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Detection of Nuclear Explosions from Satellites and Space Physics Research

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INTRODUCTION

For many years the Los Alamos Scientific Laboratory (LASL) has participated in a continuing interagency program for development, implementation, operation, and improvement of a US satellite system for worldwide surveillance of nuclear explosions in and above the atmosphere and in outer space—regions where the Limited Test Ban Treaty forbids nuclear testing. (Underwater testing is also forbidden.) Our contribution includes conception, design, and development of satellite-borne nuclear explosion detector instrumentation, participation in ground testing and field operations, evaluation of in-orbit performance, and finally, participation in the interpretation and use of the data acquired by the instruments. Our activity also includes research in other related areas, especially space physics and technology.

Detector instrumentation developed and provided by LASL is carried on Earth-orbiting Air Force satellites, which transmit the data to Air Force ground stations where it is processed by computer and then relayed to various users.

The concept of satellite-borne nuclear surveillance came about during interagency discussions from 1959 to 1962 and was called the Vela Hotel Program. Because of LASL's knowledge of nuclear explosion characteristics, including output radiations and our capability to detect and measure these radiations, it was agreed that LASL would design and develop the detector instrumentation for the satellites. The instruments were designed to observe the x rays, gamma rays, and neutrons from a nuclear explosion. Sandia Laboratories, Albuquerque (SLA), were responsible for the closely associated electronic logic circuitry. Later in the program, SLA also designed and provided additional nuclear explosion detectors. The Advanced Research Projects Agency (ARPA) had overall management responsibility; the Air Force Space and Missile Systems Organization (SAMSO) contracted to industry for development and launch of the satellites and coordinated program activities and schedules. The satellites were placed into Earth-bound orbits at an altitude of about 18 Earth radii, about 70,000 miles (112,000 km)—far enough out so that one satellite could view nearly half the Earth's surface and most of outer space; only the small fraction of space obstructed by the distant Earth as seen by the satellite was hidden from view.

Figure 1 shows an artist's concept of the ascent of the satellites into orbit.

Six pairs of Vela satellites were put into far-Earth orbits by six rocket launches between 1963 and 1970. Successive launches carried improved instrumentation for nuclear explosions surveillance. They also had progressively better instruments for investigating natural background radiations that sometimes interfere with the operation of the "bomb detectors" or with the interpretation of their data. These natural radiations in outer space include Van Allen belt protons and electrons, solar wind, and solar and cosmic charged particles, gamma rays, and x rays.

The four newest Vela satellites are still functional (August 1977) after more than seven years in orbit. But after this long lifetime some of the instruments are degraded, and the nuclear surveillance missions of the Vela Satellite Program are being incorporated into another Air Force program.

OBJECTIVES

In 1963, the United States stipulated four safeguards as necessary conditions for ratification of the Limited Test Ban Treaty. LASL contributes to all of these safeguards, and the three listed below are continuing objectives of the LASL Satellite Test Detection Program.

- Effective surveillance of foreign nuclear activities and explosions. Our satellite instruments have demonstrated their capabilities by detecting many foreign nuclear explosions in the atmosphere and by their response to natural radiations. Continuing research and development will improve the instrumentation as nuclear and space technologies evolve.
- Maintenance of readiness to resume testing in regions forbidden by the Treaty. The instrumented satellites are capable of making significant and

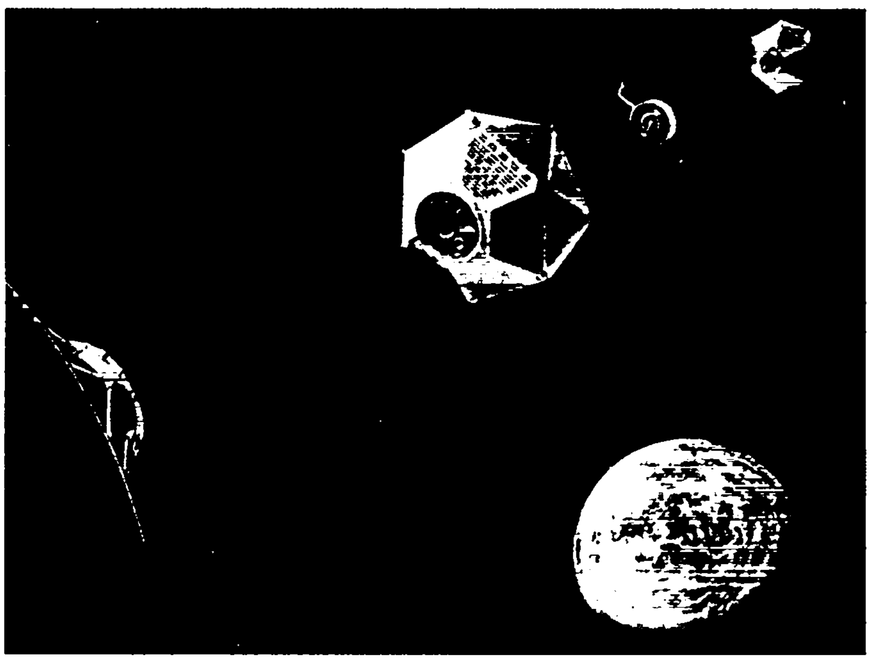

Fig. 1.
Artist's concept of two Vela satellites and a coupling device to impart spin to the satellites shortly after separation of these components from the rocket booster. At this point, the satellites are about 35,000 miles (56,000 kilometers) in altitude, and they will travel independently to their final orbit altitude of about 70,000 miles (about 112,000 kilometers).

useful measurements on US nuclear tests in the atmosphere or at high altitude if such testing becomes necessary.

- Maintenance of laboratories active in nuclear research and technology and related areas. We have demonstrated our capabilities for observation of nuclear tests and for investigation of the natural space radiation environment. In connection with these studies, we have published about 400 articles in scientific journals.

Additional objectives, recognized and achieved after the initial successful launches, are

- Support of the NASA manned spaceflights by continuous surveillance of solar flare radiation hazards to the astronauts.
- Support of the Air Force Air Weather Service requirement to provide "space weather" data and forecasts to Air Force users.

TECHNOLOGIES DEVELOPED AT LASL

LASL's technological strengths for support of the Satellite Test Detection Program include

1. Understanding of the origin, propagation, and behavior of nuclear and electromagnetic radiations emitted by nuclear explosions and existing naturally at high altitude and in space.
2. Technologies for detecting and measuring these radiations with space-borne electromechanical instruments; minimum instrument weight, power, and volume, and maximum life and reliability are of prime importance.
3. Electronic analog and logic technologies for efficient conversion of detector signals to forms suitable for transmission from a satellite to ground receiving stations.
4. The discipline of space science in general, where there is much information on many types of fluctuating space radiations.
5. Mathematical methods, including computer technologies, for analysis and physical interpretation of the large quantities of data acquired by rocket- and satellite-borne instruments.

LASL facilities that contribute to the success of our efforts in the program are the well-equipped Shops Department, the special fabrication and environmental test facilities, accelerators and radiation-producing equipment for test and calibration, and the Central Computing Facility.

SOLAR-TERRESTRIAL RELATIONS AND ASTROPHYSICS

Because we need to understand the space radiation environment, the program has led naturally into the fields of solar-terrestrial relations and astrophysics, as shown in Fig. 2. Our research in these fields has concentrated on interplanetary plasma (solar wind), dynamic processes in the Earth's magnetosphere, solar flare radiations, x-ray astronomy, and gamma-ray astronomy. Our discovery by use of the Vela satellites of cosmic gamma-ray bursts, an unexpected phenomenon in gamma-ray astronomy, is reported by The Astrophysical Journal as one of seven major astronomical discoveries of the 20th century.

CONCLUSIONS

The Satellite Test Detection Program, conceived in the first few years of the space age, has achieved its missions and has had important basic research spin-off. The direct benefits include contributions to efforts to limit the arms race and provision for reliable safeguards, to national defense, to NASA manned spaceflights, and to the Air Weather Service forecasting program. The indirect benefits have been unique contributions to space research. Continuation of the program supports treaty negotiations, national security, and both applied and basic research.

ABOUT THE AUTHOR

J. P. Conner is Group Leader of the High Altitude Physics Group at LASL. He received a Ph.D. in nuclear physics from Rice University in 1952. From 1952 to 1959 he was a LASL Staff Member conducting research in low-energy nuclear physics, specifically, interactions among light nuclei and interactions of neutrons with nuclei. In 1959, he became a member of the High Altitude Physics Group, newly formed for the development of nuclear explosions surveillance from satellites and for space science research. He was responsible for the development of several instrumentation systems for the detection of nuclear explosions from satellites and for the study of solar and cosmic x rays.

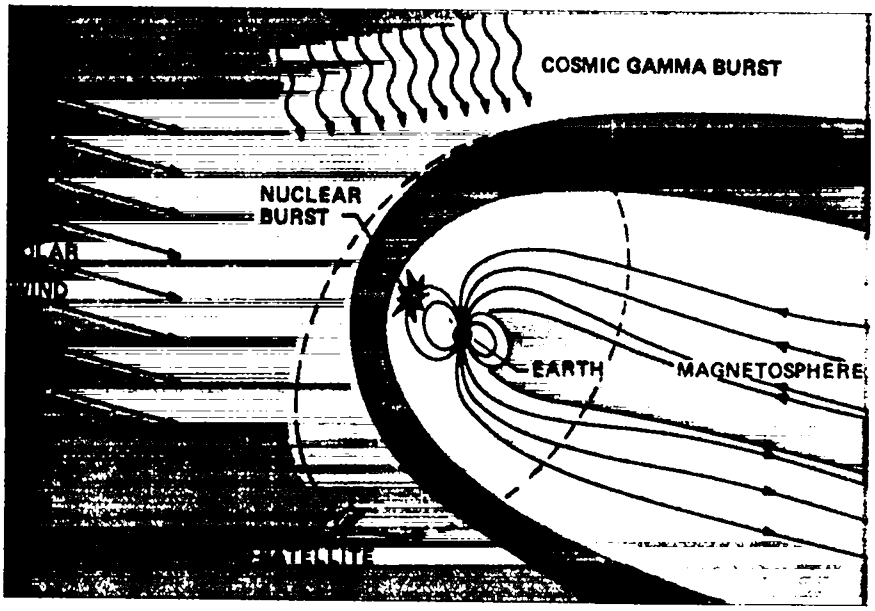

Fig. 2.
Radiation environment in which Nuclear Test Detection Satellites operate. Both interplanetary and enhanced radiation regions in the Earth's magnetic field are traversed by the Vela satellites.

Mini-Review readers are encouraged to correspond directly with the author.

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