EAS 4700 – AEROSPACE DESIGN 1 (3 credits) - FALL 2018
*** 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: Wednesdays 1pm-4pm, from August 22nd, 2018 to Dec 5th, 2018.

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

CLASS MEETS: M, W, periods 9-10 (4:05pm-6:00pm), MAE-A 303.

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

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 gamma ray mission are provided, with customer the University of Padova, Italy. 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 5**

TEXTBOOK/SOFTWARE:

Text No. 1	Title: **ELEMENTS OF SPACECRAFT DESIGN**		Author: **CHARLES D. BROWN**
	ISBN: **1563475243**	Publisher: **AIAA**	Copyright:
	Cover: **N/A**	Edition: **2ND**	This text is **recommended**
Text No. 2	Title: **SPACE MISSION ANALYSIS AND DESIGN, 3RD EDITION**		Author: **JAMES WERTZ**
	ISBN: **1881883108**	Publisher: **MICROCOSM**	Copyright:
	Cover: **N/A**	Edition: **3RD**	This text is **required**
Text No. 3	Title: **EMERGENCE OF PICO & NANOSATELLITES**		Author: **THAKKER**
	ISBN: **9781600867682**	Publisher: **AIAA**	Copyright:
	Cover: **N/A**	Edition:	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. 15 2018, MAE-A 211, scheduled as needed**) and final (**Week of Dec. 3, 2018, 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. 5, 2018, 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. 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 5, 2018**

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

<u>CLASS ATTENDANCE AND MAKE UP POLICY</u>: 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.

<u>STUDENTS WITH DISABILITIES</u>: 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.**

<u>CHEATING POLICY</u>: 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

<u>ONLINE STUDENTS COURSE EVALUATION</u>: 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

MeVcube prototype – University of Florida's Aerospace Design I class – Fall 2018
Design requirements

Overview

Gamma ray astrophysics has recently revolutionized our view of the cosmos, revealing a tumultuous Universe filled with transients and variable sources. Many observatories from ground and in space cover the sky at all times, but the energy range around ~1 MeV has the worst coverage (see Fig. 1), due mostly with the complexities of the interactions of photons with matter in the Compton regime.

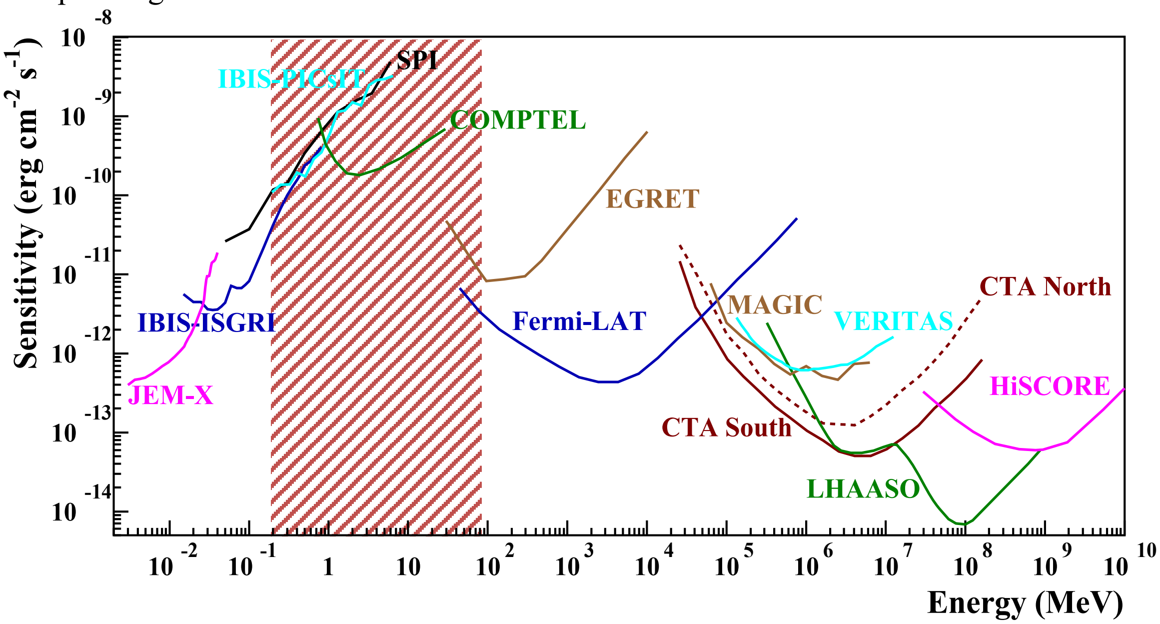
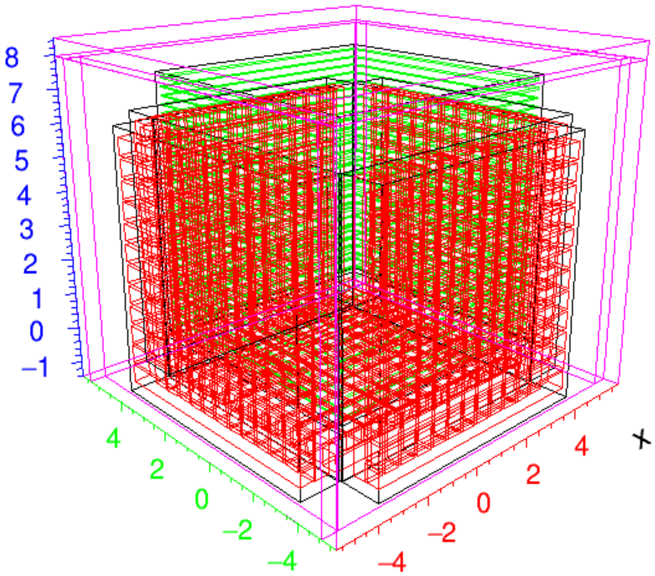


Fig. 1: Point source sensitivity (i.e. minimum detectable flux) for past, present, and future observatories, on ground and in space. Notice the limited coverage from ~200 keV to ~50 MeV.

On the other hand this is a very important energy window for astrophysics. From observations in the neighboring energy ranges we extrapolate that several classes of sources have their peak emission in this band, notably Gamma Ray Bursts associated with Gravitational Wave events. Moreover, there is a strong analogy between optical and MeV astronomy. In the optical band we observe emission and absorption lines due to the excitation of electrons in the atoms, allowing to identify the elements at the emission site and along the line of sight. Similarly, in the MeV band we observe nuclear emission lines, allowing us to probe the isotopic contents of remote sources and the details of the interactions of cosmic rays and the interstellar medium.

Large-scale observatories are being proposed (e-ASTROGAM, AMEGO). These are complex and expensive instruments (~500 M$) with long construction and commissioning times. We propose a nanoscale instrument based on a similar design, with smaller cost (<1M$) and rapid development (~3 years). From the technological point of view it can be regarded as a pathfinder mission for the proposed future large-scale observatories, allowing us to test the key design choices, the data analysis infrastructure and background rejection techniques. From the scientific point of view such a small instrument is very cost-effective, giving results that can be compared with the great observatories of the previous generation for a fraction of the cost.

Instrument



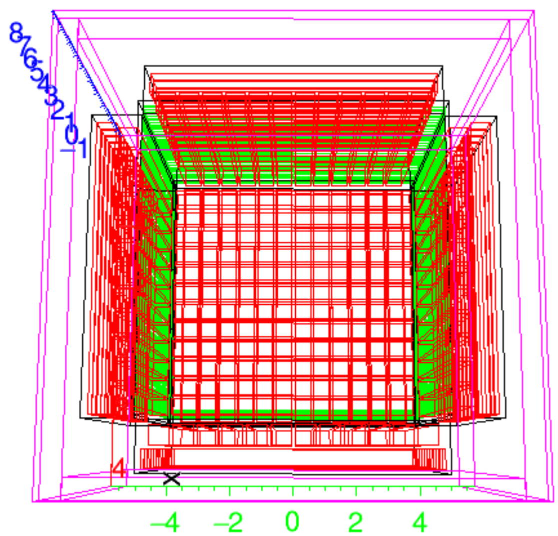


Fig. 2: The MeVcube detector; left: side view, right: top view.

The scientific payload we proposed is shown in Fig. 2. we do not yet have a detailed CAD design, so in this design there is no space reserved for support structures and readout electronics. One of the main design goals is to limit the amount of mass in passive materials.

The core of the instrument is a microstrip silicon tracker (in green), a reliable instrument with a record space heritage. It operates at high voltage (~100 V) and the power consumption depends strongly on the temperature (est. ~30 mW at 20°C, doubles every ~10°). The main concern is the

large number of readout channels (~15,000), requiring a significant power budget for readout (~4 W).
On the bottom and sides there are two CsI(Tl) calorimeters (red and blue). The main concern is the large mass (~3 kg). The optical coupling between crystals and photodetectors can be damaged by thermal expansion.
The sides and front are enclosed by a plastic anticoincidence detector (magenta).
The payload is designed to fit into a 1U slot, requiring some space at the bottom for the electronics. It is vital to reside in a quasi-equatorial low-Earth orbit, to limit the exposure to trapped protons and the consequent activation of the materials in the spacecraft, a dangerous source of internal background. COMPTEL (telescope aboard the Compton Gamma Ray Observatory) reported significant background rates from activated materials in the spacecraft, in the payload and even observed low-quantity high-Z contaminants. During transit in the fringes of the South Atlantic Anomaly the detector will be powered down.
The boresight (vertical axis in picture) should point directly opposite to the Earth. The detector operates continuously (e.g. pointing directly to the Sun is fine). On board electronics collect data, perform some rudimentary event filtering and package the science data for downlink, some short term storage will be available. The average data rate is ~10 Hz, with filtering and some zero suppression this translates into <1 kb/s. Occasional bursts can increase the event rate to ~120 Hz for 1 s, with no significant impact on the average.
Most of the power is dissipated by the tracker readout: while the sensors require only about 50 mW at room temperature, the readout ASICs will dissipate about 4 W and in principle will be bonded directly to the sensors. The little material budget available requires ingenious solutions to carry this heat away. The scintillating detectors are moderately sensitive to the temperature (considered stable between 25° to 30° C) and the silicon photosensors for the scintillators are very sensitive in both dark rate and gain (the latter due to the shift of the breakdown voltage).

Summary of requirements

Orbit requirements
Circular Low Earth Orbit >1 year mission time, quasi-equatorial (inclination <5°), 600 km altitude. Launch window 2022-2025 (following solar minimum).
Pointing
The boresight of the payload must point at the local zenith with a tolerance of 1 degree. The orientation of the spacecraft must be known with tolerance 0.1 degrees at all times.
Timing
The Event Builder timestamping process requires PPS (pulse-per-second) from GPS.
Mass of payload
Not to exceed 4 kg at launch, nominal 1.2 kg active instrument only, without readout and support materials.
Instrument power
5 W to operate the instrument, continuous during science data acquisition.
Material selection constraints
Use of high-Z materials (>Si) in the structure should be as low as reasonably achievable (including process contaminants). Negligible amount of material in front of the payload (along line of sight and down to 90°).
CubeSat Design
CubeSat Design Specification Rev. 13 (The CubeSat Program, Cal Poly SLO)
Science data stream
Average: <1 kb/s.
Vibration
Standard per NASA Goddard Environmental Specification (GEVs): (sine sweep, random sweep, fundamental frequency, burst test).
Temperature
Operational: -10 to +25 °C (any reduction of this range will make the calibrations simpler)
Storage: -20 to +40 °C
Thermal-vacuum test requirements
4 cycles, -10° to 45° C (option: -30 to 50° C).

In the event of a conflict, requirements in this document supersede other referenced requirements.