EAS 4700 – AEROSPACE DESIGN 1 (3 credits) - FALL 2017
*** Syllabus (a.k.a. our contract for the semester) ***

COURSE INSTRUCTOR: Dr. Riccardo Bevilacqua, MAE-A 308, bevilr@ufl.edu, 352-392-6230. Office hours: Tuesdays 10am-1pm, from August 22nd, 2017 to Dec 5th, 2017.

CLASS WEBSITE: canvas and http://www.riccardobevilacqua.com/teaching.html

CLASS MEETS: M, W, periods 9-10 (4:05pm-6:00pm), TUR L005.

TEACHING ASSISTANT/S: Mr. Patrick Kelly pkelly89@ufl.edu MAE-A 211, hours TBD.

Mr. Sanny Omar sanny.omar@ufl.edu and Dr. David Guglielmo dguglielmo@ufl.edu kindly agreed to be available as additional consultants.

PRE-REQUISITES: EAS4510 and EML4312 with at least D grade. Working knowledge of MATLAB and a CAD program is required.

COURSE OBJECTIVES: By the end of this course, you should be able to do the following:

1. Prepare technical documents in aerospace industry.
2. Give technical presentations, develop communication skills.
3. Work in team and lead a team.
4. Seek, find, and assimilate the knowledge you need to solve new problems.

COURSE ASSESSMENT MEASURES FOR ABET:

The following table shows which ABET Student Learning Outcomes (SLO) are targeted by this course.

	Students Learning Outcomes											
Course #	**Course Name**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
EAS4700	Aerospace Design 1			P	P		P	OP	P			P

A	B	C	D	E	F
P	P	P	P	P	P

Legend

a	An ability to apply knowledge of mathematics, science, and engineering
b	An ability to design and conduct experiments, as well as to analyze and interpret data
c	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d	An ability to function on multi-disciplinary teams
e	An Ability to identify, formulate and solve engineering problems
f	An understanding of professional and ethical responsibility
g	An ability to communicate effectively
h	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context
i	A recognition of the need for, and an ability to engage in lifelong learning
j	Knowledge of contemporary issues
k	An ability to use techniques, skills, and modern engineering tools necessary for engineering practice
A	A knowledge of aerodynamics
B	A knowledge of aerospace materials
C	A knowledge of structures
D	A knowledge of propulsion
E	A knowledge of flight mechanics
F	A knowledge of stability and control

E	Direct measure - Focused ***E*** xam or assignment problem and grade
P	Direct measure - Focused ***P*** roject section write up and grade
L	Direct measure - Focused ***L*** aboratory (section) write up and grade
OP	Direct measure - focused **O**ral **P**resentation, and write up grade.
QI	Indirect measure - Survey ***Q*** uestion "***I*** "
CG	Indirect measure - ***C*** ourse ***G*** rade
CR	Indirect measure - **C**oop **R**eports

Red	Essential aspect of course - Direct measure
Pink	Essential aspect of course - Indirect measure
Orange	Essential aspect of course - not measured
Yellow	Important aspect of course - not measured
Green	Covered, but not major aspect - no data collected
White	Not covered

The following table maps assignments to SLOs. It shows how each SLO is assessed.

Assessment	**Student Learning Outcomes**
Final Report	c, d, f, h, A, B, C, D, E, F
Presentations	g
Peer grading	d
STK Certification	k

COURSE DESCRIPTION: This course introduces all elements of the spacecraft design process. Students are organized into design teams and associated with different subsystems and tasks, to develop a solution to a space vehicle system's problem of practical interest, by drawing on their background in aerospace engineering science, machine design, and manufacturing methods. Topics include problem definition and requirement analysis, design specifications, concept development, reliability, consideration of alternative solutions, materials considerations, engineering prototyping, mission analysis, costs, and presentation skills. This is a communication-intensive and writing-intensive course.

For this semester, a set of design requirements for a Mars mission is provided. See document at the end of the syllabus.

The table below provides a tentative schedule for this course, highlighting only some events. The teams will meet around 30 times, and most of the meetings will be design work time.

TOPIC	**Meeting # or date**
Intro, syllabus, teams, action items list	1
Systems engineering, risk examples, STK examples	2
Simulink/Matlab examples	3
Reviewing applicable docs – kick off design work	4
SYSTEMS ENGINEERING 1 -- Recognize the need for new system, often a customer requires it. A market analysis often happens outside of Systems Engineering.	12
Midterm presentation	**Week of Oct 13**
Midterm survey due	**Oct 18**
SYSTEMS ENGINEERING 2 -- Collecting requirements and selecting which ones are stringent. Define Functions of the system. Iterations with customer to understand needs and balance them. Often this will clarify the customer's ideas. Identify constraints on cost, weight, volume, reliability, etc. … .	16
SYSTEMS ENGINEERING 3 -- Translate the problem definition into quantities, measurable inputs/outputs that the engineer can use. Performances definition. DESIGN OBJECTIVES: framework to compare against, when design alternatives are developed.	21
SYSTEMS ENGINEERING 4 & 5 -- Formulation of several system models (concepts) meeting the design objectives. / Selection of the best model, or combination of models. Analytical tools used to evaluate performances. First evaluation of costs can be done.	25
Final presentation & report & STK & peer grade	**Dec 6**

<u>TEXTBOOK/SOFTWARE</u>:

Text No. 1	Title: **ELEMENTS OF SPACECRAFT DESIGN** ISBN: **1563475243** Cover: **N/A**	Publisher: **AIAA** Edition: **2ND**	Author: **CHARLES D. BROWN** Copyright: This text is **recommended**
Text No. 2	Title: **SPACE MISSION ANALYSIS AND DESIGN, 3RD EDITION** ISBN: **1881883108** Cover: **N/A**	Publisher: **MICROCOSM** Edition: **3RD**	Author: **JAMES WERTZ** Copyright: This text is **required**
Text No. 3	Title: **EMERGENCE OF PICO & NANOSATELLITES** ISBN: **9781600867682** Cover: **N/A**	Publisher: **AIAA** Edition:	Author: **THAKKER** Copyright: This text is **recommended**

(End of Adoption No. 222566)

You must have access to MATLAB and a CAD program. You must have STK installed on individual machines, with running license. More requirements may arise during the semester.

PRESENTATIONS AND REPORT: Midterm (**Week of Oct. 13, 2017, MAE-A 211, scheduled as needed**) and final (**Week of Dec. 6, 2017, MAE-A 211, scheduled as needed**) presentations will be given to the instructor and customer, **20% each**. A final report, in the format of a student competition conference paper for the small satellite conference will be due **Dec. 6, 2017, 40%** (paper template: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0ahUKEwifoZ6AkdXNAhUFbSYKHWCYBrwQFggxMAM&url=http%3A%2F%2Fwww.smallsat.org%2Fstudents%2Fcompetition-paper-template.doc&usg=AFQjCNHZphaZVOka2f_i8SmNmhtiAEvDuw&sig2=21arXUNjskPs07trV7BgZg&cad=rja).

Each member of each team will evaluate his/her peers. **This peer evaluation is 20% of the grade**.

MIDTERM SURVEY: A voluntary mid-term survey will be provided, **due Oct 18**. To incentivize your participation, the survey will be valued as 5% **bonus**.

STK OPTIONAL CERTIFICATIONS: The instructor will provide instructions to access AGI's Systems Tool Kit and to get certified in its use, at the beginning of the semester (http://downloads.agi.com/u/downloads/products/STK-Certification-Flyer.pdf).
Those interested will have the opportunity to receive 10% **bonus** for the first level certification, 20% **bonus** for the second level. **The bonuses are NOT cumulative, i.e. 10% for first level, an additional 10% for second level. No credit for level 3**. THIS IS NOT REQUIRED AND COMPLETELY OPTIONAL, BUT VERY MUCH ENCOURAGED. **THE DEADLINE TO TURN IN PROOF OF CERTIFICATION/S (EMAIL FROM AGI) IS DECEMBER 6, 2017**

GRADING POLICY: The grading scale is as follows:

A: 94 to 100

A-: 90 to 93.99

B+: 85 to 89.99

B: 80 to 84.99

B-: 75 to 79.99

C+: 70 to 74.99

C: 65 to 69.99

C-: 60 to 64.99

D+: 55 to 59.99

D: 50 to 54.99

D-: 45 to 49.99

E: Less Than 45

CLASS ATTENDANCE AND MAKE UP POLICY: Students are expected to attend all meetings. There will be no early/late exams. Please make your travel arrangements according to the exam dates specified in the syllabus. The general rule is no make-up exams and no rescheduling of exams to other times.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found at: https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx.

The students remain completely responsible for timely communications with the instructor.

STUDENTS WITH DISABILITIES: Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, www.dso.ufl.edu/drc/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. **Students with disabilities should follow this procedure as early as possible in the semester. In other words: immediately at the beginning.**

CHEATING POLICY: absolutely zero tolerance. Your examinations must be completed completely independently. If anyone is caught having worked together on an exam or having used an unauthorized source, the penalty is an automatic failure of the course.

Cheating breaks the mutual trust between instructor and student. Cheating will invariably result in an automatic “E” grade and the incident will be reported to the University.

Familiarize with the concept of plagiarism as well – plagiarized work is cheating.

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Students should also familiarize with the Code of Ethics for Engineers: http://www.nspe.org/resources/ethics/code-ethics

ONLINE STUDENTS COURSE EVALUATION: Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at https://evaluations.ufl.edu. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open.

Summary results of these assessments are available to students at https://evaluations.ufl.edu/results/.

The instructor will also provide a midterm evaluation form to the students, to monitor the development of the class, and make necessary adjustments, when possible. I value your input, and that is why I am giving you an incentive to complete this optional survey at mid-semester. See also grading policy for points assigned to this survey.

CLASS DEMEANOR EXPECTED BY THE INSTRUCTOR: I have little tolerance for students who are repeatedly late to class, cell phone ringing, text messages beeps, and any behavior that may be distracting both students and instructor. Offenders will be asked to leave the classroom, and the lecture will not resume until they comply. If they do not comply, the lecture will be given for granted and the instructor will move on.

Also, I will not be eating while teaching (obviously!), and I expect you not to eat in class.

Contact information for the Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc/Default.aspx, 392-1575; and the **University Police Department**: 392-1111 or 9-1-1 for emergencies

EAS 4700
Aerospace Design I
Fall 2017

COMPASS Project Outline

Constellation for Mars Position Acquisition using Small Satellites

Overview

The **CO**nstellation for **M**ars **P**osition **A**cquisition using **S**mall **S**atellites **(COMPASS)** will establish a network of satellites around Mars to provide navigational support for assets on the Martian surface. This network may also serve as a communications array, allowing for increased connectivity among rovers and stations across the planet. A primary objective of the COMPASS project is to accomplish all tasks using CubeSats to reduce mission costs.

The COMPASS constellation design is a Ballard-Rosette design, characterized by a number of circular, inclined satellite orbits, with evenly-spaced separation about an equatorial belt (i.e., evenly-spaced right ascensions of the ascending nodes between each of the orbits). To provide complete circumferential coverage of the planet, each orbit requires a minimum of three satellites. Additionally, the COMPASS constellation is modeled with a purpose similar to the Navstar GPS constellation. By design, a user anywhere on the Martian surface will have continuous access to at least four COMPASS satellites for accurate, global positioning. For this reason, at least four orbital planes are required to allow a user access to at least four satellites at any given time. A fifth plane is added to account for occasional coverage gaps on the planet's surface. The orbital inclination is set to 45 degrees to allow for sufficient coverage of the polar regions, which are typically the least accessible regions in Ballard-Rosette constellation designs. An aerostationary orbital (ASO) altitude is selected to cycle orbits daily and operates at a high enough altitude to avoid atmosphere and moon interference.

Satellite Design Requirements

The COMPASS CubeSat must continuously transmit accurately time-stamped identifier and ephemeris data to a receiver on the surface of Mars. The satellite must also be able to withstand the deep space environment for prolonged durations. Due to the number of satellites required to complete the constellation, the final design must result in a lightweight satellite to reduce launch and transit costs. Solar sailing concepts are highly prioritized in the satellite design as solar sails provide lightweight, long-term, propellantless propulsion solutions for small satellites. The final design must meet all requirements listed in the following page. In addition, the team which proposes the best design (to be determined by the instructor and his associates) will be invited to submit a student competition paper to the SmallSat Conference in 2018.

Outline of Requirements

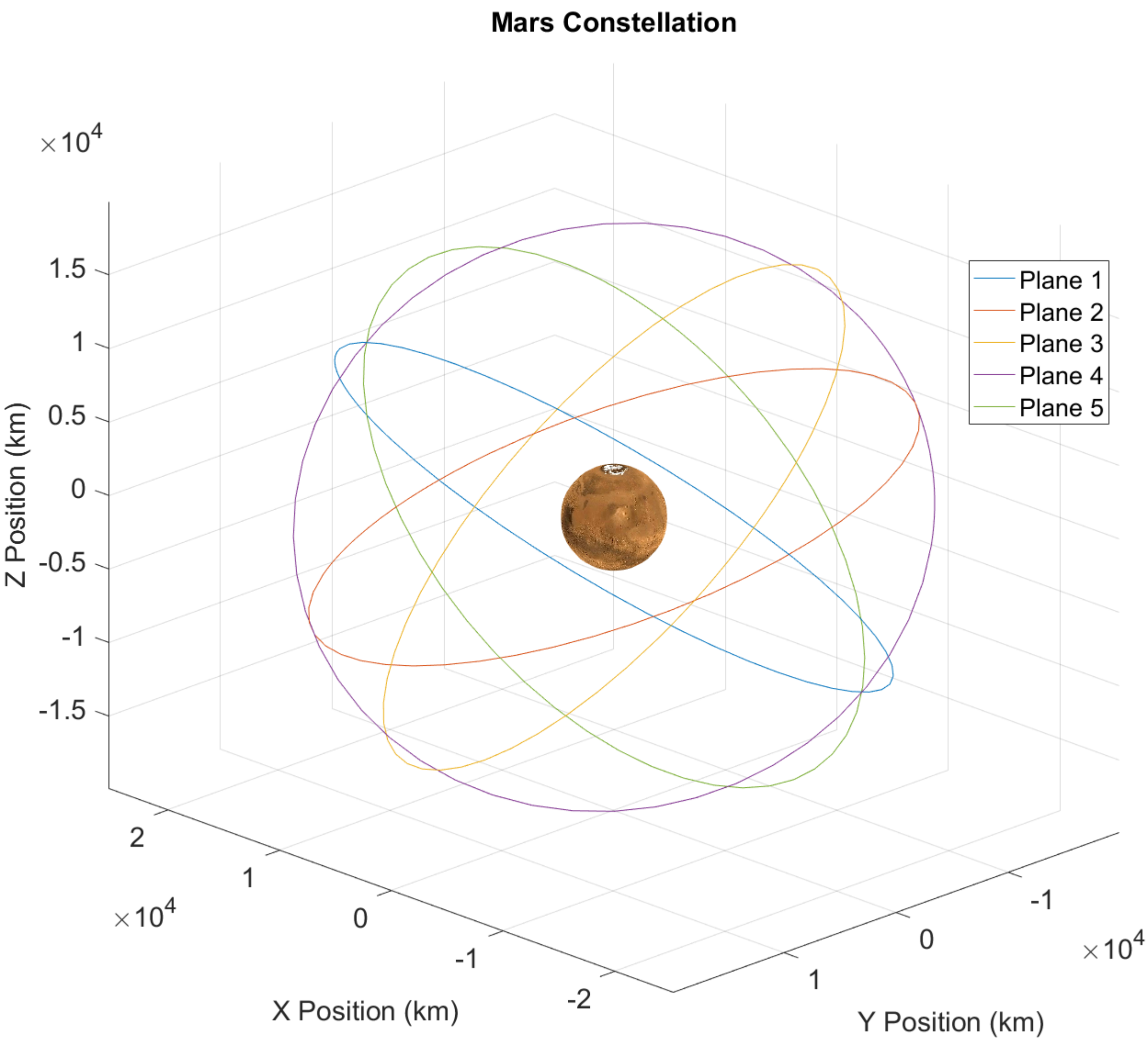
Design Benchmarks

- Precise Timekeeping
  - List expected levels of accuracy
  - Estimate expected position error due to clock accuracy
- Communications
  - Satellite to receive commands and updates from ground station
  - Satellite to transmit time-stamped ephemeris and identifier signal
  - Cone angle must always encapsulate maximum planetary surface area
  - Detailed Link Budget
- Solar Sail Design
  - Sail Dimensions
  - Sail Material
  - Proposed method of deployment
  - Proposed method of actuation
- Hardware
  - Deep-space qualified
  - 6U form factor or less

Project Benchmarks

- Satellite Design Outline
  - Systems outline diagram for satellite
  - Justification for included subsystems
- Computer-Aided Design of Satellite
  - Modeling of structure and all major subsystems
  - Complete using SolidWorks
- Orbit Simulation
  - Simulation of transfer orbit
    - Initial capture orbit to suitable COMPASS orbit (as outlined in **COMPASS Concept**)
  - Complete using Systems Tool Kit (STK)
    - Astrogator solution for orbit transfer
- Attitude Control Simulation
  - Pointing vector definition
    - Access to maximum planetary surface area for receiver and transmitter at any given time
  - Complete using MATLAB or Simulink

COMPASS Concept



COMPASS Constellation Definitions

Number of Planes	5
Satellites per Plane	3
Orbit Inclination	45°
Orbit Altitude	20427 km