EDUCATING FUTURE LEADER

Story by Diana Loucks, Dr. Ken Chadwick, Jessica Mikhaylov, Andrew Pfluger, Thomas Pugsley, and William Wright

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MAJ William Wright teaching class *U.S. Army Photo*

The employment of navigation, communications, weather, and intelligence assets based in Space makes possible the precise nature of our operations.

about Space at West Point

The United States Military Academy, commonly known as West Point, has produced junior Army leaders since its inception in the early 1800s. While the purpose of West Point has evolved over the last two centuries, its fundamental mission has remained relatively stable:

"To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country; and prepared for a career of professional excellence and service to the nation as an officer in the United States Army."

Space Operations Officers in Functional Area 40 primarily support this mission by bringing their operational and technical experience to the courses that they teach at West Point. By doing so we ensure that an ever increasing number of lieutenants enter the Army with the fundamental knowledge of how Space-based capabilities are intertwined into day to day Army operations – a role that is even more critical now that Army officers are making career field designation decisions at both four and seven years of service.

The most established venue for FA40s to pass knowledge of Space-related topics to cadets is in the classroom. Every teaching day USMA professors teach multiple classes (or sections) consisting of 15 to 20 cadets. Currently, FA40s have the unique opportunity to teach eight classes offered within four academic departments. Brief descriptions of the courses and their relevance to Space are discussed in this paper. Our ultimate goal as instructors and as Space Operations Officers is to inspire cadets interested in Space, and educate them so that they can make informed decisions not only about the employment of Space technologies but also about their choices in the CFD process.

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MAJ Diana Loucks working with a group of Yearlings during Advanced Introductory Physics.
FROM LEFT TO RIGHT are Cadets Shane Greaves, Kurt Yeager and Dylan Hanna. *U.S. Army Photo*

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An Introduction

A primary role of FA40s is to advise commanders at all levels on Space based applications and their impact on current operations. This spans all branches of service and covers a wide range of topics from satellite constellation management to the impact of Space weather on operations. To do so, Cadets must first understand Space: the environment and its causes, the impact of that environment on the Earth, and how we maneuver through its vast expanses. Two complementary courses provide cadets with a foundation of the basic physics and mathematics of orbital mechanics and the Space environment. PH472, Space and Astrophysics is taught by the Department of Physics & Nuclear Engineering, and MA488A, Mathematics for Space Applications is taught by the Department of Mathematical Sciences. These two courses are comparable to each other in their basic treatment of orbital mechanics and maneuvers, and they offer complementary treatments of the environment of Space and its affect on not only the Earth but the universe.

PH472 focuses on understanding the environment between the Sun and the Earth's upper atmosphere and introduces concepts of astrophysics, specifically the study of stellar structure and evolution, galactic structure, and cosmology. A secondary outcome of the course is to make Space topics more relevant to current Army operations by providing an introduction to Space weather, and exposure to Spacecraft design requirements in order to account for the harsh environment.

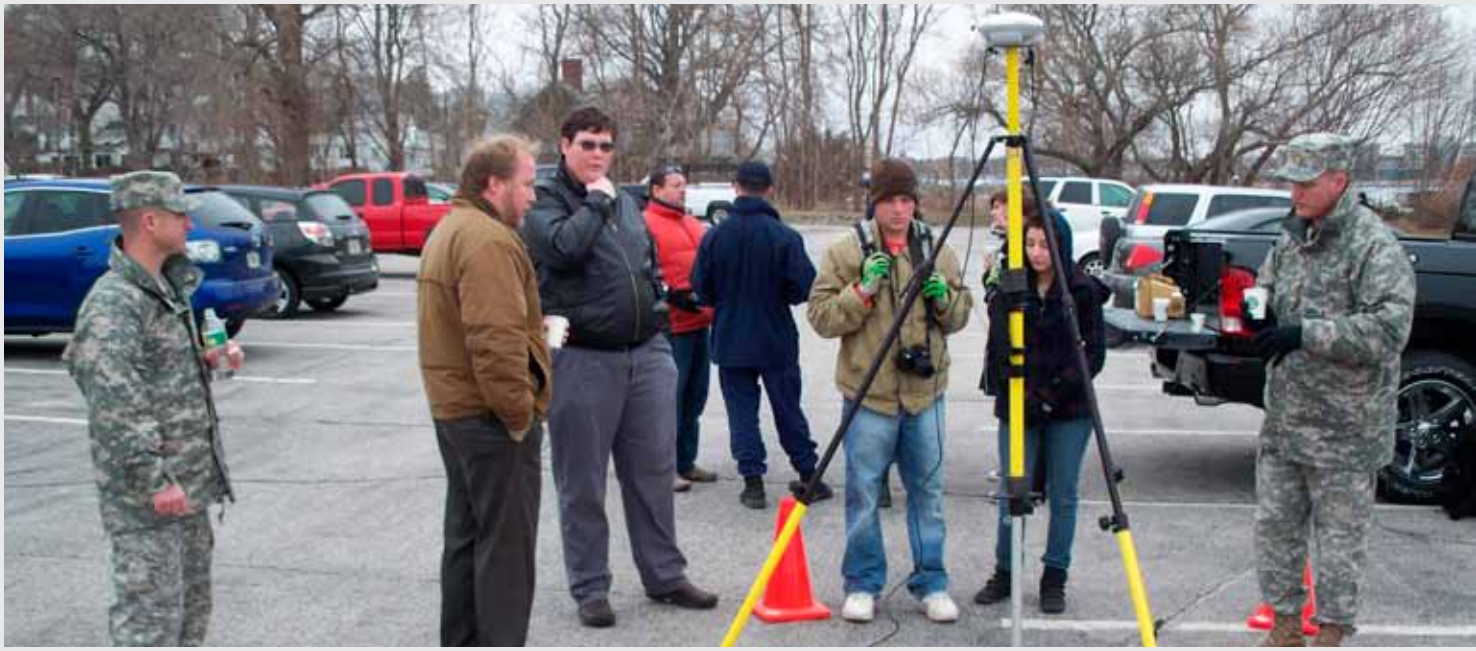
MA488A focuses on the complementary aspect of accounting for the perturbations of orbits due to the harsh Space environment, and provides cadets with foundations for analyzing this impact to the orbits of satellite constellations. Building upon the base knowledge of ideal systems, cadets explore perturbations and develop numerical methods for orbital propagation in their presence. The parallel and complementary nature of these courses provides cadets with a foundation of principles for Space related topics.

Applications

The use of Space based capabilities spans each branch of service and impacts every aspect of daily Army operations. The employment of navigation, communications, weather, and intelligence assets based in Space makes possible the precise nature of our operations. Two pairs of sequence courses offered by the Department of Geography & Environmental Engineering expose cadets to a wide range of Space based systems and allows them to see many aspects of their effective use.

EV398, Geographic Information Systems and EV498, Advanced GIS - represent a two semester sequence that allows cadets to utilize Geographic Information Systems consisting of hardware/software systems that permit the input, storage, retrieval, manipulation, analysis, and display of geocoded data. Used by environmentalists, engineers, geospatial analysts, architects, managers of large land holdings, and the military, these highly intricate decision support systems assist managers in answering important "what if" questions. Using digitizers and microcomputers cadets build a geocoded database and solve real-world problems.

In the advanced course, analytical methods are used and provide cadets with a clear understanding of the theoretical/conceptual aspects of algorithms found in GIS software. Cadets explore the underlying mathematical basis for widely used spatial analytical techniques. Among the topics covered



A GPS base station setup by West Point's Surveying class for Real Time Kinematic Surveying. This project involved West Point, the United States Coast Guard Academy, and Mitchell College students. There were three different projects involved in this effort, mapping and removal of invasive plant species, temporal change of the beach, and a survey stake out for the design and construction of a boardwalk civil engineering project. From left to right - MAJ Hannon Didier, Mr. David Shirley (Keystone Precision Instruments), Mitchell College Students, and MAJ Wright in ACU's. *U.S. Army Photo*

are neighborhood operations, map transformation, spatial interpolation, terrain analysis, network analysis, spatial overlay, fuzzy sets, neural networks, and expert systems. In-class practical exercises and laboratory assignments complement the lectures by providing hands-on experience with a variety of advanced analytical techniques. The course culminates with a capstone term project that allows cadets to identify a scientific problem, formulate a hypothesis, use GIS to solve the problem, and then present results of their analysis. Cadets are also encouraged to use their GIS skills in other related courses, such as Air Pollution Engineering, which give cadets a more comprehensive understanding of the atmosphere and other relevant topics.

EV377/EV477, Remote Sensing is the second set of sequence courses that center on the use of satellites to study the Earth. This course emphasizes one of the Space Force enhancement areas, while using both commercial and classified imagery. Cadets enjoy a wide range of practical exercises, which introduce them to several remote sensing systems to include conventional and color infrared photography, multispectral scanners, satellite imagery, thermal infrared, and radar. The capstone exercise offers each cadet the opportunity to perform real-time automated image classification using satellite data on their personal computer.

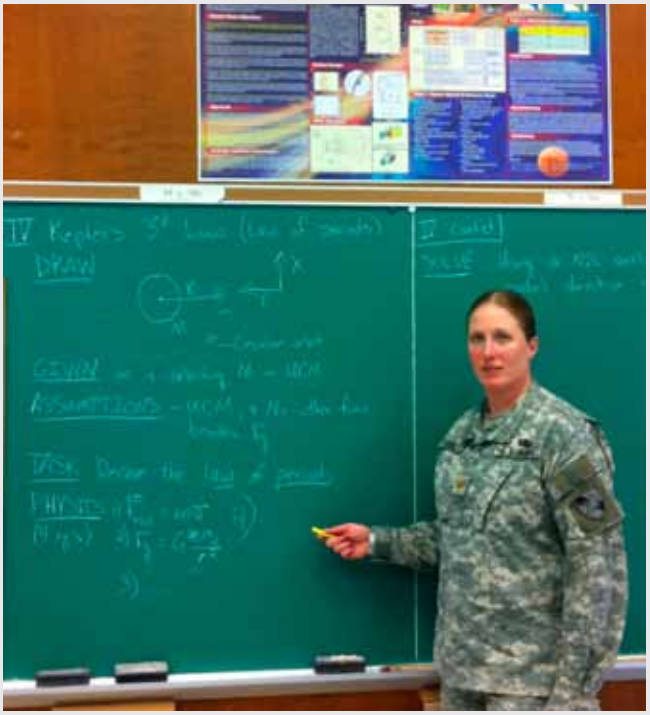
In the advanced class, cadets examine advanced remote sensing theory and digital image processing techniques suitable for the processing of remotely sensed data. Emphasis is on the processing and analysis of state-of-the-art high spatial and spectral resolution data gathered by both airborne and satellite sensors. Topics covered include geometric and radiometric image rectification, registration and re-sampling techniques, image enhancements, data merging, image segmentation and automated feature extraction. A wide range of practical exercises and in-class laboratory assignments provides hands-on experience with a variety of remotely sensed imagery ranging from multi-spectral to hyper-spectral data. The course culminates with a capstone term project that allows cadets to apply digital image processing skills to a scientific problem.

Acquisitions and Development

Another role of FA40s is to oversee the research and development, as well as acquisition of Space technologies and hardware. Two courses focus on the application of physics and engineering to Space hardware. PH495, Physics of Rockets, Missiles, Radar and Missile Defense Systems is taught by the Department of Physics & Nuclear Engineering. CS485, Space Systems Engineering is taught by the Department of Electrical Engineering & Computer Science. The two courses offer complementary perspectives on the engineering of hardware for Space applications.

PH495 challenges cadets to integrate and apply, in a weapon system development context, the fundamental physics of rockets and missiles, electromagnetic wave generation, propagation and reflection in radars and lasers, and the flight performance of guided missiles. It links sensors and missiles with a fire control system that will result in a complete weapon system capability. An integral part of the course is to determine proper selection of system component capabilities to provide a balanced combination so the individual missile defense system will have the desired weapon system capability.

CS485 introduces future leaders to working a variety of problems dealing with the Space environment, Spacecraft



MAJ Diana Loucks reviews the Physics behind Kepler's Laws, specifically derivation of the law of periods during Introductory Physics. *U.S. Army Photo*

design, Spacecraft subsystems, and military satellite operations. Specific goals of the course include introducing cadets to the concepts of orbital mechanics, Space weather, Spacecraft design and integration, and project management. It maintains a focus on mission design, Spacecraft structures, electrical power systems, data handling, communications, altitude control, and test and integration. The overall goal of this course is to produce more technically and operationally proficient leaders with a solid understanding of the basic Space sciences prior to entering the Army. The course enables cadets to understand the fundamental design and operations of military Spacecraft, as well as the missions they perform.

Relevance to Current Operations

The academic material coupled with the strong emphasis on teamwork play important roles in developing future officers for Space operations. Of import are the understanding of the Space environment, how to maneuver and operate in it, the employment of Space technologies for world-wide operations, as well as the design of Space technologies to achieve a particular mission and the communication of that design to decision makers. The education that we provide our future leaders must continue to expand as the role of Space in the Army continues to increase.

Co-Authors

Diana Loucks is an FA40 officer and instructor in the Department of Physics and Nuclear Engineering at the United States Military Academy. She has a master's degree from the University of Colorado in AeroSpace Engineering Sciences and teaches introductory calculus based Physics, Modern Physics and Space and Astrophysics. MAJ Loucks' academic and research interests include Space education, balloons and nanosatellites.

Dr. Ken Chadwick is currently Senior Staff, Optical Systems Technology Group at MIT Lincoln Laboratory and assigned to the United States Military Academy as Assistant Professor of Physics and Director of the U.S. Army Space and Missile Defense Research and Analysis Center. He received a Bachelor of Science degree in Mechanical Engineering from Northeastern University and M.S. and Ph.D. degrees in AeroSpace Engineering from Virginia Tech. He joined the Laboratory in 2000 after having spent eight years at Calspan in Buffalo, N.Y. as Head of the Hypersonic Aerodynamics and Propulsion section and Head of the AeroSpace Sciences Department. He joined Lincoln Laboratory in the AeroSpace Engineering group and served as technical staff, assistant and associate group leader (acting group leader) while managing several missile defense, flight hardware development and test, countermeasure and targets programs.

Jessica Mikhaylov holds a National Research Council Davies Fellowship in the Department of Mathematical Sciences at the United States Military Academy. She earned her Ph.D. and Sc.M. in Applied Mathematics from Brown University and her M.S. in Mechanical Engineering from Rensselaer Polytechnic Institute. Prior to her current position, she worked in industry as a Senior Engineer and Systems Analyst for the Missile Defense National Team. Her academic interests center around the mathematical modeling and analysis of complex systems with applications ranging from medical imaging to missile defense.

Andrew Pfluger is an FA40 officer and instructor in the Department of Geography and Environmental Engineering at the United States Military Academy. He has a master's degree and a Degree of Engineer from Stanford University in Environmental Engineering. MAJ Pfluger teaches Air Pollution Engineering, which incorporates aspects of Geospatial Information Science into its curriculum.

Thomas Pugsley is an FA40 officer whose previous assignment was a assistant professor in the Department of Electrical Engineering and Computer Science at the United States Military Academy. He has a master's degree from the Naval Postgraduate School in Space Systems Operations, and taught courses in Space Systems Engineering and Spacecraft Development and Design. MAJ Pugsley's academic and research interests include spacecraft design, payload development, and orbit optimization. He is currently assigned to U.S. Army Pacific as a Space Operations Officer.

William Wright is an FA40 officer and assistant professor in the Department of Geography and Environmental Engineering at the United States Military Academy. He has a master's degree from the University of Florida in Civil Engineering, and teaches courses in the Geospatial Information Science program including Surveying, Geographic Information Systems, Cartography, Remote Sensing, and Physical Geography. MAJ Wright's academic and research interests include light detection and ranging, GPS, and geographic information systems.