Integrating Education, Research, and Design-Build-Fly: Perspectives from AggieSat

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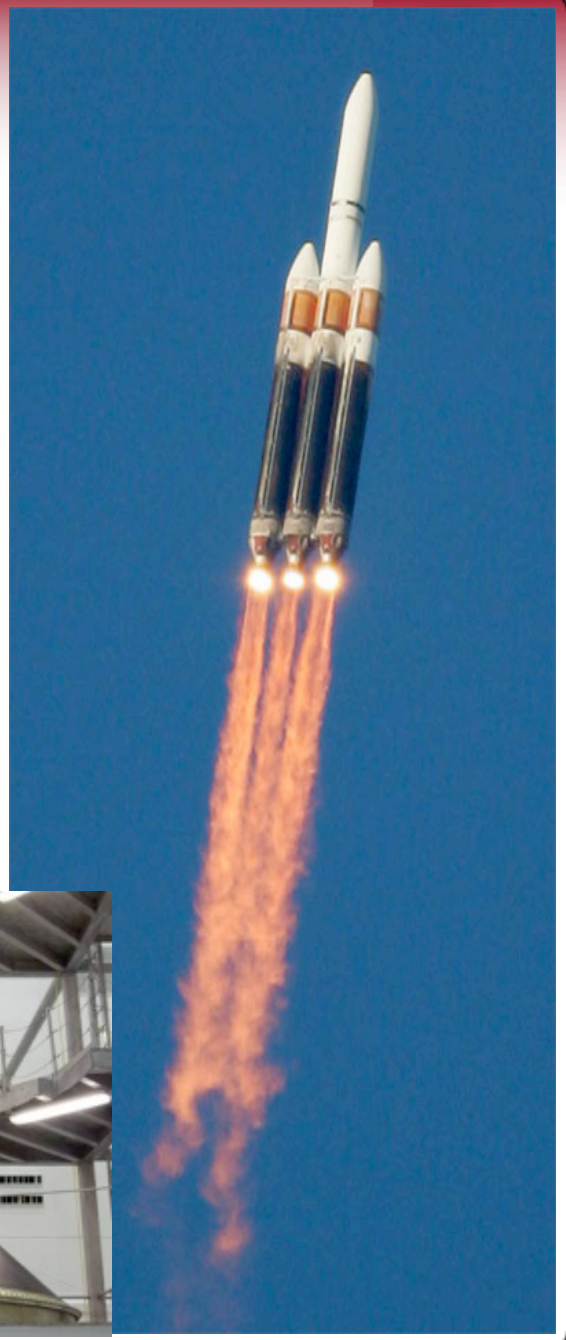
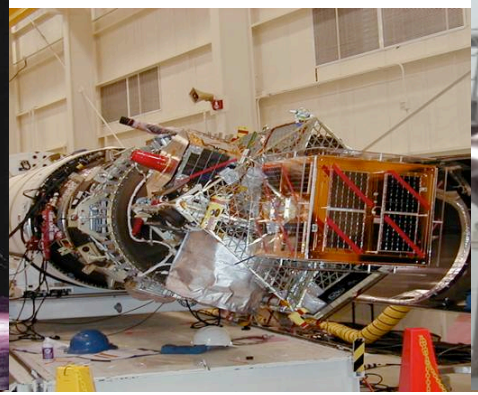
AggieSat Lab

- Established Team (together for several years)
  - 3 launches: 2 with Air Force, 1 with NASA
    - 1st Minotaur Jan. 2000
    - Delta IV Heavy Demo Dec. 2004
    - STS-127 July 2009
- Multi-year partnership with NASA Johnson Space Center, University of Texas at Austin
- Over 1000 students since 199





AggieSat Lab

To develop and demonstrate modern technologies by using small satellite platform, while educating students and enriching undergraduate experience

I. Integrated Approach to Small Spacecraft Research, Design-Build-Fly, Education.

II. Students responsible for whole design process: concept to end-of-mission.

III. Business environment with real-world deliverables, quality assurance checks, documentation, design and safety reviews, organization.

IV. Integrated Concurrent Engineering Lab: rapid trade studies, capturing corporate knowledge.

V. Students gain hands-on mastery in current tools, systems engineering, and industry practices related to specification, design, analysis, fabrication, testing of space vehicle systems.

Multidisciplinary Teamwork

Integrate graduate and undergraduate students, with ~80% freshmen through seniors. Any major is welcome to join, and since start at Texas A&M in 2005:

Engineering:
- Aerospace
- Computer Science
- Computer Engineering
- Electrical
- Industrial
- Mechanical
- Technology

Business:
- Accounting
- Marketing
- Education
- Finance
- Management
- Information Systems

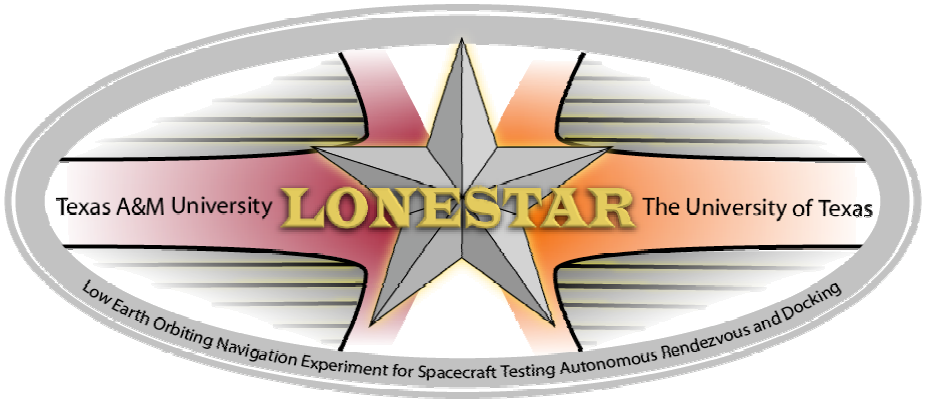
Sciences:
- Mathematics
- Physics
- Biology

Main Technical Objectives

I. Through NASA-JSC, complete 4 missions of increasing complexity with last demonstrating AR&D (Autonomous Rendezvous & Docking).

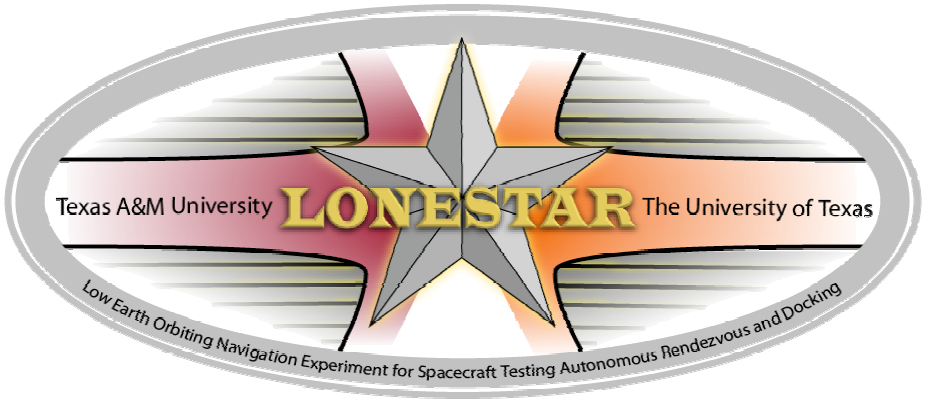
A. DRAGONSAT/AggieSat2 – Currently operating on orbit
   - Characterize NASA's DRAGON GPS

B. AggieSat4 - Launch planned for early 2012
   - Spacecraft separation, stabilization, inter-satellite communications, and navigation solutions using DRAGON



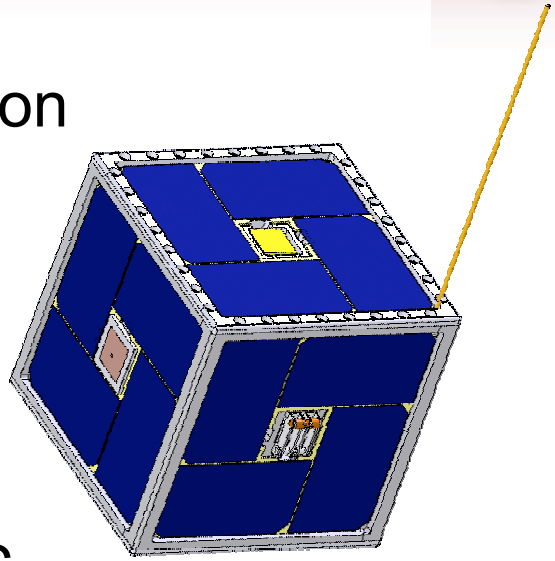
Main Technical Objectives

II. Modular software, hardware configurability
   A. Develop architecture and standard interfaces emulating PC industry
   B. Develop plug-and-play hardware
   C. Reuse software– multiple missions



AggieSat2

- Multi-year partnership with NASA Johnson Space Center, University of Texas



- 5” Cubesat

- AggieSat2 carries NASA DRAGON GPS unit to test viability as navigation solution

- Launched 15 July 2009

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MEI TECHNOLOGIES
Merging Excellence and Innovation

Department of Defense
Space Test Program

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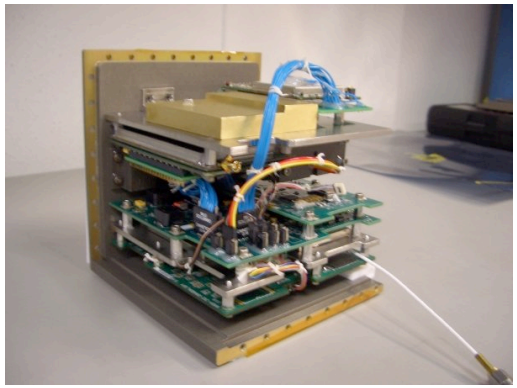
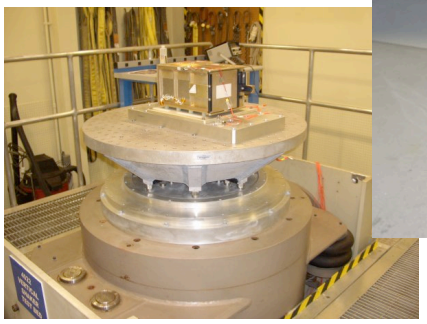
P.M. & A.M. RESEARCH

Sandstorm A&M University
Mothers Club

Development of AggieSat2





Delivery & Prep

Launch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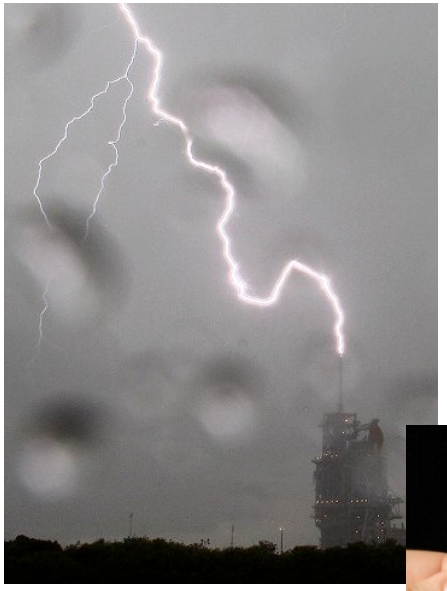


NASA
Launch
Guest
Kennedy Space Center
Florida


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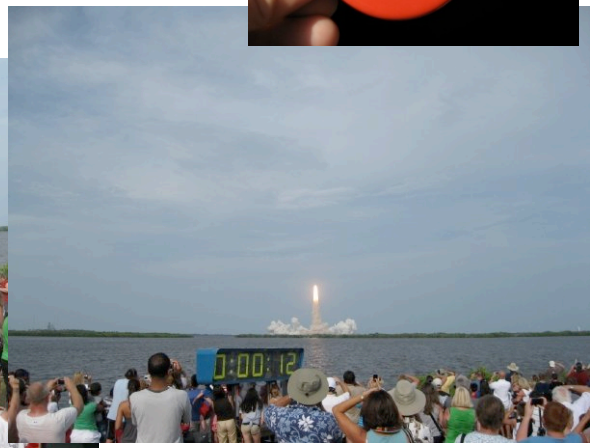
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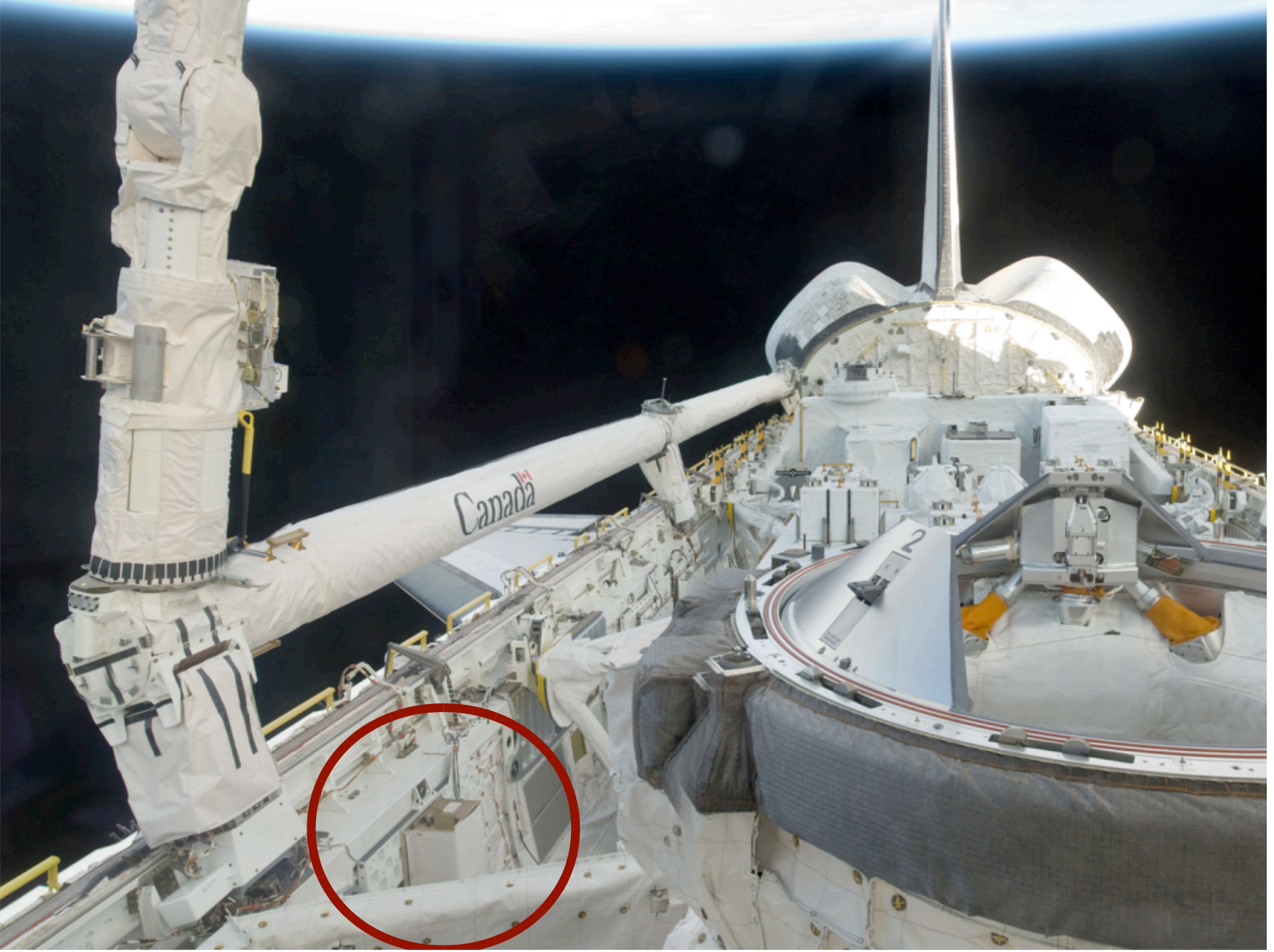
Canada

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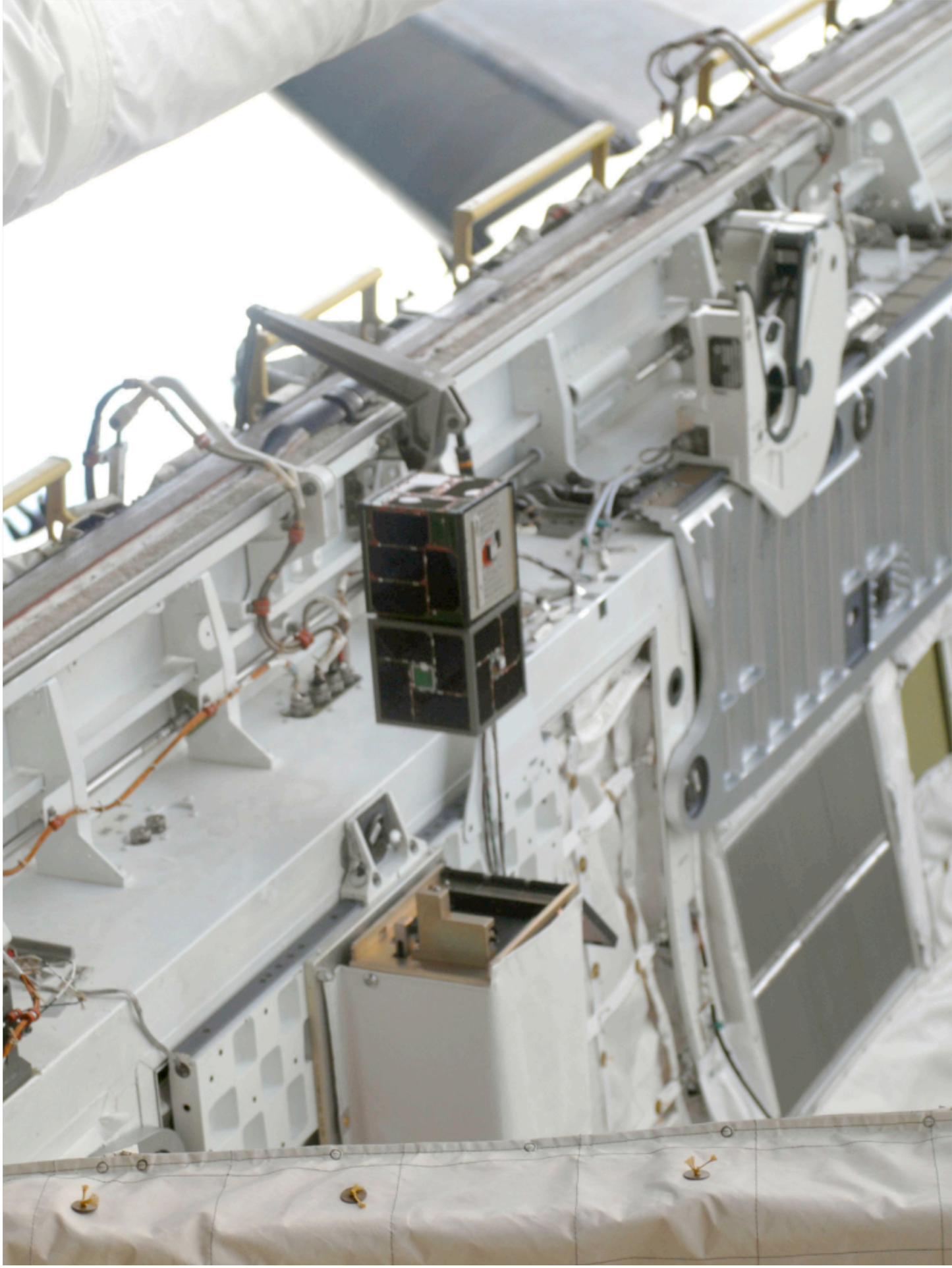
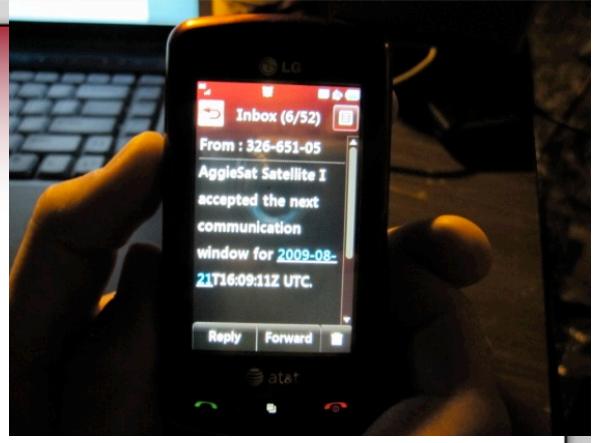
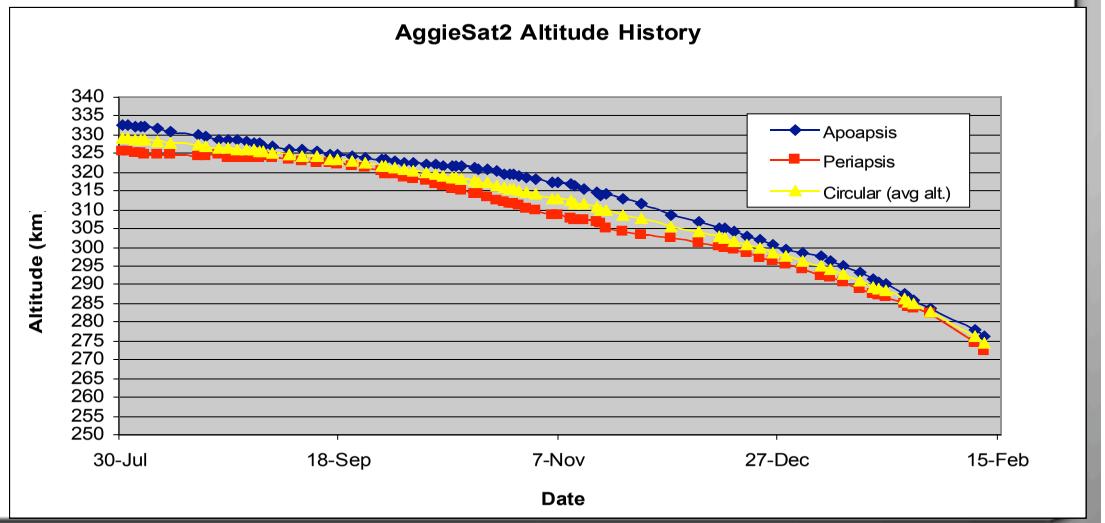


On-Orbit Status



- After AggieSat2 release
  - Alive and well
    - Heard by amateurs on first orbit
    - Heard by TAMU on first day of flight on first good pass over College Station (synchs and beacon)
  - Communications hindered because of possible captive antennas after incomplete separation from Bevo-1 – upgraded ground station
  - Power positive - health data received – commands sent and acted upon - GPS experiment initiated for mission success

- AggieSat2 continues to be operational on-orbit transmitting DRAGON data to our ground station for 205 days



AggieSat4 Mission Statement

- AggieSat4 will test viability of technologies to be used in final mission:
  - Spacecraft undocking/docking and stabilization mechanisms
  - Ability to compute navigation solutions using GPS system
  - Capture of visual data
  - Downlink of GPS, health, sensor data
  - Communication with its partner satellite
- Necessitates larger satellite -

  NTE 50 kg

Current Student Activities

AggieSat4 Preliminary Design

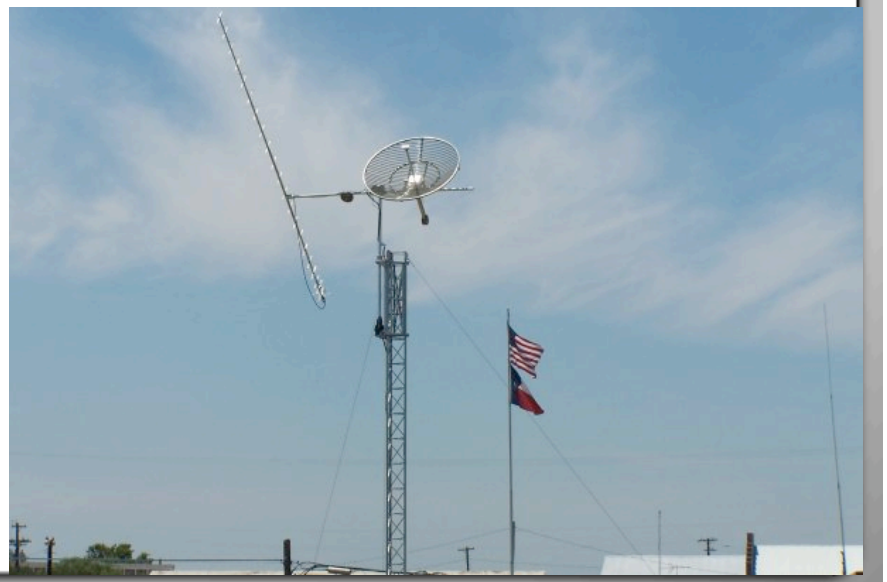
- A. Program Manager, Subsystem Leads
- B. Establishing and Flowing Down Mission Requirements
- C. Trade Studies
- D. New Documentation Procedures

Software Development

- A. Flight Software
- B. Ground Software

AggieSat2 Operations

- A. Program Manager, Subsystem Leads
- B. Tracking Operations
  - i. Flight Director
  - ii. Spacecraft Operator
  - iii. Tracking Operator
- C. Fault Tree Analysis



Why students choose aerospace

From our students,

- Students love aircraft, spacecraft, rockets, …
- High visibility organizations demonstrating impressive technologies:
  - “Can I be part of this amazing work? Next Burt Rutan?”
- Means to achieve a dream
- Enable point to point suborbital transport, colonize solar system, revolutionize Air Traffic Control, supersonic civilian transport, …
- Earlier experiences
- Look for challenge, projects to make a difference

Why space projects

- Space flight projects provide an incredible vehicle to inspire students to engage in science, engineering, and technical learning and research

- Students attest that these learning experiences provide opportunities, knowledge and skills that complement their classroom work and put their studies in context.

- **U.S. Aerospace community experiencing extreme shortfall in systems engineering experience.**
  - **Superb opportunity to educate systems engineers**

Project characteristics

Develop leadership, professional, communication skills:

- Model these projects as much as possible after industry
  - With a real launch, real constraints on requirements, testing, safety, deadlines, documentation, SPaM
  - Implement Configuration Management Plan for
    - providing framework for document release and control, including software, documents, drawings, reports, …
    - defining roles and responsibilities pertaining to document control, including review process, signature authority, …
  - Implement Quality Management System for
    - assuring all products meet or exceed customer expectations
    - describing various control points for design; product acquisition, inspection, traceability, storage; and two-person build, with all data recorded in an as-built procedure.
  - For ITAR, participants must comply with Federal law.

Project characteristics

Develop leadership, professional, communication skills:

- Model these projects as much as possible after industry
  - Responsibilities should follow industry guidelines and students serve as Program Manager, Systems Engineer, Subsystem Leads, and team members.
- Allow these projects to be student staffed and run, but with frequent oversight/mentoring
- With frequent launches, expose students to whole design process and have them be responsible for:
  - concepts, research, design/development; reviews; integration/ testing; delivery; flight/operation; data collection/report out/lessons learned.

Project characteristics

Develop leadership, professional, communication skills:

- Teach and allow students to make critical decisions
  - specification, design, analysis, fabrication, and testing

and have them defend these decisions to government and industry professionals during standard design reviews.

- Teach students professional practices
  - Use and understand software design tools
  - Understand and be able to perform analysis
  - Build and test (hands-on) many different systems and subsystems. Learn basic skills with hand tools, soldering, polymerics, harnessing, reading schematics and drawings, test procedures…

Project characteristics

Develop leadership, professional, communication skills:

- Encourage students to give back to the community in outreach activities to youth and lay persons
  - Use their social networking skills

Project characteristics

Develop teamwork skills:

- Good team experience must include project impossible for one person to complete AND it must require different areas of expertise.

- Encourage students to
  - work on subsystem outside of their majors.
  - use their social networking skills.
  - be sensitive to different disciplines, personality types, cultures, experience levels, time commitments– classes, homework, family.

Project characteristics

Develop teamwork skills:

- Main challenge is project continuity as students graduate or leave team. Information is easily lost and one has to “start from scratch” – time, resources, risk.
  - Friendly, computer automated, documentation system
  - ICE tool with databases to capture design iterations and trade studies providing central location for capturing corporate knowledge
  - Experienced students recruit and mentor freshmen to carry on
  - Modularized hardware, software, and architectures. Students can
    - learn engineering principles, design from functioning system
    - focus on mission specific development instead of reinventing system each time

[Goals also complement national objectives in Responsive Space]

Project characteristics

Encourage problem solving, creativity, and innovation:

- Engage students in challenging research

- Limited resources and rigid constraints require innovative solutions -- from the design of new low-cost components to manufacturing techniques.

Role of commercial suborbital vehicle opportunities in satellite design

- Attract students
- Familiarize them with space environment
- Teach them to be test engineers
- Validate and confirm accuracy and range of prediction tools
- Qualify hardware
  - Get hardware back to examine - lessons learned
  - Quick turnaround
  - Longer time in low g, tailored trajectories and conditions
  - Proper economics, multiple realizations

AggieSat Lab Summary

Focus on enabling systems of micro-/nanosatellites

Cradle-to-grave approach to provide low-cost, low-risk solutions and test beds for multiple technologies that feed forward to other missions

Conceive of, develop and test, ultimately obtain verifiable data in space environment to characterize and advance

- Close-proximity tracking and navigation solutions
- Miniaturized sensors and effectors
- Responsive modularized configurable space mission software, hardware, and architectures
- Release and docking

AggieSat Lab Summary

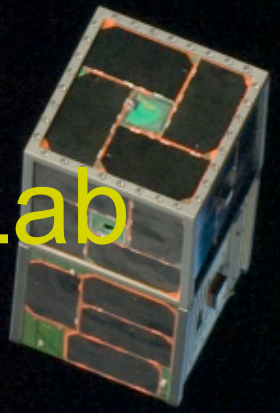
Equally important, educate systems engineers

- Hands-on systems-engineering focus, concept to operations
- Instill cognizant engineering practices
- Encourage students to innovate, problem solve, communicate, and use their social networking skills

Over 1000 students since 1993

Commercial suborbital vehicle opportunities offer an attractive and important piece to our program!

AggieSat Lab



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