High-altitude nuclear explosion

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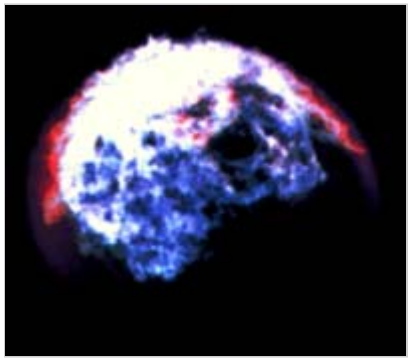
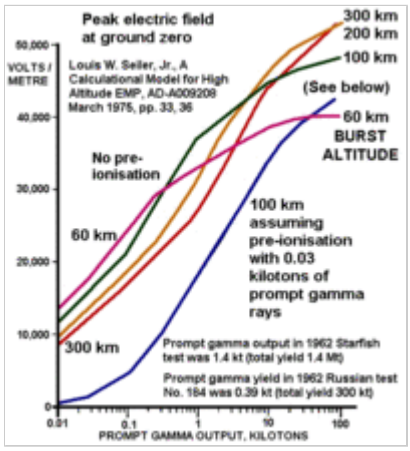
High-altitude nuclear explosions (**HANE**) have historically been nuclear explosions which take place above altitudes of 50 km, still inside the Earth's atmosphere. Such explosions have been tests of nuclear weapons, used to determine the effects of the blast and radiation in the exoatmospheric environment. The highest was at an altitude of 540 km (335.5 mi).



Bluegill Triple Prime shot, 1962, altitude 50 km (31 mi)

The only nations to detonate nuclear weapons in outer space are the United States and the Soviet Union. The U.S. program began in 1958, with the *Teak* and *Orange* shots, both 3.8 megatons. These warheads were initially carried on Redstone rockets. Later tests were delivered by Thor missiles for Operation Dominic I tests, and modified Lockheed X-17 missiles for the Argus tests. The purpose of the shots was to determine both feasibility of nuclear weapons as an anti-ballistic missile defense, as well as a means to defeat satellites and manned orbiting vehicles in space. High-altitude nuclear blasts produce significantly different effects. In the lower reaches of vacuous space, the resulting reaction grows much larger and faster than it does near the ground, and the radiation it emits travels much farther.



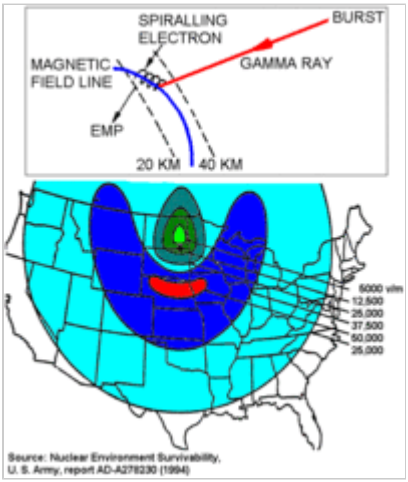
How the peak EMP on the ground varies with the weapon yield and burst altitude. Note that the yield here is the prompt gamma ray output measured in kilotons. This varies from 0.1-0.5% of the total weapon yield, depending on weapon design. The 1.4 Mt total yield 1962 Starfish test had an output of 0.1%, hence 1.4 kt of prompt gamma rays. (The **blue** 'pre-ionisation' curve applies where gamma and x-rays from the weapon's primary stage ionise the atmosphere, making it electrically conductive before the main pulse from the thermonuclear stage. The pre-ionisation can literally short out part of the final EMP.)

Contents

EMP generation

The strong electromagnetic pulse (EMP) that results has several components. In the first few tens of nanoseconds, about a tenth of a percent of the weapon yield appears as powerful gamma rays with energies of one to three mega-electron volts (MeV, a unit of energy). The gamma rays rain down into the atmosphere and collide with air molecules, depositing their energy to produce huge quantities of positive ions and recoil electrons (also known as Compton electrons). The impacts create MeV-energy Compton electrons that then accelerate and spiral along the Earth's magnetic field lines. The resulting transient electric fields and currents that arise generate electromagnetic emissions in the radio frequency range of 15 to 250 megahertz (MHz, or one million cycles per

second). This high-altitude EMP occurs between 30 and 50 kilometers above the Earth's surface. The potential as an anti-satellite weapon became apparent in August 1958 during *Hardtack Teak*. The EMP observed at the Apia Observatory at Samoa was four times more powerful than any created by solar storms, while in July 1962 the *Starfish Prime* test damaged electronics in Honolulu and New Zealand (approximately 1,300 kilometers away), fused 300 street lights on Oahu (Hawaii), set off about 100 burglar alarms, and caused the failure of a microwave repeating station on Kauai, which cut off the sturdy telephone system from the other Hawaiian islands [1]. The radius for an effective satellite kill for the various prompt radiations produced by such a nuclear weapon in space was determined to be roughly 80 km. Further testing to this end was carried out, and embodied in a Department of Defense program, *Program 437*.



The mechanism for a 400 km high-altitude burst EMP: gamma rays hit the atmosphere between 20-40 km altitude, ejecting electrons which are then deflected sideways by the Earth's magnetic field.

Drawbacks

There are problems with nuclear weapons carried over to testing and deployment scenarios, however. Because of the very large radius associated with nuclear events, it was nearly impossible to prevent indiscriminate damage to other satellites, including one's own satellites. *Starfish Prime* produced an artificial radiation belt in space which soon destroyed three satellites (Ariel, TRAAC, and Transit 4B all failed after traversing the radiation belt, while Cosmos V, Injun I and Telstar suffered minor degradation, due to some radiation damage to solar cells, etc. [2]). The radiation dose rate was at least 60 rads/day at four months after *Starfish* for a well-shielded satellite or manned capsule in a polar circular earth orbit [3], which caused NASA concern with regard to its manned space exploration programs.

Differences from atmospheric tests

How the area is affected depends on the burst altitude.

In general, nuclear effects in space (or very high altitudes) have a qualitatively different display. While an atmospheric nuclear explosion has a characteristic mushroom-shaped cloud, high-altitude and space explosions tend to manifest a spherical 'cloud,' reminiscent of other space-based explosions until distorted by Earth's magnetic field, and the charged particles resulting from the blast can cross hemispheres to create an auroral display which has led one filmmaker to characterize these detonations as 'the rainbow bombs'. The visual effects of a high-altitude or space-based explosion may last longer than atmospheric tests, sometimes in excess of 30 minutes. Heat from the *Bluegill Triple Prime* shot, at an altitude of 50 kilometers (31 mi), was felt by personnel on the ground at Johnston Atoll, and this test caused retina burns to two personnel at ground zero who were not wearing their safety goggles [4].

Soviet high-altitude tests

The Soviets detonated four high-altitude tests in 1961 and three in 1962. During the Cuban Missile Crisis in October 1962, both the US and the USSR detonated several high-altitude nuclear explosions as a form of saber-rattling. The Soviet tests were meant to demonstrate their anti-ballistic missile defenses

which would supposedly protect their major cities in the event of a nuclear war. The worst effects of a Russian high-altitude test occurred on 22 October 1962 (during the Cuban missile crisis), in 'Operation K' (ABM System A proof tests) when a 300-kt missile-warhead detonated near Dzhezkazgan at 290-km altitude. The EMP fused 570 km of overhead telephone line with a measured current of 2,500 A, started a fire that burned down the Karaganda power plant, and shut down 1,000-km of shallow-buried power cables between Aqmola and Almaty [5].

The Partial Test Ban Treaty was passed the following year, ending atmospheric and exoatmospheric nuclear tests. The Outer Space Treaty of 1967 banned the stationing and use of nuclear weapons in space.

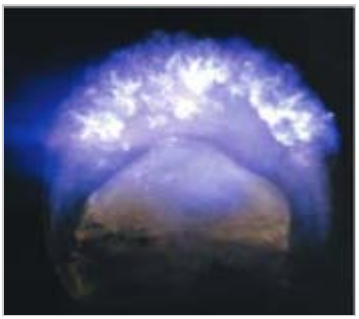
List of high-altitude nuclear explosions

USA – **Hardtack I** – Johnston Atoll, Pacific Ocean

- *Yucca* 28 April 1958, 1.7 kt, 26.2 km
- *Teak*, 1 August 1958, 3.8 Mt, 76.8 km
- *Orange*, 12 August 1958, 3.8 Mt, 43 km

USA – **Argus** – South Atlantic Ocean

- *Argus I*, 27 August 1958, 1.7 kt, 200 km
- *Argus II*, 30 August 1958, 1.7 kt, 240 km
- *Argus III*, 6 September 1958, 1.7 kt, 540 km (highest nuclear explosion)



Hardtack-Orange shot, 43 km

USSR – 1961 tests – Kapustin Yar

- Test #88, 6 September 1961, 10.5 kt, 22.7 km
- Test #115, 6 October 1961, 40 kt, 41.3 km
- Test #127, 27 October 1961, 1.2 kt, 150 km
- Test #128, 27 October 1961, 1.2. kt, 300 km

The debris fireball and aurora created by the *Starfish Prime* test, as seen from a KC-135 aircraft at 3 minutes.

USA – **Dominic I** – Johnson Atoll, Pacific Ocean

- *Bluegill*, 3 June 1962, failed
- *Bluegill Prime*, 25 July 1962, failed
- *Bluegill Double Prime*, 15 October 1962, failed
- *Bluegill Triple Prime*, 26 October 1962, 410 kt, 50 km
- *Starfish*, 20 June 1962, failed
- *Starfish Prime*, 9 July 1962, 1.4 Mt, 400 km
- *Checkmate*, 20 October 1962, 7 kt, 147 km
- *Kingfish*, 1 November 1962, 410 kt, 97 km

USSR – 1962 tests – Kapustin Yar

- Test #184, 22 October 1962, 300 kt, 290 km
- Test #187, 28 October 1962, 300 kt, 150 km
- Test #195, 1 November 1962, 300 kt, 59 km

See also

- Operation Fishbowl
- The K Project
- Operation Argus
- Outer Space Treaty
- Partial Test Ban Treaty
- Project Highwater

The *Starfish Prime* flash as seen through heavy cloud cover from Honolulu, 1,300 km away.

External links

- "High-altitude nuclear explosions"
- Peter Kuran's "Nukes in Space: The Rainbow Bombs" – documentary film from 1999
- United States high-altitude test experiences - A Review Emphasizing the Impact on the Environment
- Measured EMP waveform data and actual effects from high-altitude nuclear weapons tests by America and Russia
- American and British official analyses of photography from high-altitude nuclear explosions

US Government Films:

- Operation Argus
- Operation Dominic
- Starfish Prime
- Operation Fishbowl
- Operation Dominic - Christmas Island
- Operation Dominic - Johnston Island
- High-Altitude Effects - Phenomenology
- High-Altitude Effects - Systems Interference

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