



Educational Aspects on Small Satellites from an Aerospace Engineering Perspective

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Overview

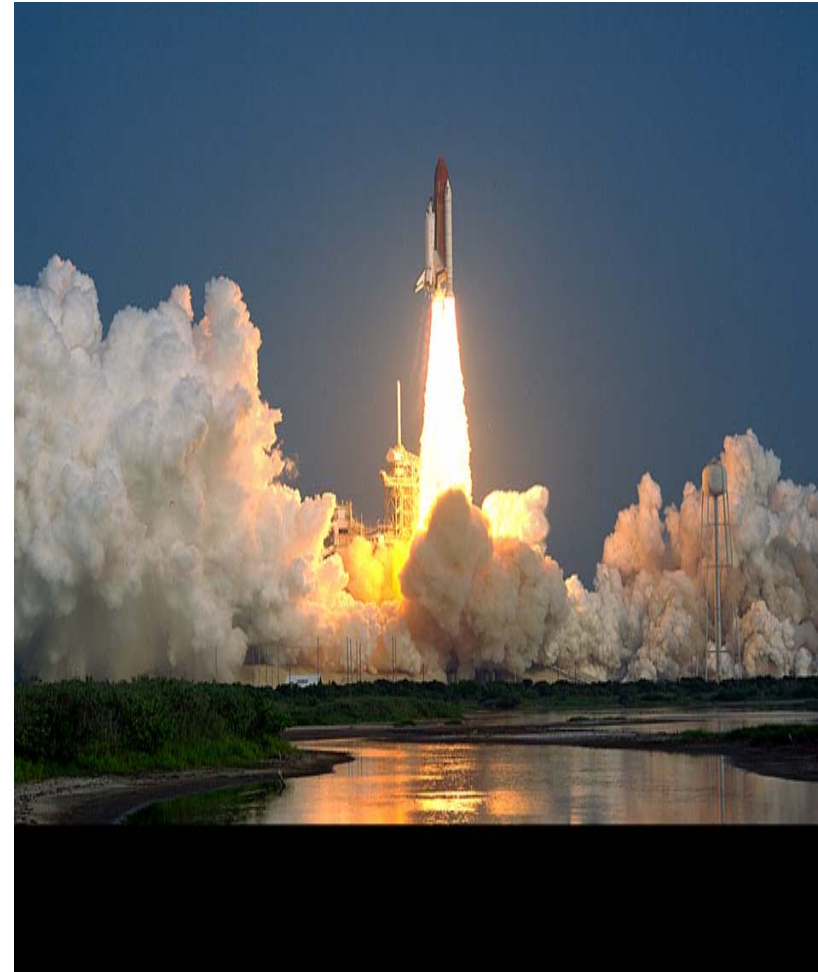


- Aerospace Engineering
- Student space hardware experiences at CU
- Lessons learned
- A systems engineering approach
- What is important from an aerospace industry perspective
- Approaches for designing and constructing satellites in an edu environment
- Engineering capstone projects and ABET
- A graduate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

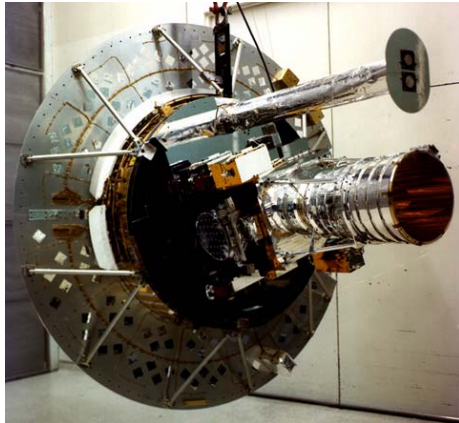
Aerospace Engineering



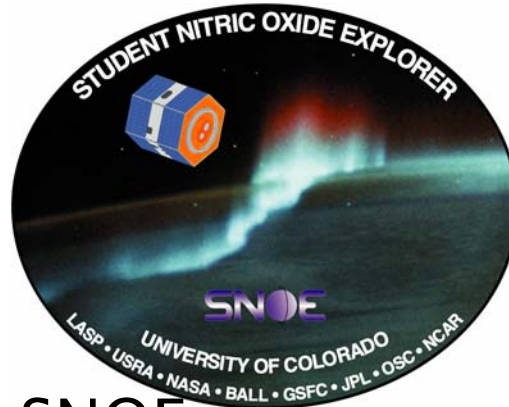
- Structures
- Materials
- Thermodynamics and heat transfer
- Aerodynamics
- Orbital dynamics
- Control systems and attitude dynamics
- Aircraft design
- Spacecraft design
- Propulsion
- Electronics and communications
- Systems engineering



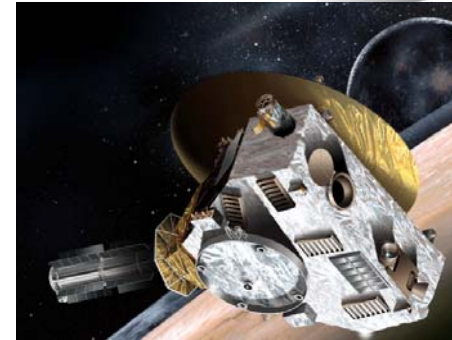
Student Satellite Experiences at CU



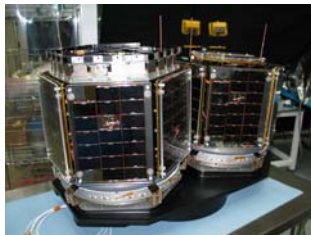
SME (1981)
7.5 years



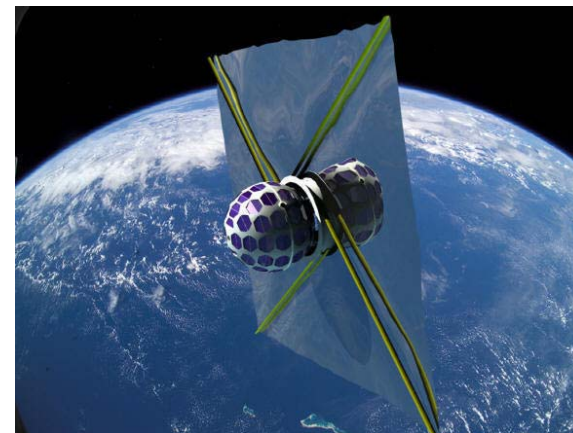
SNOE (1998) – 5 years



SDC (2006)– enroute 15 years



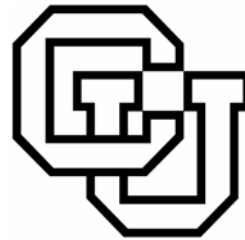
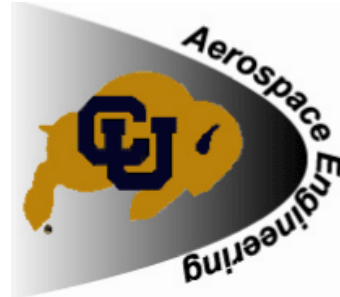
UNP-1 / 2 Three Corner Sat (2004) – launch failure



DANDE – PDR in August 2007

UNP-5

A beneficial collaboration

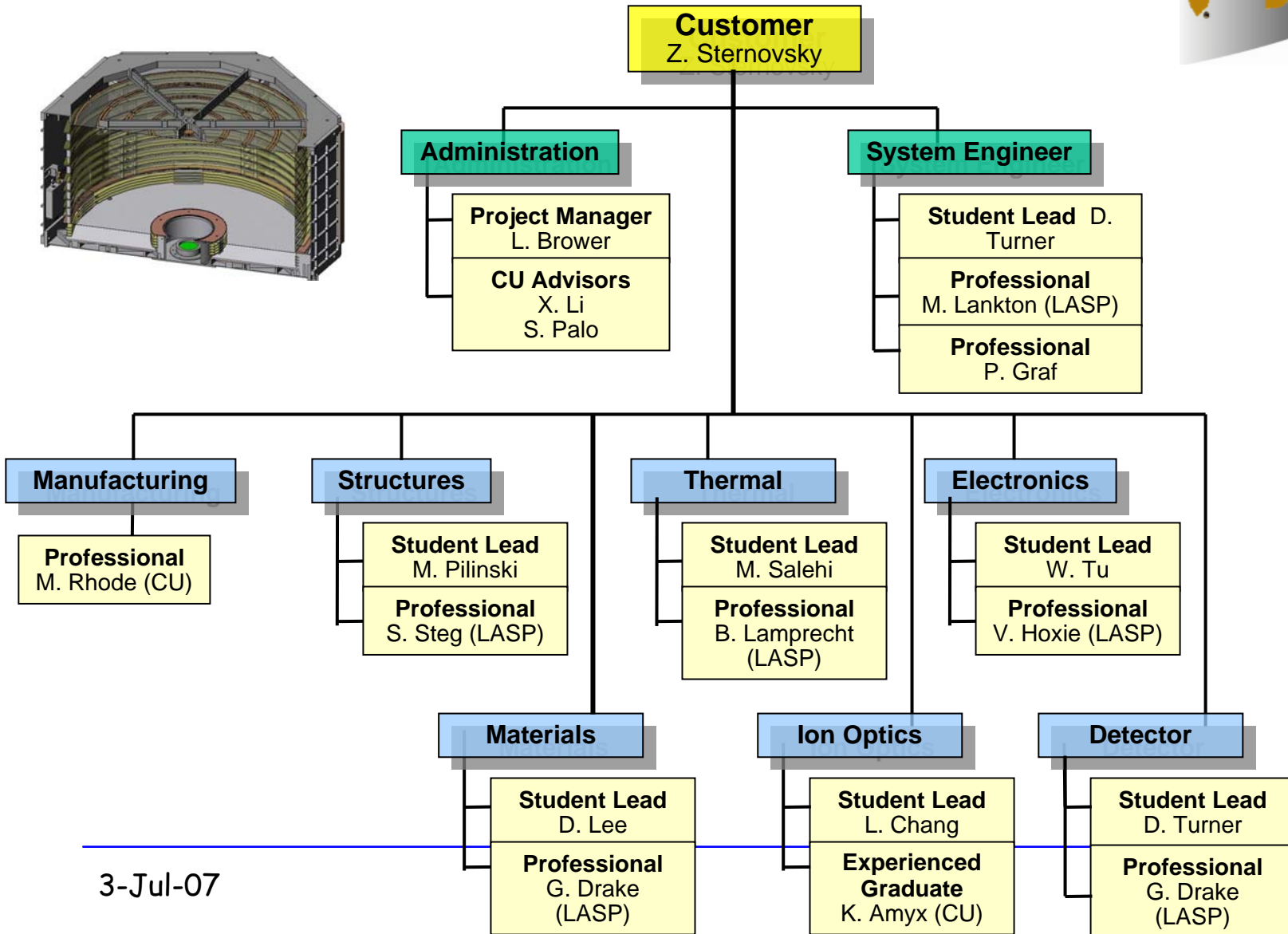
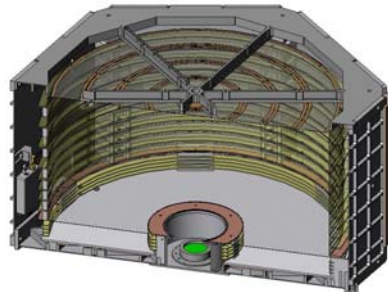


Lessons Learned



- 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



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

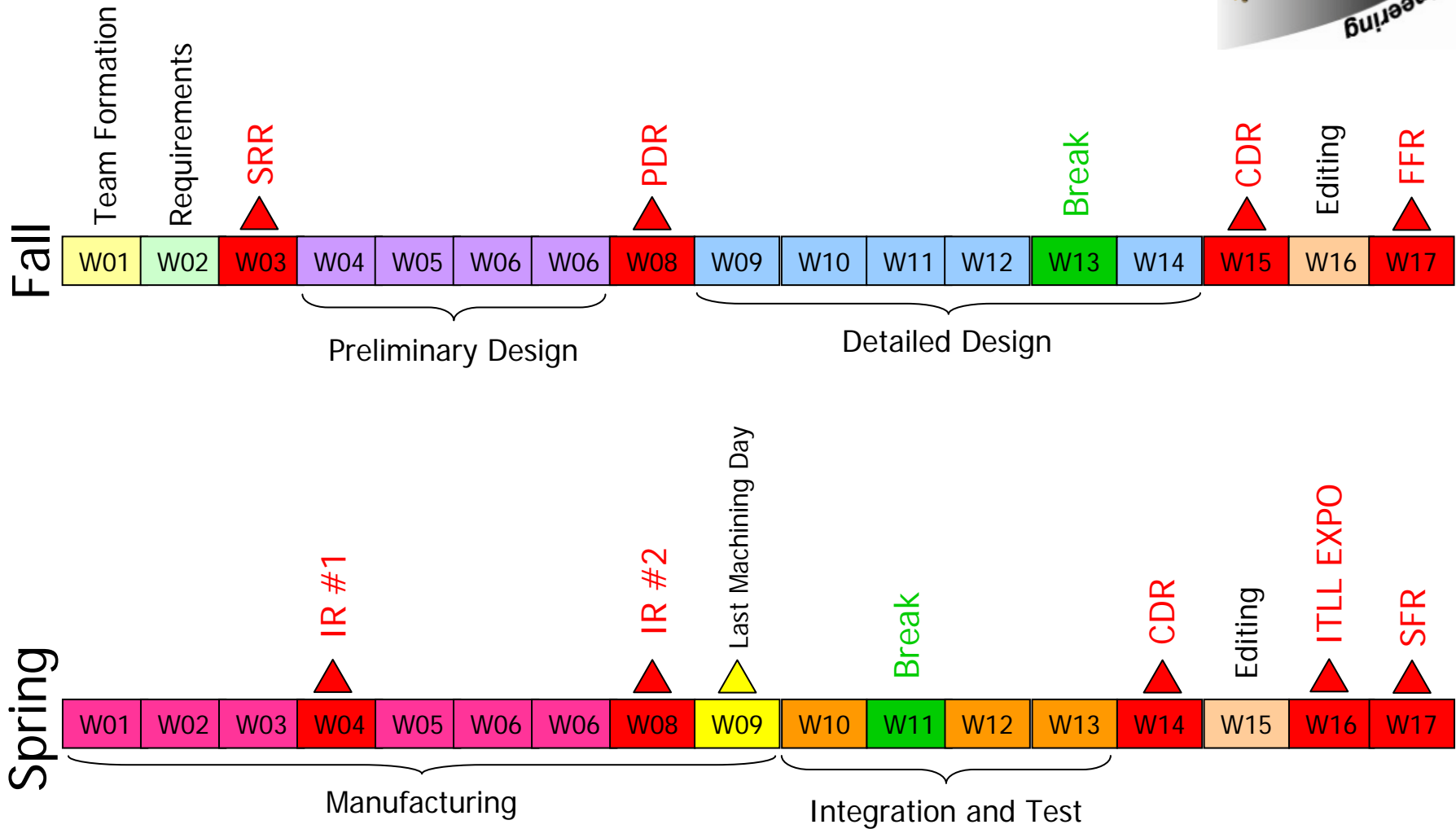
ABET EC2000 – Criteria 4



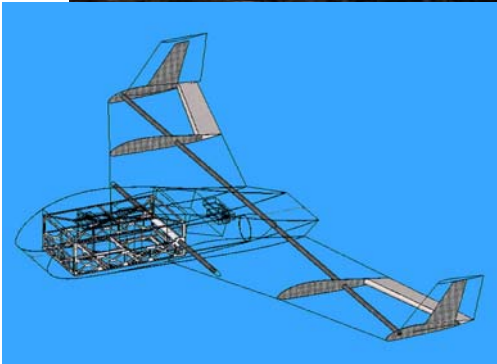
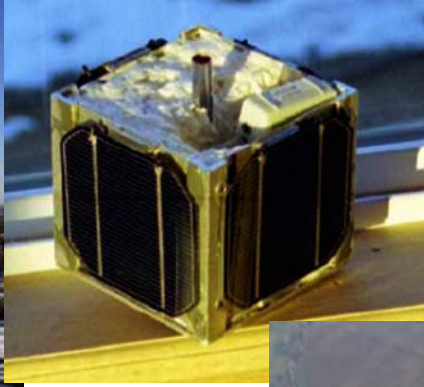
- Criteria 4 – Professional Component

“ 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



3-Jul-07

1st National Capstone Conference



Capstone design courses have become an important factor in receiving ABET accreditation at many institutions. In addition, capstone courses exist in many different forms and states of maturity. The focus of this conference is on moving a Capstone design program to the next level. Interested attendees would typically include department chairs, Capstone design faculty, Capstone design coordinators, industry sponsors, etc. To accommodate programs at all levels of maturity, papers and workshops will be accepted in three broad categories:

- 1) Starting a program featuring externally sponsored projects,
- 2) Institutionalizing a capstone design program, and
- 3) Improving and enhancing existing programs

Sessions will consist of paper presentation, workshops, and other interactive discussions. Abstract submissions are requested in several areas: papers, panel sessions, poster sessions, and workshops. Workshops should be structured for up to four hours and allow for up to 40 participants. Authors should indicate how the workshop could be expanded to accommodate additional participants if warranted by interest.



13 - 15 June 2007
 University of Colorado
 Boulder, Colorado

www.capstoneconf.org

Suggested Topics

Suggested topic areas for papers, panel sessions, poster sessions, and workshops include (but are not limited to):

- 1) Starting a Capstone Design Course with externally sponsored projects (e.g. industry, service, entrepreneurial, competition, etc.)
 - Obtaining Industry Sponsors
 - Intellectual Property
 - Project Scope Assessment
 - Faculty Buy-in, Adjunct involvement
 - What skills to impart to students
- 2) Institutionalizing Capstone Program (getting consistent results, getting and maintaining faculty and institutional support, etc.)
 - Faculty, Industry Liaison/mentor skill development
 - Team Selection
 - Communication, writing, oral presentation
 - Assessments/measurements for Capstone
 - Capstone-Curricula improvement in department
- 3) Improving and enhancing existing programs
 - Service Learning, Humanitarian/Disabled
 - Sustainable & Global Design Experiences
 - Collaborative & Multidisciplinary Projects and Team
 - Entrepreneurial Initiatives
 - Projects for under-represented groups in engineering

Consult the conference website for additional suggested topics.

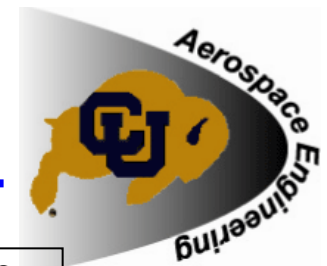
Deadlines:
 Abstracts: Due- 15 December 2006,
 Papers- 400-600 words,
 Workshops- 600-1,000 words
 Paper selection: 30 January 2007
 Final papers due: 30 April 2007
 Workshop materials due: 30 May 2007

Abstract Submission:
 Please consult the conference website (www.capstoneconf.org) for detailed directions on submitting abstracts. Required submission information includes whether the abstract is for a paper, workshop, etc. and which of the three topic areas you feel your abstract best addresses. Acceptance to the conference will be based upon the abstract. Abstract and paper format will follow ASEE guidelines (available from the conference website).



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

A Graduate Curriculum

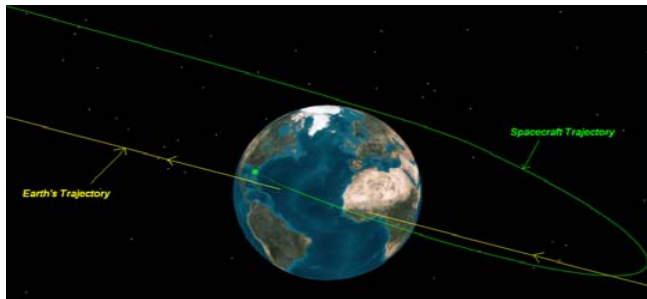
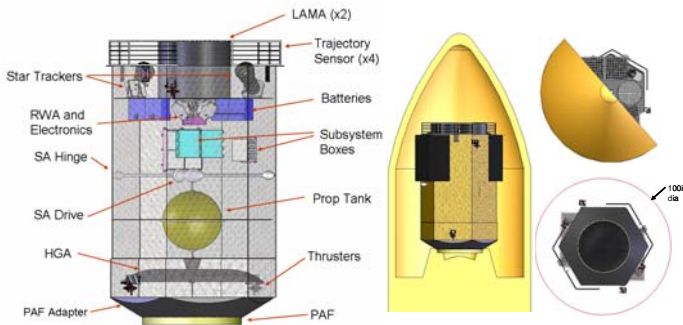


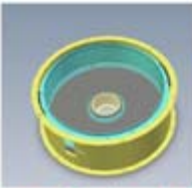
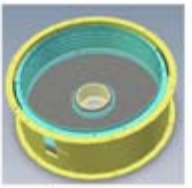

ASEN 5148
Spacecraft Design
Mike McGrath

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