

65 years in space

A TIMELINE

The Naval Research Laboratory entered the realm of space soon after American forces entered Germany in 1945 and captured the huge underground factory for V-2 rocket production at Nordhausen. The Americans confiscated about one hundred rockets and shipped them to the White Sands Missile Range in New Mexico, where the Army set about studying the propulsion system. The first American-launched V-2 flew from White Sands on April 16, 1946.

Seeing the opportunities for upper atmosphere research and solar astronomy, NRL took the lead in the Navy for conducting rocket research. The V-2 Rocket Panel was formed with membership from NRL, APL (Applied Physics Laboratory), California Institute of Technology, Harvard University, University of Michigan, and other organizations to oversee the allocation of space on V-2 rockets for high-altitude research, with NRL's Ernst Krause as the first chair. The research goals included radio and sound propagation in the atmosphere, properties of the atmosphere, cosmic rays, solar ultraviolet radiation, and various biological investigations.

NRL's V-2 experiments in 1946 and 1949 marked the beginning of a major space science program at the Lab.

Within a decade, NRL had developed a base of rocket science that had formed into two distinct branches: one related to applications, including the development of scientific payloads; the other, the development of rocket technology.

This timeline highlights some milestones in NRL's space program as it developed from those post-World War II years to the present, when NRL is about to launch its 100th satellite and is the Navy's lead laboratory for space systems research.

1946 NRL IN SPACE



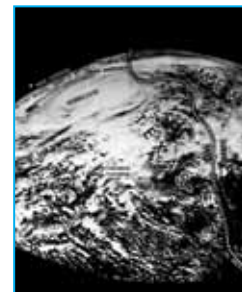
Richard Tousey's first V-2 rocket flight measured solar ultraviolet radiation.



1949 Herbert Friedman's first V-2 rocket flight measured solar X-radiation. Friedman later made the first positive identification of stellar X-rays in 1963.



1949 First flight of NRL's Viking rocket, designed to replace the V-2 for scientific missions that required higher altitudes and pointing stability.



1954 NRL's photograph of a hurricane from an Aerobee rocket was the first time a major weather feature was seen from space and a convincing argu-

TIMELINE NRL IN SPACE



ment that space cloud imagery could be a valuable tool for meteorologists.

1958 Vanguard I, the oldest man-made satellite in orbit, launched on St. Patrick's Day.

NRL conducted Project Vanguard for the International Geophysical Year of 1957–1958. NRL designed and



developed the three-stage rocket, the grapefruit-sized satellite, and the Mini-track network that tracked the satellite using radio interferometry. The Vanguard team was transferred in October 1958 to the new National Aeronautics and Space Administration (NASA).

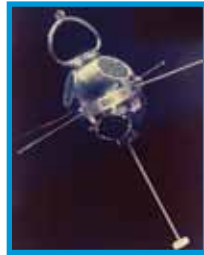
1958–1964 Extending the Mini-track concept, NRL developed the Naval Space Surveillance System (NAVSPASUR).

1960 Launch of GRAB, the first U.S. "spy" satellite, along with SolRad which monitored solar X-radiation.

The month after a U-2 aircraft was lost on a reconnaissance mission over Soviet territory, GRAB I was launched and began transponding intercepted electronic intelligence signals to ground stations. GRAB demonstrated the value and viability of space-based intelligence platforms.



The SolRad series of satellites studied the Sun's effects on Earth on missions from 1960 to 1979.



1961 First launch of the Low Frequency Trans-Ionospheric (LOFTI) radio satellite to study the propagation of radio waves through the ionosphere.

1965 Launch of OSO-2, first in a series of Orbiting Solar Observatory missions for which NRL developed solar physics instrumentation.

1967 Launch of the first of four Timation (time and navigation) satellites, which demonstrated NRL's new navigation concept that became GPS.



Followed by Timation II (1969), Timation IIIA/Navigation Technology Satellite (NTS)-1 (1974), and Timation IV/NTS-2 (1977).

1971 First observation of a coronal mass ejection (CME) from space, by an NRL coronagraph on board OSO-7.

1972 NRL's Lunar Surface Camera operated on the Moon during the Apollo 16 mission, obtaining images of the Earth and celestial objects.

1973 NRL solar spectrometers operated on Skylab, America's first space station.

1976 First launch of the Multiple Satellite Dispenser (MSD), an upper stage for the Atlas F booster, which carried multiple satellites into precise orbits.

1979 Launch of the SolWind Coronagraph on a DoD satellite to monitor the solar corona and catalog CMEs. First observation of a CME headed toward Earth, a so-called halo CME.

1982

The first of five Space Shuttle flights of NRL's Solar Ultraviolet Spectral Irradiance



Monitor (SUSIM) which measured absolute solar UV irradiance and examined the impact of solar variability on the Earth's ionosphere and climate. SUSIM also flew on the Upper Atmosphere Research Satellite (UARS) (1991–2005) and produced the longest continuous absolute measurement of solar UV irradiance to date.

1983 Launch of Living Plume Shield II (LIPS II) to demonstrate direct downlink of tactical data from a low Earth orbiting spacecraft.

1985 NRL scientist Dr. John David Bartoe flew on the Space Shuttle as payload specialist for NRL's High Resolution Telescope and Spectrograph that recorded UV spectra of the Sun.

1987 The first Special Sensor Microwave Imager (SSM/I) was flown in DoD's Defense Meteorological Satellite Program (DMSP) to map water vapor and ocean wind speed. NRL pioneered this technique.

1987 Launch of LIPS III provided a test bed for new space power sources.

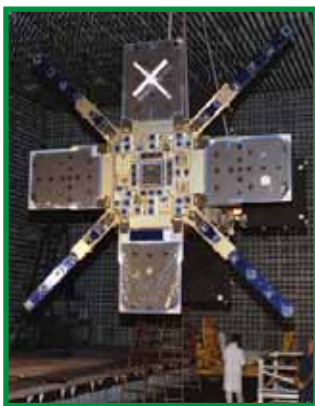


1990 NASA's Compton Gamma Ray Observatory containing NRL's Oriented Scintillation Spectrometer Experiment

(OSSE) was put in orbit from the Space Shuttle. It operated for 10 years.

1990

Launch of the Low-Power Atmospheric Compensation Experiment (LACE), a spaceborne target with sensors to characterize a laser beam emitted from a ground-based laser site.



1991 Launch of the Japanese Yohkoh solar observatory with NRL instrumentation on board to measure high-energy solar phenomena. Yohkoh provided the first definitive observations connecting solar flares to the breaking and reconnection of magnetic fields.

1993 NRL's Polar Ozone and Aerosol Measurement (POAM) instrument was launched on the French Space Agency SPOT remote sensing satellite.

1994 First flight of NRL's Middle Atmosphere High Resolution Spectrometer Instrument (MAHRSI) on the German Space Agency's Shuttle Pallet Atmosphere Satellite (SPAS) to make global measurements of OH in the mesosphere and upper stratosphere.

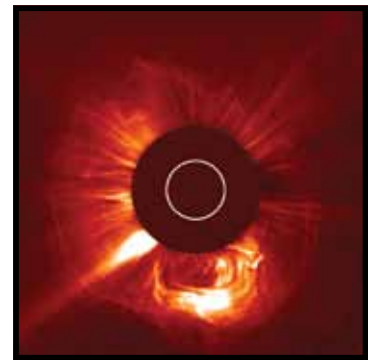


1994 The DoD-NASA Clementine satellite, developed by NRL under the mantra of "faster, better, cheaper," was launched to test lightweight miniature sensors and advanced spacecraft components, and to map the entire lunar surface.



1995 NRL's Large Angle and Spectrometric Coronagraph (LASCO) and Extreme Ultraviolet Imaging Telescope (EIT) launched on the ESA/NASA Solar

and Heliospheric Observatory (SOHO). These instruments help to understand the mechanisms that form CMEs



and drive the solar wind, providing a genuine basis for predicting geomagnetic storms on Earth.

1999 The ARGOS satellite contained five NRL instruments to measure the upper atmosphere, conduct astronomy experiments, and test new technology.

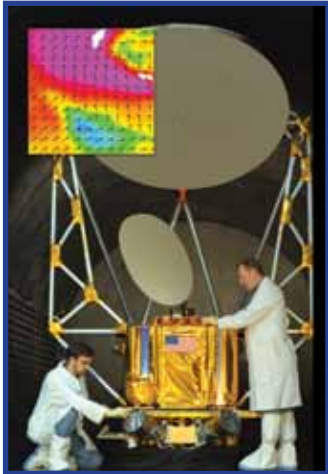
1999 First launch in Project Starshine, a science education project for measuring variations in the density of Earth's



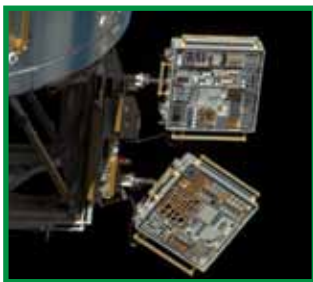
upper atmosphere during solar storms. Students from all over the world helped to build the satellites and collected data from them.

2003 The first in a series of NRL's Special Sensor Ultraviolet Limb Imagers (SSULI) flew on a DMSP satellite, providing operational environmental data for the warfighter.

2003 WindSat, the first space-borne polarimetric microwave radiometer, launched on the NOAA/DoD/NASA Coriolis spacecraft to measure wind speed and direction at the ocean surface.



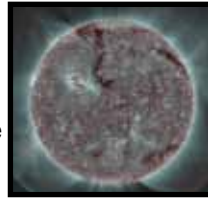
2005 MISSE-5 launched to the International Space Station. The suitcase-sized experiment exposed hundreds of samples of materials and components to the harsh space environment for later analysis of the effects. Followed by MISSE-6 (2008), MISSE-7 (2009) and MISSE-8 (2011).



2006 Launch of TacSat-2, part of the Operationally Responsive Space initiative to bring tactical capability to the warfighter rapidly, without the decade of development normally associated with operational military satellites.

2006 Launch of NASA's STEREO (Solar TERrestrial RELations Observatory). NRL's SECCHI telescopes provide 3-D observations of CMEs

as they form at the Sun and traverse interplanetary space to Earth.

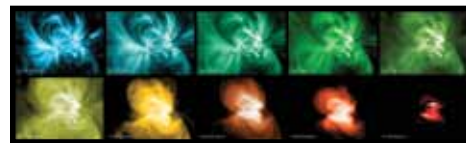


2006 Atmospheric Neutral Density Experiment (ANDE) microsattellites deployed to monitor atmospheric density for improved orbit determination of space objects. ANDE-2 was launched in 2009.

2006 Launch of the Taiwan-U.S. COSMIC/FORMOSAT3 mission with NRL's Tiny Ionospheric Photometer (TIP) compact far-UV sensors on board to study Earth's night-side ionosphere.

2006 Launch of the Microsatellite Technology Experiment (MiTeX), with NRL's Upper Stage, to test and evaluate small satellite technologies.

2006 Launch of the Japanese Hinode solar observatory with NRL's Extreme-ultraviolet Imaging Spectrometer (EIS) to measure temperature, density, and dynamics of the solar corona.



2007 Launch of STPSat-1 carrying SHIMMER and CITRUS. SHIMMER measured OH in the middle atmosphere, and demonstrated spatial heterodyne spectroscopy for space-based remote sensing. CITRIS detected when and where scintillation and refraction adversely affect radio propagation, and provided global maps of ionospheric densities.



2008 Launch of the ESA Herschel Space Observatory that measures

terahertz radiation from astronomical and planetary objects. NRL contributed to the optical system of the 3.5-meter-diameter silicon carbide Cassegrain telescope.

2008 Launch of the Fermi Gamma-ray Space Telescope to survey the high-energy space



environment. NRL led the team that designed and manufac-

tured the Large Area Telescope (LAT) calorimeter, which measures the energies of gamma rays from astronomical objects and the Sun.

2009 HICO/RAIDS launched to the International Space Station. The Hyperspectral Imager for the Coastal Ocean and Remote Atmospheric and Ionospheric Detection System collect useful environmental data for military and civilian systems.



2011 Scheduled launch of TacSat-4 with its COMMx payload to support



communications-on-the-move, data exfiltration, and Blue Force Tracking. It is designed to be reallocated rapidly to different theaters worldwide. ♦