Space Vehicles Directorate

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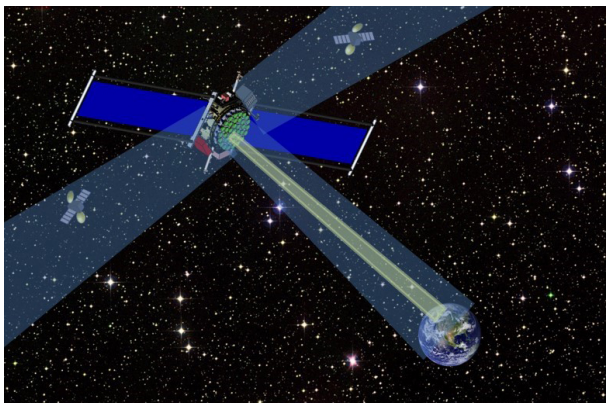
AFRL
THE AIR FORCE RESEARCH LABORATORY

Air Force Research Laboratory Space Vehicles Directorate Navigation Technology Satellite-3 (NTS-3)

Purpose:
Positioning, Navigation, and Timing (PNT) is a key mission area for the Air Force Research Laboratory, Space Vehicles Directorate (AFRL/RV) at Kirtland AFB, NM. The Global Positioning System (GPS) today provides continuous, highly accurate PNT data to civilian and military users. However, the increasingly contested space domain requires advancement in PNT capabilities in order to assure continued reliable access for users. The Navigation Technology Satellite-3 program (NTS-3), managed by AFRL/RV, will experiment with advanced techniques and technologies to detect and mitigate interference to these capabilities, thus increasing Satellite Navigation (SatNav) system resiliency for military, civil, and commercial users.

This is the third in a series of Department of Defense (DoD) SatNav space experiments, and the first in over 40 years. NTS-3 will integrate multiple advanced technologies, explore new concepts of operations, and experiment with novel techniques, tactics, and procedures. These include atomic clocks, antennas, reprogrammable digital waveform generators, new signals, automation, use of commercial assets, cybersecurity and software defined user equipment. Technology matured and knowledge gained from NTS-3 are expected to transition to future generations of GPS and potential augmentations to the GPS constellation.



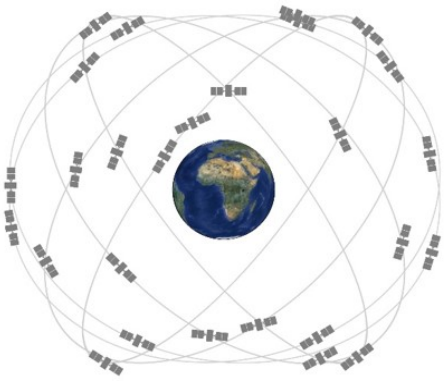
NTS-3 Space Segment artist concept depicting tailored position, navigation & timing signals available to both terrestrial and space users

Features:
NTS-3 will develop and demonstrate technologies to increase the resiliency of all segments of the SatNav architecture: space, ground control, and user equipment. As a unique testbed in Medium Earth Orbit that resides outside of the GPS constellation, NTS-3 will enable experimentation across the spectrum of users to include DoD, civil, academic, and commercial.

Space Segment:
NTS-3 will experiment with technologies to enable broadcast of an increased number of signals, improve performance by avoiding and defeating inference while maintaining signal accuracy, and counter-spoofing. AFRL will explore high gain antenna configurations to provide earth coverage and regional spot beams in multiple frequencies and signal codes. These advanced antenna options seek to improve signal availability and strength for both terrestrial and space

users. Advanced amplifiers and on-orbit reprogrammable digital waveform generators with a reduced size and weight will improve efficiency, signal flexibility, and signal strength. Other experiments emphasize maintaining signal accuracy after loss of contact with the ground control segment, and improving on-board signal integrity detection and user noti-fication. Also, NTS-3 will demonstrate advanced clock and ephemeris correction technologies. These experiments will improve both short- and long-term frequency stability. On-board high sensitivity accelerometers will monitor orbit parameters to minimize navigation solution errors in the transmitted navigation message. Finally, NTS-3 will measure the space and spacecraft environmental effects on next generation technologies.

Ground Control Segment:
The NTS-3 ground segment will demonstrate near-real time user environment sensing and control segment generation of error correction and tailored waveforms. Furthermore, the NTS-3 ground segment will experiment with automated ("lights-out") operations and demonstrate spacecraft command and control through commercial ground antennas. These advanced ground control capabilities will be compatible with the Multi-Mission Space Operations Center (MMSOC)to utilize the net-centric capabilities of these next generation Air Force ground systems.

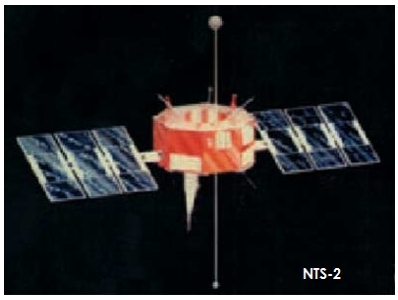


Global Positioning System Constellation artist image. Satellites in the GPS constellation are arranged into six equally-spaced orbital planes surrounding the Earth

User Equipment & Signals:
GPS modernization to date has focused extensively on new signals for both military and civilian users. NTS-3 seeks to broadly experiment and further improve signal performance in such areas as authentication, security, multipath, interference, and signal combining efficiencies. Combining software defined receivers with the NTS-3 on-orbit reprogrammable waveform generator will provide flexible, agile user equipment positioned for future upgrades.

Cybersecurity:
NTS-3 will investigate assured-by-design technologies to enhance mission resiliency in a cyber-contested environment, as well as modern processes to manage cyber risks.

Background:
NTS-1 was developed by the Naval Research Laboratory (NRL) and launched in 1974 as part of the newly formed joint NAVSTAR GPS program. NTS-1 had two rubidium-vapor frequency standards that advanced the timing and navigation precision demonstrated by the earlier TIMATION (TIMe/navigATION) satellites using crystal oscillator clocks. NTS-2 was launched in 1977 as the first NAVSTAR GPS Phase I satellite. NTS-2 featured cesium frequency standards, a nickel-hydrogen battery, 3-axis gravity-gradient stabilization with momentum-wheels for control of the spacecraft orbit, laser retroreflectors, solar-cell experiments, radiation dosimeters, and a worldwide network for data acquisition. NTS-2 verified Einstein's relativistic clock shift theory.



NTS-3 was selected as Space Vehicle Directorate's next major integrated space experiment in 2015. NTS-3 is currently in the program definition phase with a prime contract award anticipated in the summer/fall of 2017. Launch of NTS-3 is currently projected for 2022 with a 1 year on-orbit experiment planned. Launch integration and flight operations are planned to be performed in partnership with the DoD Space Test Program (STP).

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