Fall 2006

AOE 4065 — Design (Space) — CRN 90315

Instructor: Dr. Kevin Shinpaugh, 1700 Pratt Dr., 231-1260, kashin@vt.edu

Lectures: 3:30 – 4:45 T Th, Randolph 220

Office hours: After Class (*or by appointment*)

Text (required): W. J. Larson and J. R. Wertz (editors), *Space Mission Analysis and Design*, 3rd edition, Microcosm, 1999

Auxiliary Texts (optional):
T. P. Sarafin (editor), *Spacecraft Structures and Mechanisms*, Microcosm, 1995,
R. W. Humble *et al* (editors), *Space Propulsion Analysis and Design*, McGraw-Hill, 1995,

Course Web Page: http://www.aoe.vt.edu/~kashin/courses/aoe4065
http://www.aoe.vt.edu/~cdhall/courses/aoe4065

Class Listserv: spacedesign@listserv.vt.edu

Design (Space). This course introduces aerospace engineering students to the design of complex space systems. The key elements and subsystems of several important classes of space systems are presented. The systematic approach necessary to design space systems effectively is illustrated through case studies. Individual and group design projects are conducted and presented.

Goal: To serve as a senior design capstone course for the Aerospace Engineering program, integrating space science and engineering material, and introducing students to the problems associated with designing space systems. This course also meets the University "writing intensive" requirement.

Homework Policy: Each student will have one individual presentation and writing assignment. There will be several in-class and out-of-class *group* "mini-project" assignments. Mini-projects will normally be begun during the class period and completed and turned in one or two class periods after assignment. Late submittals will not normally be accepted.

Project: A large group design project assignment will comprise half the credit for this course, and will continue into the Spring semester where it will comprise all of the credit for AOE 4066. The Design Project grade will be a group grade based on the written project report and the oral project presentation. Peer evaluations will be collected and used in differentiating between individual students within a group. In addition to the Design Project, there will be subsystems groups (power, structures, *etc.*) responsible for producing a subsystem report.

Grading Distribution:

Letter	5%
Event Essay	5%
Event Presentation	5%
Technology Essay	5%
Grading	5%
Mini-Projects	15%
Design Project	30%
Functional Division Reports	30%

Honor Code: The University Honor Code will be maintained. You are encouraged to discuss project assignments with your instructor, teaching assistant, and classmates. However, all work submitted for a grade must reflect your own understanding of the material.

Topics: (text reference) *Objective*

Systems analysis for design (Notes & Chapter 1)

List and define Hall's Seven Steps of Systems Engineering. Apply the basic concepts of systems analysis for design.

Space Systems Design (Chapter 1 & Notes)

List and define the steps in the design process. Compare and contrast these with Hall's 7 steps. List and define the elements of a Space Mission Concept. List and define the typical design reviews associated with Space Systems Design.

Orbits, Constellations, & Formations (Chapter 3 & Notes)

Describe the relationship between space flight dynamics and space mission requirements. Design orbits and error budgets for given mission requirements.

Space Environment (Chapter 2 & Notes)

Describe the key environmental factors affecting the operation of a space system operating in Earth orbit, and how these relate to design requirements.

Payloads (Notes)

Describe the basic types and applications of spacecraft payloads. Apply basic techniques for preliminary design and sizing of payloads.

Propulsion (Chapter 4)

Describe the basic types and applications of spacecraft propulsion systems. Apply basic techniques for preliminary design and sizing of propulsion systems.

Attitude Determination and Control (Chapter 5)

Describe the basic types and applications of spacecraft attitude determination and control systems. Apply basic techniques for preliminary design and sizing of ADCS systems.

Power (Chapter 6)

Describe the basic types and applications of spacecraft power systems. Apply basic techniques for preliminary design and sizing of power systems.

Thermal (Chapter 7)

Analyze the thermal environment and its effects on a spacecraft and its subsystems. Apply basic techniques for preliminary design and sizing of active and passive thermal control systems.

Structure (Chapter 8)

Describe the typical interfaces and environmental effects that a spacecraft structural design must accommodate. Apply basic techniques for preliminary design and sizing of structural systems.

Communications (Chapter 9)

Describe the fundamental elements of radio communications used for spacecraft. Organize and compute a link budget for a space application. Apply basic techniques for preliminary design and sizing of communication systems.

Command and Data Handling (Chapters 10 and 11)

Describe the purpose and requirements for commands, telemetry, and data in spacecraft applications. Apply basic techniques for preliminary design and sizing of C&DH systems.

Supplementary References:

- B. N. Agrawal, *Design of Geosynchronous Spacecraft*, 1986, Prentice-Hall.
  This book is about communication satellites. It includes chapters on communications and electronics, orbital and attitude dynamics as well as structural dynamics and thermal control.
- A.I.A.A., *Design for On-Orbit Spacecraft Servicing*, 1991, AIAA.
  This is a proposed guide with very detailed guidelines and methodology.
- P. Fortescue and J. Stark (editors), *Spacecraft Systems Engineering*, 2nd edition, 1997, Wiley.
  Like SMAD, this book is written by a variety of experts and covers many of the same topics.
- M. D. Griffin and J. R. French, *Space Vehicle Design*, 1991, AIAA.
  Similar to Agrawal's book, but with more on propulsion.
- V. L. Pisacane and R. C. Moore (editors), *Fundamentals of Space Systems*, 1994, Oxford University Press, 1994
  Excellent space design book beginning with first principles.
- D. H. Waltz, *On-Orbit Servicing of Space Systems*, 1993, Krieger.
  This book gives extensive coverage of the design and operations concepts required for spacecraft planned for on-orbit construction and servicing.
- J. R. Wertz, editor, *Spacecraft Attitude Determination and Control*, 1978, D. Reidel.
  This is a monumental tome written by many people. It is quite application-oriented, with many examples.
- J. R. Wertz and W. J. Larson (editors), *Reducing Space Mission Cost*, 1996, Microcosm.
  "Reducing mission cost is hard enough if you know what the real costs are, and virtually impossible if you don't."

Professor Mike Gruntman at the University of Southern California has an excellent bibliography at: http://astronauticsnow.com/

The following journals publish papers relevant to space systems engineering:

Ad Astra, Acta Astronautica, COMSAT Technical Review,
Johns Hopkins APL Technical Digest, Journal of Guidance, Control and Dynamics,
Journal of Spacecraft and Rockets, Journal of the Astronautical Sciences
Journal of the British Interplanetary Society, RCA Review

The following *Proceedings* series have papers on space systems engineering:

Advances in the Astronautical Sciences (American Astronautical Society)
Progress in Aeronautics and Astronautics (AIAA)