SPACE EDUCATION AT THE UNIVERSITY OF TEXAS AT SAN ANTONIO:

ARMY SPACE CADRE

Learn from Southwest Research Institute Scientists

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U.S. TRAINING AND
DOCTRINE COMMAND

Best professions utilize education to continue to develop the professionals within an organization over the course of the career. The Army adheres to that practice as manifested by Noncommissioned Officer Education System, Officer training from Basic Officer Leader Course to ILE, branch/career field specific training, and the Advanced Civil Schooling program. Working as a Space Professional or a Space Cadre member as a Space Enabler allows Army personnel to be in the Space Profession which follows this developmental paradigm very well.

Continued education in a variety of venues allows for broadening of knowledge in a career field, such as FA40, or in a subset of skills, such as the 3Y Space Activities Skill Identifier. Therefore, continuing education has a significant role in professional development as indicated by Samuel P. Huntington in his book The Soldier and the State. Education is one of the distinguishing characteristics of a true profession.[1] The Army Space Profession follows this example very well. Space Cadre members increase their knowledge through many educational venues. Three of these offer great opportunities for development in Space operations.

The first is military Space training such as that found in the Space Operations Officer Qualification Course, in the National Security Space Institute, at the Naval Postgraduate School, and at the Air Force Institute of Technology. Of these, National Security Space Institute offers Web based training and short courses such as the Space Fundamentals and Space Operations Courses as well as Space 100, 200, and 300. All of these, at different phases of an Officer's career, enhance the development of an Army Space Cadre member. Naval Postgraduate School offers graduate degrees in Space Systems Engineering and

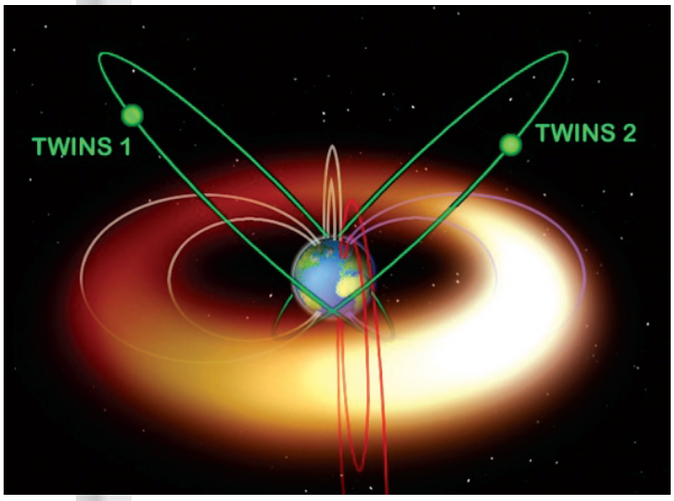

Figure 1
Shows the Two Wide-angle Imaging Neutral atom Spectrometers orbits.
Courtesy of Southwest Research Institute Web site

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Space Systems Operations as well as a Space Systems Graduate Certificate.[2] These options at Naval Postgraduate School also offer great opportunities to enhance Space cadre professional development. There are also many opportunities for graduate level education and development at civilian institutions, especially in the area of Space science. It is the study of Space science that allows for an in-depth understanding of Space weather and climate. Space weather and climate impact spaced-based assets and our knowledge of this can be used for design purposes.[3] These civilian Space science educational opportunities are outstanding options to be able to develop more understanding of Space climate impacts on Military Decision Making Process.

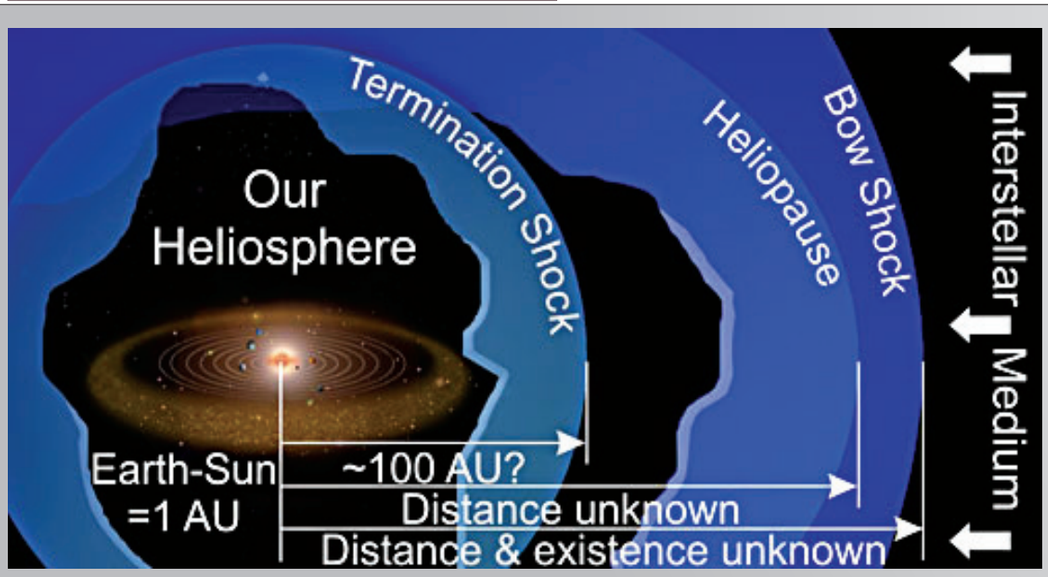
There is a second opportunity to which one could ask the question what if we could send Soldiers to a short civilian course to learn about Space science? What would be the benefit? Sometimes asking "what if" leads to the future.[4] One such possibility is the Center for Integrated Space Weather Modeling 11 day Summer School on the Boston University Charles River Campus in Boston's Back Bay. What if a soldier attended this short course? The intent of the course is to give students a comprehensive immersion in the subject of Space weather. It helps a student or a professional to answer the following questions about Space weather: What is it? What does it do? What can be done about it? These aspects of learning about Space weather are covered in many of the military courses that are available through other venues. However, the Center for Integrated Space Weather Modeling course allows for learning through visualization via computer modeling of Space weather under varying conditions which offers a different perspective on the learning. This course offers an additional huge benefit in that there is no fee for the course and thus would only require other Temporary Duty associated costs.[5] Therefore, one possible scenario would be for a Space Cadre member to attend this course enroute to one of the aforementioned graduate schools, thereby providing a great transition to the science based aspects of Space. Another is to send a Reserve Officer Training Course or U.S. Military Academy cadet to the Center for Integrated Space Weather Modeling summer course to motivate him or her to become future Space Cadre members.

Another possible short training is the International School for Space Simulations (ISSS). The intent of this course is the teaching of Space plasma simulation techniques and for the sharing of results with researchers in plasma physics." International School for Space Simulations brings together the most recent spacecraft observational results and theoretical advances to address the outstanding problems in Space plasma physics. Lastly, the course provides a view into the different types of Space science simulations and a chance to meet with the simulators who are the experts in the field.[6]

These two examples of short civilian training can be used to introduce Soldiers to Space science and techniques of computer modeling used to analyze Space phenomena. Other, more in-depth opportunities exist in which Soldiers can gain significantly more understanding of Space than through these short courses.

The third venue or opportunity which offers great opportunities for development in Space operations is the ACS program. The ACS program offers many outstanding opportunities for professional growth through continued civilian education. Depending on the goal of the specific academic plan, a Soldier can significantly augment the professional development already provided by military training and schools. A specific example of an ACS program that can increase knowledge of Space is the Masters of Science in Space physics degree program at the University of Texas at San Antonio. This program is offered in collaboration with the scientific staff at Southwest Research Institute a globally premiere institution operating at the scientific forefront in many areas, including Space research. In this program the University has partnered with the Southwest Research Institute to allow for significant student interaction with Institute scientists and missions. This is accomplished by the scientists and physicists at the Institute being adjoint professors who directly teach and mentor the graduate students in current Space science missions. By doing this, the organization is able to offer an in-depth curriculum that includes classes in Fundamentals of Space Physics, Heliospheric Physics, Magnetospheric Physics, Space Weather, Planetary Science, Computational Fluid Dynamics, Plasma Physics and Magnetohydrodynamics, and a

Figure 2
Shows the heliosphere and boundaries.
Courtesy of Southwest Research Institute Web site



Space Physics Laboratory class. The Southwest Research Institute adjoint professors also are available as facilitators for independent studies in Orbital Mechanics as well, utilizing Satellite Tool Kit for orbital mechanics simulations and MATLAB for extensive, rigorous mathematical analysis of orbital dynamics problems.

The graduate program at UTSA with the partnership with Southwest Research institute has some advantages for Army Space Cadre. First, the UTSA program utilizes adjoint faculty from the Research Institute with current scientific operational experience to teach all of the Space physics classes mentioned above. Working closely with these Research Institute scientists, students not only learn about current scientific principles and phenomena of Space but also are able to participate in design, testing, deployment, and use of scientific payloads. By being immersed in cutting edge Space science missions, Space Cadre develop new ideas and pose solutions to previous limitations. In doing so, we can "significantly benefit our warriors."[7] This benefit to the force, from this perspective, is manifested by the integration of Space science missions and Space climate awareness into the Military Decision-Making Process.[8] New ideas and unique solutions are what has lead scientists to design, develop, and launch small satellite clusters to obtain more robust, spatially and temporally comprehensive observations of the physical phenomena which occur in Space, and thus lead to the greater awareness needed. This small satellite cluster approach is one that is being explored to benefit Warfighters as well.[9, 10]

There are specific SwRI missions that enhance Space environment awareness and can thus provide information necessary for the Military Decision-Making Process. Of these missions, six are currently operational and two are in development at this time.

The six operational missions are the Two Wide-angle Imaging Neutral-atom Spectrometers or TWINS, Interstellar Boundary Explorer, New Horizons, Cassini, Juno, and Rosetta.

The Two Wide-angle Imaging Neutral-atom Spectrometers provides a new capability for imaging the magnetosphere. By imaging the charge exchange neutral atoms using two identical instruments on two widely Spaced high-altitude, high-inclination spacecraft, the spectrometer provides 3-dimensional visualization of large scale structures and dynamics within the magnetosphere for the first time.[11] *(See Figure 1 page 49)*

The Interstellar Boundary Explorer Spacecraft is a small satellite that observes the Solar System Boundary by collecting energetic neutral atoms. These atoms provide information about the Solar System's boundary by travelling toward Earth from beyond the orbit of Pluto. This boundary is created by the interaction between the solar wind and the interstellar medium. The solar wind streams out into Space and carves out a protective bubble around the Solar System called the heliosphere.[12] *(See Figure 2)*

New Horizons was built primarily by Southwest Research Institute and the Johns Hopkins Applied Physics Laboratory. New Horizons mission is to explore the Pluto-Charon system and the Kuiper belt, beginning in 2015. The New Horizons spacecraft executed a fly-by of Jupiter in 2007. The Jupiter fly-by was used to provide a gravitational assist that shaved years off the travel time to Pluto-Charon and the Kuiper belt. Charon is the largest moon of the dwarf planet Pluto. The Kuiper belt

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is a region of the Solar System beyond the planets extending from the orbit of Neptune and is similar to the asteroid belt, although it is far larger.

Cassini studies the planet Saturn and its moons. The spacecraft consists of two main elements: the National Aeronautics and Space Administration Cassini orbiter and the European Space Agency Huygens probe. The Huygens probe separated from the orbiter and reached Saturn's moon Titan where it made an atmospheric descent to the surface and relayed scientific information. Cassini is the first spacecraft to orbit Saturn and the fourth to visit it.

Juno's mission is to study the planet Jupiter. The spacecraft will be placed in a polar orbit to study the planet's composition, gravity field, magnetic field, and polar magnetosphere. Juno will also study Jupiter's formation process, including the possible existence of a rocky core, the amount of water present within the deep atmosphere, and mass distribution within the planet.

Last of the operational Space missions discussed here, in which SwRI participates, is the European Space Agency Rosetta mission; to the comet 67P/Churyumov-Gerasimenko. Rosetta consists of two main elements: the Rosetta cometary orbiter and the Philae cometary lander. Enroute to its target, the spacecraft will flyby and examine Mars, Earth (twice), and two asteroids.

There are also two Space science spacecraft with associated instruments currently in development at Southwest Research Institute and their partner organizations. These two missions are the Magnetospheric Multiscale mission and the Radiation Belt Storm Probes. These and other missions, not yet selected but in competition or early formulation, provide students in this program with continual exposure, not only to the elements of Space mission formulation and development, but also the associated scientific data flow and the intellectual deduction processes from which new scientific knowledge is born.

There will be significantly increased understanding of Space weather, climate, and associated impacts on Military Decision-Making Process through Two Wide-angle Imaging Neutral-atom Spectrometers, Magnetospheric Multiscale, and Radiation Belt Storm Probes.

Specifically, as previously eluded to, "TWINS will provide stereo imaging of the Earth's magnetosphere, the region surrounding the planet controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles."[13] The imaging technique, Energetic Neutral Atoms analysis, is a newly developed approach to remotely observing hot plasma populations. This 3-dimensional visualization will expand our current understanding of overall magnetosphere dynamics. A better understanding of the magnetosphere, especially with variations of solar input to this system, will allow for better modeling, better forecasting, and thus a greater ability to predict impact on the mission.

Magnetospheric Multiscale "will use Earth's magnetosphere as a laboratory to study the microphysics of magnetic reconnection, a fundamental plasma-physical process that converts magnetic energy into heat and the kinetic energy of charged particles."[14] Magnetic reconnection is thought to be the dominant element in many forms of astrophysical energy release, including solar flares and auroral storms on Earth. Increased knowledge of the reconnection process, and thus the mechanism which drives the amount of energy needed for geomagnetic storms, will also lead to a greater ability to analyze its effects on

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Figure 3
shows the Magnetospheric Multisphere spacecraft and magnetic reconnection.
Courtesy of Southwest Research Institute Web site

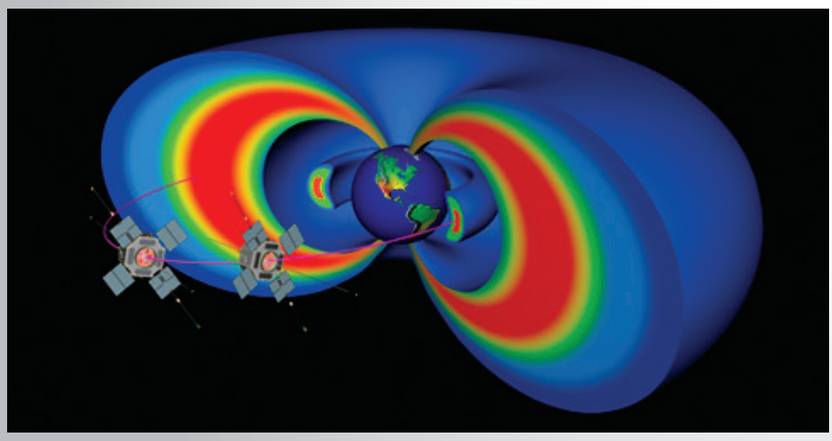
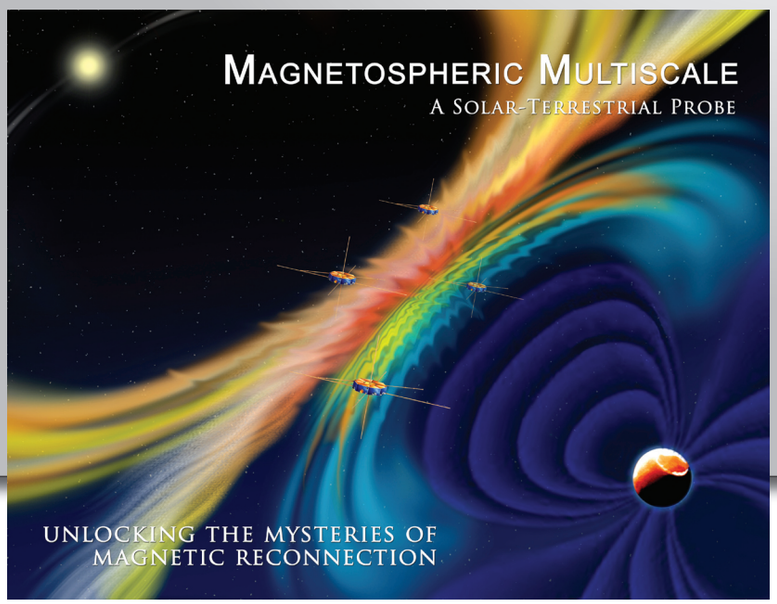


Figure 4
Shows Radiation Belt Storm Probe Spacecraft, the inner and outer radiation belts, and the slot region.
Courtesy of Jet Propulsion Laboratory Web site



Military Decision-Making Process. *(See Figure 3)*

Radiation Belt Storm Probes "will provide unprecedented insight into the physical dynamics of the radiation belts and give scientists the data they need to make predictions of changes in this critical region of Space."[15] These physical dynamics of the outer radiation belt are resultant from solar event drivers and are often a function of solar cycle fluctuations and frequency of the mechanisms which cause geomagnetic superstorms and subsequent possible effects on military satellite operations.[16] *(See Figure 4)*

With this new understanding of the solar cycle effects on the radiation belts, the Earth's magnetosphere, and magnetic reconnection provided by Radiation Belt Storm Probe, Magnetospheric Multiscale, and Two Wide-angle Imaging Neutral-atom Spectrometers respectively, we will be able to better predict how these fluctuations will affect our military Space based assets, Military Decision-Making Process, and thus our support to the Warfighter. Space is one of the best jobs in the Army especially when Space education and professional development can be augmented by leading scientists with instruments in flight and first-hand knowledge of the future missions that they are developing. The UTSA/Southwest Research Institute graduate program in Space physics offers precisely this opportunity.

BIO

MAJ Stacy Godshall is a Space Cadre member and Signal Corps Officer currently assigned to the United States Military Academy as a Physics Instructor. He is responsible for teaching a two-course sequence of university-level, calculus-based physics to USMA Cadets. His previous tour was at the University of Texas at San Antonio where he completed a Master of Science Degree in Physics emphasizing in Space Physics. The topic for his comprehensive examination for the M.S. degree was "Lunar Crossings of the Earth's Magnetotail and Interplanetary Influences on Lunar Dynamics." Simultaneous to the completion of the M.S. Physics degree, he earned the Space Systems Certificate from the Naval Post Graduate School. His professional Space Operations experience includes Company Command of D Company, 1st SATCON BN (now 53rd SIG BN). In addition, he has completed the Space Operations Course and Space 200 at the National Security Space Institute and earned the Air Force Space Badge.

Special thanks to:

Dr. Craig Pollock,
Southwest Research Institute Adjoint
Space Physics Professor, The University of Texas at San Antonio for his contributions in editing this article.

References

[1] Samuel P. Huntington, Soldier and the State, page 8.

[2] CDR Mark M. Rhoades and CDR William J. Welch, Naval Postgraduate School—Committed and Prepared to Support the Space Cadre, Air Force Space Command Higher Frontier, November 2007, Vol. 4, Issue 1, p.39.

[3] LTG Kevin T. Campbell, Utilizing Space Assets Space Awareness, Army Space Journal, Spring 2008, Vol. 7, Number 2, p. 5.

[4] BG John E. Seward, "Technology & the Customer", Army Space Journal, Winter 2008, Vol. 7, Number 1, p. 15.

[5] http://web.bu.edu/cism/SummerSchool/logistics.html

[6] http://www.isss8.ucla.edu/

[7] BG Kurt S. Story, Human Understanding Necessary in Technology Equation, Summer 2008, Vol. 7, Number 3, p. 13.

[8] MAJ Stacy H. Godshall, Space Climate and the Military Decision Making Process in Solar Cycle 24, Spring 2008, Vol. 7, Number 2, p. 48-53.

[9] BG Kurt S. Story, An Evolution of Space Support, Fall 2008, Vol. 7, Number 4, p. 13.

[10] Andy Roake, SMDC/ARSTRAT is securing the Space high ground as the command leads Army responsive Space initiatives, Military Space and Missile Forum, Vol. 1, Issue 1.

[11] http://twins.swri.edu/mission.jsp#mission

[12] http://www.ibex.swri.edu/students/What_is_IBEX.shtml

[13] http://twins.swri.edu/

[14] http://mms.space.swri.edu/

[15] http://rbsp.jhuapl.edu/

[16] MAJ Stacy H. Godshall, Space Climate and the Military Decision Making Process in Solar Cycle 24, Spring 2008, Vol. 7, Number 2, p. 51.