The unclassified periodical of the National Reconnaissance Office

UNCLASSIFIED

SPACE SENTINEL *Select*

Vol.2 No.2 2010

A *Space Sentinel* Article

NRO WEATHER COLONY PROGRAM

by Lt Col Danial Edwards, USAF

NRO Weather Colony Program

Good Things Do Come in Small Packages

CubeSats offer NRO opportunities to rapidly vet technologies and demonstrate capabilities at dramatically reduced expense.

By Lt Col Daniel Edwards, USAF

An April 2009 *Air Force Magazine* article, "Downshifting in Space," reported the Air Force could field some space capabilities faster and at less expense by using simpler satellites. Affirming this notion, Betty Sapp, Principal Deputy Director of the National Reconnaissance Office (NRO), asserted during a May 28, 2009 townhall, the need to have a mix of systems that include smaller, more affordable satellites.

(U) Artist rendering of the NPOESS satellite. (Credit: NOAA)

In an effort to implement this innovative approach, the NRO Advanced Systems and Technology Directorate (AS&T) Weather Colony Program is demonstrating the feasibility of placing payloads on CubeSats (satellites about the size of a loaf of bread) to accelerate technology evaluations, address underserved missions, field capabilities with reduced cost, and tighten schedules relative to larger satellite acquisitions. AS&T collaborated with the Office of Naval Research to identify space weather mission areas for integration on CubeSats. Subsequently, AS&T awarded a contract to the Naval Research Laboratory, in April 2009, to identify and integrate small, lightweight, and low-power space weather sensors on CubeSats to monitor solar radiation, changes in the Earth's magnetic field, and other space weather phenomenon.

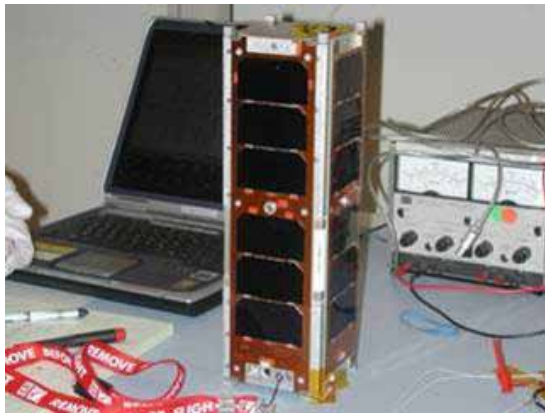
The capability demonstration will aid in determining the utility of CubeSats for augmenting the overall space environment monitoring mission. While CubeSats currently have an expected mission life of less than two years on orbit, they have several advantages. For example, CubeSats can orbit in geostationary, low-earth, and highly elliptical orbits, making them incredibly flexible. Additionally, CubeSats can launch off any vehicle and, due to their small size and weight, it is possible to have multiple CubeSats on a single payload. Finally, because of their low cost (AS&T's goal is less than $250,000 per satellite bus), a robust CubeSat constellation is achievable and maintainable at a fraction of the cost compared to a constellation of multiple, large satellite systems. Although CubeSats represent a relatively new and emerging capability, over 100 United States companies, universities, and high schools are involved in the development and maturation of CubeSats and CubeSat technology.

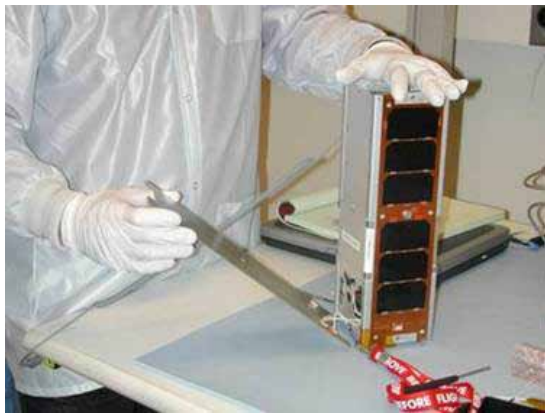
The Air Force Weather Agency (AFWA) at Offutt Air Force Base, Nebraska provides the NRO with space environment warnings and advisories, as well as space environment analysis and forecast specifications from the Global Assimilation of

Ionospheric Measurements (GAIM) model. The AFWA is working to improve data assimilation into GAIM and forecast capabilities by transitioning from a statistic-based to a physics-based approach by 2013. The AFWA currently assimilates data from a variety of worldwide ground-based sensors, but the Defense Meteorological Satellite Program (DMSP) satellites are currently the only source of space-based data for GAIM.

The current limitation in observed space weather data available for input into the GAIM model limits the quality of GAIM's characterization of the ionosphere, because the effectiveness of GAIM output (like that of any other environmental model) relates directly to quality and density of observed data. Just like weather models of the lower earth atmosphere, GAIM is more accurate in locations where new data collection is available for processing. However, DMSP is limited because it flies in two primary orbital planes: early morning and mid-morning low earth orbits. In contrast, a constellation consisting of a number of low cost CubeSats could conceivably overcome this limitation and enhance the quality and spatial resolution of data collected and available as input into GAIM.

Initially, the Air Force and National Oceanographic and Atmospheric Administration (NOAA) planned to replace DMSP, scheduled to fly-out in 2018, with the National Polar-orbiting Operational Environmental Satellite System (NPOESS). However, in 2006, NPOESS was restructured, following a program review, which resulted in the removal of the Space Environmental Sensor Suite and a potential space environment information gap. In June 2008, Scott F. Large, then-Director of the NRO, sent a letter to Gen Robert Kehler, Commander of Air Force Space Command (AFSPC), highlighting the NRO's reliance on space environmental information and advocating the need to address this future information gap. In the letter, Mr. Large pledged to identify opportunities where space weather sensors could be placed on NRO satellites.





(U) Weather Colony Program CubeSats undergoing Payload Accommodation Study at the Naval Research Laboratory to determine candidate configurations for placing space weather sensors on a CubeSat.

Shortly thereafter, the Secretary of Defense's office funded the Space Situational Awareness (SSA) Environmental Monitoring program, a new AFSPC effort to address the gap in space environment characterization. However, the Weather Colony Program possibly provides an alternative for AFSPC to close the gap in coverage without incurring the costs of more expensive, larger platforms. AFSPC plans to complete an analysis of program alternatives, including the potential role of CubeSats.

The first two NRO Weather Colony CubeSats will have sensors to measure the radiation, electron density, and ion composition of the space environment. They will also have the ability to measure the charge on the spacecraft as it passes though the ionosphere. Col John Anttonen, USAF, former Chief of AS&T's Technology Testbed Division, compares these two satellites to the weather balloons meteorologists have used for decades to measure the lower earth atmosphere. For the third and fourth Weather Colony CubeSats, the Naval Research Laboratory will assess and propose candidate sensors. Candidates include a Global Positioning System (GPS) occultation sensor and an ultraviolet (UV) photometer.

Both sensors have the capability to aid in the specification of three-dimensional electron density distributions in the

(U) The Late Jim Arnold, former director of the NRO Advanced Systems and Technology Directorate, with a CubeSat model.

atmosphere, and provide significant value to the physics-based version of GAIM. For example, the GPS occultation sensor measures changes in navigation signals transmitted by GPS satellites to deduce ionospheric electron density, while UV photometers measure emissions from the ionosphere in order to help characterize horizontal gradients in ionospheric density.

Due to the highly dynamic state of the ionosphere, data currently measured by DMSP and ground-based sensors is highly perishable. Specifically, the value of collected data in GAIM expires after a short period. Currently, AFWA stops assimilating data into GAIM once it becomes three hours old. One goal of the Weather Colony Program is the efficient processing of space weather data for useful input into GAIM.

In May 2009, Douglas Loverro, deputy commander of AFSPC Space and Missile Systems Center, was briefed about the Weather Colony program. Mr. Loverro, who manages DMSP and the SSA Environmental Monitoring program, commended the NRO's leading effort on CubeSats and envisioned they would play an integral role in future Department of Defense and Intelligence Community satellite operations. The NRO will continue to share lessons learned on the Weather Colony's progression as AFSPC moves forward in developing the SSA Environmental Monitoring program.

CubeSats represent a paradigm shift from the large satellites the NRO and AFSPC operate today. Not all missions are CubeSat-appropriate, due to size and power requirements of their payloads. However, CubeSats offer NRO opportunities to rapidly vet technologies and demonstrate capabilities at dramatically reduced expense. The first two Weather Colony CubeSats, targeted for launch in 2011, will ascertain the continued viability of this technology. ■

Lt Col Daniel Edwards is a Chief Weather Officer in the NRO Systems Engineering Directorate, Office of the Chief Engineer, Mission Engineering Division.

Space Sentinel Select publishes unclassified articles from the *Space Sentinel* magazine, the quarterly classified publication of the National Reconnaissance Office (NRO). The NRO Office of Strategic Communications publishes the *Space Sentinel* to inform the NRO workforce, Congressional oversight committees, and others interested in defense and intelligence community topics about the NRO's mission, contributions, and heritage. For more information, please contact the *Sentinel* staff at ***SpaceSentinel@nro.mil*** or call 703-808-1198.

Director of the NRO
Gen. Bruce Carlson, USAF (ret.)

Vision
Vigilance from Above

Mission
Innovative Overhead Intelligence
Systems for National Security

National Reconnaissance Office
14675 Lee Road, Chantilly, VA 20151-1715
www.nro.gov