AFRL

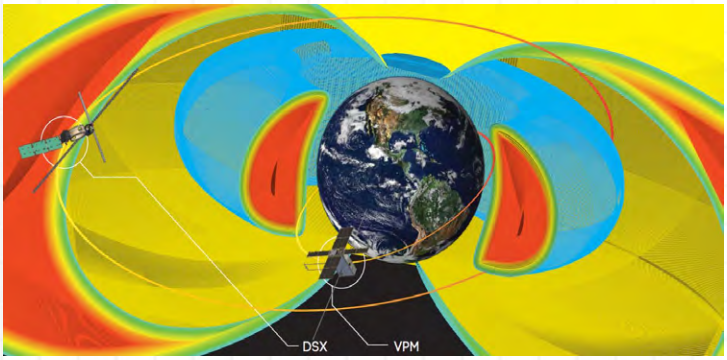
VERY LOW FREQUENCY (VLF) PROPAGATION MAPPER (VPM)

Mission Overview

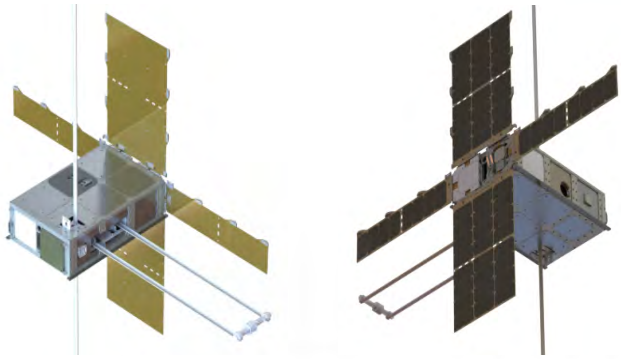
VPM is an Air Force Research Laboratory Space Vehicles Directorate nanosatellite program. The six cubic unit (6U) nanosatellite is designed to augment the AFRL's Demonstration and Science Experiments (DSX) satellite launched in June 2019. DSX is a larger (approx.1,100 lbs) mission to study the magnetosphere from an elliptical 6,000 km x 12,000 km altitude medium-earth orbit (MEO). The DSX payload includes the Wave Particle Interaction Experiment (WPIx) designed to study particle interactions with VLF waves transmitted into the complex plasmas trapped in Earth's magnetosphere.

To complement DSX, VPM will fly lower in a circular low-earth orbit (LEO) at approx. ~500 km altitude to measure the presence and intensity of VLF transmissions from DSX. When DSX and VPM are in the same magnetic field, there is a possibility to gather in-situ science data where VPM will serve as a receiver of DSX's transmitter.

Data received from VPM will be analyzed with the information from the DSX WPIx equipment to obtain an unprecedented, simultaneous evaluation of two points in the inner magnetosphere. This type of constellation introduces a low-cost, versatile analysis of the dynamic space environment and demonstrates the SmallSat architecture as a highly capable experiment platform to enhance existing missions.



VPM's orbit with respect to DSX's orbit. The rings are the various L-shells comprising the Earth's magnetic fields within the magnetosphere. Photo credit: AFRL



VPM Design Pictures: spacecraft rear (left), spacecraft front (right). Photo credit: AFRL

PAYLOAD INSTRUMENT SUITE

Search Coil Boom Assembly (SCBA)

- Deployable sensor measuring the local magnetic field part of VLF waves from 0.3-30 kilohertz.

VLF Dipole Antenna Array (DAA)

- Deployable antenna oriented perpendicular to the SCBA axis measuring the electric field part of VLF waves from 0.3-30 kHz.

Payload Electronics Module (PEM)

- The VLF payload suite providing payload control, power, antenna deployment, and data processing. The heart of the PEM is the VLF Micro Broad Band Receiver (µBBR), which processes DAA and SCBA data on-board and creates data files for transmission to the ground. Stanford University initially developed the data unit.

Test and Evaluation

- VPM will evaluate commercially available assets, such as commoditized spacecraft buses and subsystems, attitude determination control systems (ADCS), and global command, control, and communication (C3) networks

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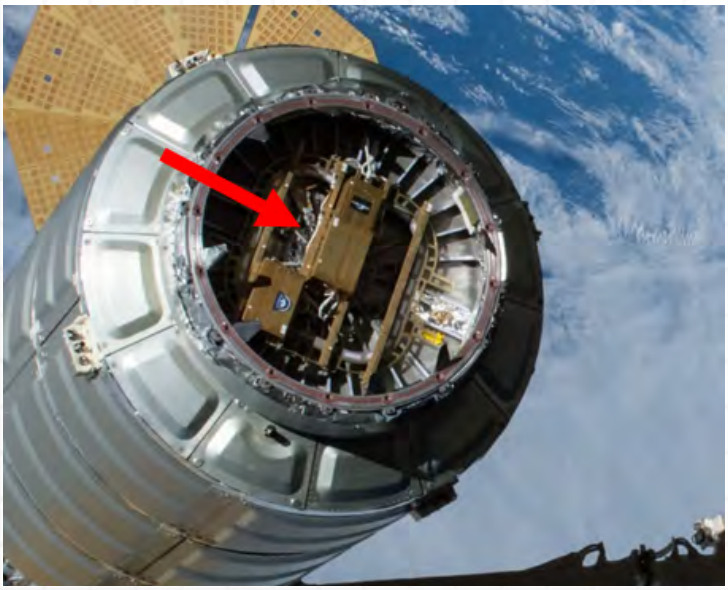
VPM Launch and Operations

VPM launched in December 2019 on board a SpaceX Falcon 9 within a Dragon capsule for the SPX-19 ISS resupply mission. VPM will be offloaded on the ISS and installed on the Cygnus resupply spacecraft (NG-12 resupply mission). NG-12 is scheduled to depart from the ISS in January 2020, where it will boost from the ISS and eject VPM via the SEOPS Slingshot CubeSat deployer.

Upon ejection, VPM will initialize, deploy solar panels, deploy the DAA and SCBA, and perform checkouts in preparation for VLF payload calibration and the ultimate establishment of full mission capability for the approximately yearlong mission.



SEOPS Slingshot CubeSat deployer on the Northrop Grumman Cygnus resupply capsule. Photo credit: NASA/SEOPS.

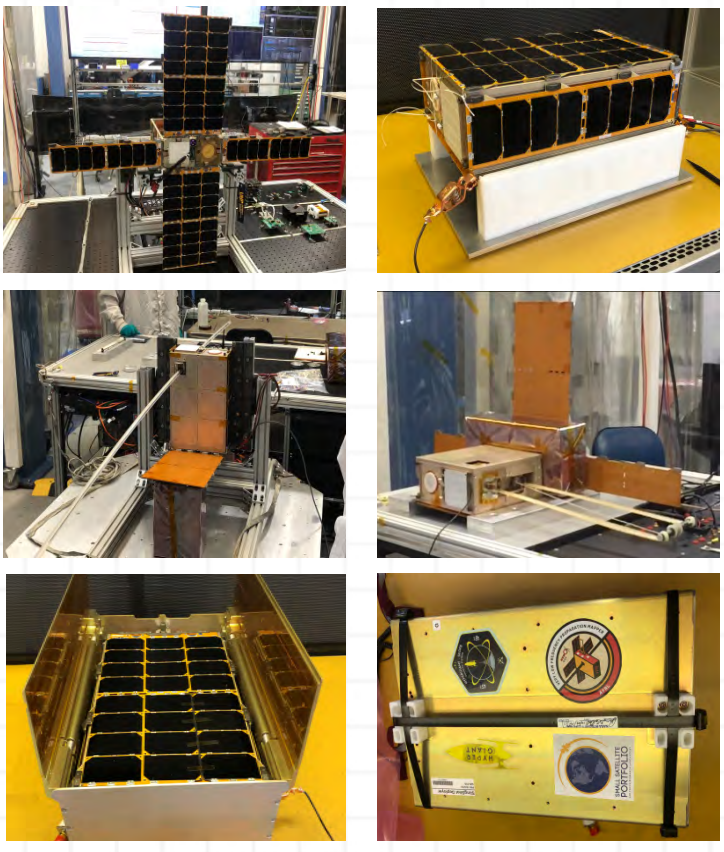
Evaluating Commercially Available Resources

The VPM spacecraft is evaluating commercially available products such as the Pumpkin 6U spacecraft structure and Pumpkin batteries and solar panels. VPM will also evaluate the capabilities of the Clydespace Electrical Power System, the utility of the Beaglebone Black as a flight computer, a Blue Canyon Technologies XACT ADCS, Globalstar Simplex Transmitter Unit-3 beacon, and a Vulcan Wireless software-defined radio transponder.

In addition, VPM will evaluate data uplink/downlink capabilities of the Kongsberg Satellite Services Lite C3 network.

KSAT Network Ground Sites. Photo credit: KSAT

Additional Media



Top Row: VPM Integration (left), VPM Closed Up (right). Mid Row: DAA deployment (left), SCBA deployment (right). Bottom Row: VPM integration in SEOPS Slingshot (left), VPM stowed in SEOPS Slingshot (right). Photo credit: AFRL