Redefine Technologies

Spinning Technology into Future Resources ™

Testbed for Responsive Experiments And Demonstrations in Space (TREADS) Concept of Operations

Summary

The Testbed for Responsive Experiments and Demonstrations in Space (TREADS) is a full-service technology and science demonstration platform specifically designed to allow investigators to quickly and easily integrate and launch their instrumentation into an orbiting test environment. Two potential customer groups include component developers seeking to increase the Technology Readiness Level (TRL) of a new product in order to reduce risks and science/tactical instrument developers that cannot wait for dedicated multi-million dollar missions. TREADS' first flight is being proposed on-board an Atlas 5 GTO launch in mid-2009. A baseline of 1-2 launches per year, depending on need, are envisioned beyond the initial flight to support a mix of commercial, civil, and military clients.

Redefine Technologies has developed various configurations of the TREADS platform to best satisfy the customer base. Instruments such as board-level electronics (i.e. mass storage units, flight computers, and hardware support modules), software (i.e. mission managers, artificial intelligence, or device drivers), or full components (i.e. scientific instruments, momentum wheels, solar panels, mechanisms, or other subsystems) can easily be accommodated on any of the testbed variants. TREADS offers payload capacities from 0.5kg electronic boards to 40kg stand-alone components. Power allocations range from 5W to 100W according to instrument requirements.

This paper will discuss how TREADS, a new commercial technology testbed, can change the way you think about your acquisition, development, and testing processes. You will read a brief summary of the spacecraft capabilities, a timeline of our launch opportunities, and a conceptual view of the way in which TREADS simplifies the process required to put your instrument into space.

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New Product Development Methodology

New technology and scientific instruments are being developed every year through the SBIR program, Broad Agency Announcements (BAAs), and other types of research and development (exploratory, project specific, or internal R&D). These projects spend millions of dollars on validating their devices with ground tests and peer reviews. However, no amount of ground testing can compare to actual flight heritage and the ability to engage the space environment—on your terms. Actual flight heritage turns a good idea into a product with history. The acquisition of flight heritage adds value to your product and allows for a more confident marketing approach that reflects proven reliability of your product.

Self-Manifest™

TREADS offers a unique opportunity that has not existed before—the opportunity to Self-Manifest™ your technology onto a spacecraft and orbit that technology on your terms. You or your organization can now dictate the testing and data gathering schedule of your component. You can start today on quantifying flight characteristics of products that are already in production. You can fly new components that have not yet flown, but are being considered for future projects. Or you can prove your new ideas at a prototype level and fly an instrument to get some initial data that will convince your customers to continue funding the research that will finalize your product's development.

Reduce Risk

Mission/Project Managers may also elect to perform some early testing of a new technology or science instruments before a multi-million dollar, dedicated mission relies on that same device. TREADS reduces the risk of each mission in a way that extensive peer-reviews cannot match. On-orbit data can be gathered by a quick, low-cost TREADS flight and the instrument can be fully characterized for future uses. This low-cost flight can easily fit into the budget of the larger programs and it helps ensure the capabilities are on the final spacecraft that were initially envisioned by the users when it was originally requested.

Realize Essential Science

In addition to reducing risks, the TREADS recurring missions of opportunity offers the realization of *incremental mission objectives*. As instruments are readied for flight, they can be incrementally deployed on a TREADS platform. On-orbit data from a first launch will be analyzed and new data will be desired. Thereafter, the appropriate instrument can be launched on follow-up flights to maximize scientific return. A cadre of instrumentation investigating a particular scientific phenomenon can be arrayed as more TREADS launches loft more instruments to complement previous launches. This approach eases the budget constraints of the current methodology where the entire investigation has to be known up-front and all the instrumentation in place before any launch occurs (which exposes the entire mission to cancellation). An incremental TREADS buildup gives the investigation a chance to build credibility and to achieve an essential amount of scientific achievements, which is better than none at all if the full mission never gets launched.

Description of Opportunities

Most launches, no matter who the primary payload provider may be, have a certain degree of excess capacity on the vehicle that can be used to put smaller, secondary payloads on-board. Most primaries do not choose to fill this capacity because of the logistics and costs associated with dealing with a secondary customer. Four payload adapters (Figure 1) have been developed to address this issue: the Air Forces' EELV Secondary Payload Adapter (ESPA), NASA's Multiple Payload Ejector (MPE), Space Access Technologies' (SAT's) RideShare Adapter (RSA), and United Launch Alliance's Secondary Payload Carrier (SPC). Each supports the primary payload on the "top" of the adapter, with secondary and tertiary payload around the "base" of the structure. The RSA, for instance, is an adapter ring that sits between the rocket's second stage and the primary payload. The RSA has one position inside their structure for a deployable satellite, and Cubesat launchers can be arranged around the outside of the structure to deploy $10cm^3$ structures. All three payload adapters use a standardized 15" interface for their secondary payloads.

Redefine Technologies uses these payload adapters as the infrastructure to support TREADS. TREADS extends the payload adapter capabilities beyond simply deploying secondary satellites. The TREADS platform enables the flight of "stand-alone instrumentation." Instrument such as board-level electronics (i.e. mass storage units, flight computers and hardware support modules), software (i.e. mission managers, artificial intelligence, or device drivers), or full components (i.e. scientific instruments, momentum wheels, solar panels, mechanisms, or other subsystems) can easily be accommodated by the testbed.

TREADS is a technology and science demonstration platform specifically designed to allow investigators to quickly and easily, get their instrumentation integrated, launched and operating in the space environment

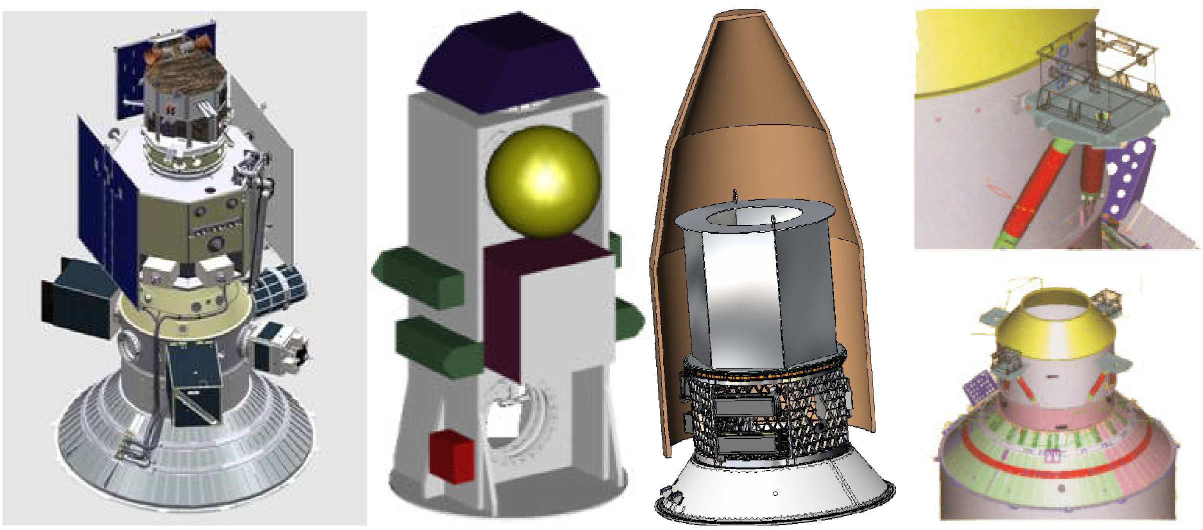

Figure 1: Three payload adapters widely used to launch secondary payloads: a) the Air Forces' EELV Secondary Payload Adapter (ESPA); b) NASA's Multiple Payload Ejector (MPE); c) Space Access Technologies' (SAT's) RideShare Adapter (RSA); and d) ULA's Secondary Payload Carrier.

As commercial, civil, or military organizations identify scientific or technology demonstration instruments that they would like to orbit, Redefine Technologies will work to secure a position on a launch vehicle that is in route to the desired orbit. TREADS can be launched to almost any orbital position: Low, Medium and High Earth Orbit (LEO, MEO, HEO), as well as to Geo-Transfer Orbit (GTO). All TREADS missions provide the customer with several months to several years on-orbit. After launch, TREADS will provide an operational environment for the science and technology instrumentation. Power generation, thermal control, and communication capability are included on the

TREADS bus. The TREADS mission operators will support the customer in running the experiments on-board the platform and retrieving the data.

Platform Configurations

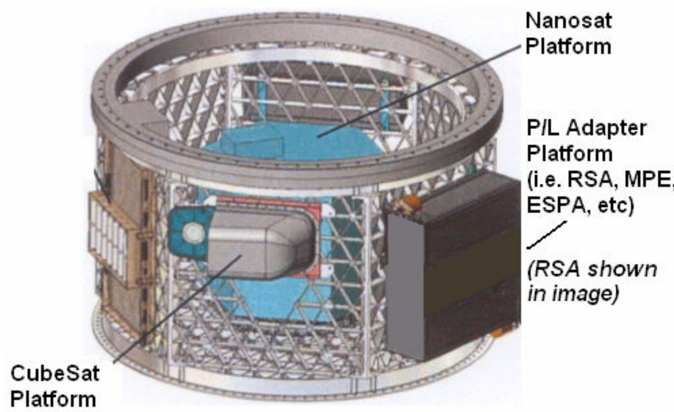

Figure 2: TREADS Platform Variants on an RSA

TREADS has three configurations shown in Figure 2: the CubeSat Platform, the Payload Adapter Platform, and the Nanosat Platform. These variants can be mixed on a single launch to meet your unique needs. Each platform can support a variety of software, board-level electronics, or components called Devices Under Test (DUTs). The Payload Adapter Platform offers the greatest mass and volume capabilities. The CubeSat and Nanosat Platforms offer free-flying satellites that will separate from the payload adapter to test other science instruments or technology demonstrations with special requirements such as pointing, thermal, and power needs.

TREADS offers payload capacities from 0.5kg electronic boards to 15kg free-flying payloads to 40kg stand-alone components. Power allocations range from 5W to 100W per component. Figures 3 and 4 show closer views of the Nanosat Platform and the Payload Adapter Platform on an adapter panel.

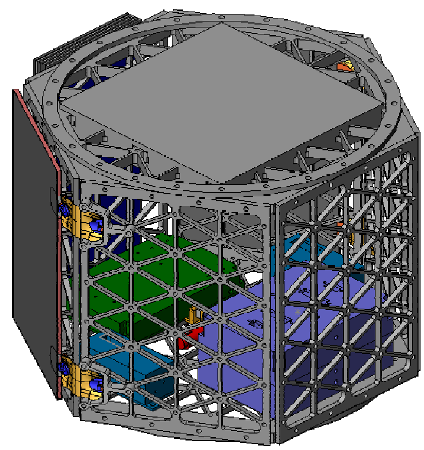

Figure 4: NanoSat Platform

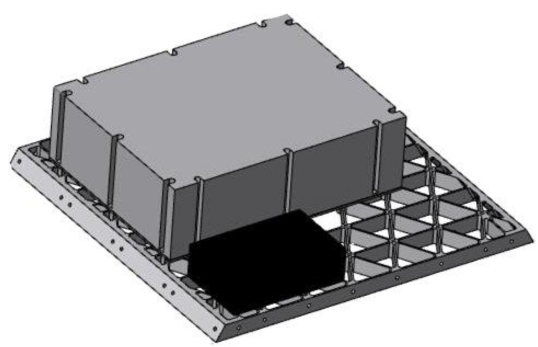

Figure 4: Payload Adapter Platform

Mission Status

TREADS is a recurring mission of opportunity designed to provide affordable access to space for technology demonstration and scientific instrumentation. The RSA adapter ring that mounts TREADS to the launch vehicle is already qualified on two launch vehicles: Falcon I and Minotaur I. Agreements with other launch providers are being negotiated and acceptance is anticipated within 12 to 24 months. TREADS is also being fitted to the Atlas 5 payload adapter for access to geo-transfer orbit (GTO).

The TREADS bus is planning a first flight in the 2009-2010 timeframe into GTO orbit. The GTO launch opportunity has positions available for two additional instruments. Space Micro Inc. of San Diego will fly their space weather dosimeter and the Ames Research Center will fly T3RSS, a demonstration of non-rad hard fault tolerant FPGA SBIR technology on that particular launch. These two technology demonstrators will partially fund the first TREADS mission. Thereafter, two (2) TREADS launches per year are baselined, but may increase as the number of launch vehicles increases.

Customer Contribution

The commercial, civil, and military organizations only contribute their portion of the cost of each TREADS mission (for instance, NASA may only require one science DUT position, the Air Force may want to fly multiple board-level DUTs, and a commercial company may have an IR&D project in the last position all on a single Payload Adapter Platform). The cost of each DUT location is proportional to the mass and power requirements of each. A typical electronics board (3U size) may costs between $400K and $600K. An instrument with larger mass and power needs may cost $500K to $1.5M. A "half-ESPA" sized NanoSat Platform satellite would cost between $4M to $6M if a customer required all the payload capability provided by that vehicle. The cost of each TREADS launch includes a standard duration of mission operations support. The total mission operations costs will then vary according to the lifetime, power requirements, and special needs of each investigation beyond the standard support.

Concept of Operations

When a technologist or scientist has proven their instrument on the ground, they can choose to manifest their component on a TREADS launch to prove their instrument in space. That component can be flown in full flight condition or even as a prototype in order to acquire baseline science returns. If components are already being considered for another multi-million dollar mission, project managers may determine that a TREADS pre-mission flight is warranted to reduce the risks associate with flying brand-new technology on a dedicated mission that will depend on 100% reliability. In either case, any of the TREADS launches can be used to validate the technology in a few simple steps.

Step 1: Self-Manifest™

At some point, your technology development will progress to a point where flight data is needed. This point could be:

- market driven (i.e. need to earn flight heritage to qualify for the next Earth observing or interplanetary mission),
- concept driven (i.e. need 'in-situ' measurements to refine your devices' design such as gain controls, mirror quality, sampling rate, etc.), or
- environment driven (i.e. to verify your technology can survive the radiation, vacuum and temperature variations found in space).

To manifest your device on the next TREADS flight, the technology owner simply needs to fill out the Self-Manifest™ form on www.redefine.com/TREADS. This form will identify the mass and power needs of the device. While most components will not need specific orbital requirements, this form also helps identify certain parameters that are required to obtain the data the owner is looking for. The Redefine Technologies Team will then find a near-term launch to satisfy the requirements of each suite of instruments.

Step 2: Pre-Integration

A unique Plug-and-Play TREADS Integration Box (TIB) is being designed to ease the integration procedures required to put a new instrument on-board a TREADS platform (or on-board any other mission). The TIB is an exact replica of the TREADS Platform that the instrument will be attached to, including mechanical, power, and data interfaces. The TIB has a dedicated DUT Manager board (also present during the mission) which is used to control the on-orbit tests each DUT will undergo. This DUT Manager is programmed by each customer so that their tests are exactly what they desire. A TREADS Integration Box will be sent to the instrument provider so they can "pre-integrate" their device at their own facilities. The TIB exposes many of the integration issues that arise only after the instruments are delivered in the typical integration process. The pre-integration steps allow full, end-to-end mission operation testing even before the instrument leaves the test-bench. The TIB is based on Redefine's Distributed Wiring Harness (DWH) product (Figure 5). The instrument is mounted to the TIB and "plugged in" with native data and power connectors on the backplane. On the outside of the TIB is an Ethernet connection to communicate with the DWH. The TIB is configured through a simple web-based interface. The DWH is then used to simulate the real mission. The DWH can be controlled locally by a virtual flight computer, a physical flight computer which is located at the Redefine office for TREADS simulations, or a third-party component provider for other missions. The simulation will direct the flight computer to turn on the Device-Under-Environmental-Test and exercise that device for a complete end-to-end simulation where the users can send commands to their device, get data from each test, and upload new tests to run on the next orbit.

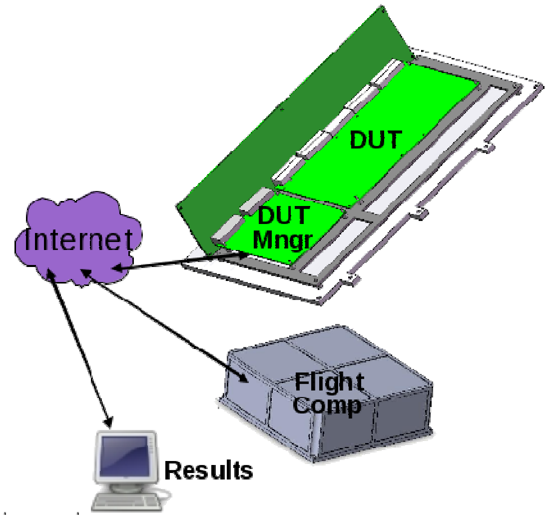

Figure 5: A component level view of the Distributed Wiring Harness getting data to the user.

Step 3: Integration and Launch

The Pre-Integration step above will help resolve many of the integration headaches seen by the non-modular satellites typically assembled. When the components are delivered, the simple flight interfaces will duplicate what has already been performed at each of the customer's facilities. More end-to-end tests will verify data and power connections. The assembled box will then go through random vibration tests to prove launch vehicle compatibility. Thermal and/or vacuum tests of each device are the responsibility of the device provider. The entire assembly will then be shipped to the launch site.

Step 4: Flight Operations and Analysis

After launch, the flight computer will go through an entire system checkout and report back an initial status of each DUT. Depending on the test schedule established by the customers, each DUT will be turned on and the user's test scenarios run. These tests can be run simultaneously or sequentially depending on the power requirements of each test. After each test, the results gathered by the flight computer will be downloaded to a ground station. The test results have the option of being encrypted to avoid transmission interception. The results will be sent immediately to the customer for analysis. After analysis, the customer may opt to change the next test. New test code and/or parameters can be uploaded to TREADS. The duration of each TREADS mission will vary. Some customers will want only a few weeks of tests, while others will want years of operations support.

We look forward to hearing how well the TREADS platform matches the requirements that new technology providers are developing, and we are excited to help commercial, civil, and military organizations make the most of this recurring opportunity. Please contact Redefine Technologies if you have any questions or need further details.

Sincerely,

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