Educational Aspects on Small Satellites from an Aerospace Engineering Perspective

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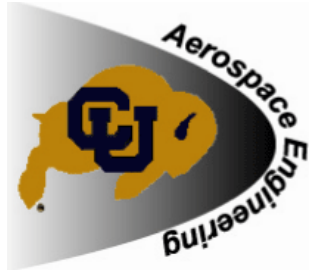
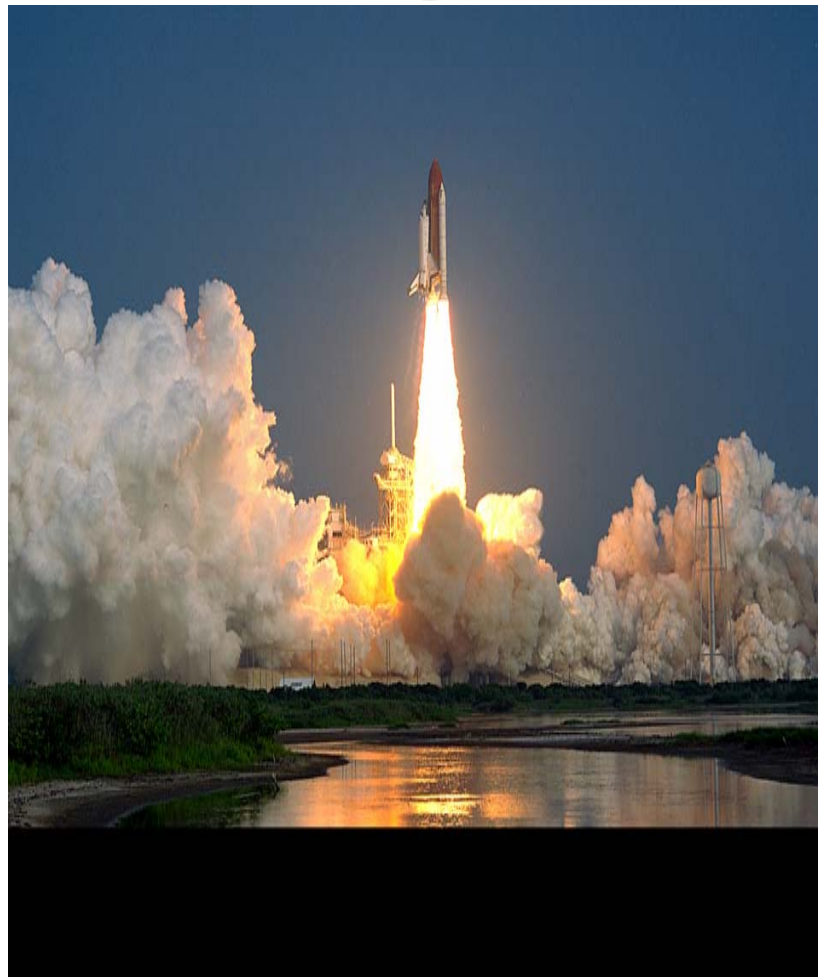
Overview



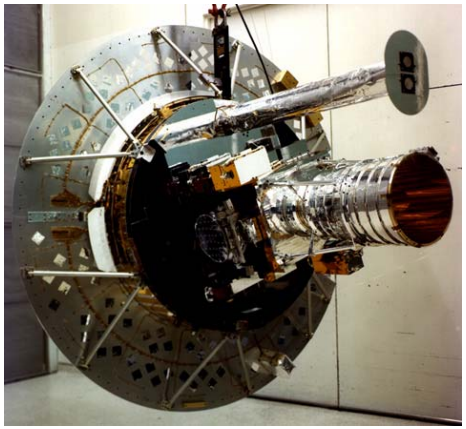
- Aerospace Engineering
- Student space hardware experiences at CU
- Lessons learned
- A systems engineering approach
- What is important from an aerospace industry perspective
- Approaches for designing and constructing satellites in an edu environment
- Engineering capstone projects and ABET
- A graduate curriculum for space hardware design
- DANDE and CRIA examples of current student satellite projects at CU from a student perspective (Laura Brower)

Aerospace Engineering

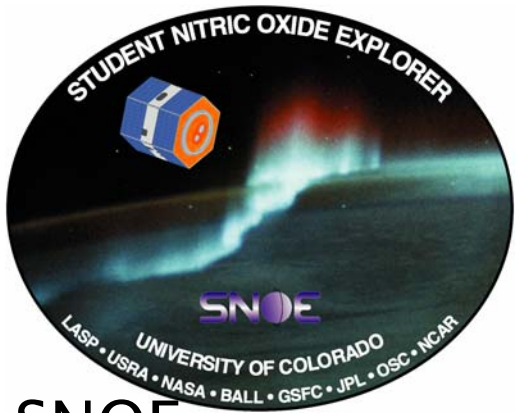
- Structures
- Materials
- Thermodynamics and heat transfer
- Aerodynamics
- Orbital dynamics
- Control systems and attitude dynamics
- Aircraft design
- Spacecraft design
- Propulsion
- Electronics and communications
- Systems engineering



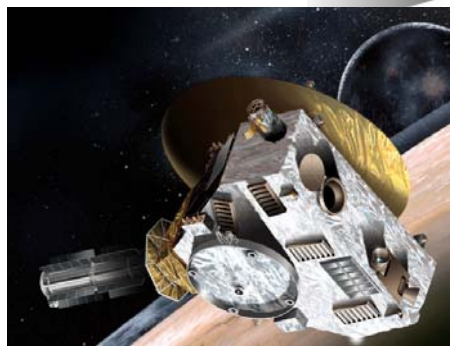
Student Satellite Experiences at CU



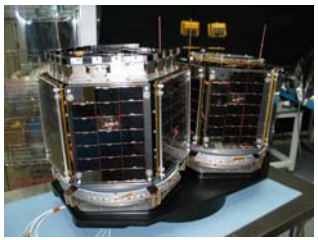
SME (1981)
7.5 years



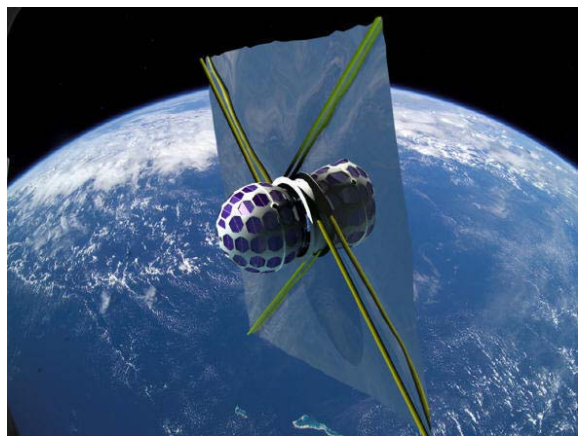
SNOE (1998) – 5 years



SDC (2006)– enroute 15 years



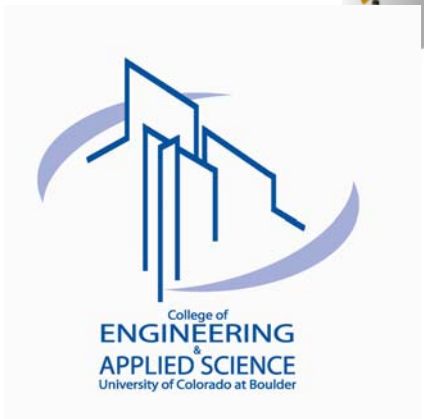
UNP-1/2 Three Corner Sat (2004) – launch failure



UNP-5

DANDE – PDR in August 2007

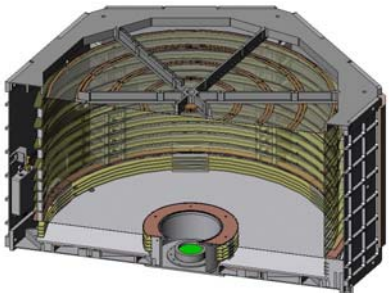
A beneficial collaboration



Lessons Learned

- Students have lots of energy but it needs to be directed!
  - Faculty and professional involvement is imperative
- Teaching students the engineering design process (systems engineering) is key
  - Such a process provides project discipline (performance, interfaces, etc..)
  - Presentation at major milestones (SCR,PDR,CDR,PSR, etc) are critical
- Lack of revision control, institutional memory and solid project management can cause a project to fail
  - Students often come and go on such project
  - Project management provides structure for budget, schedule etc.

CRIA Team Structure



Customer
Z. Sternovsky

Administration
- **Project Manager** L. Brower
- **CU Advisors** X. Li, S. Palo

System Engineer
- **Student Lead** D. Turner
- **Professional** M. Lankton (LASP)
- **Professional** P. Graf

Manufacturing
- **Professional** M. Rhode (CU)

Structures
- **Student Lead** M. Pilinski
- **Professional** S. Steg (LASP)

Thermal
- **Student Lead** M. Salehi
- **Professional** B. Lamprecht (LASP)

Electronics
- **Student Lead** W. Tu
- **Professional** V. Hoxie (LASP)

Materials
- **Student Lead** D. Lee
- **Professional** G. Drake (LASP)

Ion Optics
- **Student Lead** L. Chang
- **Experienced Graduate** K. Amyx (CU)

Detector
- **Student Lead** D. Turner
- **Professional** G. Drake (LASP)

Systems Engineering Approach

- Specification of mission goals
- Requirements development
- Evaluation and selection of system concept
- Requirements flow down to subsystems (comms, thermal, power, ADCS, C&DH, science, etc..)
- Evaluation and selection of subsystem concepts (iterate)
- Detailed design
- Test plan development
- Subsystem/system test and integration
  - Functional, vibration, thermal vac, emi, etc...

Boeing Desired Attributes of an Engineer

- A good understanding of the engineering science fundamentals
- A good understanding of design and manufacturing processes
- A multi-disciplinary, systems perspective
- A basic understanding of the context in which engineering is practiced
- Good communication skills
- High ethical standards
- An ability to think both critically and creatively – independently and cooperatively
- Flexibility
- Curiosity and a desire to learn for life (ability to learn independently)
- A profound understanding of the importance of teamwork

Taken from "Some Systemic Issues in the Development of the Aerospace Industry Technical Workforce of the Future" by J.H. McMaster and R.H. Cummings, 42nd Annual Aerospace Sciences Meeting, Reno NV, 2004.

Develop students with a "T" personality type

Academic Approaches

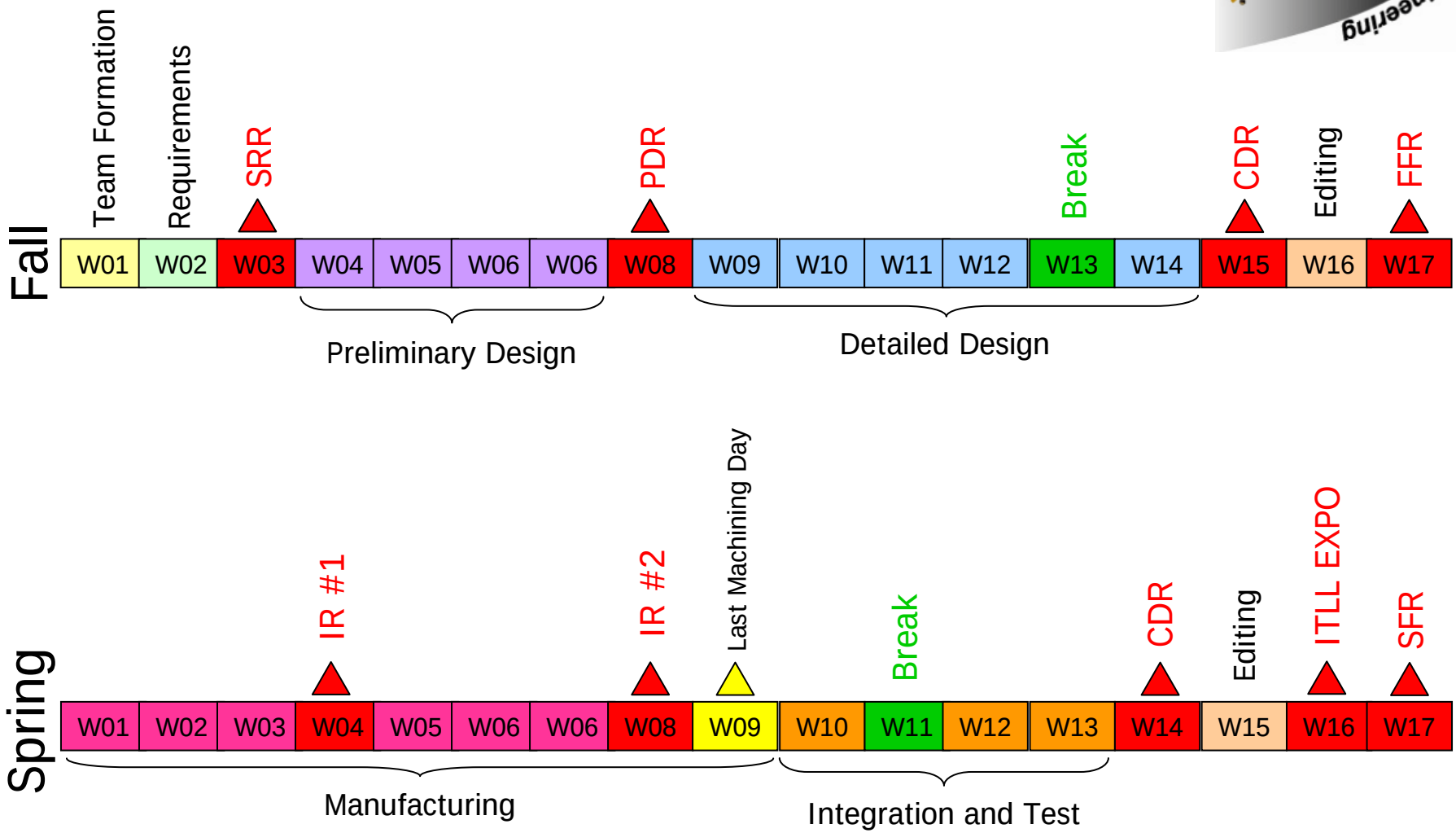
- Approaches for designing and constructing satellites in an edu environment
  - Capstone project course (multiple semesters)
  - Graduate course (multiple semesters)
  - Graduate research
  - Independent study
  - Paid hourly support
- Academic schedules can conflict with mission schedules
  - Courses typically come first
- Faculty buy-in can be difficult
- Solution: Make it a course

ABET EC2000 – Criteria 4

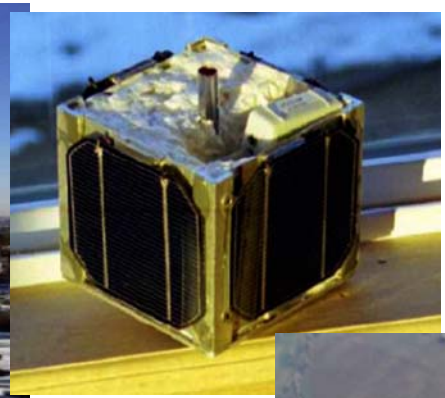
- Criteria 4 – Professional Component

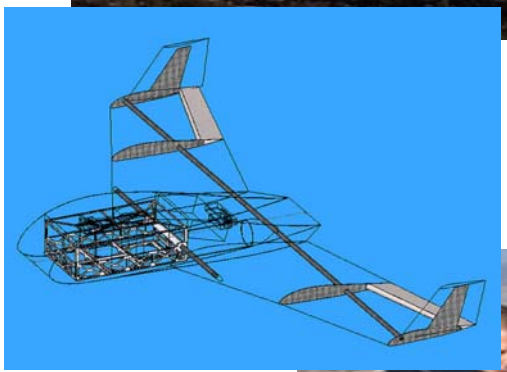
" Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints."

AES Senior Projects Course Schedule



AES Senior Project





1st National Capstone Conference

Capstone +/-3 & strong industry involvement ($10k-40k per project)

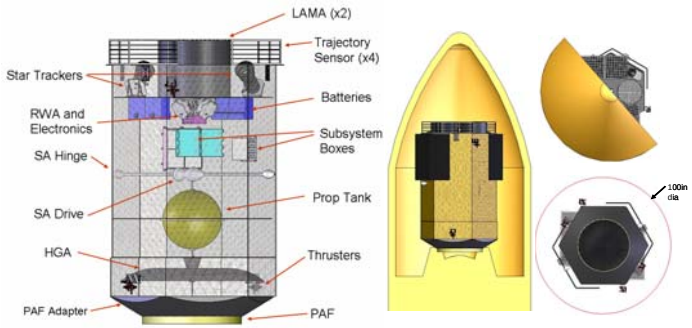
A Graduate Curriculum

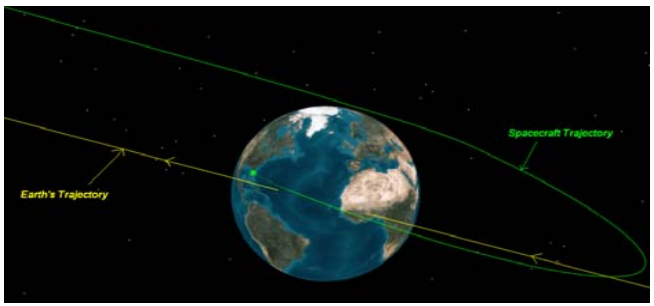
ASEN 5148
Spacecraft Design
Mike McGrath

ASEN 5519-006
Systems Engineering for Space Missions
Paul Graf

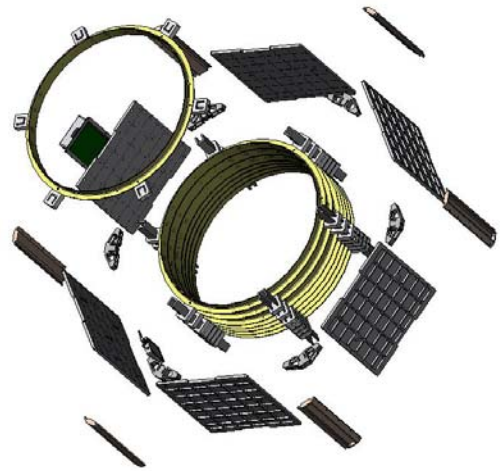
ASEN 5519-010
Space Hardware Design
Scott Palo & Xinlin Li

ASEN 6519
Space Hardware Construction and Test
Scott Palo & Xinlin Li





30 cm Cylindrical	40 cm Cylindrical	40 cm Hexagonal
Aperture Requirement Not Met	Meets aperture requirement	Meets Aperture requirement
Medium Material Cost	High Material Cost	Low Material Cost
[80%] in-house manufacturing*	[40%] in-house manufacturing	[80%] in-house manufacturing
[9 kg]	[13 kg]	[14 kg]
[40 cm] external envelope	[48 cm] external envelope	[53 cm] external envelope
[80] manufactured parts	[80] manufactured parts	[116] manufactured parts



CRIA