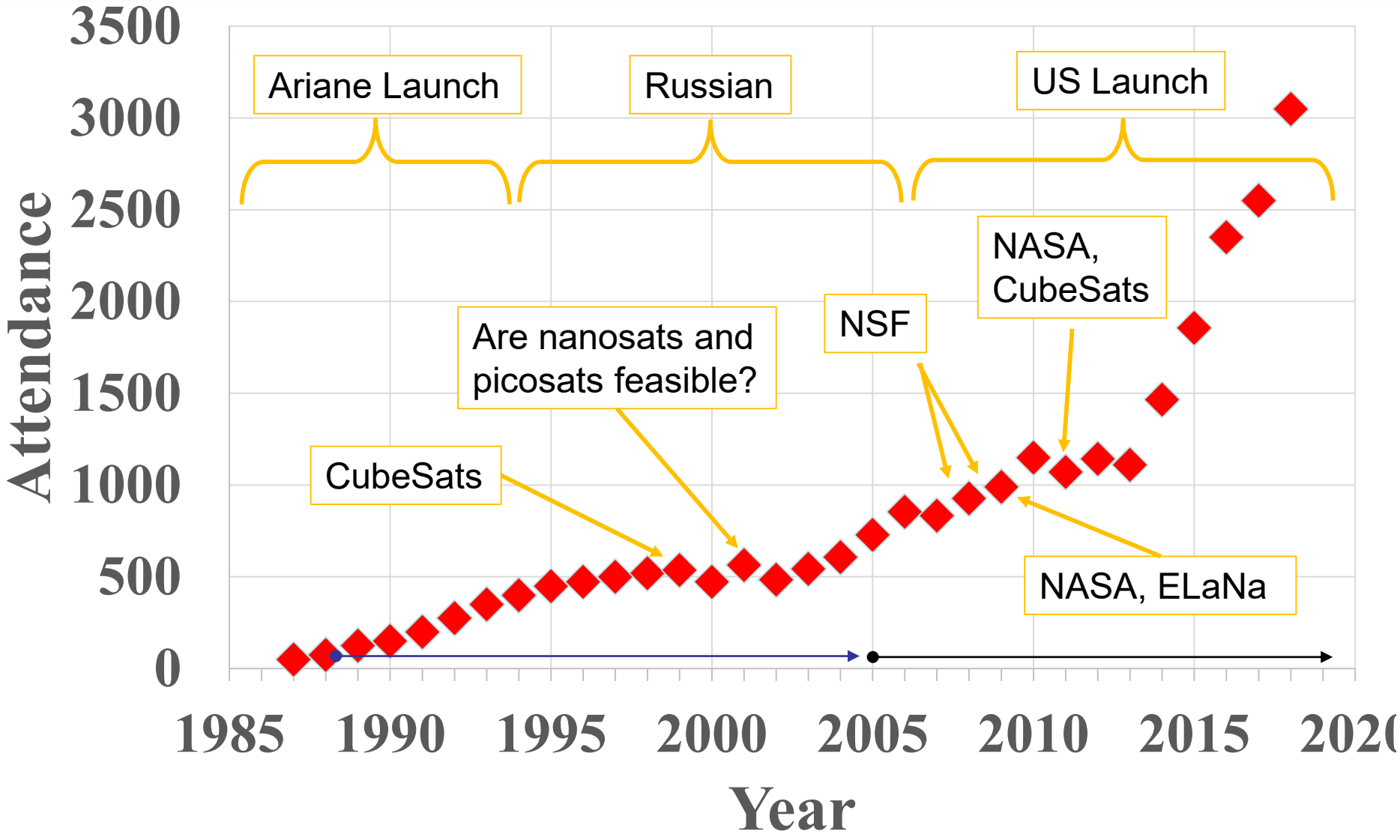
Powerful concepts:

- **Building to a standard**
- **Containerized launch**

New paradigm:

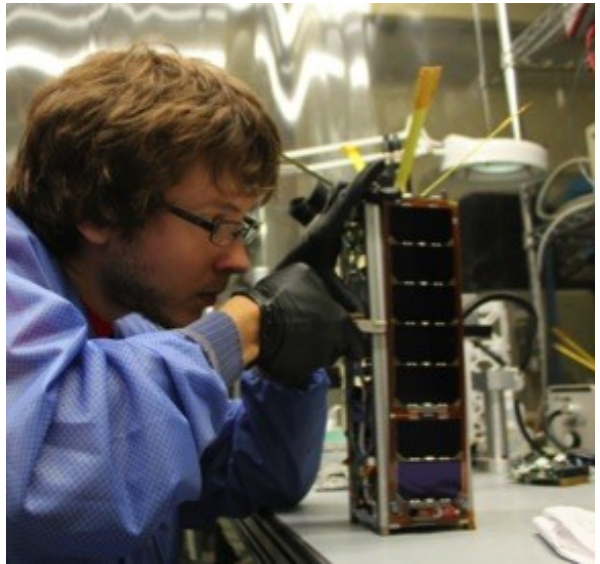
- **Low cost**
- **Higher risk acceptance**
- **Broad participation:**
  - **High influx of innovation**
  - **Widespread expertise**

USU Small Satellite Conference



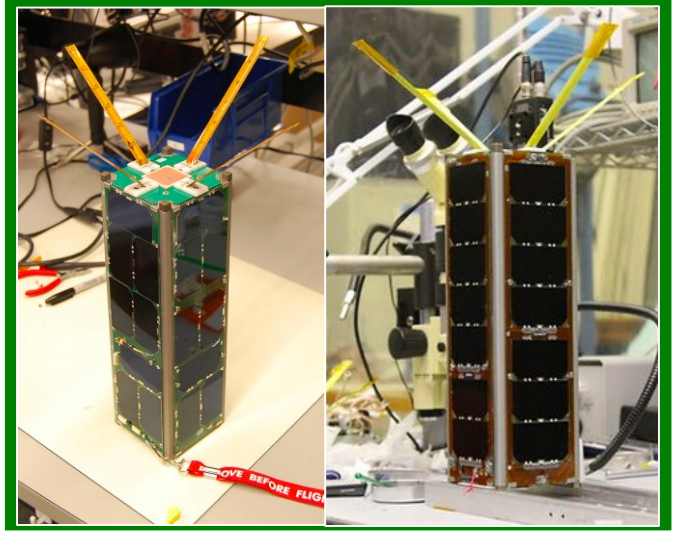
NSF Cubesat Program since 2008

- Geospace & atmospheric science and education
- ~2 new projects per year
- 5 competitions; 122 proposals
- 15 projects funded
- Grants $900,000 total cost and 3 year duration

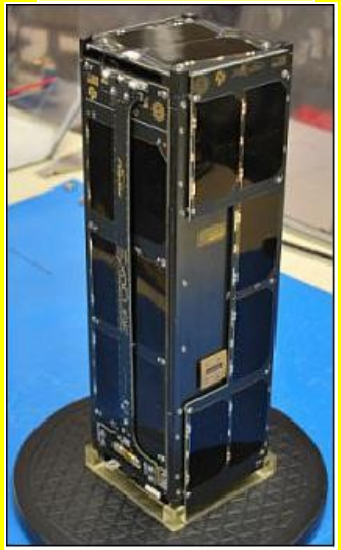


FIREFLY

RAX I & II

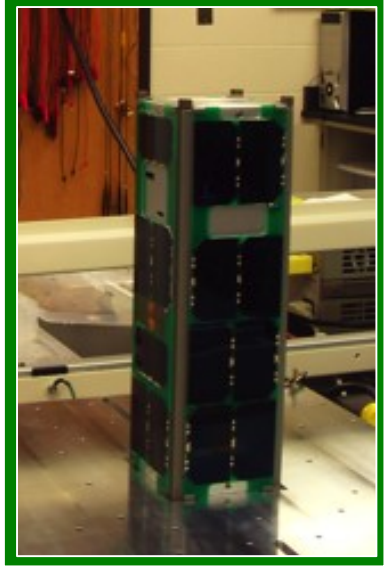


EXOCUBE



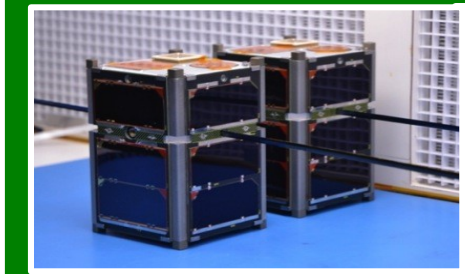
DICE

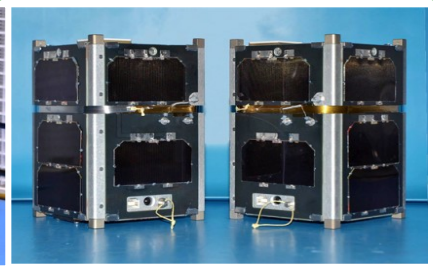
CSSWE



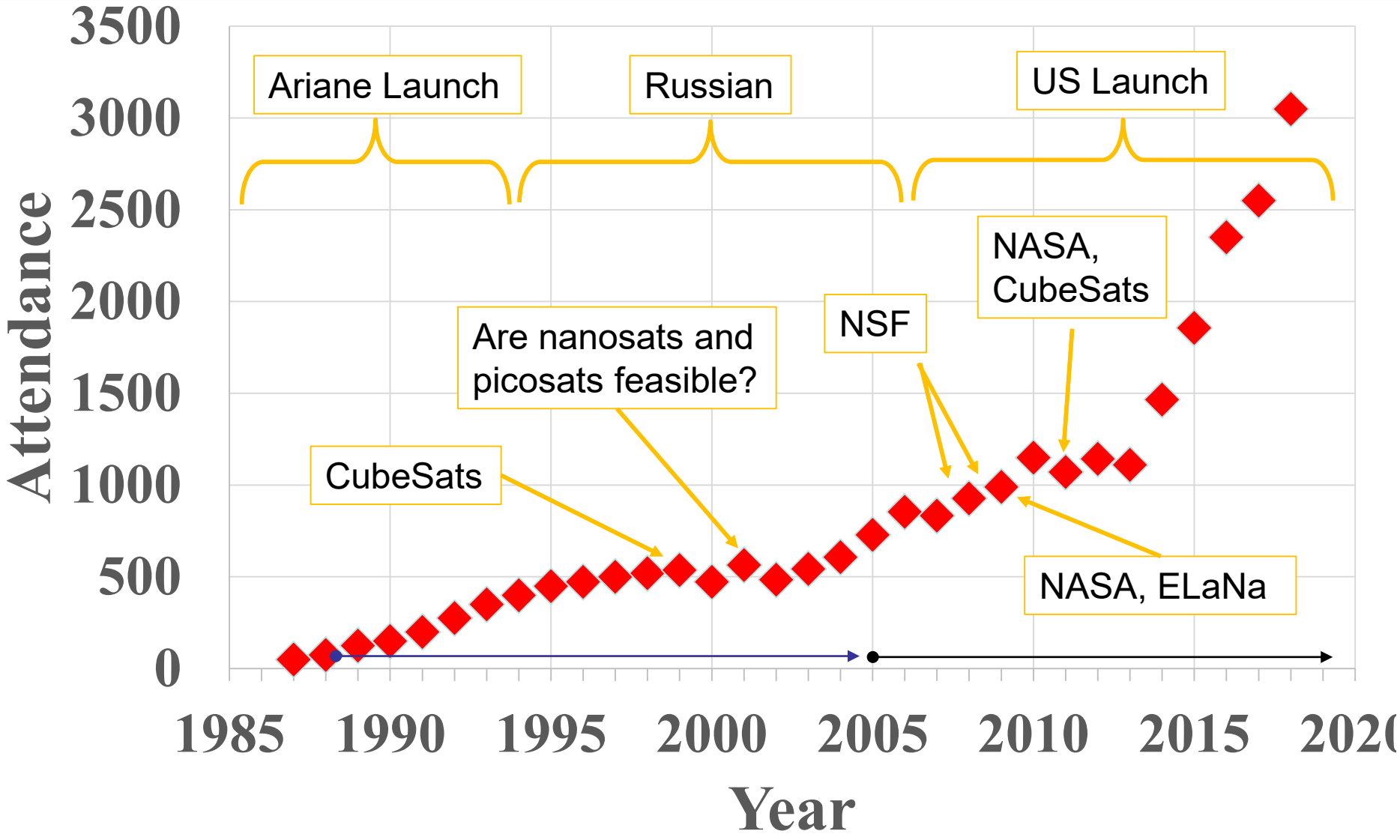
CINEMA

FIREBIRD I & II



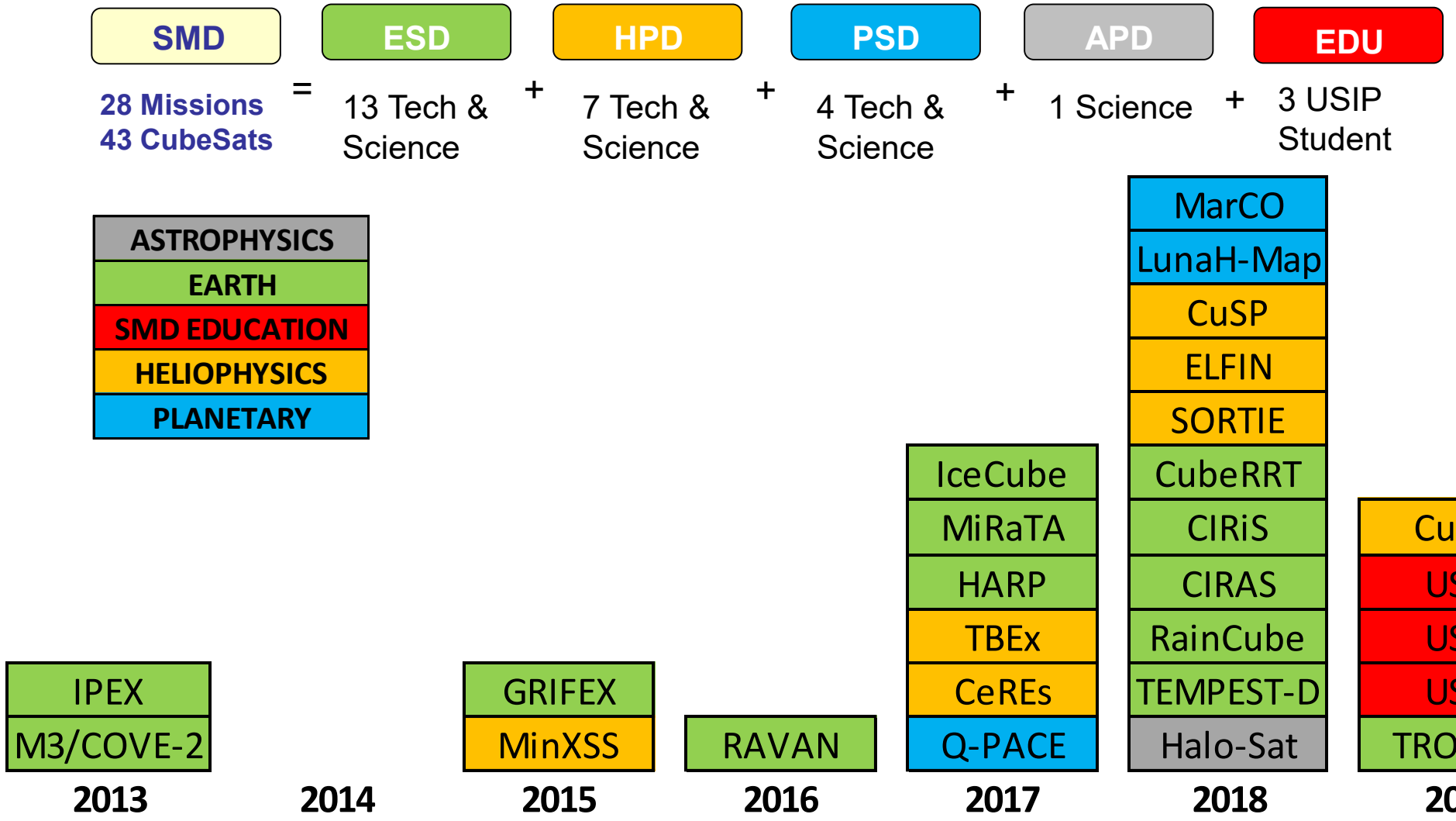


USU Small Satellite Conference

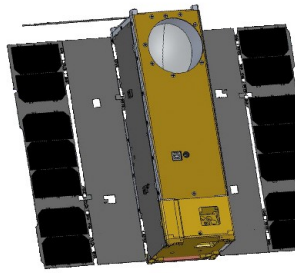


NASA Science CubeSat Highlights

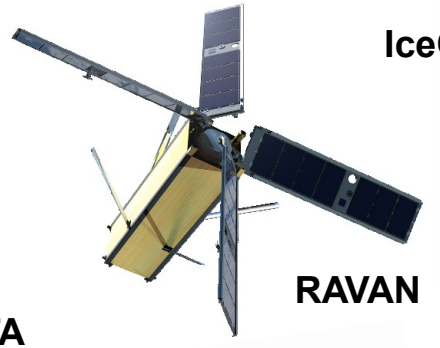
SMD CubeSats by science theme and projected launch date



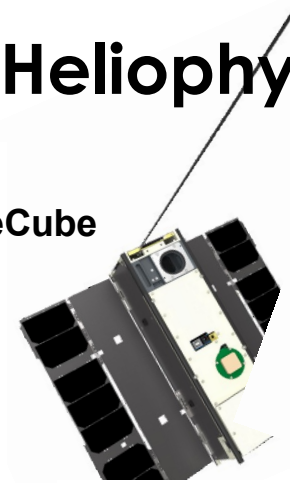
Earth Science & Heliophysics CubeSat Missions



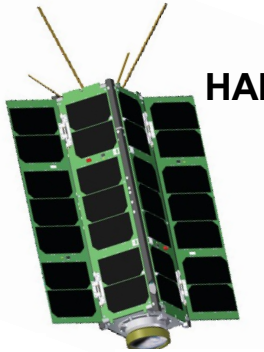
MiR- TA



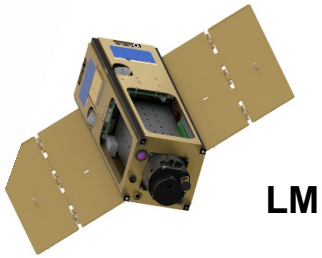
RAVAN



IceCube

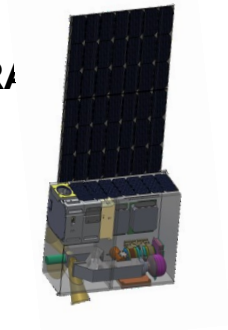


HARP

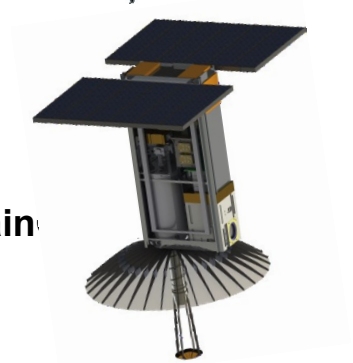


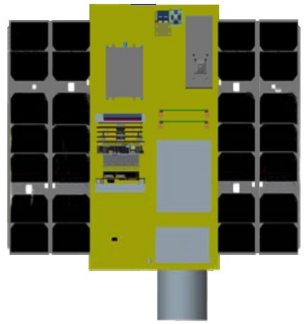
LMPC

CIRA



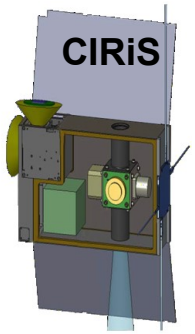
Rain



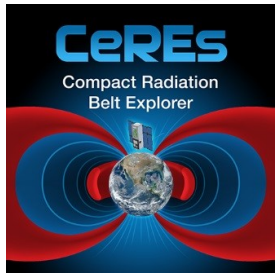


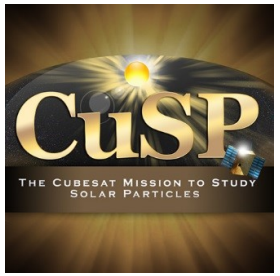
CubeRRT

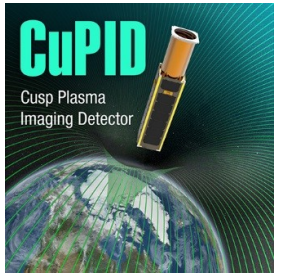
CIRiS

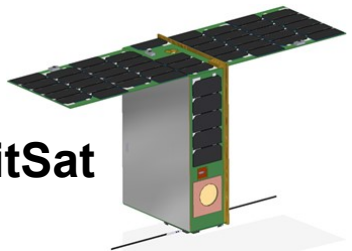


TEMPEST-D

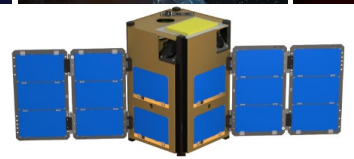








petitSat



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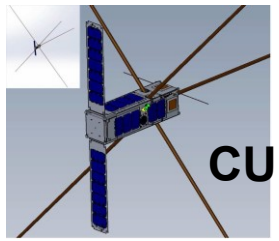
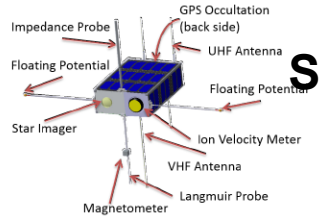


CURIE



SPORT

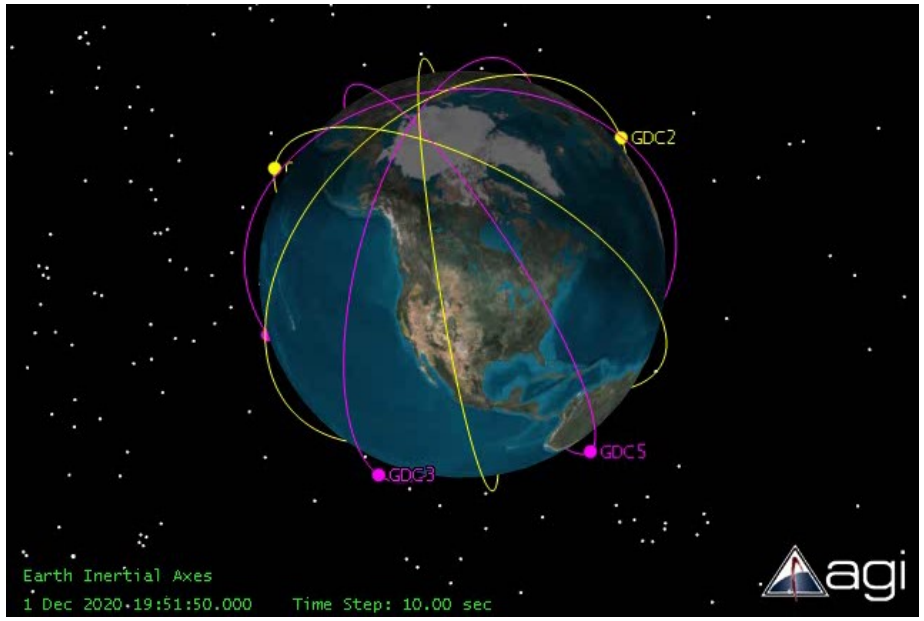
Global Dynamics Constellation (GDC) (2016)

1. How do solar wind/magnetospheric energy energize the ionosphere and thermosphere (I-T)?

2. How does the I-T system respond and ultimately modify how the magnetosphere transmits solar wind energy to Earth?

3. How is solar-wind energy partitioned into dynamical and chemical effects in the I-T system, and what temporal and spatial scales of interaction determine this partitioning?

4. How are these effects modified by the dynamical and energetic variability of the ionosphere upper atmosphere introduced by atmospheric wave forcing from below?

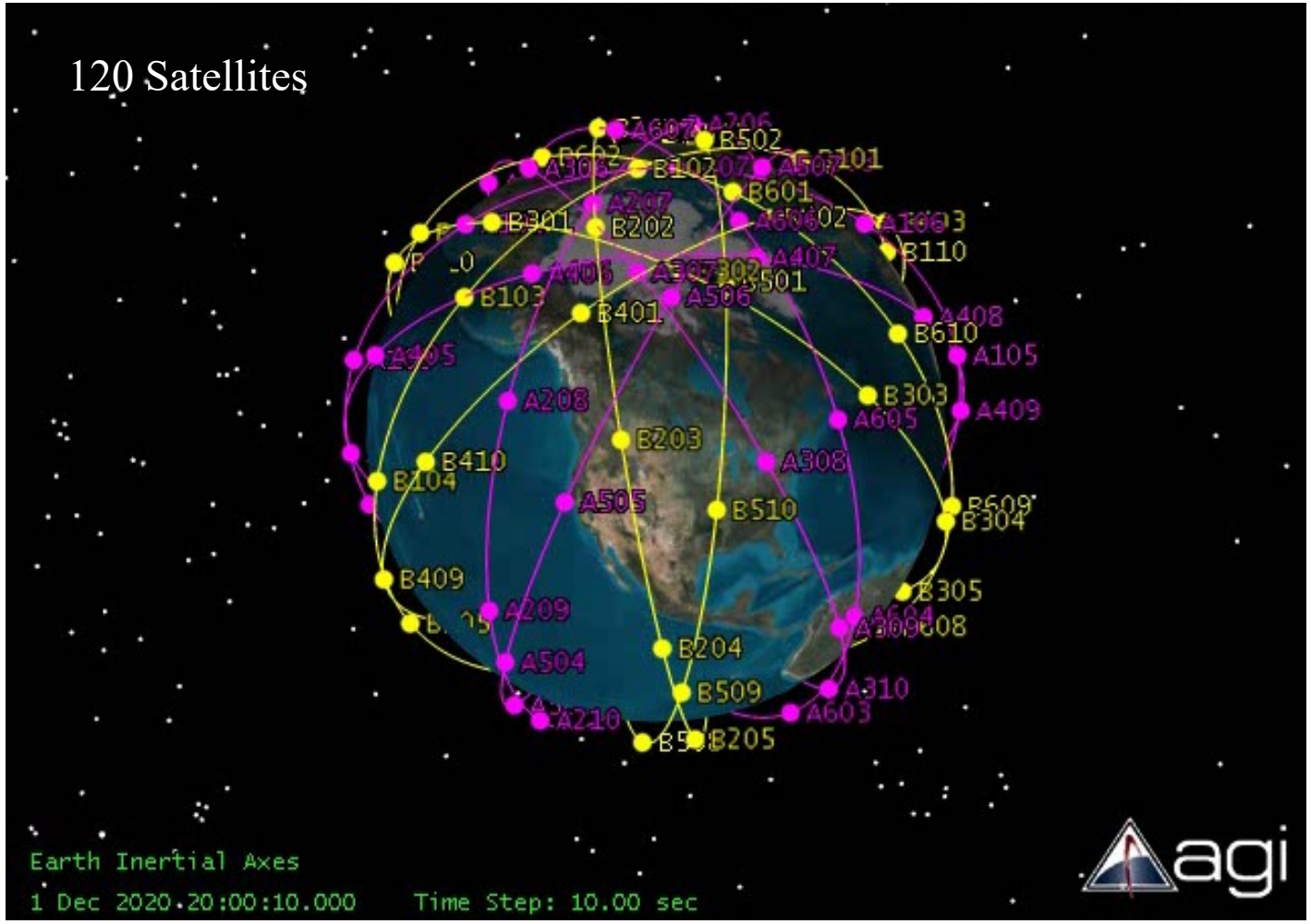


Energy, Momentum from above

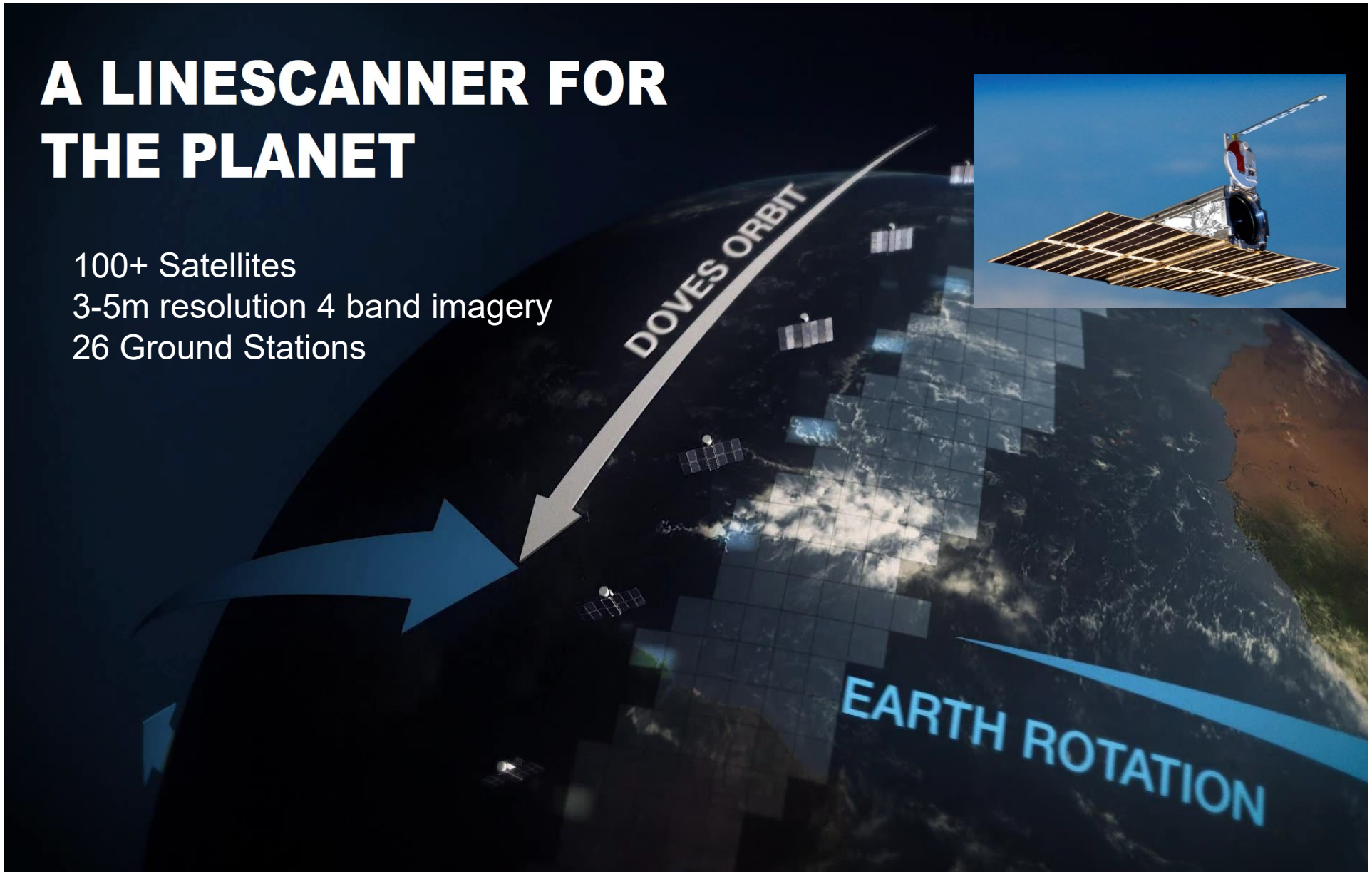
Ionosphere-Thermosphere

Energy, Momentum from Below

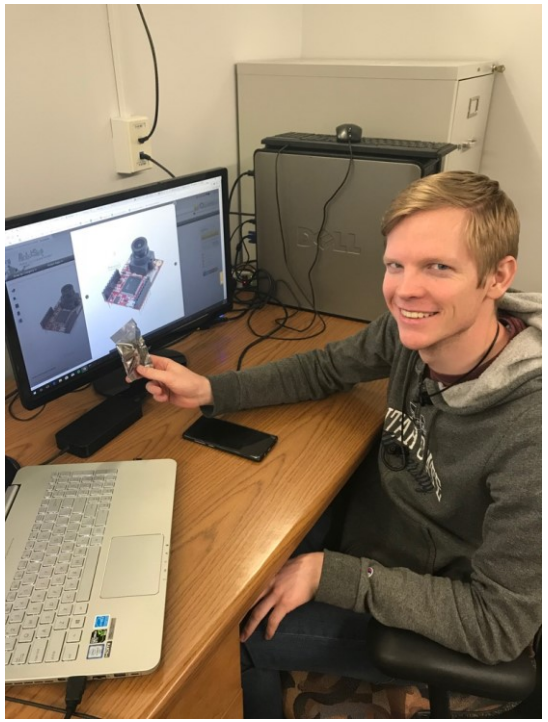
What is REALLY needed



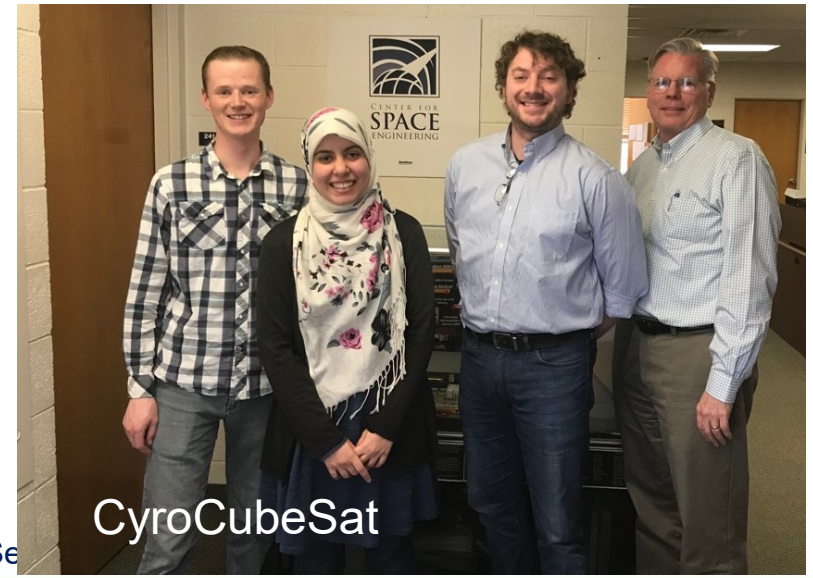
Planet Labs (CubeSats)



Students At Utah State University



SPORT



There is more going on then just space missions

Conclusion

- **The most significant advances in solar and space physics, or Heliophysics, over the next decade are most likely to derive from new observational techniques.**

- **One of the most promising new observational techniques becoming available are miniaturized sensors and satellite systems called small satellites and CubeSats.**

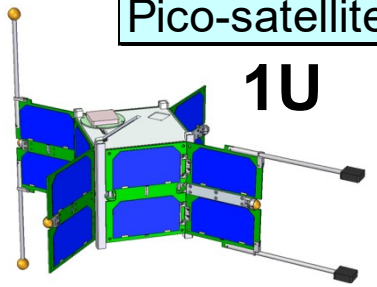
- **Small Satellites represent a opportunity for many new space endeavors and many new countries.**

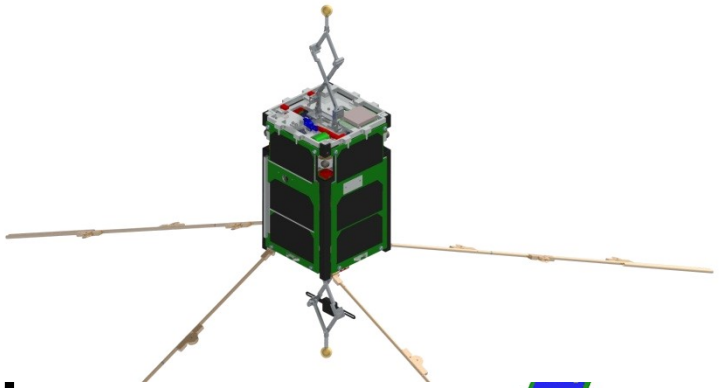
Backup

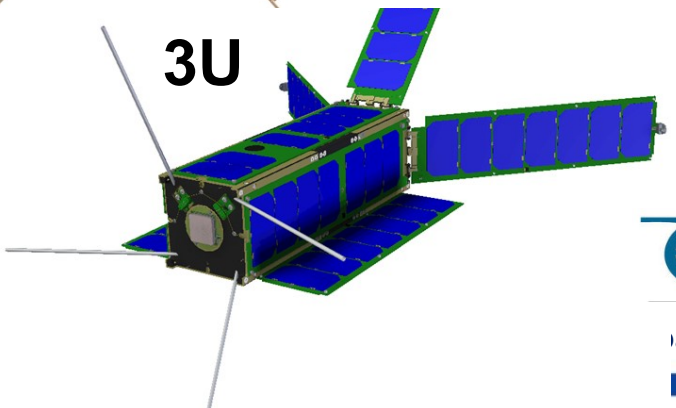
Small, Mini, Micro, Nano, Pico Satellites

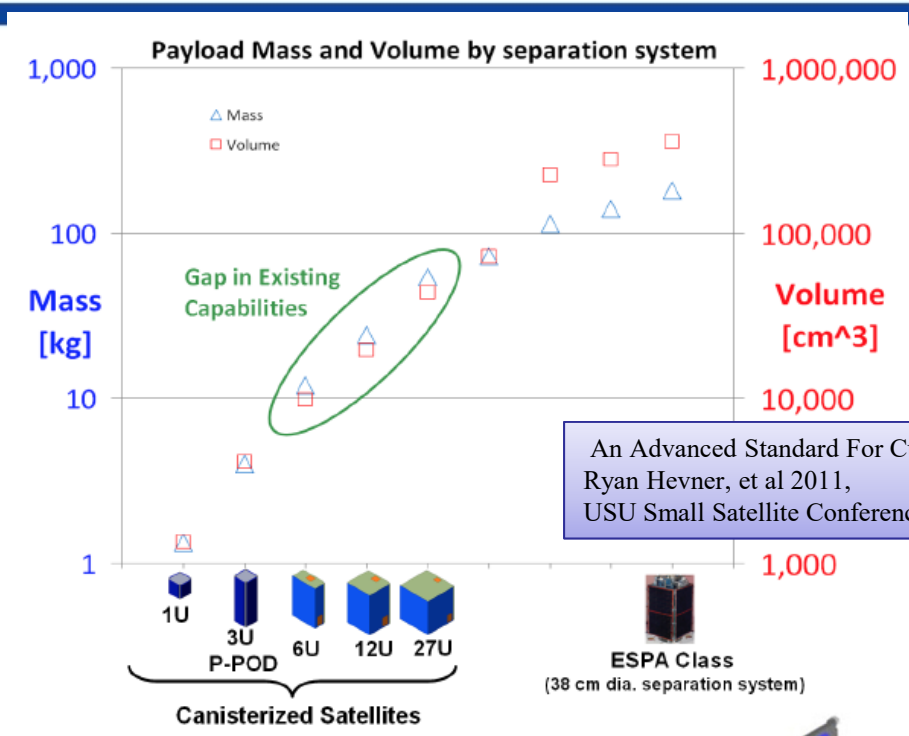
Sir Martin Sweeting

Class	Mass (kg)	Cost ($M)
Large satellite	> 1000	> 100
Small satellite	500 - 1000	50 - 100
Mini-satellite	100 - 500	10 - 40
Micro-satellite	10 - 100	4 - 8
Nano-satellite	1 - 10	0.5 - 2
Pico-satellite		









An Advanced Standard For Cubesats
Ryan Hevner, et al 2011,
USU Small Satellite Conference