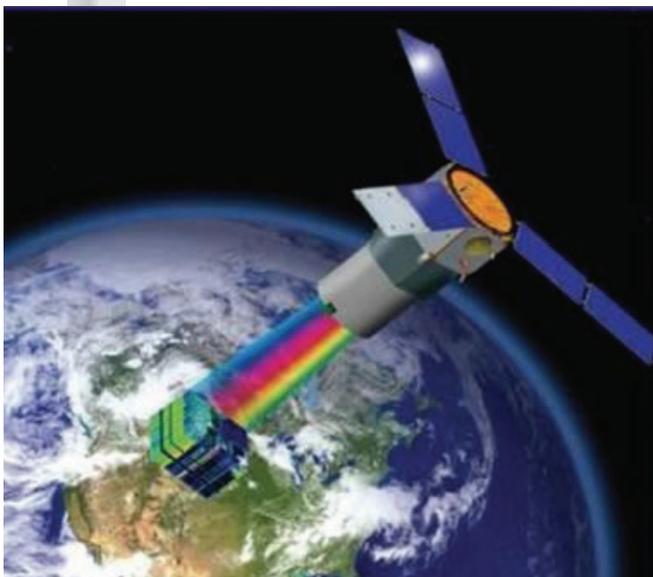

TACSAT-3

Joint Military Utility Assessment

BY ALLEN KIRKHAM,
ERIK PEREZ AND
KENNETH KRINER



Artist's rendering of TacSat-3
collecting hyperspectral imagery

Combat Situation

*Tuesday morning, 9 a.m., SOUTHCOM/ARSOUTH/
Honduras Army Counter Drug Mission Planning Cell:*

CPT Erik Perez and his Counter-Drug and Counter-Insurgency Team has intelligence information that a local drug cartel is suspected of conducting illegal narcotics production in a newly operational drug lab in the Honduras jungle in CPT Perez's area of interest. This lab is suspected of producing illegal drugs for shipment to the United States to help finance an insurgent force operating out of the Honduras jungle in his area of interest.

Commander's Critical Information Requirement:

Locate and identify all operational and active drug production laboratories in the Honduras area of interest, and provide imagery products to the Honduras Army to perform counter-drug and counter-insurgency operations in the area of interest.

Request For Information:

Task the TacSat-3 ARTEMIS hyperspectral sensor to image the area of interest to determine materials associated with an active drug lab vs. baseline rainforest vegetation present in the area of interest. Identify and locate camouflage, manmade blue tarps and plastics. Identify and locate live vegetation to include coca plants and marijuana. Identify and locate new areas of cut vegetation and disturbed earth.

The U.S. Army Space Operations and Military Intelligence Communities are very excited to participate in the experimentation of the TacSat-3 satellite and its Advanced Responsive Tactically Effective Military Imaging Spectrometer (ARTEMIS) hyperspectral sensor. This satellite and sensor will be the first of its kind on orbit. What is unique about TacSat-3 is that its sensor is dedicated directly to a Theater Joint Force Commander, to solve critical information requirements such as the fictional example above. The ARTEMIS sensor is designed to detect and



TacSat-3 Minotaur Launch from Wallops Island Space Flight Facility, May 19th, 2009
Photo courtesy of NASA

locate materials that are observed when the sunlight is reflected or refracted off the material. It will find materials as opposed to military targets. It looks for material vice vegetation. It looks for more than the shape of the gun barrel pointing off the tank turret. The US military needs this capability to prevail in the illegal drug war and the Global War on Terror.

TacSat-3 Mission and Background

The overall mission of TacSat-3 is to launch, deploy, and employ a small satellite, with an ARTEMIS hyperspectral imaging sensor. TacSat-3 is a science and technology and military utility demonstration program conducted under the umbrella of the Operational Responsive Space program. The Army is working with the Operationally Responsive Space office to lead the multi-service Joint Military Utility Assessment of TacSat-3 and its ARTEMIS sensor.

Two Mission Modes

TacSat-3 has two primary mission modes: Tactical and Routine.

- **Tactical Mode** The primary purpose of TacSat-3 is to demonstrate a tactically responsive Space-borne hyperspectral sensor. TacSat-3 scans the selected area of interest. The data collected is called a hypercube. For a tactical collect, the hypercube is processed on board the satellite and the location and identification of material (via a spectral match filter) will be provided to the tactical user in near real time via one of two communication links; Space-Ground Link System or UHF. UHF products will include text messages (commonly referred to as a Target Cue Report), and a tactical summary message. Target Cue Reports will include the type of material detected, its location, and a score to indicate the likelihood that it is the material in question. If S-Band Space-Ground Link System is used, a geo-referenced high-resolution (approximately 1 m ground sample distance) image “chip” centered on each

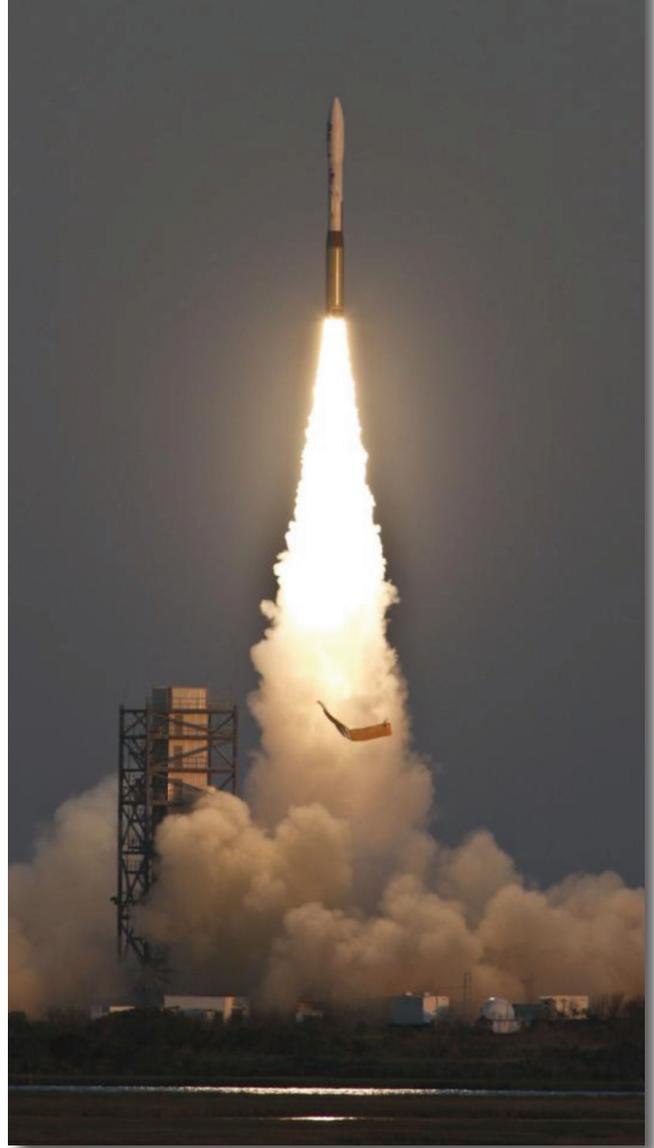
individual cue and a 3-band (selectable) hyperspectral imagery “context” image will be provided along with the text reports. Both images will be JPEG compressed. If Tactical UHF downlink, via the Navy’s Satellite Communications Payload is selected, only a text Target Cue Report message will be received. The hypercube, cue reports and tactical summaries will be stored on board for downlink to the Common Data Link high bandwidth ground station.

- **Routine Mode** During times when TacSat-3 is not committed to tactical collections or participation in exercises, it will operate in the “Routine Mode.” This gives the experiment mission partners the opportunity to task the sensor to help satisfy their internal requirements or requests from others in the community including the Combatant Commanders. The hypercube is collected and stored on the satellite. After several hypercubes are collected, they will be downloaded at a later time to the Common Data Link ground station. After calibration, the hypercube will be exploited by intelligence agencies; National Air and Space Intelligence Center, National Ground Intelligence Center, National Geospatial Intelligence Agency, Army Geospatial Intelligence National-To-Theater Nodes and Military Intelligence Brigades. Intelligence products will be provided to the customer. Other products will also be generated, especially Science and Technology products to provide technical assessments.

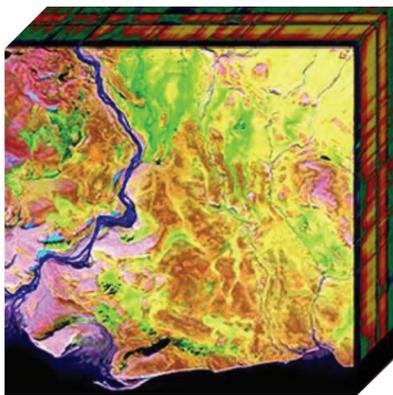
What the Army means by “Tactical”

Tactical operations are the lowest level of combat operations when compared to operational or strategic operations. Joint Publication 3.0 Joint Operations define tactical level operations, “... focuses on planning and executing battles, engagements and activities to achieve military objectives assigned to tactical units ... a short-duration action between opposing forces.” For a clear historical, yet current, definition we can think of strate-

TacSat-3 Minotaur Launch from
Wallops Island Space Flight
Facility, May 19th, 2009 (*Official
NASA Photo*)



Antenna Control Unit (ACU) Display, TGS Equipment Racks,
and Telemetry Tracking and Control (TT&C) Light Display



Hypercube Illustration

gic operations as being GEN David Petraeus' overall plan for counter-insurgency operations within U.S. Central Command. The Operational plan would be GEN Stanley A. McChrystal plan for operations within Afghanistan. And the Tactical plan would be that executed by the commanding officer of the 24th Marine Expeditionary Unit fighting in Helmand province within Afghanistan. The key concept of the word "tactical" is low level planning and execution of combat operations by highly mobile units.

Joint Military Utility Assessment Objective

The JMUA team will assess the feasibility of responsive satellites providing responsive intelligence, surveillance and reconnaissance information to support accomplishment of Theater Joint Force Commander missions. The established JMUA criteria, based on operational considerations, will be used to evaluate the ability of the satellite to satisfy stated objectives. As mentioned above, the primary mission of TacSat-3 is the Tactical Mode of allow a Joint Force Commander direct tasking access to the satellite sensor from the theater, onboard processing of the hyperspectral collection, and direct downlink to the Joint Force Commander before the satellite passes over the horizon.



Tactical Ground Station (TGS) at the US Army Space and Missile Defense Battle Lab in Colorado Springs, Colorado includes the trailer-mounted 10' S-Band auto-tracking antenna, the 1-meter Ku-Band SATCOM antenna, TGS Shelter, and Generator.

The Brigade Combat Team is the focus of Tactical Mode (“the Warfighter”)

The U.S. Army Brigade Combat Team is the basic deployable maneuver unit in the U.S. Army. A brigade combat team consists of one combat arms maneuver brigade, and its attached logistical support and artillery support units. These teams are generally commanded by a Colonel (O-6), and have around 3700 Soldiers. A Brigade Combat Team carries with it support units necessary to sustain its operations separate from its parent division. This means a Brigade Combat Team can prosecute an appropriate size target all by itself without support from other combat formations. There are several flavors of Brigade Combat Teams, some are heavily focused armor such as the M1-A1 tank, some are built around reconnaissance light armor such as the STRIKER and still others are built around mechanized infantry (currently used in Iraq and Afghanistan). The one true constant with a Brigade Combat Team is that its capable of sustained traditional combat operations with minimal external support.

The above description DOES NOT marginalize the often sited individual Special Ops or other non-traditional combat units. We are only trying to clarify the “Warfighter” baseline terminology. The Space gap generally lies in the fact most Space-based National Technical Means assets are very hard to secure at the O-6 and below levels, thus the advent of the Operationally Responsive Space concept and displayed by the TacSat family of systems. Rarely, if ever, will a Space-based system support a single troop in the field yet many of our current briefings and graphics display just that idea. The “Warfighter” hyperspectral imagery requests for information for the TacSat-3 experiment Joint Military Utility Assessment will come from the Military Intelligence Brigade collection manager assigned to the Theater to support the Brigade Combat Team that requires the information.

Joint Force Commander Critical Operational Issues

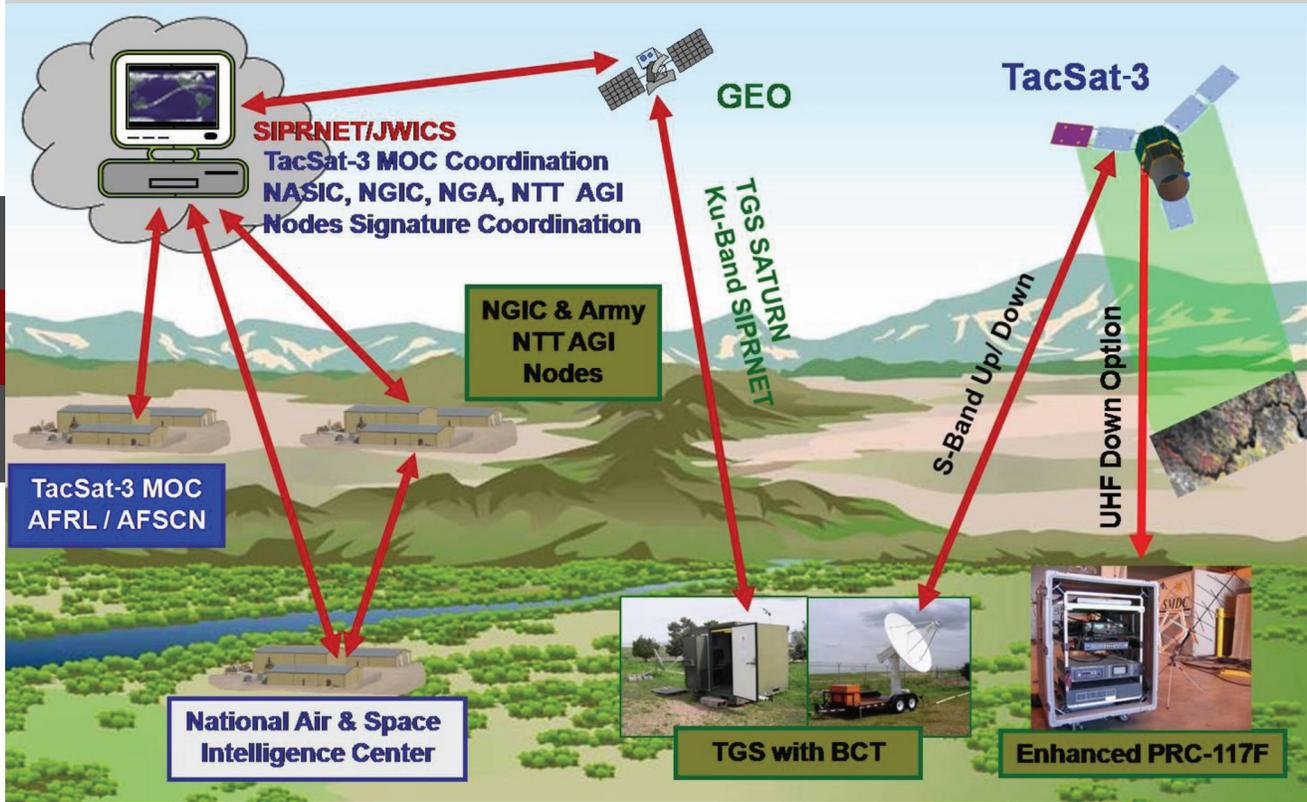
The Army TacSat Management plan assigns Space and Missile Defense Command Battle Lab in Colorado Springs as the lead agent for the Tactical mission mode Military Utility Assessment.

Appendix D of the TacSat Management Plan details the Army requirements for the TacSat-3 satellite. Air Force Research Laboratory designed the satellite to meet the needs of appendix D. SMDBL derived four Critical Operational Issues and numerous measures of effectiveness and measures of performance from this appendix:

- COI 1 Can the Joint Force Commander effectively utilize in-theater tactical tasking capability?
- COI 2 Can the Joint Force Commander receive tactical messages from TacSat-3?
- COI 3 Do the downloaded tactical messages meet the Joint Force Commander’s need for hyperspectral imagery (text file) and high-resolution imagery (chip) information?
- COI 4 Did Joint exploitation of ARTEMIS hypercube yield Service specific utility?

How will we actually do the Joint Military Utility Assessment?

Data will be collected during selected demonstrations, experiments, exercises, and day-to-day operations after launch. Following the U.S. Air Force Research Lab’s Launch and Early Orbit testing and calibration; we will begin U.S. Army Space and Missile Defense Command/Army Forces Strategic Command’s Test Plan for tactical operations of the ARTEMIS sensor. Each testing event is composed of the end state goal and precursor events that must happen in order for the end state goal to be accomplished. Each and every time a tactical collection is made in support of USASMDC/ARSTRAT testing, the resulting hypercube will be fully processed by the USASMDC/ARSTRAT hyperspectral imagery processing experts. The tactical product will be compared with collected ground truth of known targets. Testing focuses on 1) Defeating the enemy’s efforts to hide actions or assets, 2) Detect man-made objects for seeking out tactically relevant manmade objects that are not readily apparent to other intelligence, surveillance and reconnaissance methods. Other testing events will be planned and executed as operational constraints allow.



What potential services could TacSat-3 provide to the Brigade Combat Team and how would those services help him win the fight?

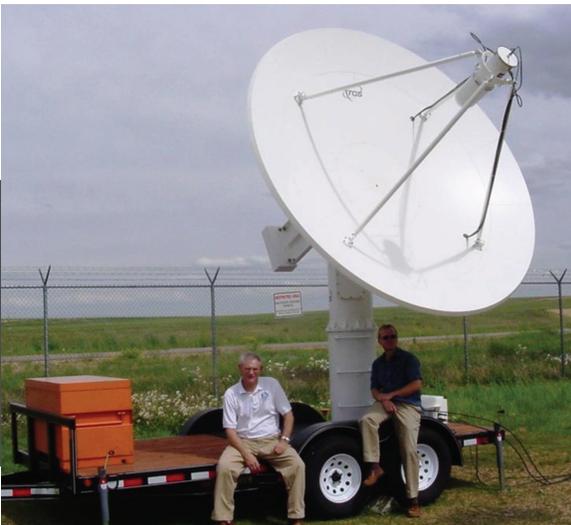
TacSat-3 has the potential to provide the combat commander text based reports that tell him where particular material types are located within his battlespace. These text based reports could be supported by images of the target in question. These reports could be delivered in a matter of hours from the time of request. If accurate, these text based reports and images could allow the commander to find enemy assets previously unseen due to camouflage.

Joint Military Utility Assessment Baseline Scenarios:

The Space and Missile Defense Battle Lab has developed scenarios that will assess the Critical Operational Issues. The Battle Lab will collect data to determine military utility of TacSat-3. In the first step after satellite functional checkout and sensor calibration, the Space and Missile Defense Battle Lab will perform

Tactical Mode initial checkout testing with the Army's Tactical Ground Station at Fort Carson Ranges south of Colorado Springs, Colo. Data collected from TacSat-3 will be compared to ground truth and processing of the full hypercube by when available. Subjective questionnaires and surveys (qualitative data) will be used to gather Operator and Warfighter (user) feedback during and at the completion of each demonstration event. The Space and Missile Defense Battle Lab will employ a building-block approach, testing each variable individually and with success, progress to more stressing events, where multiple variables will be exercised in a single scenario. Completion of all the proposed test scenarios will give the Battle Lab and the Joint Operationally Responsive Space community an accurate picture of TacSat-3's capabilities, which can then be assessed in select military exercises. As part of test planning, the Space and Missile Defense Battle Lab will use a matrix that ties measures to each event or scenario. This matrix will be used to determine which Critical Operational Issues, are being assessed in each test event. It will also be useful in determining which Critical Operational Issues, are not being assessed so they can be built into future testing events.

...the ability to task and download a product from the field with no human processing in the loop.



TGS 10' auto-track S-Band antenna trailer-mounted.
Allen Kirkham, Government Civilian SMDBL
TacSat-3 JMUA Technical Lead and
John Andrews, SMDBL TacSat-3 Tactical Ground
Station (TGS) Operator and Technician

Modeling & Simulation:

There is only one TacSat-3 for live experimentation. So, during the Joint Military Utility Assessment, the performance of the single TacSat-3 satellite will also be extrapolated in simulation scenarios to estimate the capabilities of an operational constellation of small, responsive satellites in various orbits.

Concepts of Operations and Tactics, Techniques and Procedures

The Joint Military Utility Assessment will also be used to identify Concepts of Operation, Tactics, Techniques and Procedures, and technical capabilities that would allow TacSat-3 and a Space-based hyperspectral sensor to more fully meet the needed capability of the future.

TacSat So What?

Space intelligence, surveillance and reconnaissance has been around for sometime; the new “so what” of TacSat-3 is the ability to task and download a product from the field with no human processing in the loop. The beneficial evolution of the Space-based intelligence, surveillance and reconnaissance asset to the Brigade Combat Team would be the ability to task the asset from the supported commander’s area of operations. Since tactical operations are usually thought in terms of hours, the TacSat family of systems is well suited to support this operational tempo. The fact the requested products could be delivered within hours of request and delivered directly to the commander’s tacti-

cal operations center further improves the commander’s ability to react to enemy actions. Traditional NTM assets are very ill suited to this mission set and higher levels of command typically outweigh the Brigade Combat Team commanders intelligence, surveillance and reconnaissance support request.

Looking to the Future

Army participation in the TacSat-3 ARTEMIS hyperspectral imagery project provides the opportunity to shape future tactical satellite development to meet critical joint land force operational requirements. This opportunity includes the ability to influence the selection of mission payloads, support and refine concept, combat, and materiel development activities, and exploit “leave-behind” capabilities developed through the experiments. Critical to the Army is the ability to influence system design to ensure compatibility and integration with ground system architectures and infrastructure. Such compatibility and integration will be an essential element of the Joint Force Commander’s capability to employ combat forces effectively. 