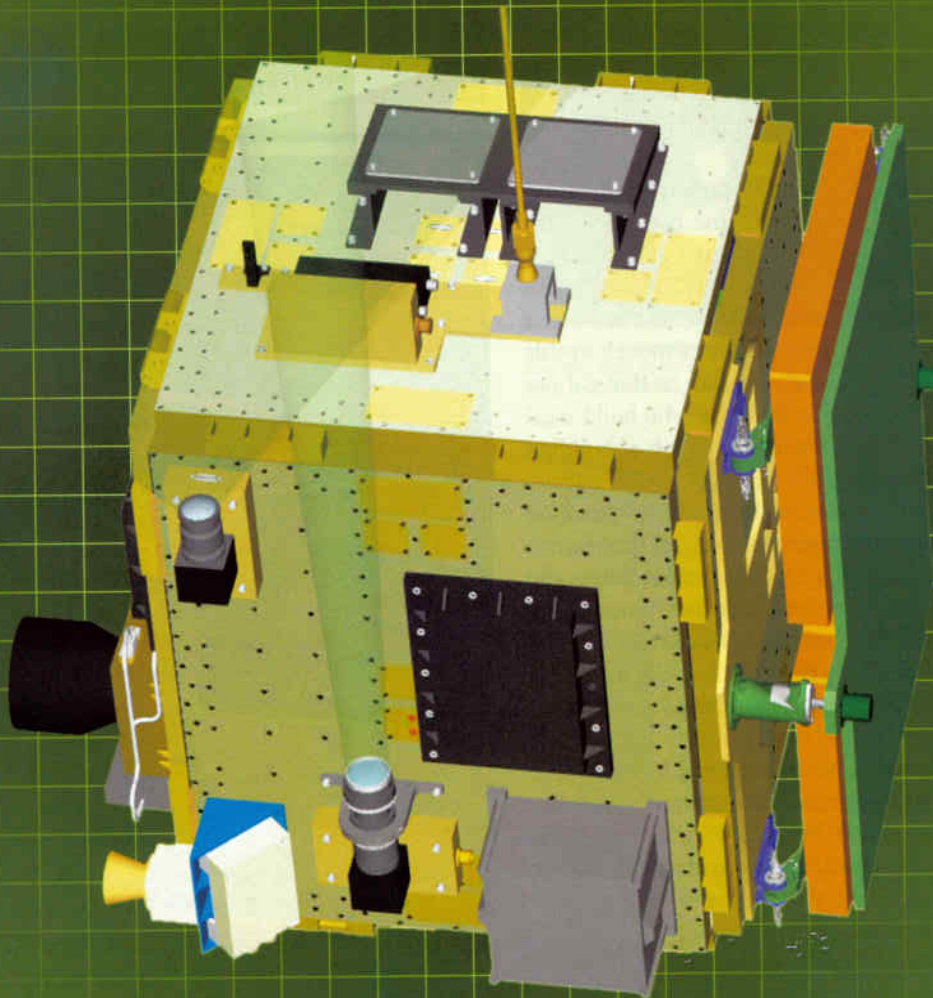


Being Responsive to Space Needs

**AFRL ADVANCES ORS CAPABILITIES THROUGH TWO
COLLABORATIVE SATELLITE EFFORTS.**

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Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE DEC 2008		2. REPORT TYPE Final		3. DATES COVERED 00-01-2007 to 00-11-2008	
4. TITLE AND SUBTITLE Being Responsive to Space Needs AFRL Advances ORS Capabilities through Two Collaborative Satellite Efforts			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER 65502F		
6. AUTHOR(S) Barbara Sorensen; Veronica Hernandez			5d. PROJECT NUMBER 3005		
			5e. TASK NUMBER HA		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Research Laboratory/RHA, Warfighter Readiness Research Division, 6030 South Kent Street, Mesa, AZ, 85212-6061			8. PERFORMING ORGANIZATION REPORT NUMBER AFRL; AFRL/RHA		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Research Laboratory/RHA, Warfighter Readiness Research Division, 6030 South Kent Street, Mesa, AZ, 85212-6061			10. SPONSOR/MONITOR'S ACRONYM(S) AFRL; AFRL/RHA		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) AFRL-RH-AZ-JA-2008-0002		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Published in Military Space & Missile Forum, December 2008, Vol 1, Issue 3					
14. ABSTRACT Under the auspices of the joint Operationally Responsive Space (ORS) program, two supporting aggressive research programs are being conducted by the US Air Force Research Laboratory (AFRL). ORS is actively focused on timely satisfaction of the urgent needs of the joint force commanders for improving the responsiveness of space capabilities to meet national security requirements. ORS communication, navigation, and intelligence, surveillance, and reconnaissance (ISR) satellites are being designed to rapidly meet near-term space needs of in-theater tactical forces by supporting contingency operations, such as increased communication bandwidth and ISR imagery over the theater for a limited period to support air, ground, and naval force missions. This article discusses two of these programs: the plug-and-play (PnP) satellite design for rapid construction through modular components, and the Training and Tactical ORS Operations (TATOO) Laboratory, which provides a computer-based simulation environment directed at improving warfighters' space capability responsiveness.					
15. SUBJECT TERMS PnP; TATOO; ORS; Operationally Responsive Space; AFRL; Space capabilities; ISR; Mobile hardware and software technologies; Training; Computer-based simulation environments					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Public Release	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

AFRL's Space Vehicles Directorate, together with Scientific Simulation Inc., was the first to create the plug-and-play (PnP) satellite design for rapid construction through modular components that encompass the structural panels, as well as the guidance and health and status components. Expansion of the PnP technology is currently being led by AFRL's Human Effectiveness Directorate and Star Technologies Corp. by pushing the boundaries of mobile hardware and software technology through the development of the team's Training and Tactical ORS Operations (TATOO) Laboratory located in Great Falls, Va. The TATOO Laboratory provides a computer-based simulation environment directed at improving warfighters' space capability responsiveness by delivering the means to create and exercise methods of in-theater tactical satellite tasking for and by the warfighter.

Through an evolutionary design approach, the Space Vehicles Directorate has led a continual search for optimum solutions for accelerating satellite technologies within the same core design; though the formal configuration has remained the same, several significant changes have come through material and mechanical innovations, resulting in an extremely modular and complexly hidden PnP satellite model. The PnP satellite architecture is a key com-

ing launch and satellite operation. Consequently, the newly developed technological configurations of the satellites allow for them (under strict time constraints) to receive a design description and promptly structure accurate response predictive models of satellites in return.

and can mount components in multiple places to meet the various configurations needed to support the requirements for different stages of the project. The innovative design dramatically simplifies the assembly process and limits the complexities and integration challenges faced by both small and large spacecraft by including microsystems (the combination of microelectronics, advanced packaging, and microelectromechanical systems), high-performance com-



puting on orbit, and reconfigurable systems approaches (such as field programmable gate arrays, adaptive wiring and software-definable radio concepts), resulting in an integrated system whose testing tasks can be automated and abridged.

The PnP satellites represent an extremely impressive technological achievement in next-generation space-based communication.

TATOO

At present, the approach of delivering satellite information to the warfighter is not adequate on the modern battlefield; however, through the development of the TATOO Laboratory and the collaboration with the Air Force Special Operations Command (AFSOC), this problem is being addressed through select space-technology deficiencies. The solution provides direct tasking satellite software; training material; and procedures for the warfighter and satellite systems operators. The technological underpinnings of this newly developed

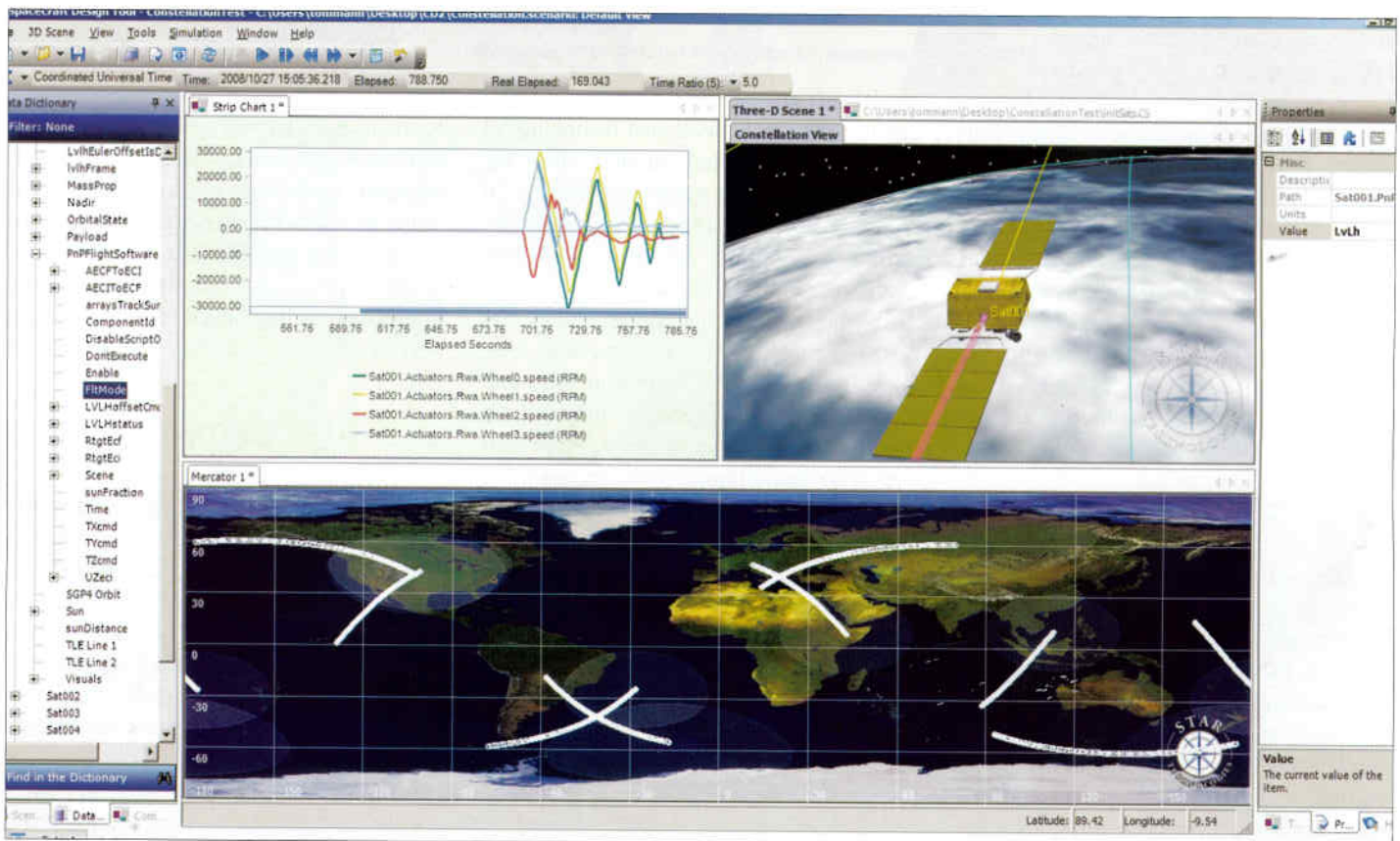
technology will be the ease that allows warfighters to model ORS satellite processes and directly task the satellites for communications and sensor data in operationally relevant time frames. The TATOO Laboratory builds on concepts that tie in directly with the operational side of ORS by using realistic training and simulation to support the development and evaluation of ORS-specific concept of operations (CONOPS) approaches, along with the training and evaluation of those CONOPS implementations for in-theater tasking, image collection, and data retrieval from various tactical satellites. TATOO fosters an environment for improving existing ORS tactical CONOPS through the development, demonstration and assessment of realistic operations and training for autonomous satellite tasking, scheduling, interface and data retrieval for TacSats owned by in-theater commanders.

For training exercises, TATOO incorporates the Spacecraft Design Tool (SDT) to emulate ORS satellites and to provide an environment for rapid prototyping of spacecraft using true PnP components, environments and subsystems. SDT is AFRL's high-fidelity dynamic spacecraft 6 degree-of-freedom (6-DOF) simulation software

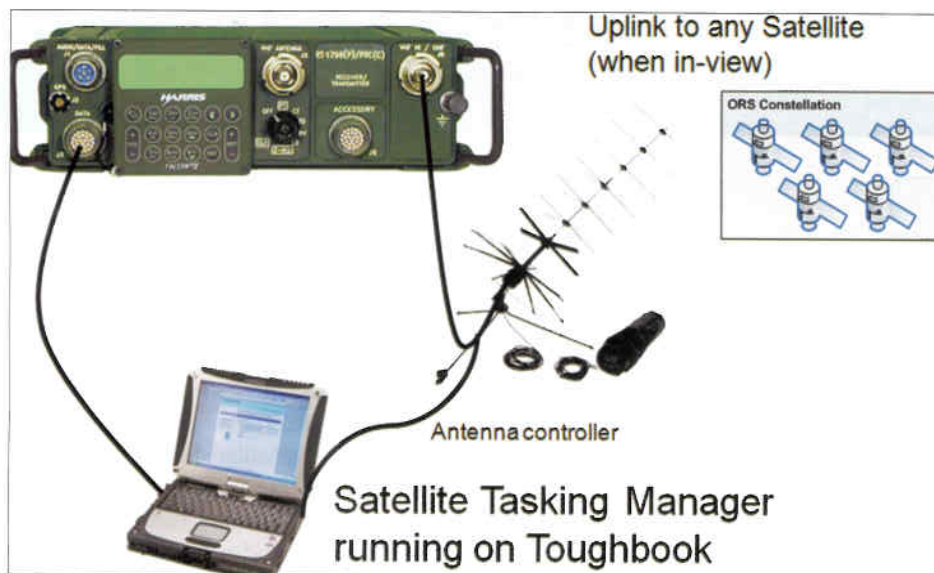
used inside its Responsive Space Testbed that offers both simulation and real-time data display capabilities, including attitude. The simulation tool can create an array of component models for rapid responsive space satellite and tactical satellite design, including sensors, actuators, electrical, propulsion, and attitude determination and control systems (ADACS); moreover, it can integrate with virtually any external program, including MATLAB and other thermal, structural and optics modeling tools. The SDT also provides real-time messaging that allows distributed satellite systems operators (SSOs) to address each ORS satellite via a TCP/IP port, replicate aspects of proposed ORS operations, and communicate the autonomous state-of-health activities and battery-life status of each satellite. TATOO can also run 3-D interactive training exercises focused on modeling and experimenting with ORS constellation sizes within the PnP framework, allowing users to understand the resulting effects on the timelines on meeting battlefield requests.

The TATOO Lab also supports the advancement of tactical ground station mission operations; tactical operations for mission tasking and scheduling; tactical mission data retrieval; and warfighter sup-

port systems. Through the use of ESRI's Geographic Information Systems (GIS) based tools (currently ArcView and FalconView), combined with Star's Satellite Tasking Manager (STM) plug-in, the warfighter and theater commander in the theater node can view a projected ground trace of each ORS satellite over a location with their expected pass time, current tasking load and capabilities. STM is a revolutionary advancement in satellite tasking, providing users a point-and-click interface designed to simplify the process of requesting and receiving satellite products. The plug-in, accessed via a toolbar button in ArcMap and FalconView, provides a mapping and annotating functionality, giving users the ability to create and model the processes that are used to request a collection and accordingly determine the best choice asset for given ORS requirements. Working with the ORS Service and Targeting component (on-board each satellite in the ORS constellation), the ground terminal-STM is able to task any satellite in a given constellation, move tasking requests from satellite to satellite to meet constraints, track satellite tasking loads and priorities, supervise slew rates, and monitor the availability of ORS assets.



SDT is AFRL's high-fidelity dynamic spacecraft 6-DOF simulation software. [Source: AFRL]



Satellite Tasking Manager is a revolutionary advancement in satellite tasking. [Source: AFRL]

A typical scenario for a PnP satellite or tactical ground station request entails a user connecting a Toughbook to a PRC-117 military radio. The user then opens FalconView and ArcMap to select a coordinate set to represent an area of interest on a map, and if needed informs the STM of additional constraints. When a satellite is in view, the user is alerted by the ORS service and asked to authenticate with the satellite. After authentication and processing, the satellite transmits a text-based message to the warfighter containing the satellite's expected pass time, current tasking load and capabilities to the STM through a TLE (two-line elements) file that represents the satellite's orbit. The STM interprets the message and creates symbols to represent the satellite's ground trace on a map using FalconView and ArcMap's GIS-based drawing tools. The user can then determine which satellite is best suited to meet operational requirements and eventually prepare and send a tasking request directed through an RF or an SIPRNet connection to a specific satellite in-view within an ORS constellation. If the satellite can perform the task in the same pass, the product is downloaded as soon as available; however, if the satellite cannot perform the task in the same pass and/or there are insufficient ORS assets, then the user is alerted by the STM as to when the product can be retrieved.

Star Technologies' STM not only offers solid task-management support to meet operational objectives; it also offers the possibility of high performance on-orbit computing (HPOOC) for the war-

fighter's software, and image-processing algorithms envisioned for AFRL's PnP satellite effort. This technology is streamlining satellite tasking, spanning mission capture to deployment, and is continuing to expand the breadth of support for ORS services through the integration of TATOO with PnP.

TATOO AND PnP PROGRAM UNIFICATION

Accessible via the TATOO Lab, the PnP satellite models will be used to demonstrate and evaluate leading edge satellite technologies, such as guidance navigation and control, attitude control, formation flying and PnP electronics.

Inside the test environment, users will conduct functional demonstrations and experiment with warfighter-satellite interactions. Using the SDT, users in the TATOO Lab will be able to supervise and control the simulated satellites and their product delivery. The integration of the two AFRL research programs will rectify the current outmoded controller workstations and ultimately minimize the footprint for processing and displaying space-derived information, as well as accelerate the delivery of space information and products from deployed and forward deployed locations.

Testing will also demonstrate a very sound approach to satellite specialty training by assisting ground force personnel in the preparation of satellite tasking and resource decisions across all field conditions and at all security classification levels. Through the integration of TATOO with the PnP satellites, the USAF ultimately intends to aggressively work toward equipping warfighters with a higher degree of knowledge, precision and efficacy needed for the successful operation of advanced satellite systems.

Capabilities for both PnP and TATOO will be demonstrated via a first launch in 2009. The experimental PnP, incorporating TATOO communications for satellite and ground systems, will provide a critical advance for ORS. ★

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