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James L. Grogan III

Colonel, USAF Commander, Consolidated Space Test Center, Onizuka Air Force Base, CA 94088-3430

SPACE TEST RANGE

MEETING THE DOD SPACE TEST OPERATIONS SUPPORT REQUIREMENTS OF THE FUTURE

by

James L. Grogan III, Colonel, USAF
Commander, Consolidated Space Test Center
Onizuka Air Force Base, CA 94088-3430

ABSTRACT

Current and proposed DoD programs require a broader on-orbit space test support capability and the availability of space based assets to support non-space, ground or sea based RDT&E and OT&E programs. These programs include Strategic Defense Initiative Organization, National Aeronautics and Space Administration (NASA), Army, Navy, and Air Force systems existing, planned, or being developed. The proliferation of these systems brings about new problems and concerns for safety. They increase the number of on-orbit objects and increase the complexity of coordinating and integrating missions with a resulting increase in potential hazards to operational and R&D space systems. Future testing requirements will require better control of debris and spent vehicles reentering the atmosphere to avoid additional risk to people and property on the earth's surface. Laser and beam systems in space will introduce new challenges for developing well-established and documented procedures for minimizing any safety risks.

With the concern for safety, the high cost of world-wide testing of space systems makes it imperative that more efficient use be made of existing and new test resources. A central coordinating agency is required to schedule and integrate use of increasingly complex multi-range support to avoid duplication of test support resources among the existing DoD ranges and satellite control systems.

To meet these needs, the Office of the Secretary of Defense and the Air Force have officially acknowledged the requirement for a DoD-wide space test capability. Activation of the Space Test Range (STR) to provide the DoD-wide space test capability began in October 1988 with an emphasis on safety, and recognition of increasing mission complexity and the need to achieve economy in space testing. The STR will schedule, integrate and coordinate numerous assets from various ranges to support space testing for a particular program. The STR will provide coordination, planning, preparation, evaluation, control, and safe conduct of space test operations.

The STR architecture, which melds existing and future national space and support resources into a synergistic test support network, is the subject of the DoD Operations technical paper "Space Test Range - Meeting the DoD Space Test Operations Support Requirements of the Future".

BACKGROUND

In September 1986, the Strategic Defense Initiative Organization (SDIO) launched the DELTA 180 mission, known as "Vector Sum". The data collection portion of the mission lasted 165 minutes. The satellite observed earth backgrounds, a cooperative rocket launch, and a collision event outside the earth's atmosphere. Seven ranges comprised of twenty-two radars, thirteen telemetry sites, thirty-one satellite links, two optics aircraft (NC-135, Lear), and one ground optics station were required for support. In February 1988, the SDIO team launched DELTA 181, known as "Thrusted Vector". This second mission's data collection phase lasted 650 minutes and involved observations of both earth and space backgrounds, rocket firings from White Sands Missile Range, and in-flight calibrations. Twelve ranges comprised of thirty-one radars, fourteen telemetry stations (including ARIA), thirty-one satellite links, two optics aircraft (NC-135, Lear), and one ground optics station were required for support. A briefing on lessons learned from DELTA 180 and 181 experiments indicated during the interim between the two missions, a tremendous base of expertise was disbanded and had to be reformed at great expense in time, money, and risk to mission test success. The resulting recommendations called for the coordinated development of a detailed Space Test Range architecture and the creation and maintenance of an expert base for test safety and mission coordination for future missions.

On 17 April 1989, the Office of Secretary of Defense (OSD) issued a Test Package Directive, Project No. 3-02-F, that directed the establishment and development of a DoD Space Test Capability (DSTC) to conduct integral tests to major experiments, evaluate components, and perform integration testing of space based systems; establish and develop a safety function for positive control of space testing; and plan and design a space test capability to make the best potential use of NASA and other US agency assets. The Air Force was appointed as Executive Agent, and with delegation from the Assistant Secretary (Acquisition), Air Force Systems Command Space Systems Division (AFSC/SSD) was designated as the action agency. Space Systems Division's Consolidated Space Test Center (CSTC) is the Air Force office of primary responsibility for the execution of the DSTC project.

Space Test Range (STR) is an environment of space testing and the collective use of assets to support a given test. This is not a range in the traditional sense (e.g., Western Test Range (WTR), Eastern Test Range (ETR), Pacific Missile Range Facility (PMRF), etc), but a "virtual range" comprised of the various assets from existing ranges that are required to support a given mission. The configuration of the STR and the organizations involved changes from mission to mission in accordance with the demands of the test.

Until all DoD services have established formal interfaces with the CSTC and the STR, two bodies support the planning and development efforts underway:

1. STR Executive Advisory Board (STREAB) - a multi-service board which provides high level guidance and direction for the establishment and management of the STR.

2. STR Working Group (STRWG) - a Tri-Service and multi-agency group for evaluation of existing assets and the development of new STR support capabilities.

Two offices have been formed at the CSTC to execute development and daily test planning and support activities:

1. STR Organization (STRO) - the Tri-Service organization responsible for establishing, managing, and coordinating the STR activities.

2. DSTC Joint Program Office (DSTC JPO) - provides Tri-Service dedication to the DSTC acquisition process for development and acquisition of space test capability.

The relationships between the elements of the DSTC are shown in Figure 1.

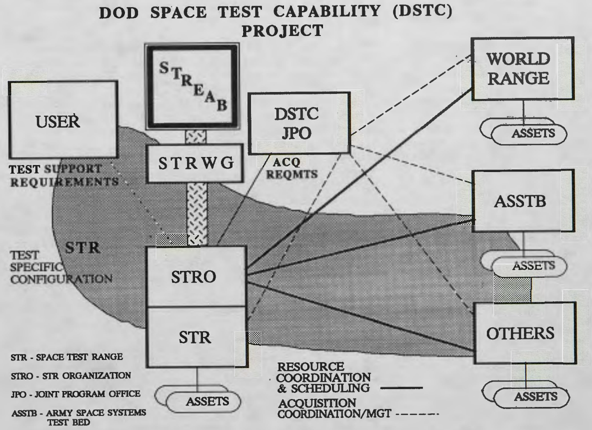

Figure 1. DSTC Organizational Interfaces

INTRODUCTION

The STR architecture is the configuration of the test and evaluation resources (personnel, procedures, facilities, communications, command/data links, computer hardware and software, etc.) necessary to execute on-orbit space system test operations. The configuration is a dynamic rather than static entity. Many STR resources are not dedicated, but rather are drawn from a pool of existing distributed assets, such as those from the Major Range and Test Facility Base (MRTFB). These assets come together to accomplish test objectives for the Army, Navy, Air Force, SDIO, and other government and commercial users. Assembled resources are supplemented with other national assets and with a core resource set dedicated to the performance of the STR mission functions.

The characteristics of the STR architecture are embodied in the major functions executed by the core resources. These functions are to:

a. Provide user service by acting as a single point of contact for space test and evaluation support.

b. Establish and implement STR standards and procedures necessary to conduct responsive and successful test operations with particular emphasis on the important issues of range safety assurance and security.

c. Provide mission planning, spacecraft design feedback and preparation services to potential users of STR capabilities to assist definition of integrated test experiments.

d. Conduct pre-flight safety analysis of planned experimental programs to mitigate hazards and ensure range safety standards will be met during test operations.

e. Coordinate across major ranges and resources to integrate the required assets of the MRTFB, perform test planning, provide test engineering, deploy special mission support systems and assure proper execution of all test mission phases (e.g., operations simulation, rehearsals, mission operations, and data retrieval, processing and evaluation).

THE STR TODAY

There is an identified group of MRTFBs and other organizations and national assets which can provide significant support for on-orbit testing. These organizations are shown below:

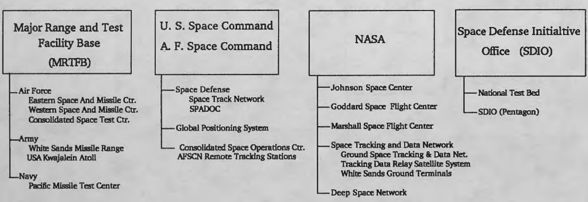

Figure 2. Current Major Range Test Facility Bases

The present capabilities of the STR are:

1. Mission Planning - Mission planning is the pre-test and daily coordination of various range assets needed to meet mission support requirements. STRO is the coordinating agency for DoD test support and is the focal point for new space experiments. The STRO is the center of expertise for on-orbit testing. Detailed mission planning will actually be a consolidated effort between all ranges and agencies involved in a particular mission and encompasses all activities including launch and early orbit, daily state-of-health support, experiment control, coordinating sensor and data collection, and end-of-mission activities.

2. Safety Analysis - Safety is a function of mission planning and is paramount for space test missions. On-orbit safety analysis is conducted by or coordinated with the STRO and involves the capabilities and expertise of the user, USSPACECOM, AFSPACECOM, and AFSC. The safety considerations for on-orbit spacecraft and ballistic missions include: collision avoidance, reentering debris, directed energy devices and beam avoidance, Electro Magnetic Interference sources, Ionizing Radiation, explosion, kinetic energy devices, chemicals, and natural phenomena. The CSTC is

responsible for the STRO safety and shall exercise safety-related "go" and "no go" decisions during passive and most active on-orbit tests which utilize STR assets.

3. Mission Control - The mission control element contains the facilities and expertise to control a spacecraft/payload using the scheduled resources in support of the STR. For on-orbit testing, this capability is usually resident within the Mission Control Complexes of the CSTC. For DoD operational programs, on-orbit operations are conducted at the Air Force Space Command's Consolidated Space Operations Center. NASA's Johnson Space Center and Goddard Space Flight Center are responsible for NASA civilian missions. Ballistic and launch control facilities are located at ETR, WTR, PMRF, WSMR, and other launch ranges.

4. Communications - The STR communications capability includes both intra-range and inter-range communications and is accomplished with the use of satellite/terrestrial links for communication/data, voice, teletype, facsimile, and video. Currently, links exist between a few, but not all, of the various ranges and their resources. Some ranges own and operate systems which will require future modification in order to provide compatible communication links. Current missions use existing communications with upgrades made as required on a mission by mission basis.

5. Commanding - The transmission of commands to an on-orbit spacecraft will be accomplished on the STR by using an interface with the AF Satellite Control Network (AFSCN) or multiple MRTFB ground/mobile tracking stations and data relay satellite systems.

6. Telemetry Reception and Processing - The reception of digital and analog telemetry from orbiting spacecraft and ballistic missiles will be accomplished by the use of various space-to-ground telemetry receiving systems and satellite-to-satellite-to-ground link systems within the AFSCN and MRTFBs.

7. Orbital Tracking - The provision of time-oriented positional information of an orbiting body is accomplished in several ways on the STR. These include Space Ground Link System tracking, C-band Coherent and Skin Track Radars, Optical Tracker and Laser Radars, and Global Positioning System Receivers and Translators.

8. Orbit Determination - Tracking data processing enables orbit determination and ephemeris generation. This capability exists at numerous MRTFB facilities.

9. Mission Data Processing - Intensive data processing is required for dynamic, real time computation of position data, propagation of debris clouds and lethal corridors, and real time signal processing for spacecraft and payload analysis. Propagation of debris clouds is currently accomplished by USSPACECOM and AFSC/SSD with data processing capability resident at the CSTC, ETR, WTR, PMRF, and other facilities. All of these areas of mission data processing will require further development for upcoming and future missions.

10. Security - The security function for the STR is based on existing DoD security programs. Security covers protection of test operations and data, physical protection of range and user assets, encryption of communications links, information protection activities for documentation, computer

systems, and TEMPEST or compromising emanations evaluations. These services are provided by the individual ranges and assets utilized by users of the STR.

USING THE STR

The process of obtaining STR support follows an established sequence of activities beginning with a system description in the form of the "Program Introduction" (PI) document. The user or program office, in accordance with the activities prescribed in the Universal Documentation System (UDS), makes its formal request for STR support by submitting the PI on standard forms and with STR assistance. Requirements analysis is accomplished by the STR, matching requirements against resources available and identifying any deficiencies. A Safety Group also reviews and analyzes the PI for safety requirements and impacts. The results of this analysis are given to the program office in a "Statement of Capability" (SC).

As program requirements become better understood and more detailed, a "Program Requirements Document" (PRD) is submitted by the program office to STR on UDS standard forms for each specific requirement. The STR will respond to the detailed requirements in the PRD with a "Program Support Plan" (PSP). This PSP addresses each PRD requirement, identifying how it will be met or that it can not be met by the STR.

Programs consisting of multiple missions or mission objectives may develop "Operations Requirement" (OR) documents which describe in detail the requirements for each mission. These OR documents cover not only the test, but all health and status support require as well. The OR is prepared by the program office with STR assistance and should not introduce any new system requirements. The STR responds to the OR with an "Operations Directive" (OD). The OD incorporates the responses from supporting organizations, the detailed roles of each support function, the technical configuration of support equipment, and the duties of all personnel involved in the test.

Once on-orbit, space tests are accomplished in accordance with the PSP and ODs. Deviations from these plans as a result of system failures or changes in mission objectives will be managed in accordance with criteria which assure the highest degree of safety and mission success possible.

THE STR IN ACTION

A prime example of the successful use of STR support capabilities was the SDIO DELTA STAR mission. DELTA STAR was launched 24 March 1989 with an expected lifetime of 180 days. The actual lifetime was nine months due to the ability of mission control personnel to effectively manage on-board consumables. The mission objectives were to observe and collect data on specific targets of opportunity, space objects, and scientific phenomena of interest. The STR supported DELTA STAR with the CSTC as the primary control center using assets of the AFSCN, NASA, US Army Kwajalein Atoll (USAKA), and ETR for on-orbit telemetry, tracking, and commanding. The STRO provided on-orbit safety management, inter-range coordination and scheduling, and cooperative launch coordination. Figure 3 shows how the STR "virtual range" configuration worked for the DELTA STAR mission. Other programs are currently being supported by the STR, but DELTA STAR was the first to operate utilizing the new concept.

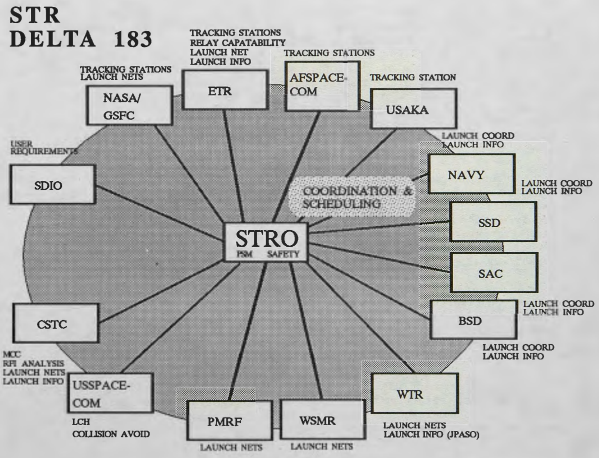

Figure 3. STR Virtual Range Configuration for DELTA 183

STR AND FUTURE PROGRAM SUPPORT

A list of potential test missions and non-operational programs manifested for upcoming and future launches is shown in Figure 4. The STRO is involved in evaluation/mission planning for support of these programs.

P675	LAGOES-2	ERIS/HEDI
BSTS	GOES	STEP
SSTS	MSX	SHAD
DFS-2	ZENITH STAR	AFE
STARS	NOAA	ALS
RME	NASP	LACE
ROSAT	RFE	

Plus Others as Capability Evolves

Figure 4. Missions With STR Support

Many of these missions will require upgrades to current range capabilities for support. An example of several future upgrades required or currently planned include:

1. Inter-range communications: Common/Compatible voice, teletype, facsimile and other communication media (both secure and unsecure) must exist between range asset nodes to allow for integrated and rapid mission control. Internetting of test ranges will provide a wide area DoD range complex to support space and space-related testing with command, control, and data links. This project will provide the testing community with cross-access and shared utilization of test assets. Plans call for the Army's Electronic Proving Ground to procure/lease communication I/F equipment or fiber optic/SATCOM links to supplement existing communication systems. Full communications capability is planned for 1994.

2. A Space Test Support Center will provide a secure control complex with computer systems and software for space test planning, coordinating, and execution. It will provide simulation tools for developing optimum test scenarios and capabilities for user data formatting and dissemination, test data archiving, and data reduction. For rapid coordination of test procedures, video teleconferencing will be available. Full operational capability is planned by 1995.

3. A Space Test Range Safety System will provide dedicated computer systems and software to perform collision avoidance processing during launch and on-orbit test operations; debris avoidance and beam/projectile prediction and measurement support; and integrate space range safety assessment for space test missions. Full operational capability of the system is planned by late 1993.

4. Other projects include an integrated and far-ranging scheduling system for efficient, effective scheduling and utilization of assets across several national ranges. The Navy's Pacific Missile Test Center is responsible for executing this project.

SUMMARY

The STR was established in the interests of safety, recognition of increasing space test mission complexity, and the need to achieve economy by the use of available assets in space testing. Since its activation in 1988, it has supported the SDIO's first long-duration, multi-sensor experiment, numerous sounding rockets launched by NASA, and is currently providing mission planning support to over twenty-eight DoD and commercial programs. The STR holds many exciting challenges for meeting DoD space test operations support requirements of the future.

For further information on how to obtain program assistance, write to the Consolidated Space Test Center, Space Test Range, CSTC/OSR , Onizuka AFB, CA 94088-3430 or FAX:(408)744-6514. For telephone inquiries, call (408)744-6574 or AUTOVON 799-6574.

REFERENCES

1. "Space Test Range (STR) Handbook", Revision A, published by the CSTC, 5 May 1989.

2. General Electric, "DELTA 180/181 Lessons Learned Study", Briefing presented at Vandenberg AFB, CA, 9 Mar 1988.

3. The Aerospace Corporation, "STR Architecture Study", Prepared for Air Force System Command Space Systems Division, 30 Sep 1988.