was orbiting at 345 miles above the Pacific Ocean. The target satellite was kinetically destroyed, shattered into space debris.

Although the test was a success, there is a spectrum of technologies available to neutralize satellite systems.

II 2.1 Kinetic Weapons

Kinetic energy weapons such as the one described in the case involving the USAF F-15 do not use explosives. These weapons shatter their target through a high-speed impact. This concept may be referred to as a "hard kill" weapon. Another form of such a weapon is the "KE ASAT" which uses a Mylar shroud to impact the targeted satellite[73]. This system is intended to hit and impair the satellite but not to destroy the satellite. Thus unlike the unlike the case of hard kill weapon systems, space debris is minimised. This may be referred to as a "soft kill" weapon system.

II 2.2 Electromagnetic and Radiation Weapons

These are weapons that can destroy electronic circuitry by the creation or emission of electromagnetic pulse (EMP) or radiation. A nuclear explosion creates both and can effectively neutralize satellites, which have not been hardened against such effects[74]. EMP lasts for a small fraction of a second but causes damage to unprotected circuitry within several hundred miles radius of the blast. Following a nuclear explosion, the resulting beta particles and gamma rays can also create havoc in space assets affecting both radio waves and radar waves. According to General Kenneth Hagemann, director of the Defence Nuclear Agency, a 50-kiloton nuclear weapon exploded at 62 miles above the earth would pump up the Van Allen radiation belt[75] to the extent that increased exposure "would cause satellites to die in hours, days, or weeks"[76]. General Hagemann also points out that miniaturized electronics which make satellites lighter and smaller increases the vulnerability of satellites since they require less power and are consequently susceptible to smaller disruptions.

II 2..3 Directed Energy Weapons (DEW)

Directed Energy Weapons "include laser, radio frequency[77]" weapons. A laser weapon produces a concentrated beam, which can be projected from earth towards space assets. An example of such a system is the Mid-Infrared Advanced Chemical Laser (MIRACL). On October 17, 1997, the MIRACL laser successfully illuminated a satellite. Another program is the airborne laser (ABL) onboard a Boeing 747 aircraft. Laser weapons can be used to either physically harm the satellite or simply to" blind" the satellite sensors. Satellites in LEO are easier to target with earth-based lasers than those in geostationary orbit, which are much farther away[78].

II 2.4 Signals Weapons

Electronic weapons are used to interfere with satellite uplinks and downlinks by either spoofing or jamming these links. For example a GPS signal is spoofed if *"a receiver processes fake signals as if they were the desired signals. Users of GPS which are spoofed can be made to believe that they are on course when they could actually be very far from their desired position"*[79]. Jamming on the other hand is the rendering of radio transmissions unintelligible by causing interference. According to Rear Admiral Robert Nutwell, Deputy Assistant Defense Secretary for C3I Reconnaissance, Surveillance and Space Systems: "the vulnerability of GPS to jamming is pretty well recognized ...because it is...a weak signal and it is not

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[73] See www.fas.org/spp/military/program/asat/ke_asat.htm

[74] The U.S. had initially developed an ASAT system called Program 437 which used a nuclear warhead launched atop a Thor missile with a 1 megaton yield and a kill radius of 5 miles. See High Frontier pp. 62-65.

[75] James A. Van Allen is credited with the discovery of the belt of high-energy particles that surround the Earth. The discovery resulted from experiments originally designed to use captured German V2 rockets. See www.sspi.org/orbiter/Dec-Jan03/anniver2.html.

[76] www.globalsecurity.org/space/library/news/1995/at_950504.htm. Can be referred to as a Van Allen Attack

[77] Major William L. Spacy II, "Does the United States Need Space-Based Weapons?" CADRE Paper, Air University Press, Maxwell AFB, Alabama, September 1999 at p.10; www.maxwell.af.mil/au/aul/aupress/CADRE_Papers/PDF_Bin/spacy.pdf.

[78] IBID p.18.

[79] Scott Pace, *The Global Positioning System Assessing National Policies,* supra note 56 at 219.