**Hi-Tech Weaponry**

**Particle Beams, Microwaves, EMPs and More**

**Various Hi-Tech Weapons**

Source: The World of 2025
http://tuvok.au.af.mil/au/2025/

Neutral Particle Beam:

A Neutral Particle Beam (NPB) weapon produces a beam of near-light-speed-neutral atomic particles by subjecting hydrogen or deuterium gas to an enormous electrical charge.62 The electrical charge produces negatively charged ions that are accelerated through a long vacuum tunnel by an electrical potential in the hundreds-of-megavolt range. At the end of the tunnel, electrons are stripped from the negative ions, forming the high-speed-neutral atomic particles that are the neutral particle beam. The NPB delivers its kinetic energy directly into the atomic and subatomic structure of the target, literally heating the target from deep within.63 Charged particle beams (CPB) can be produced in a similar fashion, but they are easily deflected by the earth's magnetic field and their strong electrical charge causes the CPB to diffuse and break apart uncontrollably. Weapons-class NPBs require energies in the hundreds of millions of electron volts and beam powers in the tens of megawatts.64 Modern devices have not yet reached this level.65

Particle beams are an outgrowth of conventional atomic accelerator technology. Weapons-class particle beams require millions of volts of electrical potential, powerful magnetic fields for beam direction, and long accelerating tunnels. Current technology accelerator devices with these capabilities weigh in the hundreds of tons and require enormous power sources to operate.66 Composed of neutral atoms, NPBs proceed in a straight line once they have been accelerated and magnetically pointed just before neutralization in the accelerator. An invisible beam of neutrally charged atoms is also remarkably difficult to sense, complicating the problem of beam control and direction.67

Capabilities:

Like lasers, NPBs are essentially light-speed weapons. More difficult to control and point than the light weapon, the NPB is strictly a line-of-sight device (cannot be redirected). Moreover, a NPB would be difficult and expensive to place in orbit. Many tons of material must be lifted and a complex device must be constructed under free-fall conditions. This means the power supply, accelerator, beam line, magnetic focusing and pointing device, stripper, maneuvering system, and SAT/BDA system must all be located on a large platform on orbit. A useful constellation of NPB systems in LOW must contain many platforms (dozens) to avoid gaps in coverage. A constellation in higher orbit would require fewer platforms, but it would be correspondingly more difficult to control the beam and put it on target.

In addition, the NPB is strongly affected by passage through the atmosphere, attenuating and diffusing as it passes through dense gas or suspended aerosols (e.g., clouds, and dust).68 A space-based NPB is therefore most useful against high flying airborne or spaceborne targets. At relatively low powers, the penetrating beam can enter platforms and payloads, producing considerable heat and uncontrollable ionization. Thus, the NPB is useful at the low end of the spectrum of force, producing circuit disruption without necessarily permanently damaging the target system. At higher powers, the NPB most easily damages and destroys sensitive electronics, although it is fully capable of melting solid metals and igniting fuel and explosives. Like the laser, the NPB is inherently a precision-aimed weapon. To be most effective, an NPB weapon should therefore receive very precise targeting information (inches) and must have a pointing and tracking system with extreme stability (10 to 100 nanoradians). With this level of support, the NPB would be able to quickly disable targets by centering its effect on vulnerable points (e.g., fuel tanks, control cables, guidance and control electronics, etc.).

Like the pulsed laser weapon, the NPB can be used to discriminate against decoys in a ballistic missile defense scenario (e.g., a very difficult, but theoretically possible mission). When the beam penetrates a target, the target's atomic and subatomic structure produce characteristic emissions that could be used to determine the target's mass or assess the extent of damage to the target. The SDIO/BMDO has already researched and demonstrated detector modules based on proportional counter and scintillating fiber-optics technologies that are reportedly scaleable to weapon-level specifications.69

Countermeasures:

Rapid maneuvers and dense shields are the best countermeasures for an NPB. If the beam can be generated successfully and pointed at the target, it is difficult to defend against. Since the beam deposits its energy deep into the target's atomic structure, the primary weapon effect is penetrating heat deposited so rapidly it causes great damage.

Evaluation:

It does not appear feasible to develop an NPB weapon system as a space-based system even by 2025 due to the weight, size, power, and inherent complexity of the NPB. Also, due to the line-of-sight restrictions, the timeliness and responsiveness would be low to moderate as the weapon "waited" for the target to move within view. The flexibility and selective lethality of the NPB is also moderate in that it can range from temporary to permanent damage. Precision is excellent in theory, but questionable in use due to earth's magnetic field and countermeasures. Since the beam is strongly affected by passage through the atmosphere, ground-or sea-based targets probably could not be targeted. Finally, the reliability of such a complex, easily-affected weapon is moderate at best. The NPB weapon system does not appear to be practical in 2025.

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High-Power Microwave:

A high-power microwave (HPMW) device also employs electromagnetic radiation as its weapon effect. Not as powerful as nuclear-driven EMP weapons, HPMW weapons create a narrower band of microwave electromagnetic radiation by coupling fast, high energy pulsed power supplies to specially designed microwave antenna arrays. Microwave frequencies (tens of megahertz to tens of gigahertz) are chosen for two reasons: the atmosphere is generally transparent to microwave radiation (all-weather capability) and modern electronics are particularly vulnerable to these frequencies. Unlike most EMP weapons, HPMW weapons produce beams defined by the shape and character of their microwave antenna array. HPMW beams are broader than those produced by NPBs and lasers, and this space-strike weapon system does not require extreme pointing and tracking accuracies (100 nanoradian stability and one meter target accuracy are adequate). HPMW weapons can be trained on a target for an extended period of time, provided the power supply and HPMW circuitry can withstand the internal currents. As a rough point of comparison, HPMW systems produce 100 - 1,000 times the output power of modern electronic warfare (EW) systems.87

Capabilities:

This light speed weapon can be understood as a microwave "floodlight" that bathes its targets in microwave radiation. More directional and controllable than EMP, the general effect of this weapon on electrical systems is well described in the section on EMP. Unlike conventional EW techniques, the effects of a HPMW weapon system usually persist long after the "floodlight" is turned off (depends on power level employed).88

Laboratory experiments have revealed that modern commercial electronic devices can be disrupted when they receive microwave radiation at levels as low as microwatts/cm2 to milliwatts/cm2.89 The more sensitive the circuit, the more vulnerable it is. While many electronic devices can be shielded using the same techniques outlined in the section on EMP weapons, most sensors and high-gain antennas cannot be shielded without preventing them from performing their primary functions.

HPMW weapons are inherently limited by the fundamental laws governing electromagnetic radiation. A space-based HPMW weapon must have an antenna or array of phased antennas with an area measured in acres to point and focus its beam properly on terrestrial targets. The resources necessary to construct such huge structures could be expensive to lift into orbit, and difficult to assemble in the free-fall environment. Like the NPB, the HPMW weapon is a line-of-sight device that must "see" its target before it can fire.

The level of pulsed, electrical power required to produce weapon-level microwave fluxes is now becoming available (for ground-based systems). Compact, scaleable laboratory sources of narrow-band, high-power microwaves have been demonstrated that can produce gigawatts of power for 10 to a few hundred nanoseconds. Ultrawideband microwave sources are less well developed, but research in this area appears promising.90 A HPMW weapon should, however, be able to temporarily disrupt circuits and jam microwave communications at low-power levels.

A space-strike HPMW system would consist of a constellation of satellites with very large antennas or arrays of antennas. The farther out in space the constellation resides, the fewer the number of satellites required. However, there is a corresponding increased requirement for more power and larger antennas. Another possibility is to overlap "spot" beams from many smaller HPMW satellites on each target, gaining the benefit of high power on centroid (but a very much larger combined spot) at the cost of satellite proliferation. A useful distributed HPMW weapon system of this type might resemble the Iridium or Teledesic constellations of LEO communication satellites (many tens to hundreds of satellites; however, the HPMWs would not be small satellites).

At low powers, the HPMW weapon system is fully capable of jamming communications when pointed at the opponent's receiving stations or platforms, in addition to its obvious uses against an enemy's electrical and electronic systems at higher power levels. Since water molecules are also known to absorb certain bands of microwave frequencies, it is also possible a properly designed HPMW weapon system could be used to modify terrestrial weather.

Countermeasures:

Modern advances in microelectromechanical devices and nanotechnology could eventually result in devices and sensors so small that they are only a tiny fraction of a microwave wavelength in size. Minute devices, if small enough, could be immune to HPMW weapons simply because microwave frequencies cannot couple enough energy into them to cause damage. Advances in optical computing and photonic communications could also be a useful countermeasure. Optical devices are inherently immune to microwave radiation, although the sections of optical circuits where light is converted back into current would still have to be shielded. The counter-countermeasures outlined in the section on EMP weapons are also useful for HPMW weapons.

Evaluation:

The all-weather characteristics of the HPMW make it very attractive for a 2025 weapon. With a space-based version, this light-speed weapon would be high in timeliness and responsiveness. However, the flexibility and precision characteristics are similar to the nuclear EMP device-low. In addition, like the NPB, it is limited by line-of-sight restrictions. Moreover, its requirement for acres of antenna for each of the satellites required for a LEO constellation simply make it impractical. Finally, selective lethality is, like EMP, somewhat unpredictable. And by 2025, if nanotechnology is perfected and incorporated widely into electronic systems, this could negate much of the effects of a HPMW. Thus, the HPMW weapon system is not deemed suitable for space-force application in 2025.

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Electromagnetic Pulse:

An electromagnetic pulse (EMP) is a sudden, high-intensity burst of broad-band electromagnetic radiation. The range of electromagnetic frequencies present depends on the source of the EMP. The high-altitude airburst of a nuclear weapon produces an intense EMP which, because of the relatively long duration of the explosion, contains strong low-frequency components (below 100 MHz).70 Conventional EMP devices built with explosively driven, high-power microwave technology produce a less intense, very short (nanoseconds) burst composed primarily of microwave frequencies (100 MHz - 100 Ghz).71 The range of the EMP effect depends on the strength of the source, as the initial electromagnetic shock wave propagates away from its source with a continuously decreasing intensity.72

The gamma radiation produced by a fission or fusion bomb interacts with the atmosphere, creating a large region of positive and negative charges by stripping electrons from atmospheric gasses.73 The motion of these charges create the EMP. The pulse enters all unshielded circuits within range, causing damage ranging from circuit malfunction and memory loss to overheating and melting.74

Militarily useful EMP can also be created by mating a compact pulsed power source (gigawatt range), an electrical energy converter, and a high-power microwave device such as the "vircator" (virtual cathode oscillator).75 An advantage of a conventional EMP device is that it can be triggered in a shorter amount of time, thereby putting more output energy into the higher microwave frequencies (above 100 MHz). Since modern electronics operate primarily in these microwave bands, the EMP produced by conventional devices is potentially very effective in shutting down electronics. Explosively pumped EMP devices such as the vircator have another advantage: it is possible to design them to focus their EMP in a particular direction. Even a focused EMP effect produced by a conventional device will probably have a lethal radius measured only in hundreds to thousands of meters, depending upon the strength of the power source and atmospheric absorption (particularly at frequencies above 20 Ghz).76

Finally, the USAF Phillips Laboratory has produced compact plasma toroids with energies in the range of 10 kilojoules.77 Directed at solid targets, the plasma toroids induce rapid heating at the surface, producing extreme mechanical and thermal shock as well as a burst of X rays.78 The X-ray burst can also be used to generate EMP. While theory predicts the toroids will be rapidly dissipated by the atmosphere, there may well be a method of delivering high-energy plasmas to the vicinity of a target that does not involve long paths in air.

Capabilities:

The few experiments with nuclear bursts in space have revealed that the size of the nuclear EMP effect is related less to the yield of the bomb than to the altitude of the burst. A 100-kiloton burst at an altitude of 60 miles would create damaging EMP over an area equal to half the US. At 300 miles, the same burst would create EMP over an area equal to the entire US plus most of Mexico and Canada. The gamma burst from a (purely theoretical) microyield nuclear device might be used to create a more manageable EMP effect.79

Electrical devices exposed to an EMP burst experience effects ranging from temporary electronic disruption at the outer edge to destructive electrical overvoltages near the center. Modern semiconductor devices, particularly those based on MOS (metal oxide semiconductor) technology such as commercial computers, are easily damaged by these high-voltage transients.80 Long ground lines, such as electrical transmission wires, act as enormous antennas for the EMP burst.81 Power transmission and communication grids are therefore extremely vulnerable and will probably be destroyed by the burst. Any system containing semiconductor electronics, including airborne platforms, would be shut down or burned out by the burst unless it was completely protected with heavy, expensive electrical and magnetic shields, well designed electrical filters, and careful grounding. An extremely effective area weapon, the EMP produced by a nuclear airburst would undoubtedly produce severe damage to the civilian infrastructure.

A more flexible form of EMP weapon system would employ either a microyield nuclear weapon (yield below two kilotons), a conventional explosively driven EMP device or plasma technology to produce the EMP.82 Microyield nuclear weapons or conventional EMP devices could be delivered to the vicinity of the target as a bomb (perhaps by a TAV) or as the warhead of a missile. Given the unpredictable but damaging effect of EMP on electrical and electronic equipment, these EMP "explosions" are best used against enemy platforms and facilities that depend on sophisticated electronics, particularly the enemy's command, control, and communications system (strategic target) and the enemy's air defenses (operational target).83 Missiles equipped with EMP warheads are also effective weapons in the fight for air superiority, since modern high-performance fighter aircraft depend heavily on sophisticated, and therefore vulnerable, electronics.

The main difficulty with the nuclear EMP effect is its indiscriminate nature. The pulse travels in every direction and covers large areas of the planet, potentially damaging friendly assets just as greatly as those of the enemy. Another impediment to the use of nuclear-driven EMP weapons is the worldwide aversion to nuclear weapons, particularly nuclear weapons on orbit. Once a nuclear bomb explodes in space, the charged particles produced can easily be trapped in the earth's Van-Allen radiation belts. This would greatly increase the radiation exposure for any satellite passing near the radiation belts, disrupting or destroying poorly shielded satellites. The charged particles would remain in the radiation belts for an extended period of time, denying the use of space to friend and foe alike.84

Countermeasures:

Nuclear-driven EMP is omnidirectional, spraying large areas with damaging, broadband electromagnetic radiation. EMP created using more conventional technologies is characterized by directionality, relatively short range, and electromagnetic output centered in the damaging microwave frequencies. Arriving at light speed, the broadband nature of EMP makes it extremely difficult and expensive to defend against.85 Thus, the primary countermeasure for EMP weapons is electromagnetic shielding. Shielding must be provided separately against the electric and magnetic field components of EMP and it must take into account the broadband nature of the pulse. Since a great range of frequencies are present in EMP, the designer must shield against low, medium, and high frequencies. The designer must also install protective electrical filters wherever an electrically conductive channel enters electrical systems (e.g., power cables, transmission lines, antenna inputs, etc.). Since filters perform differently at different electrical frequencies, this is a difficult task.86 A single mistake in grounding, filter design, or shielding geometry is enough to provide entry for damaging amounts of EMP, especially in high-speed computer circuitry. This suggests the appropriate counter countermeasure. The antagonist need only break a few electrical grounds, shift the output spectrum of his EMP attack, or penetrate the shielding at a few critical points to render this countermeasure worthless. Once the energy from an EMP effect has entered a region's power grid, communications grid, or computer grid, the entire network can be disrupted for a period of time or even destroyed.

Evaluation:

Due to its indiscriminate nature, nuclear-driven EMP is only appropriate in total war scenarios (zero flexibility). The conventional EMP weapon, on the other hand, shows more flexibility in that it could be directional and its effects could be localized. Both forms of EMP weapons are at least moderate in their timeliness and responsiveness, since an EMP "bomb" could potentially reach its target within 30 minutes after launch (by means of a delivery vehicle similar to the modern ICBM). The precision of the EMP weapon is relatively low-it is generally useful only for area targets (e.g., enemy towns, large facilities, or a squadron of enemy aircraft). The survivability and reliability of EMP weapons are moderate to high, particularly if the weapons themselves are ground based (as the payload of an ICBM or surface launched ballistic missile [SLBM]). Finally, and most unfortunately, the selective lethality of EMP weapons is low. The effect of an EMP burst on any given electrical system is highly unpredictable, since it depends in great detail on the precise geometry of the engagement, the exact design of the electrical system under attack, and even the current state of the atmosphere. In sum, the conventional EMP weapon has very interesting possibilities as a potential future weapon. However, the currently unpredictable lethality, limited flexibility, and questionable precision make it unattractive as the primary component of a space-strike weapon system in 2025.

Illusion:

Sun Tzu said "all war is based on deception."91 Military commanders have always sought to hide their intentions, capabilities, and forces from their opponents. The most prominent modern example of deceptive techniques is stealth technology, which seeks to hide platforms from sensors by reducing the various sensor cross sections (i.e., radar, optical, infrared, acoustic, etc.). Modern advances in holographic technologies suggest another possibility: weapons that project false images to deceive the opponent.92

Holograms are produced by scattering laser light or intense bursts of white light off objects and forming three-dimensional interference patterns. The information contained in the interference pattern is stored in a distributed form within solid emulsions or crystals for later projection with a source of light similar to that used to produce the interference pattern.93

Capabilities:

Full color holograms can only be produced with white light sources, and even the best modern white-light holograms are imperfect.94 It is certainly possible to make holograms of troop concentrations, military platforms, or other useful objects, although the larger the scene the more difficult it is to produce the proper conditions to create a convincing hologram. No credible approach has been suggested for projecting holograms over long distances under real-world conditions, although the Massachusetts Institute of Technology's Media Lab believes holographic color projection may be possible within 10 years.95 Holographic and other, less high-technology forms of illusion may became a potent tool in the hands of the information warriors (see the AF 2025 information warfare white papers).96

Countermeasures:

The best countermeasure for holographic illusions is the use of multiple sensor types. The most convincing optical illusion could easily be exposed by its lack of an appropriate infrared or radar signature. The likely proliferation of sensors and sensor types on the battlefield of 2025 makes the use of merely optical illusions a temporary expedient, at best. Nevertheless, considerable confusion could be created, at least temporarily, by projecting false infrared signatures (platform exhausts) or radar signatures (missiles) or by concealing one type of platform within the illusion of another type (or of nothing at all- a form of camouflage).

Evaluation:

Illusion weapons are and will probably continue to be too limited in the 2025 time frame. The flexibility is low, precision uncertain, survivability and reliability are low, and the selective lethality involves deception only. With the proliferation of sensor devices projected for 2025, the attempt at deception would likely be detected so quickly as to have little effect.

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Projectile Weapons-Ballistic Missiles:

Ballistic missiles are popular with many countries today due to their capability to deliver a payload to the country next door or to a country on the other side of the world. They can even be used to deliver satellites into space (Atlas and Titan IVs are popular in the US). Their fuel can be liquid or solid and they are fairly reliable. The guidance systems can use global positioning system (GPS) receivers or inertial navigation systems and US systems are known to be very precise (measured in feet). Finally there is a wide range of possible payloads: nuclear warheads, chemical/biological devices, submunitions, solid masses, satellites, nonlethal payloads like foams or a debilitating gas, and so forth.

Capabilities:

The modern ICBM/SLBMs are strategic weapons of deterrence. As such, they inevitably carry devastating nuclear payloads. However, this is not the only possibility. With a CEP already measured in feet, ballistic missiles (theater or intercontinental) could be configured to carry more conventional payloads.98 The simplest useful payload is a solid tip (essentially a ton of cement in the nose). Few fixed targets could resist the sheer momentum of several tons of material delivered precisely at high speed from space. A simple variation on this approach replaces the solid tip with a high explosive charge. Equipped with the proper high speed fuse and possibly a shaped charge, this weapon could be very effective against many hardened facilities, especially shallowly buried bunkers or tunnels.

A ballistic missile could also be configured to carry a variety of submunitions. A reentry vehicle could be equipped with many long, dense rods that, when properly dispensed at high speed, would be excellent bunker busters. Alternatively, the reentry vehicle could contain hundreds or thousands of metal or ceramic flechettes (darts) designed to shred area targets such as enemy bases, weapon-making facilities, or threatening troop concentrations. The conventional EMP bombs described previously could be delivered to enemy C4I, air defense, and industrial facilities, disrupting or damaging all electronics without necessarily exacting a high cost in lives. Finally, a ballistic missile could be configured to deliver some form of nonlethal payload such as hardening foam, irritating gas, or foul smelling liquid.99

As regional wars in the Middle East have recently demonstrated, it is also possible to deliver chemical and biological weapons (CBW) with ballistic missiles. These unsettling, but potentially very effective area weapons share several disadvantages with nuclear weapons. CBWs are condemned by most nations as cruel and unusual weapons. Preemptive use of these weapons certainly invites worldwide condemnation. CBW devices are also uncontrollable once released-the areas affected are denied to friend and foe. Worse yet, chemical and biological agents are spread uncontrollably by environmental and natural vectors (e.g., insects and animals). In their current form, CBW devices are decidedly not precision weapons.

Countermeasures:

Ballistic missiles, whether theater or strategic in nature, are a particularly high-value target for space-strike laser weapon systems. Ballistic missiles spend tens to hundreds of seconds in the boost phase (theater ballistic missile [TBM] versus ICBM) followed by tens of seconds to tens of minutes in the post-boost phase.100 These missiles are easily detected by their plumes only during boost phase, the shortest phase of their trajectory. During this brief interval of vulnerability, a light-speed kill by a space-based or space-borne laser weapon system can settle the problem before it has the opportunity to deploy MIRVs (multiple independently targeted reentry vehicles). In general, ballistic missile countermeasures have been addressed in great detail by the Ballistic Missile Defense Organization. The solutions range from direct interception by high-speed rockets and missiles to airborne and ground based-high energy laser strikes.101

The appropriate counter-countermeasures are obvious. Stealthy reentry vehicles could be built that elude ground- and space-based sensors, although the designer would be forced to address optical, infrared, and multifrequency radar problems simultaneously. Alternatively, very small, very agile reentry vehicles that greatly complicate the problem of terminal defense could be designed.

Evaluation:

Most of these missile-delivered weapons could be built today. All of the essential technologies, including precise delivery, are already available. The flexibility of the/a ballistic missile system is moderate, precision good, survivability may be tenuous in 2025, reliability is good, and selective lethality is limited with this system. Because of these limits on selective lethality and potential survivability problems, the ballistic missile will probably not be suitable for space force application in 2025.

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Projectile Weapons-Kinetic Energy:

This type of projectile weapon is closely related to the solid-tipped ballistic missile. Kinetic-energy weapons come in two classes related to their velocity-the Kinetic Energy Penetrator (KEP) and the Hydrodynamic Penetrator (HP).102 The KEP has a maximum impact velocity of 3 kilofeet per second (kfps), about the maximum speed of an SR-71 Blackbird. The KEP destroys the target by shattering it with an enormous blow. Since some areas of a target are more vulnerable to shattering blows than others, precise targeting is necessary for an effective KEP.

The HP has a minimum impact velocity of 8 kfps. When a penetrator strikes a target at this extreme velocity, both target and penetrator react to the collision as if they were fluids (their behavior described by hydrodynamic equations of motion). The impact attacks the molecular composition of the target, spreading dense impact shocks at enormous speed.

A nagging problem for KEW systems is the heat and shock generated on reentry. This can affect the precise delivery of the weapon. An exciting new concept has been proposed that promises to ameliorate this problem. By concentrating a laser beam in the area immediately in front of the hypervelocity KEW, it is possible to create a laser-supported detonation wave (called an "air spike") that partially shields the KEW. The air spike transforms the normal conical bow shock into a much weaker, parabolic-shaped oblique shock.103 Researchers estimate that a properly designed air spike could decrease the effects of shock and heat on a hypervelocity object by over 75 percent (making Mach 25 seem like Mach 3).

Researchers have also experimented with enhancers for the two basic classes of KEW. Pyrophoric compounds might be added to increase lethality by generating intense heat. Provided extremely high-speed fuses could be developed, explosive charges might be added to increase the weapon's ability to penetrate the target's outer shell. The dense rods or flechettes mentioned above as submunitions for ballistic missiles might also be used by a KEW to increase its area of effect, provided the submunitions could be dispersed properly at these enormous velocities. It has been suggested that low-speed submunitions or dispersed EMP bombs might be used to help the KEW penetrator overcome defensive systems and reach the target.104

The high velocities needed by KEW systems can be generated chemically (by rockets) or electromagnetically (by the "rail-gun"). The rail-gun consists of a long, usually evacuated, tube containing electrically conducting rails and surrounded by high-power electromagnets.105 The projectile is the only moving part. The projectile is placed on the rail and a large current is generated within the rail and the projectile. Simultaneously, time-varying magnetic fields are induced in the magnets with powerful pulsed power supplies. The resulting electromagnetic force rapidly accelerates the projectile to extreme velocities. Rail-guns are being actively studied by the US military, although to date researchers have only been able to accelerate small masses to hypervelocity. Velocities achieved 20 years ago have not been exceeded to this day. Navy technologists report that their main problem lies in developing small, high-power, stress-resistant power supplies.106

Finally, an interesting variation on the HP concept involves the use of meteorites as a weapon.107 Naturally occurring meteorites at least the size of large houses (necessary to survive drag-induced heating in the atmosphere) could be intercepted in space and redirected to a terrestrial target. If done with sufficient stealth and subtlety, the impact could even be "plausibly denied" as a natural occurrence. Meteorites 30 feet in diameter could be counted on to generate nuclear weapon-size explosions (20 kilotons), but without the lingering radiation.108

Capabilities:

The capabilities of a kinetic-energy projectile would be similar to the better known precision guided missiles (PGMs). The kinetic-energy projectile would most likely be a PGM without explosives, but which travels so fast it can take out surfaces as well as targets buried hundreds of feet underground. Moreover, the kinetic-energy projectile can take out single targets or area targets (using hundreds of flechettes or rods). Besides precision, perhaps its most attractive capability is that it is an all-weather weapon. Finally, KEW are versatile in that they could be safely launched from the US and find their targets anywhere in the world within 30 minutes or they could reside in relatively small satellites (storage containers) in LEO waiting to be dispensed and reach their target within a few minutes. These rather simplistic satellites could easily be integrated with the global information network (GIN), the "utilities," and a command and control system.

Meteors can be hundreds of magnitudes more deadly than KEW. However, there are several significant shortfalls to meteorites as weapons. They are hardly a timely weapon- the war fighter must patiently wait for nature to deliver his "ammunition." The uneven shape and heterogeneous composition of meteorites makes it highly unlikely they can be guided precisely to a target. Since it is also impossible to predict how much of the meteorite will survive the fall from space, meteors are best classified as area weapons with a very uncertain radius of effect.

Countermeasures:

The countermeasures against KEWs are basically the same as for ballistics missiles, except that the KEWs are envisioned to be considerably smaller. Thus, they would be more difficult, if not impossible, to attack once they begin their descent from space. The countermeasure would best be applied against the KEW delivery platform be it a small satellite, a TAV, or some sort of pod.

If the KEW uses GPS for terminal guidance, it may be possible to jam the GPS signal. This may be especially effective for protecting mobile targets (the KEW GPS receiver would require real-time updates to hit these mobile targets). However, this would do nothing to prevent the use of KEWs that work strictly on trajectory or an internal guidance and targeting system against static targets.

Evaluation:

Meteors, as a weapon, are impractical, even in 2025. Of course, since KEW technology is available today, it will certainly be even more precise and deadly in 2025. A few hundred KEW "storage containers" placed in a LEO would make the timeliness and responsiveness very high (within a few minutes). Precision and reliability would also be high. However, the flexibility and selective lethality would be low-total destruction would be the only choice, unless used as a demonstration of power. Thus, the KEW would not be the ideal weapon of 2025. Due to its all-weather capability, however, it would be a good complement to some other weapon capability.