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STPSat-1: The First Space Test Program Mission to Capitalize on the New ESPA Secondary Launch Capability

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Paper Highlights

- **Summarizes the multitude of technical challenges encountered by the STPSat-1 team during the Space Vehicle development cycle**
  - **Designing to the constraints of the uncharacterized ESPA environment**
  - **Designed secondary payloads for non-interference with a primary payload**
  - **Range safety requirements including new rules for Lithium-ion battery usage**

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STPSat-1 Background

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- **First AF-developed spacecraft designed and fully qualified for compatibility with the ESPA**
  - **First to sign ESPA ICD Mar 2004 (Atlas V LV ICD)**
- **Successfully launched on March 8, 2007 as part of STP-1**
- **The primary mission objectives of STPSat-1 are:**
  - **To provide a successful one-year duration mission in the target orbit after a one month checkout, that satisfies the two on-board experiments' nominal success criteria**
  - **To aid STP's objective of "Getting technology to space for the war fighter," and**
  - **To provide a pathfinder for future STP ESPA missions**

STPSat-1 Experiments

- Primary experiment is the Spatial Heterodyne Imager for Mesospheric Radicals (SHIMMER)
  - Built by the Naval Research Laboratory (NRL) in Washington, D.C.
  - High-resolution ultraviolet spectrometer-based Spatial Heterodyne Spectroscopy (SHS)
- Secondary experiment is the Computerized Ionospheric Tomography Receiver in Space (CITRIS)
  - Naval Research Laboratory built four frequency receiver connected to an antenna located on the top face of the STPSat-1 satellite
  - Transmissions from ground French DORIS beacons provide ground-to-satellite ionospheric data.
  - Transmissions from NRL CERTO beacons located on other space vehicles are detected by the CITRIS receiver to provide measurements of satellite-to-satellite TEC and signal fluctuations.
- Third experiment, MEPSI, demanifested in Oct 2006, but SV still carries Picosat Launcher Assembly

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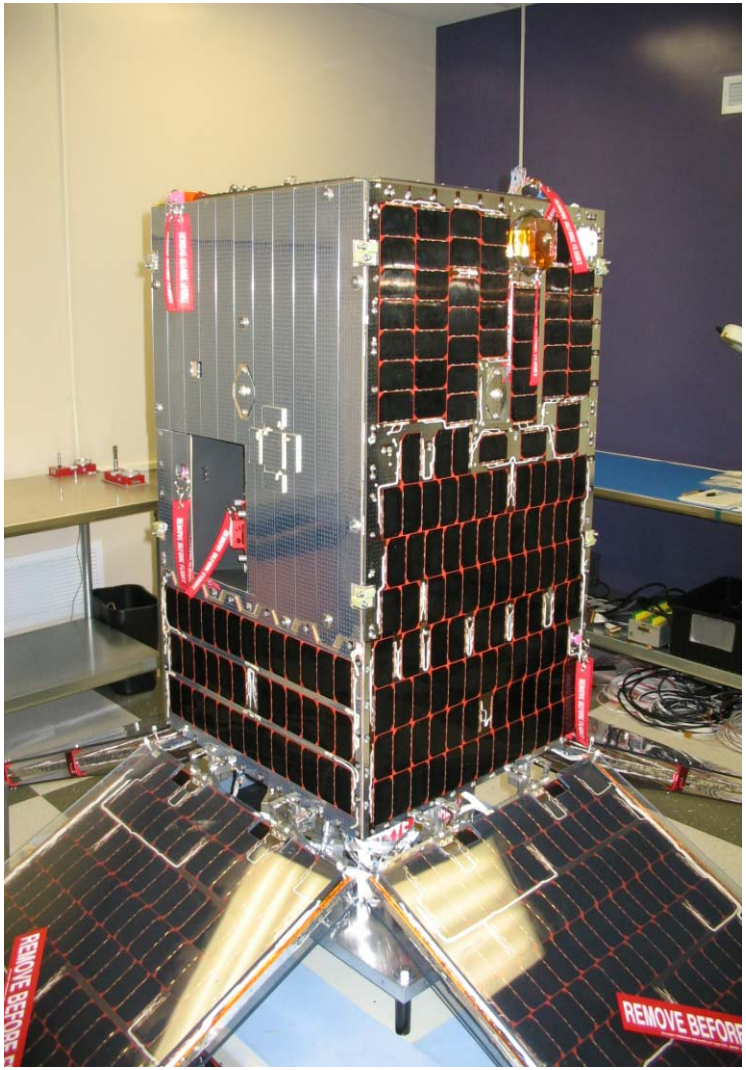
STPSat-1 Space Vehicle



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- **SV consists of spacecraft subsystems and the three payloads, SHIMMER, CITRIS, and the MEPSI PLA**
- **SV provides a stable platform for on-orbit operations of the science instruments while meeting technical and mission requirements**
  - **Mass at launch was approx. 164 kg**
  - **Size is approx. 63 cm x 63 cm x 98 cm (solar panels stowed)**
  - **Power subsystem delivers approximately 171W of average orbit power @ 28V with the solar arrays deployed**

ESPA Interface

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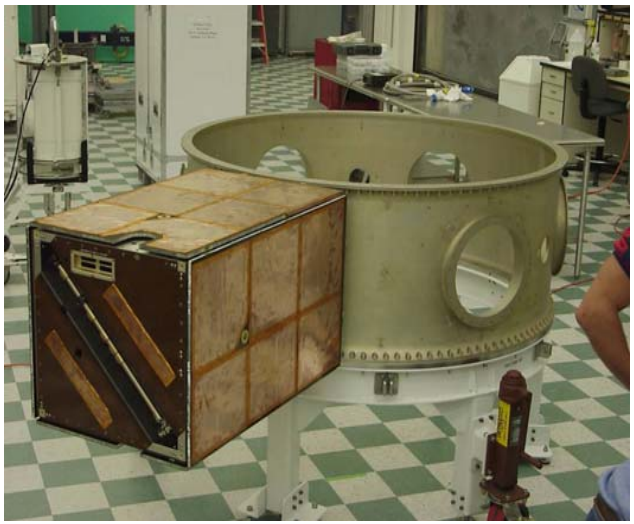
- STPSat-1 is mechanically attached to the ESPA ring using a separation system
- Separation system attaches to both STPSat-1 and the ESPA with twenty four ¼" diameter bolts in an equally spaced 15" diameter bolt pattern

- Challenges for access to the separation system when STPSat-1 was mounted to the ESPA
  - To mitigate this, fit check and integration performed in Aug 2003 with STPSat-1 EDU structure



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ESPA Mechanical Environment

- ESPA ring not well characterized in terms of launch loads transferred to the ESPA satellite payload
- Change in the LVs from Delta to Atlas in July 2003 meant the previous Coupled Loads Analysis (CLA) used for the EDU structure testing had to be redone
  - New CLA not completed until after the flight structure was already built, and shortly before the start of its random vibration testing
  - Path forward was to increase test levels for the vehicle by using guidelines in Mil-Hdbk-340A for unit qualification testing to provide some test margin, and testing the flight structure to Proto-Qualification (PQ) levels

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Secondary Payload Deployment Issues

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STP-1 Integrated Payload Stack (IPS)

- **STPSat-1 was one of five spacecraft to be deployed via the ESPA ring on the STP-1 mission**
- **Complex STP-1 secondary payload deployment sequence was found to present challenges due to a number of factors**
  - **Separation time constraints**
    - **Mitigated by slow roll, time constants**
  - **Possible pyroshock event from separation of the primary payload (Orbital Express) before the ESPA payloads**
    - **Analysis performed to identify shock to sensitive components**
  - **Possible interference with the launch vehicle's transponder**
    - **Implemented delay before SV boot-up**

Launch Range Safety Considerations

- STP-1 was launched from Cape Canaveral Air Station (Complex 41)
  - Required compliance to EWR 127-1
- Areas of scrutiny included unintentional deployments while integrated with the LV, and unintended power-up of the satellite resulting in RF transmissions
  - 2 inhibits present to prevent deployments, and 2 inhibits to prevent RF transmissions at all times when Safe Plugs were not in use
- Area of concern from Range Safety was use of Li-Ion batteries
  - Joint Policy Letter issued late in program with extensive monitoring and safety requirements
  - Battery charging and discharging, connection and disconnection, transport, storage, etc.

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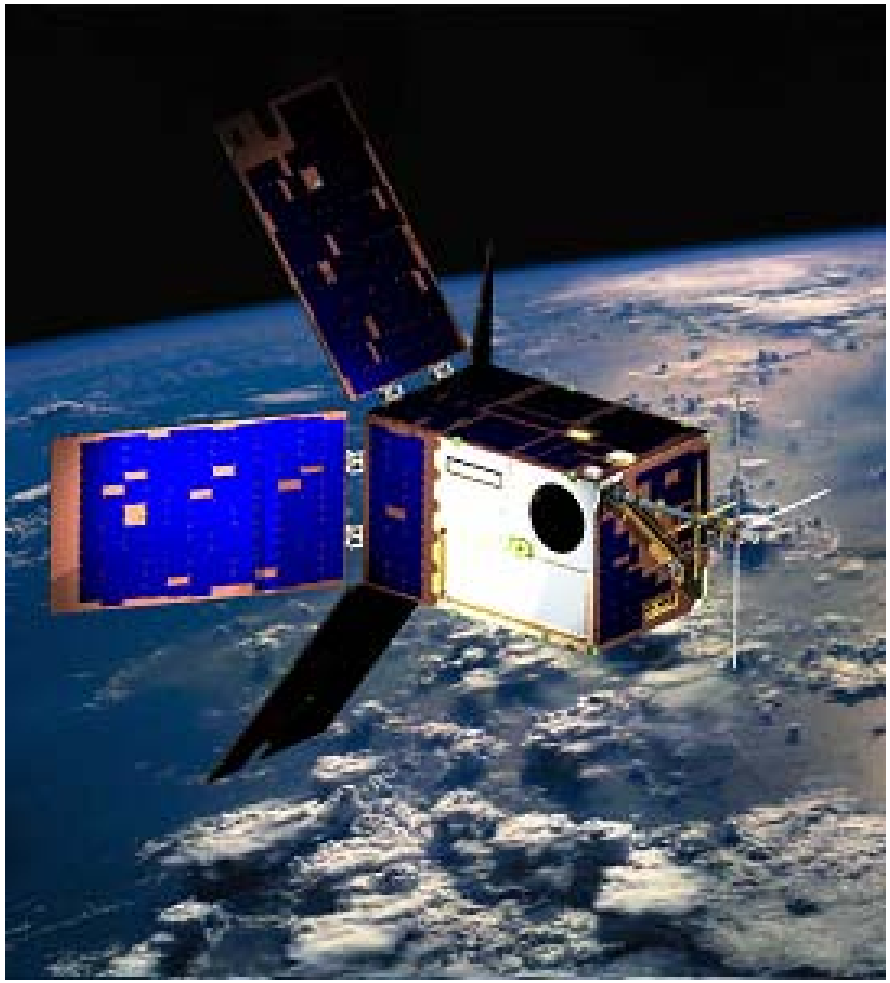
Conclusion



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- **STPSat-1 was successfully launched on March 8, 2007 with the other STP-1 payloads, with no negative effects due to the use of the ESPA payload accommodation**
- **The spacecraft is fully-functional on-orbit, providing NRL SHIMMER and NRL CITRIS experimenters with data as part of its one-year mission**
- **Many of the ESPA and launch site related issues faced by STPSat-1 are likely to be faced by subsequent ESPA missions**

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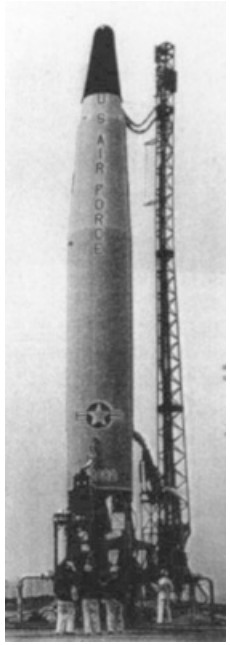
STP Conference and 40th Anniversary



- P 67-1
- 29 June 1967

- The Space Test Program will host the DoD Space Experiment Review Board and an STP Conference at Kirtland Air Force Base 5-9 Nov 2007
- Contact Capt Andre Huscko for details:

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- STP-1
- 8 March 2007

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