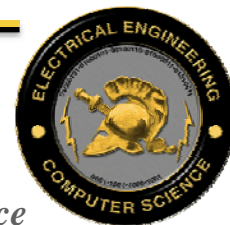




Small Satellite Research Group (SSRG)



Army Space Education: Closing the Gap with Operational Space

Brief to:

23rd Annual Small Satellite Conference

13 August 2009

Presented by:

MAJ Tom Pugsley

US Army Space Operations Officer (FA40)

Assistant Professor: United States Military Academy at West Point

Director: Small Satellite Research Group



Agenda

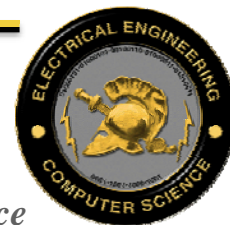


1. History: The inequity
2. Why undergraduate space education?
3. USMA: Where we are now
4. The unique concerns and issues of a Military Academy
5. The way forward at West Point
6. Closing Discussion and Questions





History: The Inequity



Operationally, the Army is good at training its space professionals, and these professionals do their jobs well, meeting the needs of the Army.

Educationally, the Army focuses space education ONLY on these selected space professionals, a relatively small percentage of the operational community.

... the Army can do better than this.

There are still numerous space educational opportunities that have yet to be tapped.

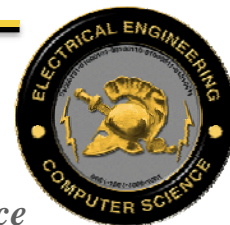
Simply put, the Army has failed to capitalize on space educational opportunities that could improve the quality of its space professionals, as well as the overall Army as well. The two primary periods where space education can be injected are:

The 4-5 years of Army service prior to selection as a space professional

Undergraduate level education



Why Undergraduate Education?



How do we close the gap between operational space and space education?

- By pushing space education down to junior level leaders, soldiers, as well as undergraduate institutions.
- By getting future Army leaders at West Point in the game earlier, and giving them the opportunity to be part of Army relevant space education and research.

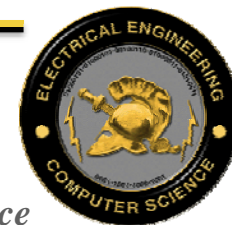
Undergraduate level education can greatly improve Army space education by:

- Do interesting, important, and relevant space research that can directly impact the Army.
- Teach students about Army space, inspiring a future pool of Army FA40s.
- Inform future junior officers about space, producing a more competent and space savvy leader who:
 - understands space and satellite communications.
 - are exposed to Electronic Warfare concepts.
 - are exposed to collection architectures.
 - understand the utility of space based assets as battlefield multipliers.



Then, Now, and Tomorrow

■ USAFA
■ USNA
■ USMA

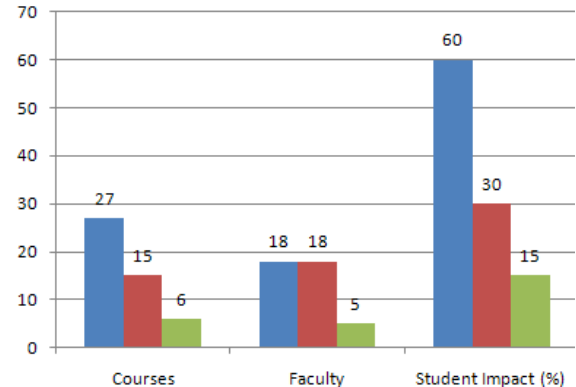
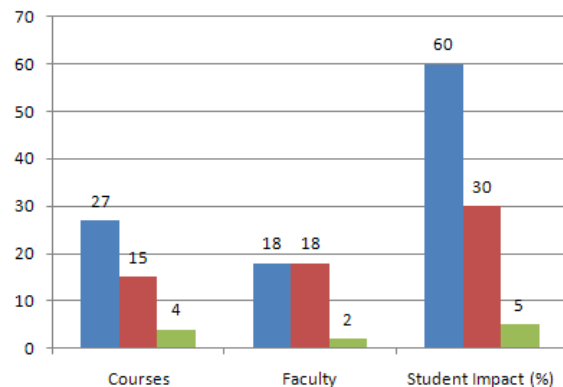
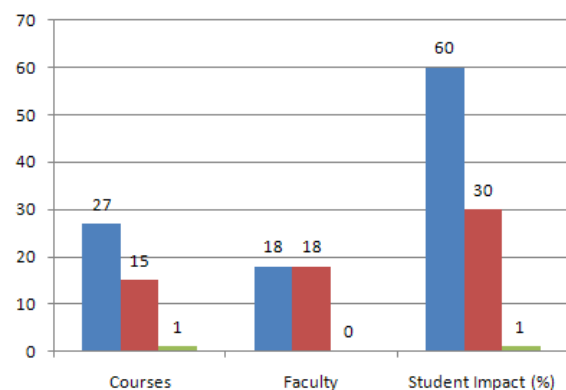
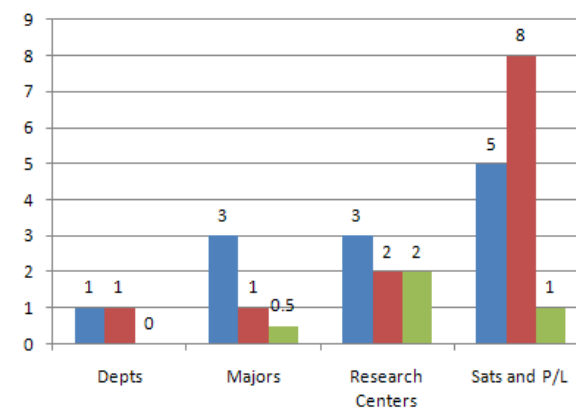
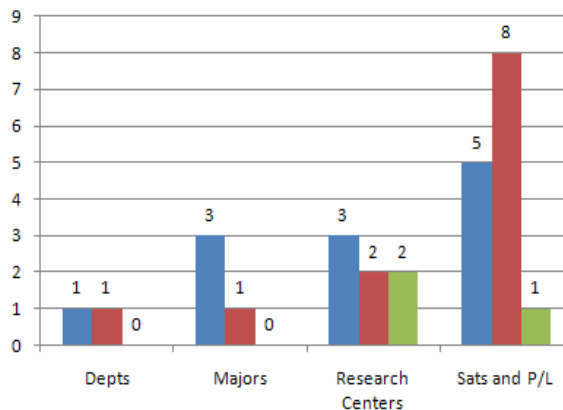
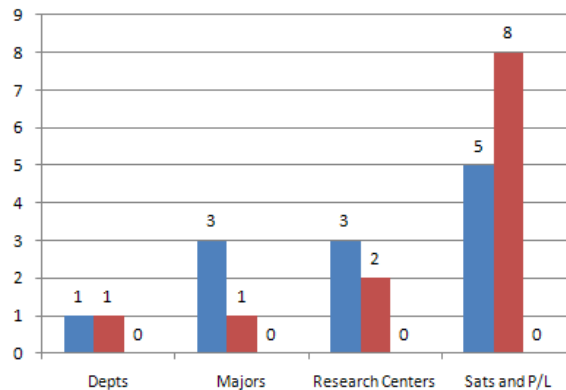


Electrical Engineering and Computer Science

2008

2009

2010





Where we are now (Aug 2009)



Significant progress has been made at West Point to bring space education to undergraduate students.

Over the last year, the following programs and courses have been added:

Small Satellite Research Group (SSRG)

EE 401/402: Satellite Senior Design Project (Black Knight 1)

CS485: Space Systems Engineering

MA488: Mathematics for Space Applications

PHY472: Space and Astrophysics

Independent studies and cadet/faculty research papers

Cadet Astronomy and Space Engineering Club



[Space and Missile Defense Command Research and Analysis Center \(SMDC RAC\)](#)



Small Satellite Research Group (SSRG)



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The purpose for the founding of the SSRG was to provide a stable foundation from which to build West Points infrastructure to support more advanced satellite research and design projects in the future.

➤ The goals of the SSRG are to:

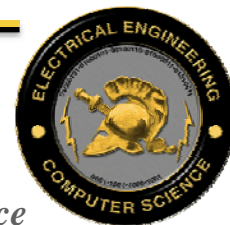
- Serve as the center of knowledge, funding, and management of all space related research, education, and training at West Point.
- Help legitimize the work being done, drumming further support from other departments, and the academy itself, giving research endeavors a more formal stature.
- Build West Points name as a serious player in the university satellite and space research arena, and to develop partnerships throughout the community.

➤ Sponsoring Department:

- Electrical Eng. and Computer Science, MAJ Tom Pugsley.



EE401/402: Senior Design (Black Knight 1)



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BK1 is a three year, multi-discipline project, requiring cadets from West Point's Electrical Engineering, Computer Science, Mechanical Engineering, Systems Engineering, and Physics Departments to work together to develop, design, build, integrate, test, and launch the **Academy's First Satellite.**

➤ The goals of this project are to:

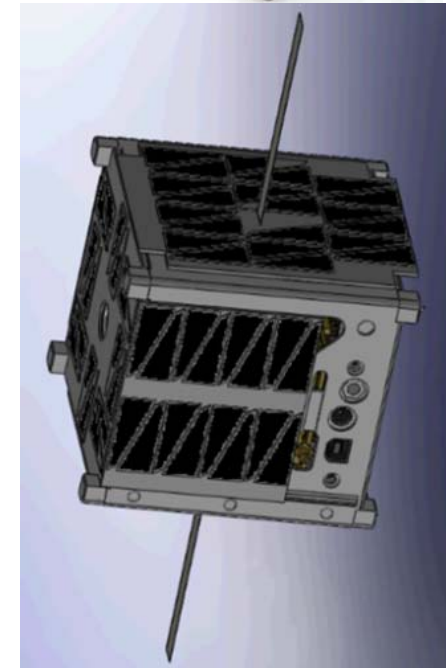
- Develop a low cost experimental spacecraft with experimental and operational significance.
- Educate future Army leaders on a wide range of space related topics in order to develop more "space savvy" junior leaders.
- Build a solid foundation for satellite development at West Point in order to expand into more advanced spacecraft projects in the future.

➤ Students are "Interested" in Space related topics:

- Of the 34 total projects presented to last years seniors, the BK 1 project received 70% of the interest.

➤ Sponsoring Department:

- Electrical Eng. and Computer Science, MAJ Tom Pugsley





CS485: Space Systems Engineering



Electrical Engineering and Computer Science

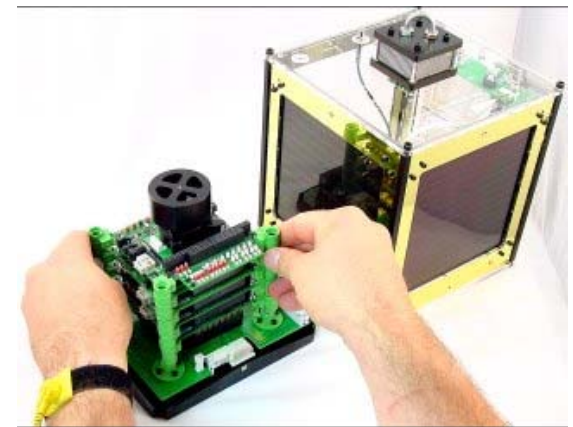
CS485 will introduce students to a broad range of space related topics, giving them hands on experience working a variety of problems dealing with the space environment, spacecraft design, spacecraft subsystems, and military satellite operations.

➤ The goals of this course are to:

- To produce more technically and operationally proficient leaders with a solid understanding of the basic space sciences prior to entering the Army.
- Introduce cadets to the concepts of orbital mechanics, space weather, spacecraft design and integration, and project management.
- Focus on mission design, spacecraft structures, electrical power systems, data handling, communications, attitude control, and test and integration.

➤ Sponsoring Department:

- Electrical Eng. and Computer Science, MAJ Tom Pugsley





MA488: Mathematics for Space Applications



Electrical Engineering and Computer Science

MA488 will introduce students to the development of a wide variety of useful skills, as well as learning mathematical tools focused on applications relating to space.

➤ The goals of this course are to:

- Explore different space-time coordinate systems and perform coordinate transformations.
- Examine some of the most classic orbit types.
- Learn the parameters required to uniquely define orbits.
- Discuss the mathematics behind orbit determination.
- Discuss propagation techniques.
- Calculating orbital elements by hand.
- Develop numerical methods to solve propagation problems.

➤ Sponsoring Department:

- Mathematics, Dr. Jessica Mikhaylov.



The interplanetary transport network. Gravitational tugs of the different planets and their moons create a vast network of passageways by which a spacecraft can travel over large distances while expending very little energy. (*Image Courtesy of NASA/JPL, Artist: Cici Koenig*)



PH472: Space and Astrophysics



Electrical Engineering and Computer Science

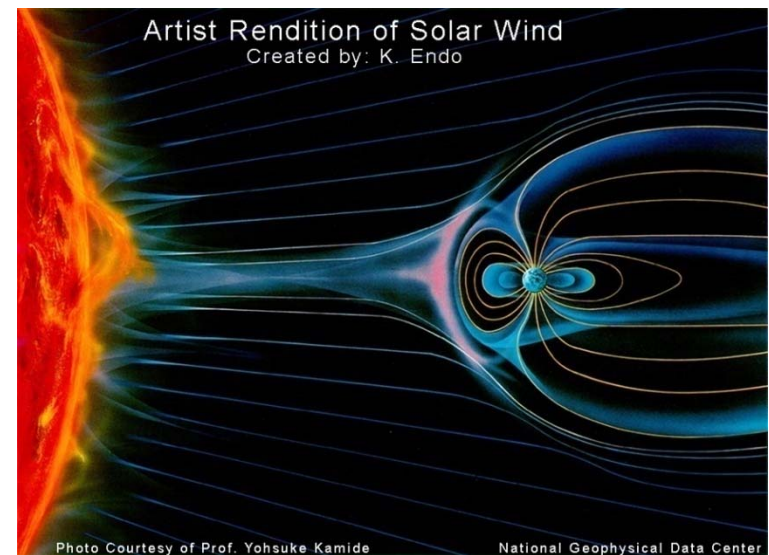
PH472 will serve to introduce students to two related, but not identical, disciplines of physics: space physics and astrophysics.

➤ The goals of this course are to:

- Introduce concepts of space physics, concerned with understanding the environment between the Sun and the Earth's upper atmosphere.
- Introduce concepts of astrophysics, specifically the study of stellar structure and evolution, galactic structure, and cosmology.
- Introduction to space weather, and spacecraft design requirements in order to account for the harsh environment.

➤ Sponsoring Department:

- Physics, MAJ Diana Loucks.





Cadet Astronomy and Space Engineering Club



Electrical Engineering and Computer Science

Proposal for expansion of the Astronomy Club in a joint venture with both the Amateur Radio Club as well as the Electronics Experimenters Group. This will allow us to circumvent many of the constraints faced in space courses, bringing space education to a much larger group than possible in courses.

➤ The goals and activities of this club are:

- **Astronomy & Space Physics**
 - Visual/Radio Astronomy
 - Data/Statistical Analysis
 - Orbital Mechanics
- **Satellite Design, Manufacturing, Control**
 - Basic Satellite design and construction
 - **Balloon Sat construction and launches**
 - Student Hands-On Training (SHOT I)
 - Ground Station Operations and management
- **Space and Missile Defense Education**
 - Missile Defense seminars
 - Sounding Rocket Construction and Launch



➤ Sponsoring Department:

- Physics, MAJ Diana Loucks; EECS, MAJ Tom Pugsley



Other Space Opportunities



Independent Studies:

- 1-2 semesters long
- Individual research that is under the sole supervision of the advisor
- These are good opportunities to get serious research done on smaller problems
- Open to all levels of undergraduates (as long as they have room)
- I see the potential for as many as two of these for any one advisor

Research Papers:

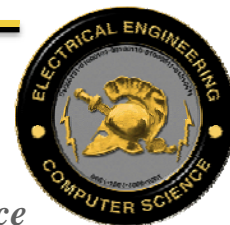
- First student paper won 3rd place at Regional IEEE student scholarship competitions:
 - “Characterization and Optimization of the MHX2420 Radio and Link Budget Analysis for the Black Knight I Satellite
- Numerous opportunities for faculty/student papers

Conferences:

- Small Satellite Conference and many others



SMDC Research and Analysis Center



Electrical Engineering and Computer Science

Serves as a SMDC facility located at West Point focused on Space and Missile Defense education, research, and analysis that will leverage available resources to improve outcomes for both SMDC and USMA mission accomplishment.

➤ The goals of the SMDC RAC are:

- Research funding focuses on capabilities that already exist at USMA
- RAC provides an oversight office to bring in funding for that research
- Provide a tie in to USMA educational and research capabilities
 - Gives SMDC/FA40 opportunities to drive/leverage research efforts
 - Involves cadets in current and relevant space research topics
 - Brings the resources of USMA to bear on space related topics
- Future Focus
 - Creates young officers executing today's missions, with a knowledge of capabilities that will be used to innovatively accomplish tomorrow's SMD mission
 - Improves fighting unit's capabilities with enhanced SMD knowledge down to the platoon level



Priorities

- **NANOSat Technology**
- Radar/Side-Car
- High Energy Lasers
- Global Comms
- Alt. Energy Sources
- Space Utilization
- Space Control
- Sensors for ISR

➤ Sponsoring Department: Physics

- Initial MIT/LL Representative of SMDC at West Point – Dr. Ken Chadwick



Concerns

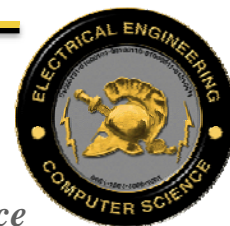


Major road blocks facing future growth:

- **Ownership:** Unlike the other academies, West Point has no natural home or parent department. We have no Aerospace Engineering or Astronautical Engineering programs and we never will.
- **Limited resources:** Work and lab space, test equipment, as well as funding is at a premium.
- **Limited flexibility:** Cadet have little academic room to support space electives.
- **Course flexibility:** Will need to tailor the courses to be able to teach both MSE and non-MSE majors.
- **Scheduling:** Most courses are “Special Topics Electives”. Getting them hard coded on the books as permanent courses is difficult. This typically is a zero sum gain, meaning something must come off the books, for these courses to become permanent... Most department would fight this.
- **Department Conflicts:** Will need to reach cross department agreements in order for space electives to qualify as electives in other department curriculum.
- **Continuity:** Instructors rotate, without a proper champion to continue to press forward, all this work has the potential to fall to the side.



The Way Forward



Electrical Engineering and Computer Science

3 Course Engineering Sequence in Space Systems

5 Course Minor in Space Systems Operations:

A champion in every department, headed by some Army organization

EECS + ME + Systems + Physics + Math + Army input = Cross Dept. Research = WIN

More space related senior design projects from other departments

Student Interest + Champions + Army input = WIN

More independent studies across the departments

We have interested students...we need direction and a problem (Army input)

Some Organization to monitor, control, provide continuity and Army input.

 SMDC RAC 



Questions?



Electrical Engineering and Computer Science



Cadets working
Space...its pretty cool