THE MINIATURE SENSOR TECHNOLOGY INTEGRATION PROGRAM: AN OVERVIEW

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The Ballistic Missile Defense Organization Technology Deputate's Miniature Sensor Technology Integration (MSTI) program was established to test in realistic operational scenarios, BMDO developed miniature sensors for missile detection and tracking on low cost, rapidly built and deployed low-earth orbit satellites. With the first MSTI mission launched less than a year after it was initiated, BMDO plans include launching 2-3 satellites per year throughout the five year defense plan. The near term direction of the MSTI program is to perform on-orbit functional demonstration of integrated sensor technologies that support theater missile launch detection and tracking. Embodying a "build a little, test a little" philosophy, the MSTI program builds upon the capabilities of both the spacecraft bus and the integrated payload suite for missile tracking, background clutter measurements, and ecological disaster monitoring from mission to mission. In addition to its primary mission, the MSTI program also serves as BMDO's cornerstone both for exploring the potential for dual-use of DOD space-based sensors for environmental/ecological disaster monitoring and for executing joint, international space missions, such as with the Russians under proposals advanced within the Global Protection System political context. This paper will describe the MSTI program approach, results of the first mission and plans for the future.

INTRODUCTION

The present need for rapidly deployable defenses against Theater Ballistic Missiles(TBMs) has driven the need to develop and execute technology programs which demonstrate concepts for rapid limited deployment of space based and ground based TBM detection and track. Sensors have been developed, but not yet demonstrated, which provide the Search, Acquisition, and Track (SAT) functions required to support standoff interception of the TBM threats by air and surface launched missile assets. These technology demonstrations are required to transition hardware from the R & D arena into the operational systems arena. Additionally, data must be gathered which verifies the performance of the hardware as well as expands the current scope of knowledge on earth backgrounds. The knowledge is required to increase the probability for detection, track and kill of TBMs. The sensors used for the TBM mission also can provide useful scientific information for remote sensing and other dual use technology applications.

In order to assure the success and longevity of any technology demonstration in today's budget constrained, and highly political environment, the program must be relatively low cost and produce results on a regular basis. It was with these overarching goals in mind that BMDO initiated the MSTI program. Specifically, the objectives of the program are to:

a) Detection, Track, and Process Track Files (On Board) for Theater Class Missile Targets and Transmit Track Files to Ground Assets

b) Optimize Integrated Sensor Packages for TMD Surveillance

c) Develop and Demonstrate Space-To-Space Communications for Distributed Sensing

d) Demonstrate C3 Data Fusion-Connectivity to Other Theater Assets

e) Explore Dual Use Potential for DoD Space Sensors For Environmental/Ecological Monitoring

The first MSTI spacecraft, MSTI Scout-1, was successfully launched on November 21, 1993.

PROGRAM APPROACH

The MSTI program utilizes the "build a little, test a little" philosophy which aims to control program risk and cost by incrementally demonstrating hardware and processes. In order to produce the MSTI Scout-1 in the required time, a new approach to spacecraft design, hardware procurement, systems integration, testing, and data collection was required. The aggressive schedule required significant management innovation in both the design philosophy, and the integration and testing efforts, and dictated the use of existing hardware developed on previous programs. By capitalizing on previous design work, the program has successfully proven a modular spacecraft platform capable of demonstrating various technologies developed by the BMDO and others. By providing the subsystem engineers with the authority and responsibility from component design though integration and test, any design changes and schedule impacts could be identified earlier and quickly resolved.

The demonstration of TMD tracking capability will be conducted over the first four missions. Each successive mission will have increasing capabilities and technologies of both the spacecraft bus and the integrated payload suite for theater-class ballistic missile detection and tracking sensor and on-board trackfile processing technologies using cooperative target launches, primarily those launched in support of the Lightweight ExoAtmospheric Projectile (LEAP) interceptor technology demonstration program. The MSTI satellites will validate the contribution of a space based sensor to the Short Range Attack Missile (SRAM)/LEAP and Terrier/LEAP flight tests. Concomitantly, launch point identification will be demonstrated as a byproduct of the on-board track file generation to evaluate the potential use of space based sensors for counter force operations. With MSTI-3 and -4 on orbit together in a managed constellation, distributed sensor concepts, using space-to-space communications and data fusion techniques, will be explored.

Figure 1. illustrates the evolution and shows the objectives for each mission.

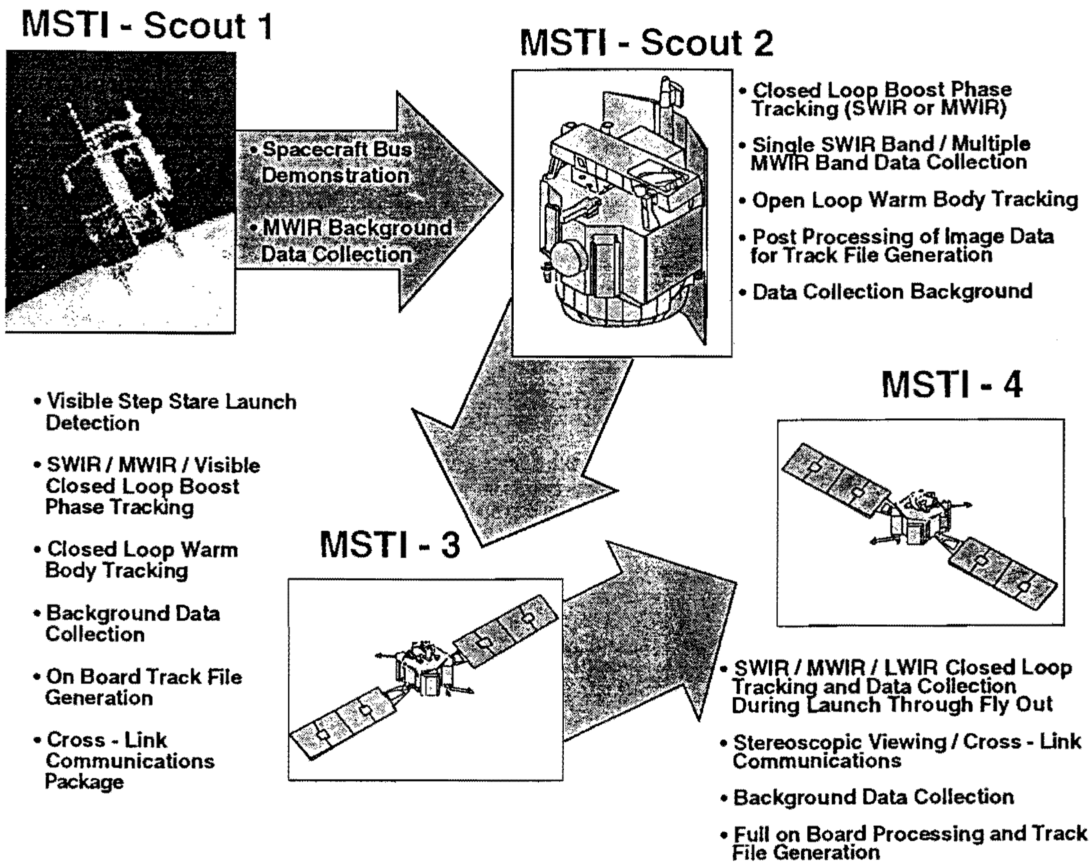

Figure 1. MSTI Program Evolution

While the MSTI program has emphasized its "space element", the program also includes the development of a mobile command and control capability. This Mobile Ground Telemetry Station (MGTS) capability explores technologies required for theater-level spacecraft tasking and data exploitation. MGTS is a mobile self contained telemetry station capable of worldwide deployment. It is being developed in a parallel and evolutionary path to the MSTI series of spacecraft. The system, once complete, will provide the commander-in-the-field with the ability to directly task a MSTI payload any time the satellite is within line of sight of the MGTS antenna. The final system will also include basic data analysis and manipulation capabilities that are now available only within large data processing centers. MGTS has been designed to be fully compatible with existing satellite control networks and will have direct connectivity to emerging C3I architectures.

In addition to its primary mission, the MSTI program also serves as BMDO's cornerstone both for exploring the potential for dual use of DOD space-based sensors for environmental/ecological disaster monitoring and for executing joint, international space missions with our traditional allies. Discussions are ongoing with representatives from England, France, Italy and Israel. One thrust advanced within the Global Protection System (GPS) political discussions is the concept of joint U.S.-Russian space-based sensor missions. While the exact design of such missions is still being considered, the concept for the Russian American Observational Stereo Satellites (RAMOS) is receiving high interest. In the MSTI/RAMOS Program, the U. S. and Russia would jointly build individual satellites that would be operated together to collect high resolution background data and track various ballistic missile targets in the visible and infrared wavelengths. U. S. studies of this concept are continuing with a conceptual design of the U. S. RAMOS payload suite for integration to a standard MSTI satellite bus and the development of a mission requirements specification. The technical payoff for the MSTI/RAMOS program is high, for example, the background data that would be gathered would fill long standing gaps in U. S. knowledge of the mid-wave infrared clutter data base.

OPERATIONS

The mission operations concept for MSTI mission 1 and 2 is depicted in Figure 2. The Spacecraft is Space/Ground Link Subsystem (SGLS) compatible and will utilize the Air Force Satellite Control Network for data acquisition, command, and control. One secondary ground station will also be used within the overall MSTI-2 mission operations architecture. Command, control, and health and status data downlink operations will be conducted at DET 2 SMC/TDOF, located at Onizuka AFB, Sunnyvale, CA, and can be accomplished using any of the AFSCN remote tracking sites. Payload data may be taken at any time. For MSTI mission after MSTI-2 the function now performed by DET 2 may be transferrred to the Falcon AFB.

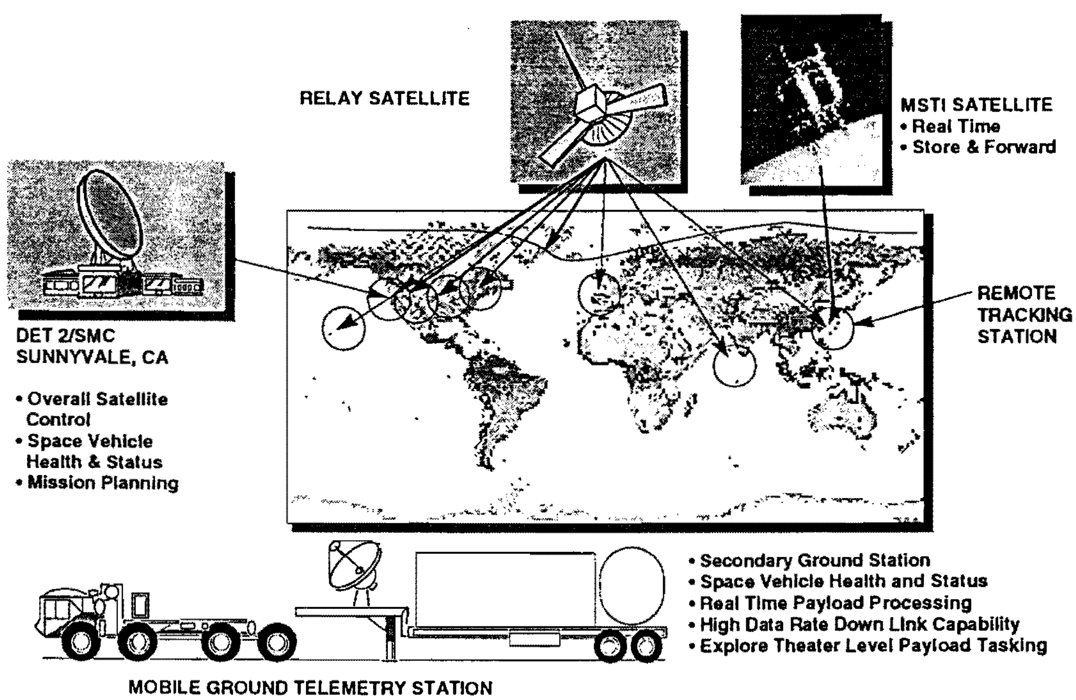

Figure 2. MSTI Operations

MSTI SCOUT-1 RESULTS

The MSTI 1 satellite was launched on 21 November 1992 and succeeded in meeting all primary mission objectives, surpassing the 6 day data collection mission requirement. The spacecraft operated until the Spring of 1993 and collected well in excess of 100,000 frames of data.

The mission data collection requirements concentrated on clutter background and target data collection which included land, oceanic, cloud cover and representative target image data. All image data received from MSTI 1 was generated with a HgCdTe, 256 X 256 staring Focal Plane Array operating in the 4.4 to 4.8 micron waveband. The field of view of the payload optical system was pointed via a single axis rotating mirror with a 90 degree field of regard centered around nadir. The imagery produced by this system was transmitted and received by standard analog telemetry techniques and was time coded to coincide with all spacecraft health and status information.

The image shown in Figure 3 is characteristic of the target data collected during imaging experiments performed with MSTI 1. This picture is a composite of a Landsat MSS image of the southern California Antelope Valley region, and MSTI 1 images collected during a rocket motor firing at Edwards AFB. The rocket motor is seen in the image as a group of bright pixels highlighted by the arrow.

Figure 3. MSTI-1 Imagery

Conclusions

The launch of the first MSTI spacecraft from Vandenberg Air Force Base, last November was the beginning of a new era in Air Force space technology development. It represented the first time in many years that an Air Force Laboratory had planned, designed, fabricated, integrated, tested, and launched a satellite with most of the effort performed in-house. The success of this first flight coupled with the progress made to date on MSTI-2 validates the build a little-test a little approach and the integrated government/industry team concept for conducting advanced technology demonstrations. Additionally, the strong desire on the part of the international community to participate helps to strengthen the process.