Starfish

(How the blast of a nuclear warhead high above the earth led to
the creation of the Internet)

By
Sheldon Breiner

The following is not science fiction.

> "That test, Project Starfish Prime, on July 9, 1962, removed any lingering uncertainty of whether the EMP did indeed work. It was no longer a theory but proven fact, namely, that a single thermonuclear device at an altitude of 250 miles, will incapacitate electronic devices on the ground over a diameter of 1,000 miles and thus subvert hyper-critical Command-and-Control, making America vulnerable to any subsequent attack. The action taken by the US Department of Defense necessary to obviate such a disaster was to establish, on the ground, a network of nodes with sufficient redundancy to survive this EMP. Initially called *ARPAnet*, it became the Internet seven years later after the addition at the nodes of compute capability and enabling packet-switching innovation. Meanwhile, the Soviets, one month after *Starfish,* conducted their own tests to confirm the EMP. Their solution to the problem was solved by placing nuclear missiles out of harm's way under what is, effectively, the American EMP-free shield -- in Cuba."

Starfish Prime was a high-altitude nuclear test conducted by the United States of America on July 9, 1962, a joint effort of the Defense Atomic Support Agency (DASA) and the Atomic Energy Commission (AEC). Launched via a *Thor* rocket and carrying a W49 thermonuclear warhead (manufactured by Los Alamos Scientific Laboratory) and a Mk. 4 reentry vehicle, the explosion took place 400 kilometers (250 miles) above Johnston Island in the Pacific Ocean. It was one of five tests conducted by the USA in outer space as defined by the FAI. It produced a yield of 1.4 megatons of TNT.
The rocket cut through the blackness of the night sky over the atoll, the fluttering orange flame looking like feathering of an arrow in flight. The thunderous roar, gradually diminished as it entered the rarified atmosphere no longer able to transmit sound to us earth-bound observers. Thirty seconds later, the now low rumbling sound and vanishingly small light suddenly extinguished and in its wake just silence and darkness, leaving you, as in a fireworks show, anticipating the boom and its associated fountain of light. You guess where to look to see the inevitable starburst, wondering if it will be shower of brilliant white, a radiating flower of strontium red or perhaps copper-green starbursts. This 'boom', in this case is no 4th of July sideshow and is to a fireworks show what a stick of dynamite is to the popping of a balloon. You are imagining, for some reason, a giant, neon-speckled *starfish*, intensely bright, taking over the darkness of space, where the only previous competition was the sun.

There is was, suddenly, overwhelming, absolutely awesome. Where there is supposed to be silence and darkness, there is this literally blinding light, not just a very bright light, but the most brilliant light ever created by man, so bright the radiated heat would surely sear your exposed face, if it weren't protected – a light that could well have been seen by a telescope from a distant planet across our solar system.

Thousandths of a second later, as expected, another dazzling, dancing light appears in the night sky far to the north -- an artificial aurora. This is not an *aurora borealis*, but,

technically speaking, an *aurora temporalis*, an aurora in the North Pacific, thousands of miles from the polar regions where all such natural aurora are supposed to occur.

It worked! An artificial aurora was created by experimenters, precisely as planned, or so it seemed. As announced to the public, this exotic, space-born project to create an aurora was understood, even by this writer, then a passive technical observer of this experiment, to be just another piece of science. The experiment was said to investigate the earth's magnetic field and its interaction with high energy particles from *space* -- or, as the truth be known, -- such particles from *man*..

Experiments like this sometimes involved launching satellites to measure the magnetic field of the earth or planets or peer through the corona of the sun or measure the spectrum of electrons, cosmic rays or other high energy particles emanating from our sun or from distant galaxies. Creating the artificial aurora seemed simple relative to those that sent satellites orbiting space. After all, it was just another rocket with a payload of some kind to elicit esoteric phenomenon of interest to a few space scientists in order to write yet more scientific papers.

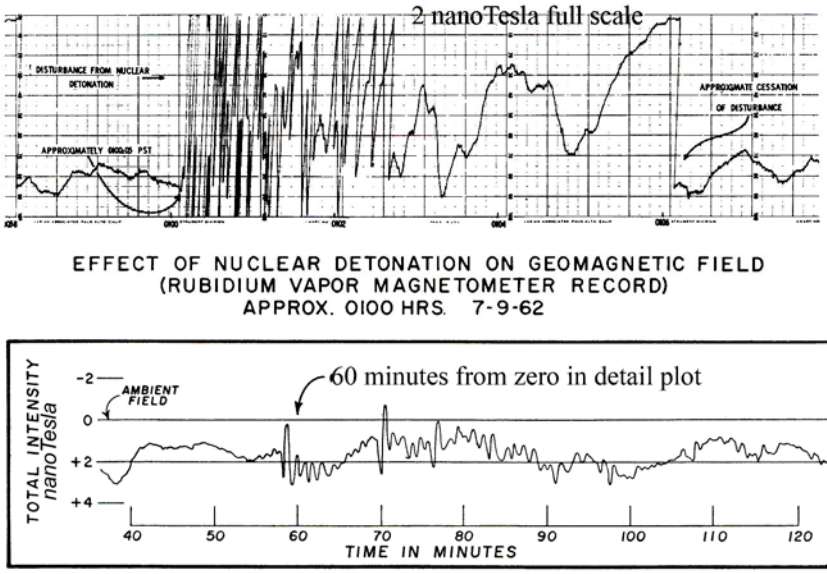
This particular experiment was far different than any other and had not-so-obvious discoveries in mind. The rocket carried a payload that was inherently very dangerous, if something went wrong, more dangerous than possible space debris showering down on us or our roofs. The rocket had a nuclear warhead, the equivalent of 1,400,000 tons of high explosive. Even this amount of explosive, if ordinary chemicals, was not, by itself the dangerous factor. It was, rather, that this rocket carried the *nuclear equivalent* of this explosive, a *1.4 megaton nuclear warhead*, a hydrogen bomb to be exploded in space. Designed to detonate at an altitude of 248 miles above the ionosphere, this nuclear missile was intended to create a vast source of gamma rays in the vacuum of space to see what effect, if any, it had on other systems our government considered critical to our national defense.

The real purpose of this experiment was classified secret, until it was de-classified about 1980. According to Dr. Palmer Dyal (now of Los Altos Hills, California), then chief scientist at Kirtland Air Force Base in New Mexico, " . . .." The heart of the experiment required the launching of rockets, one for the large nuclear payload and half-dozen others rockets carrying sensing devices. All of this needed space, a landing site and privacy. An atoll with the not-so-Polynesian name of Johnston Island in the central pacific was selected as being sufficiently remote and with facilities to support the necessary ground crew. About 800 miles to the northeast lay the Hawaiian Islands, at times downwind from the burst. The experiment, or test, as nuclear explosions were sometimes termed, was postponed several times due to weather conditions. Certainly, with all of the potential for radioactive (plutonium) fallout, if things went awry, this test had to be announced to the public. Moreover, the detonation of something so extraordinarily bright could not very well be clandestine.. The bit about creating an artificial aurora was a canard, a plausible one to interested scientists like me, in order to hide the real reason.

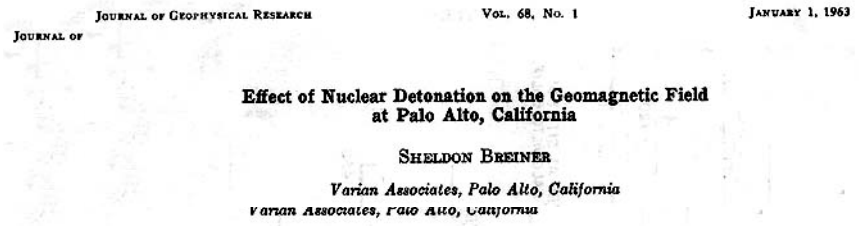
Sarcasm aside, I will venture to say that the results of this scientific investigation, called "Project Starfish," led, eventually, albeit indirectly, to the creation of the Internet, one of the most significant and universal innovations of modern time: one that influences all of our lives.

But, please read on without first running to your browser to look up Project Starfish nuclear.

More about the explosion.
Record below was recorded by Sheldon Breiner in Palo Alto, CA at Varian Associates from the EMP from *Starfish*, 4000 miles away.



Paper by Sheldon Breiner in Journal Geophysical Research 1963


JOURNAL OF GEOPHYSICAL RESEARCH VOL. 68, NO. 1 JANUARY 1, 1963

JOURNAL OF

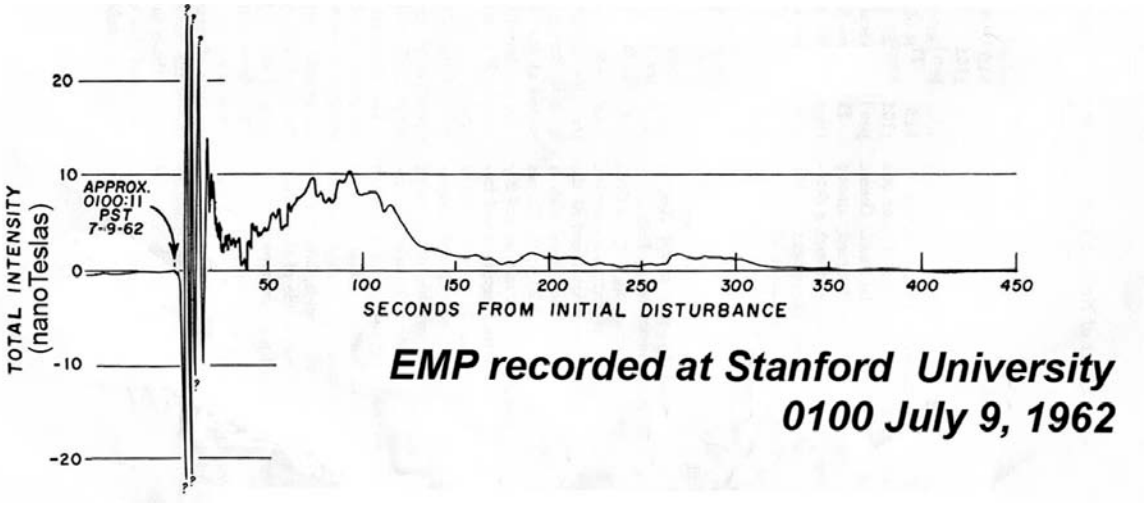
Effect of Nuclear Detonation on the Geomagnetic Field at Palo Alto, California

SHELDON BREINER

Varian Associates, Palo Alto, California

Varian Associates, Palo Alto, California

SB's paper on observation of the EMP at Stanford and at Varian Associates in Palo Alto, CA. 4,000 miles away from Johnston Island.



Sheldon Breiner's trailer at Frenchman's Hill, Stanford in 1962 with rubidium magnetometer under tripod at right. Site is just uphill from Peter Coutts Drive near Page Mill Road and Junipero Serra Blvd.

W-49 (1.4 megaton) warhead going off at 250 miles altitude

(EMP in Palo Alto, CA)

http://ed-thelen.org/comp-hist/CORE-3-1-SRI-TCP-IP.html

Mention Susan Packard Orr observations in Hawaii Jul 9, 62 in her letter to her mom) Mrs. Lucille Packard, wife of founder of HP)

A bit about natural aurora

First transmission using TCP on the Internet (SRI at Rossotti's to BBN)
See plaque.

Six other rockets sent aloft simultaneously, containing ruggedized, miniature rubidium magnetometers to measure the gamma ray-induced electromagnetic shock wave.

What actually happened, when.
projects Starfish, operation Dominic.

Johnston Island, Hawaii.

Cold war and nuclear terror.

What was measured on earth - magnetic field changes

What if EMP test has negative results??
Compare US, actually, DOD, control of Internet early days to same controls on GPS - The what-if one country did not control and create standards to current multi-system of GPS EU, Russia and the non-usability resulting .

Called off several times due to unfavorable winds.

EMP (electro-magnetic pulse) - the basis for the whole magilla

A possible scenario for the Cuban missile crisis follows:
Was this test, Project Starfish, perhaps conducted in part to know our vulnerability vis-à-vis loss of command and control or rather to use this nuclear-age means of exploiting a hole in the Soviet defense, allowing the US to have peremptory "First-Strike" capability? Would we have used it -- ever? Could the Soviets have been concerned in 1962 that we might use the EMP so that their only defense, in addition to submarine-launched missiles would have been to place some missiles in Cuba, safely out from under the EMP-targeted USSR.

Project Starfish was only one small part of “Operation Domenic”, to test essentially all of our nuclear weapons launched from submarines, aircraft and the like. Palmer Dyal, Project manager of Starfish, reported (personal communication) that a Soviet trawler sporting many antennae, was a quarter mile offshore Johnston Island during the entire four months of the project, monitoring what they could. In August 1962, one month after the successful, confirming U.S. test on July 9, 1062, the Soviets conducted one of their own high altitude tests over Novaya Zemlya, presumably to confirm the findings. Once, the Soviets knew what we knew, they could then play out several scenarios: 1) the U.S. was only confirming the theorized effects of the EMP and plan around that eventuality, or

2) that the U.S., could exploit the EMP as an offensive action against the Soviets. If the latter, there would only be a short window in which to play that card and that was very soon after both parties confirmed the strategic manifestations of the EMP. Each party knew what they knew and knew that the other party had the same information.

Thus, it is possible that the Soviets, suspicious and with conservative paranoia, had to defend against a possible offensive action taken by the U.S.
What better strategy is there than to install batteries of nuclear missiles close to the underbelly of the U.S. – in Cuba – one place in the world that the Soviets could count on there being no EMP. With a Soviet general in command of such missiles and a decision-to-launch system based upon a sophisticated fail-safe communications scheme* to confirm when and if the motherland was suddenly without communications, a retaliatory attack could be launched against the perpetrators. But, based upon the aforementioned premise, they would have to do so immediately, should the U.S. want to exploit this offensive window of opportunity before the Soviets could prepare for such a move.

> *On an operating basis, such a system to prevent a false alarm could take the shape of , for example, the following: the Soviets would have had to have a system that would not have resulted in their mistakenly launching missiles if there were no basis for doing so. One obvious means would have been a communications system that had, say, two, geographically separated sites that constantly broadcast a signal to at least two receivers in Cuba. If both of those signals were to cease, communications back to a third site not in the Soviet Union would be attempted. That third site would always be in contact with both Cuba and the Soviet Union.

It may not have been important to actually be fully prepared to launch such a retaliatory attack, but rather to create the perception that the Soviets *could* do so, if an EMP *were imposed upon them – certainly a form of* mutually assured destruction, the 'MAD' basis for keeping peace between rival superpowers.

In order to inform the Americans, a more subtle nuance of this strategy would be to somehow inform the U.S. that it would be foolish to attempt--- or even think about attempting—any such action. Thus, by transporting these nuclear missiles in a manner sure to be detected by the sophisticated surveillance systems operated by the U.S., the Soviets will have delivered their message.

Therefore, per the plan, the warning was indeed received by the U.S., per the Soviet plan and what we later termed the Cuban missile crisis was, merely the negotiations fully anticipated by the Soviets.

(The Soviets, the 'David' in this scenario with the American Goliath, monitored the Starfish results from their front-row seats on a trawler within shouting distance of the remote Pacific launch site on Johnston Island. This info from personal communication with Dr. Palmer Dyal, Scientific Director of Project Starfish who resided on Johnston Island for 4 months during the test.)

Cite similar tactical "EMP" device, the HPM ("High Power Microwave, or UWB, electronic equivalent of a neutron bomb) High-Powered Microwave (HPM) electronic blast from cruise missile, miniature EMP offensive weapon (1,000 feet instead of 1,000 miles effective radius) Proposed for use in Iraq -- and, who knows, Iran or North Korea. I can say these things, as I am not under a secret clearance.

What was measured. Experimental results

Consequence of this detonation and study

Establish dense net of ground-based stations for Command and Control. Define C&C

If communicate point a t point b, no matter what route, a long as it does get through.

Electronic effects
medical effects - why held at Johnston Island rather than Enewetak or XXX do search for other. It was because there were so many inhabited islands around the test site, many were subject of damaging their eyesight were they to look at the blast unprotected (personal communication, Baruch Blumberg, MD)

Establishment of ARPANET - or why the Dept of Def was always in control of the Internet. Did anyone ever ask, why? Compare GPS with Internet. Differentiate the World Wide Web from the Internet

Later more computers, packet switching , IP, the WEB, Electronic lingua franca

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http://nuclearweaponarchive.org/Usa/Tests/Dominic.html

http://en.wikipedia.org/wiki/Starfish_Prime
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List of high alt tests, both US, Soviet:

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)

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

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

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Starfish Prime (second test, after failure of rocket)

9:00 GMT July 9, 1962

Johnston Island

Thor Missile Airburst, 248 miles, yield 1,450,000 tons

Warhead was 20 inches in diameter, 54.3 inches long and weighed 1,665 lbs.

This was the second attempt to launch the Starfish test. The original Starfish was launched on 20 June, but the Thor missile engine cut out only 59 seconds after launch. The range safety officer sent the destruct signal 65 seconds after launch, and the missile was destroyed at 30-35,000 ft. The warhead high explosive detonated in 1-point safe fashion, destroying the warhead without producing nuclear yield. Large pieces of the missile fell back on Johnston Island, and more wreckage along with plutonium contamination was found on nearby Sand Island.

Starfish Prime was successful. The Thor missile carried the test instrumentation and the W-49 warhead/Mk-4 RV payload to 248 miles. The test appeared quite spectacular from Hawaii (800 miles away) and at Kwajalein (1600 miles away), with impressive light displays from an artifical aurora lasting up to seven minutes. The electromagnetic pulse (EMP) from this test sent power line surges throughout Oahu, knocking out street lighting, blowing fuzes and circuit breakers, and triggering burglar alarms.

The W-49 warhead used in this test was used on the Thor, Atlas, Jupiter, and Titan missiles, and was a descendant of the versatile Mk-28 thermonuclear bomb.

Pictures seen from Honolulu. Cite Susan Packard Orr's commentary that evening from a beach in Honolulu that night.


Dominic Starfish Prime (30 K)


Dominic Starfish Prime (23 K)

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[From a MD observing representing an instrument company measuring radiation fallout]

I was present on Samoa and observed the effects of radiation from Starfish, one of several nuclear devices detonated high above the earth's surface. The radiation particles followed the magnetic field of the earth from the explosion above Johnson Island and impinged upon the earth in the area of Western Samoa (the approximate conjugate location to Johnson Island). How much radiation people were exposed to has never so far as I know been determined. In my opinion it was substantial. The sky above Samoa lit up, especially to the north, providing almost as much light as during daytime, due to ionization of the air molecules.
(Click on the picture for a larger view.)

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High-power microwave (HPM) / E-Bomb

High-power microwave (HPM) sources have been under investigation for several years as potential weapons for a variety of combat, sabotage, and terrorist applications. Due to classification restrictions, details of this work are relatively unknown outside the military community and its contractors. A key point to recognize is the insidious nature of HPM. Due to the gigahertz-band frequencies (4 to 20 GHz) involved, HPM has the capability to penetrate not only radio front-ends, but also the most minute shielding penetrations throughout the equipment. At sufficiently high levels, as discussed, the potential exists for significant damage to devices and circuits. For these reasons, HPM should be of interest to the broad spectrum of EMC practitioners.

Electromagnetic Pulse (EMP) and High Powered Microwave (HMP) Weapons offer a significant capability against electronic equipment susceptible to damage by transient power surges. This weapon generates a very short, intense energy pulse producing a transient surge of thousands of volts that kills semiconductor devices. The conventional EMP and HMP weapons can disable non-shielded electronic devices including practically any modern electronic device within the effective range of the weapon.

The effectiveness of an EMP device is determined by the power generated and the characteristic of the pulse. The shorter pulse wave forms, such as microwaves, are far more effective against electronic equipment and more difficult to harden against. Current efforts focus on converting the energy from an explosive munitions to supply the electromagnetic pulse. This method produces significant levels of directionally focused electromagnetic energy.

Future advances may provide the compactness needed to weaponize the capability in a bomb or missile warhead. Currently, the radius of the weapon is not as great as nuclear EMP effects. Open literature sources indicate that effective radii of “hundreds of meters or more” are possible. EMP and HPM devices can disable a large variety of military or infrastructure equipment over a relatively broad area. This can be useful for dispersed targets.

A difficulty is determining the appropriate level of energy to achieve the desired effects. This will require detailed knowledge of the target equipment and the environment (walls, buildings). The obvious counter-measure is the shielding or hardening of electronic equipment. Currently, only critical military equipment is hardened e.g., strategic command and control systems. Hardening of existing equipment is difficult and adds significant weight and expense. As a result, a large variety of commercial and military equipment will be susceptible to this type of attack.

The US Navy reportedly used a new class of highly secret, non-nuclear electromagnetic pulse warheads during the opening hours of the Persian Gulf War to disrupt and destroy Iraqi electronics systems. The warheads converted the energy of a conventional explosion into a pulse of radio energy. The effect of the microwave attacks on Iraqi air defense and headquarters was difficult to determine because the effects of the HPM blasts were obscured by continuous jamming, the use of stealthy F-117 aircraft, and the

destruction of Iraq's electrical grid. The warheads used during the Gulf War were experimental warheads, not standard weapons deployed with fielded forces.

Col. William G. Heckathorn, commander of the Phillips Research Site and the deputy director of the Directed Energy Directorate of the Air Force Research Laboratory, was presented the Legion of Merit medal during special retirement ceremonies in May 1998. In a citation accompanying the medal, Col. Heckathorn was praised for having provided superior vision, leadership, and direct guidance that resulted in the first high-power microwave weapon prototypes delivered to the warfighter. The citation noted that "Col. Heckathorn united all directed energy development within Army, Navy and Air Force, which resulted in an efficient, focused, warfighter-oriented tri-service research program." In December of 1994 he came to Kirtland to become the director of the Advanced Weapons and Survivability Directorate at the Phillips Laboratory. Last year he became the commander of the Phillips Laboratory while still acting as the director of the Advanced Weapons and Survivability Directorate.

As with a conventional munition, a microwave munition is a "single shot" munition that has a similar blast and fragmentation radius. However, while the explosion produces a blast, the primary mission is to generate the energy that powers the microwave device. Thus, for a microwave munition, the primary kill mechanism is the microwave energy, which greatly increases the radius and the footprint by, in some cases, several orders of magnitude. For example, a 2000-pound microwave munition will have a minimum radius of approximately 200 meters, or footprint of approximately 126,000 square meters.

Studies have examined the incorporation of a high power microwave weapon into the weapons bay of a conceptual uninhabited combat aerial vehicle. The CONOPS, electromagnetic compatibility and hardening (to avoid a self-kill), power requirements and potential power supplies, and antenna characteristics have been analyzed. Extensive simulations of potential antennas have been performed. The simulations examined the influence of the aircraft structure on the antenna patterns and the levels of leakage through apertures in the weapons bay. Other investigations examined issues concerning the electromagnetic shielding effectiveness of composite aircraft structures.

Collateral damage from E-bombs is dependent on the size and design of the specific bomb. An E-bomb that utilizes explosive power to obtain its damaging microwaves will result in typical blast and shrapnel damage. Ideally, an E-Bomb would be designed to minimize and dissipate most of the mechanical collateral damage. Human exposure to microwave radiation is hazardous within several meters of the epicenter. However, there is a relatively low risk of bodily damage at further distances.

Any non-military electronics within range of the E-bomb that have not been protected have a high probability of being damaged or destroyed. The best way to defend against E-bomb attack is to destroy the platform or delivery vehicle in which the E-bomb resides. Another method of protection is to keep all essential electronics within an electrically conductive enclosure, called a Faraday cage. This prevents the damaging electromagentic field from interacting with vital equipment. The problem with Faraday cages is that most vital equipment needs to be in contact with the outside world. This contact point can allow the electromagentic field to enter the cage, which ultimately renders the enclosure useless. There are ways to protect against these Faraday cage flaws, but the fact remains that this is a dangerous weakpoint. In most circumstances E-bombs are categorized as 'non-lethal weapons' because of the minimal collateral damage they create. The E-bomb's 'non-lethal' categorization gives military commanders more politically-friendly options to choose from.

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Test: Starfish Prime
Time: 9:00 9 July 1962 (GMT)
Location: Johnston Island
Test Height and Type: Thor Missile Airburst; 248 miles
Yield: 1450 kt

Device Diameter (inches):	20
Device Length (inches):	54.3
Device Weight (lb.):	1665

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The W-49 warhead used in this test was used on the Thor, Atlas, Jupiter, and Titan missiles, and was a descendant of the versatile Mk-28 thermonuclear bomb

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See Wikipedia at

http://en.wikipedia.org/wiki/High_altitude_nuclear_explosion

High altitude nuclear explosion

High altitude nuclear explosions 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).

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 fireball grows much larger and faster than it does near the ground, and the radiation it emits travels much farther.

The strong 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.

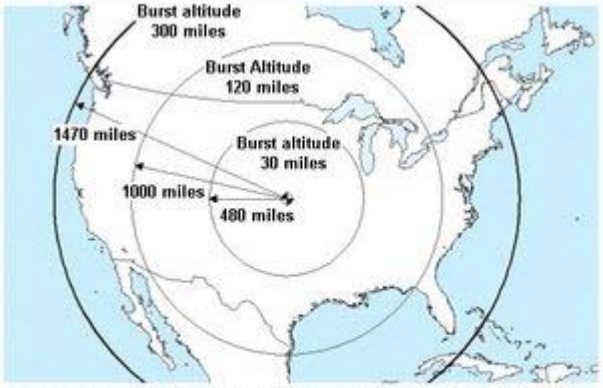
The potential as an anti-satellite weapon became apparent in August 1958 during *Hardtack Teak*. The EMP observed at the Apia Observatory at Samoa was four times more powerful than any created by solar storms, while in July 1962 the *Starfish Prime* test damaged electronics in Honolulu and New Zealand (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*.

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 transversing 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.

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].

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

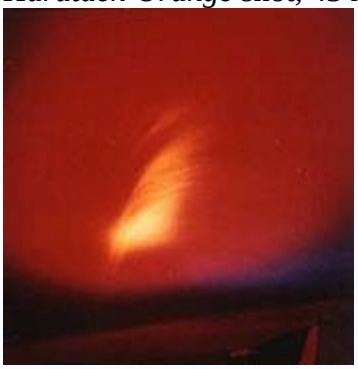
occurred on 22 October 1962 (during the Cuban missile crisis), in 'Operation K' (ABM System A proof tests) when a 300-kt missile-warhead detonated near Dzhezkazgan at 290-km altitude. The EMP fused 570 km of overhead telephone line with a measured current of 2,500 A, started a fire that burned down the 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.



EMP AREA BY BURSTS AT 30, 120 and 300 MILES
Gary Smith, "Electromagnetic Pulse Threats", testimony to House National Security Committee on July 16, 1997

How the area is affected depends on the burst altitude.
List of high-altitude nuclear explosions

Hardtack-Orange shot, 43 km



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

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

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)

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

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

- Outer Space Treaty
- Partial Test Ban Treaty

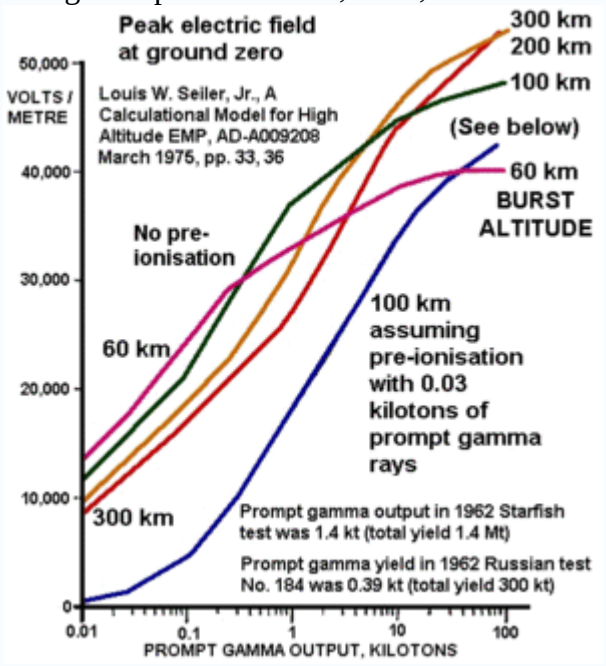
- "High-altitude nuclear explosions"
- Peter Kuran's "Nukes in Space: The Rainbow Bombs" – documentary film from 1999
- United States high-altitude test experiences - A Review Emphasizing the Impact on the Environment
- Measured EMP waveform data and actual effects from high altitude nuclear weapons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

US Government Films:

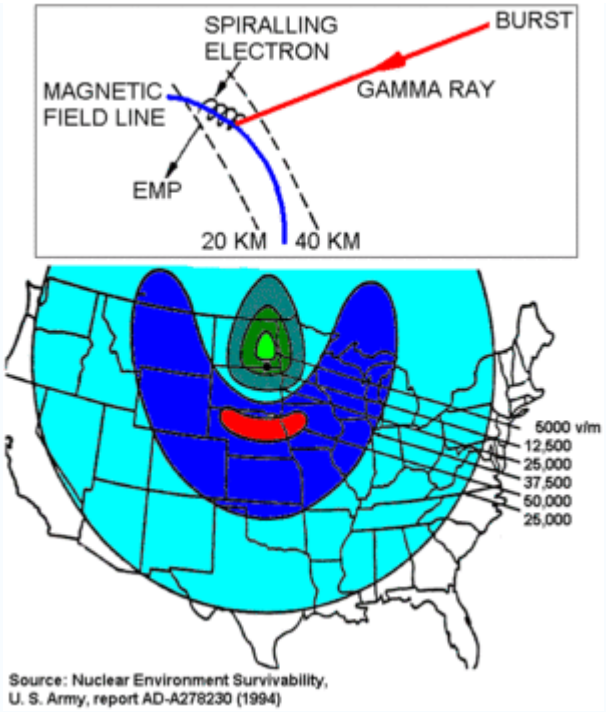
- Operation Argus

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

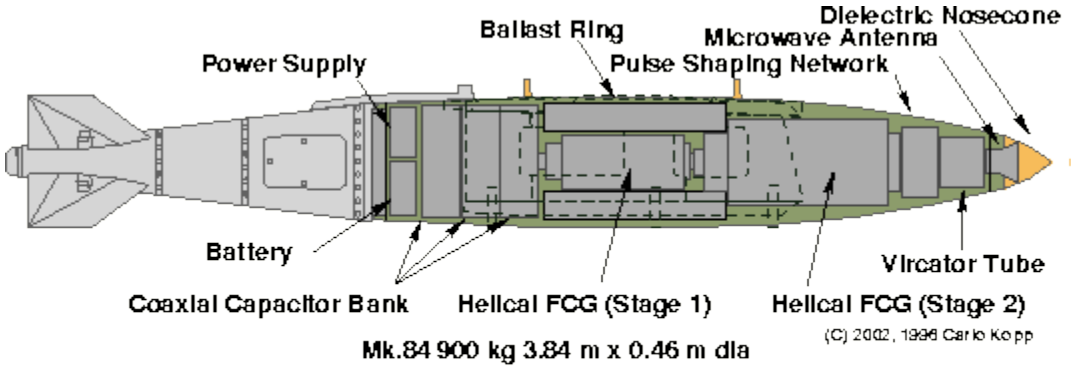
Bluegill Triple Prime shot, 1962, altitude 50 km (31 mi)



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.)



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.



HIGH POWER MICROWAVE E-BOMB – GENERAL ARRANGMENT MK.84 PACKAGING WARHEAD USING VIRCATOR AND 2 STAGE FLUX COMPRESSION GENERATOR

HPM E-BOMB WARHEAD (GBU-31/Mk.84 FORM FACTOR)

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http://www.astronautix.com/sites/johsland.htm

1962 Jul 9 8:46 - Starfish Prime Thor DSV-2E. **Engine shut down after 59 seconds. Destroyed by range safety..** Thor DSV-2E 195 *LC*: LE1. *Apogee*: 400 km.

Successful high-altitude test of a Thor IRBM with a live nuclear warhead. The payload included test instrumentation and a W-49 warhead/Mk-4 re-entry vehicle. The 1.45 megaton bomb exploded at an altitude of 400 km. The explosion was visible 2,600 km away, at Kwajalein Atoll; an artificial aurora lasted

seven minutes. The unforeseen and most militarily significant effect was the electromagnetic pulse (EMP) generated by the test. This caused power mains surges in Oahu, knocking out street lights, blowing fuses and circuit breakers, and triggering burglar alarms (and this in the days before microelectronics). The explosion supercharged the Van Allen radiation belts, resulting in several satellites malfunctioning.

1962 Jul 9 - Nike-Cajun. Nike Cajun *Apogee*: 100 km.

1962 Jul 9 - Nike-Cajun. Nike Cajun *Apogee*: 100 km.

1962 Jul 9 - Nike-Cajun. Nike Cajun *Apogee*: 100 km.

1962 Jul 9 - Nike-Cajun. Nike Cajun *Apogee*: 100 km.

1962 Jul 9 - Javelin J2 Javelin. *Apogee*: 500 km.

1962 Jul 9 - Javelin J1 Javelin. *Apogee*: 500 km.

1962 Jul 9 8:59 - HJ Nike X-3 HJ Nike. **Failure.** *Apogee*: 0.000 km.

1962 Jul 9 9:08 - HJ Nike X-4 HJ Nike. *Apogee*: 100 km.

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