Syllabus for AERO 401 Aerospace Vehicle Design – Spacecraft Design – Fall 2018
3 credits (3-0), satisfies senior capstone design requirement

Instructor: Daniel Selva, HRBB 620C, dselva@tamu.edu
Office hours: Fridays 2-4 or by email appointment

Class Location and Time: ZACH 260 Lectures: MWF 11:30-12:20 Labs: TR 11:10-12:00

Ext. Advisors: William Blackwell, MIT Lincoln Laboratory, wjb@ll.mit.edu
TBD: Tom Heinsheimer, Aerospace Corporation, Thomas.heinsheimer@aero.org

Course Description
This course is based on knowledge and skills acquired in earlier undergraduate course work. The objective of this course is to provide the students with a major design challenge that will give them firsthand experience with the design process, including the use of modern Systems Engineering principles and tools. Project Management is also emphasized as an important element of achieving a successful design. Prevailing practices used in modern space system design, and knowledge from space-related engineering disciplines, will be applied to a design challenge. Oversight, mentoring and review of the students' work will be provided by subject matter experts from NASA and/or industry. The students will work in teams to survey and report on the state-of-the-art in various disciplines before developing requirements for a mission architecture. Design aspects will account for engineering as well as operational considerations. Mission concepts will be implemented with some level of fidelity. Analysis, modelling and simulation of the design components will be required. Projects will be presented at a design review attended by NASA and/or industry leaders. Topics covered during lectures include subsystem technologies and the systems-engineering principles that tie them together into a spacecraft architecture. Subsystem technologies discussed include communications, thermal subsystems, structure, spacecraft power, payloads (remote sensing, in-situ sensing, human life support), entry/descent/landing, surface mobility, and flight-computer hardware and software.

Pre-requisites: AE 302, AE 303, AE 306, AE 321, AE 351

Required textbook: Space Mission Engineering: The New SMAD (Space Technology Library, Vol. 28, Microcosm Inc., July 2011 Edition, ISBN: 1881883159.

Optional materials:
- Fortescue et al., Spacecraft Systems Engineering (Wiley, 2011).
- Griffin and French, Space Vehicle Design, 2nd Ed., (AIAA, 2008).

Attendance Policy: Students are expected to attend all classes. Only university excused absences will be accepted. Frequent in-class questions and quizzes will be unannounced, and count toward the final grade. Absences must be arranged/excused with the instructor before the class time. Otherwise, there are no make-up opportunities for missed workshop/quiz submissions. Attendance will be recorded and will affect the final grade.

Learning Outcomes
By the end of this course, students will:

Objective	Assessment Method	ABET outcome
Have the ability to design a system or mission to optimize figures of merit while meeting technical and programmatic requirements and constraints.	Oral status reports, written reports, final design review.	**3(a), 3(c), 3(d), 3(e), 3(f), 3(g), 3(h), 3(j), 3(k), 3(PC2), 3(PC3), 3(PC4), 3(PC5)**
Understand the basic Systems Engineering processes and how they apply to spacecraft system design.	Quizzes, written reports, final design review	**3(c), 3(i), 3(k)**
Successfully function in a controlled team environment during which they will work on cross-discipline teams in which clear communication and cooperation are imperative.	Oral status reports, written reports, final design review	**3(d), 3(g)**
Improve their technical communications skills	Oral status reports, written reports, final design review.	**3(g)**
Understand the basic industry standard design and review procedures as practiced by NASA and the Air Force among others.	Quizzes, written reports, final design review	**3(k)**
Understand the need for engineering standards, how to apply them, and be able to incorporate them into their design project.	Oral status reports, written reports, final design review	**3(k), 3(c)**

Course Requirements

1. Project Design Documents and Presentations: This course mimics U.S. industry and government practice in documenting spacecraft system architecture and analysis details in written reports and presentations that correspond to key decision points in the lifecycle of a spacecraft. The lectures will include discussion of all aspects of this lifecycle. However, a single semester is simply not enough time to walk through a full-scale design process for a realistic system, regardless of size or complexity. So, design reports in this class require that the design be analyzed up to the "Preliminary Design Review" stage and include a plan for completing work up to the "Critical Design Review" stage. Additional work—e.g. completing more detailed analysis, building prototypes, etc.—will be undertaken in AERO 402.

The summary below is meant as an overview. Each assignment will include more detail and will draw from material provided in lecture:

- **SRR Document**: The System Requirements Review establishes the correctness of key requirements for the space system, including performance, functionality, and design processes. This written document will be approximately 10 pages, consisting of precisely articulated requirements at the level of the mission, space and ground segments, and high-level subsystems.

- **SDR Document**: The System Design Review is a milestone that confirms that the system architecture is solving the right problem: that the requirements are reflected in the basic choices that comprise the spacecraft to be analyzed in greater detail. The document to be completed is a roughly 10 page (min 2000 words + figures) summary that explains the big picture: images of the spacecraft, high-level diagrams, the concept of operations, and a mission timeline.

- **PDR Presentation**: The Preliminary Design Review documents the analyses that demonstrate the spacecraft as architected can feasibly meet the requirements. More detailed analysis will have to be performed before the spacecraft's components can be procured or built, but after PDR, there is no longer a question that the story holds together. At this point some "long-lead items" might be procured for a real spacecraft; so, some insight into possible vendors is required at the PDR level. This presentation will be scheduled for a time/day near the end of the semester and will offer an opportunity for the students on the team to receive critiques that can be incorporated into the Final Design Report.

- **CDR Plan**: The Critical Design Review marks the end of design and analysis and the beginning of fabrication/procurement, assembly, integration, and testing. Unique to this class, the CDR plan required here is a 5-page (~2000 words) document that summarizes what analyses will be required if the project were to continue to CDR.

- **End of semester design Report**: This report might be called a "PDR Analysis Book." It documents the details of the analysis presented at PDR. It takes the form of a design report, which begins with describing high-level requirements, the mission and spacecraft architectures that meet these requirements, and post-PDR activities. It is meant to stand on its own but likely will incorporate most of the material already submitted during the semester. Creating this report should be more of an exercise in organization of existing work into the form of a report and verifying completeness than generating new material. There is no specific length requirement, but a reasonable length is 10,000 words.

2. <u>Quizzes</u>: There will be a number of in-class and take-home quizzes. The quizzes will be individual, open books and open notes, but access to internet will not be permitted. They will consist of questions similar in nature and difficulty to those used in the problems solved in class.

3. <u>Participation</u>: As per the attendance policy paragraph above, attendance to all lectures and labs is required and will be monitored through the use of iclickers or similar (to be confirmed during the first week of classes). In order to get full credit for participation, students must also submit all the required peer evaluation forms.

Grading procedures:

(a) 25% Final Design Report
(b) 25% Individual in-class and take-home quizzes
(c) 10% Participation
(d) 10% Final PDR Presentation
(e) 10% SRR Report
(f) 10% SDR Report
(g) 10% CDR Plan

For the grades that involve group activity, individual grades are assigned on the following basis:

- Each design document is assigned a single grade X. Criteria for grading each document will be provided along with the specifics of the assignment. The total points (T) available to the N members of the team is given by $T = X \cdot N$.
- The default is that each student receives the grade given to the group's document. This distribution of points would reflect the case where each student contributes similar quality and quantity of work.
- Students are asked to identify which portion of the reports they worked on. The instructors' assessment of these sections may alter the distribution of points among the team members so that each student's grade differs from the overall document grade, keeping T constant.
- For the final report, each student is asked to assess each team member's contributions (quality, quantity, timeliness, etc.), and the total points are redistributed if it's clear from these assessments that some students deserve more credit than others.

All grading appeals must be made to the instructor in writing with justification (including references to lecture notes or readings) within one week after graded material is returned. The entire homework will be re-graded, not merely the part in question. So, a regrade may raise or lower the score.

Grading Scale: A 90-100% B 80-89% C 70-79% D 60-69% F < 60%

Academic Integrity

The Texas A&M University Code of Conduct is the Aggie Code of Honor: "*An Aggie does not lie, cheat or steal, or tolerate those who do.*"

Any form of cheating, plagiarism, and/or academic dishonesty may result in an "F" grade and/or other disciplinary action. See http://aggiehonor.tamu.edu for more information.

Accommodations for students with disabilities

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, located at the Disability Services Building at the Student Services at White Creek complex on west campus, or call 979-845-1637. For additional information visit: http://disability.tamu.edu.

Inclusivity Statement

We understand that our members represent a rich variety of backgrounds and perspectives. The Texas A&M University System is committed to providing an atmosphere for learning that respects diversity. While working together to build this community we ask all members to:

- share their unique experiences, values and beliefs
- be open to the views of others
- honor the uniqueness of their colleagues
- appreciate the opportunity that we have to learn from each other in this community
- value each other's opinions and communicate in a respectful manner
- keep confidential discussions that the community has of a personal (or professional) nature
- use this opportunity together to discuss ways in which we can create an inclusive environment in this course and across the Texas A&M community

Tentative Course Schedule (*May change to accommodate guest presenters & student needs*)

Date	Weekday	Lecture/Lab	Topic
8/27/2018	Monday	Lecture	Introduction
8/28/2018	Tuesday	Lab	Intro to STK
8/29/2018	Wednesday	Lecture	[No class]
8/30/2018	Thursday	Lab	Intro to this semester's projects
8/31/2018	Friday	Lecture	The Space Mission Engineering Process
9/3/2018	Monday	Lecture	Requirements Engineering
9/4/2018	Tuesday	Lab	Requirements lab
9/5/2018	Wednesday	Lecture	Space Environment
9/6/2018	Thursday	Lab	Space environment exercises
9/7/2018	Friday	Lecture	Review of basic astrodynamics
9/10/2018	Monday	Lecture	Orbit design
9/11/2018	Tuesday	Lab	STK Exercise 1
9/12/2018	Wednesday	Lecture	[Career fair - no class]
9/13/2018	Thursday	Lab	[Career fair - no class]
9/14/2018	Friday	Lecture	Constellation design
9/17/2018	Monday	Lecture	ADCS, GN&C subsystems
9/18/2018	Tuesday	Lab	Pointing budget exercise
9/19/2018	Wednesday	Lecture	Propulsion
9/20/2018	Thursday	Lab	Delta V budget and sizing exercise
9/21/2018	Friday	Lecture	Overview of payloads and comms
9/24/2018	Monday	Lecture	Communications I
9/25/2018	Tuesday	Lab	Comms exercises
9/26/2018	Wednesday	Lecture	Communications II
9/27/2018	Thursday	Lab	STK Exercise 2
9/28/2018	Friday	Lecture	Microwave remote sensing
10/1/2018	Monday	Lecture	Microwave payloads

10/2/2018	Tuesday	Lab	Payload exercises
10/3/2018	Wednesday	Lecture	Optical remote sensing
10/4/2018	Thursday	Lab	STK Exercise 3
10/5/2018	Friday	Lecture	Optical payloads
10/8/2018	Monday	Lecture	Power
10/9/2018	Tuesday	Lab	Payload exercises
10/10/2018	Wednesday	Lecture	Thermal
10/11/2018	Thursday	Lab	Power and thermal exercises
10/12/2018	Friday	Lecture	Structures
10/15/2018	Monday	Lecture	Avionics
10/16/2018	Tuesday	Lab	Structures and avionics exercises
10/17/2018	Wednesday	Lecture	ECLSS
10/18/2018	Thursday	Lab	ECLSS exercise
10/19/2018	Friday	Lecture	Ground segment
10/22/2018	Monday	Lecture	Launch vehicles
10/23/2018	Tuesday	Lab	Launch vehicle user guides
10/24/2018	Wednesday	Lecture	Cost modeling
10/25/2018	Thursday	Lab	Cost exercises
10/26/2018	Friday	Lecture	Risk and reliability
10/29/2018	Monday	Lecture	Humans in space
10/30/2018	Tuesday	Lab	Risk exercises
10/31/2018	Wednesday	Lecture	Tradespace exploration
11/1/2018	Thursday	Lab	Tradespace exploration exercise I
11/2/2018	Friday	Lecture	Cubesats and smallsats
11/5/2018	Monday	Lecture	Space Policy
11/6/2018	Tuesday	Lab	Tradespace exploration exercise II
11/7/2018	Wednesday	Lecture	SDR presentations
11/8/2018	Thursday	Lab	SDR presentations
11/9/2018	Friday	Lecture	SDR presentations
11/12/2018	Monday	Lecture	Entry Descent and Landing
11/13/2018	Tuesday	Lab	SDR Feedback
11/14/2018	Wednesday	Lecture	Earth Science Missions
11/15/2018	Thursday	Lab	SDR Feedback
11/16/2018	Friday	Lecture	Astrophysics missions
11/19/2018	Monday	Lecture	Planetary Science missions
11/20/2018	Tuesday	Lab	Project Q&A
11/21/2018	Wednesday	Lecture	[Reading Day - no class]
11/22/2018	Thursday	Lab	Thanksgiving holiday
11/23/2018	Friday	Lecture	Thanksgiving holiday
11/26/2018	Monday	Lecture	Navigation missions
11/27/2018	Tuesday	Lab	Project Q&A

11/28/2018	Wednesday	Lecture	Human exploration missions
11/29/2018	Thursday	Lab	Project Q&A
11/30/2018	Friday	Lecture	Space weather missions
12/3/2018	Monday	Lecture	PDR presentations
12/4/2018	Tuesday	Lab	PDR presentations
12/5/2018	Wednesday	Lecture	PDR presentations

Prepared by Daniel Selva on 8/17/2018