Space Weapons from a Technical Perspective

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• This presentation deals with definitions and types of space weapons from a technical perspective

• It is meant to give a basic understanding of the physics involved, the technical workings of space weapons, and their feasibility

• Comments and questions are welcome at any time during this presentation
Overview

• The basic rules (physics review)

• General types of space weapons
  – Earth-based weapons that move through space to attack targets on the ground
  – Earth-based weapons that attack targets in space
  – Space-based weapons that attack targets in space, air, or on the ground

• The grey areas
PHYSICS AND SPACE
The Basic Rules

• Velocity (speed) is not an independent variable
  – It is a function of altitude, and changing one changes the other
  – A school bus and an apple at the same circular orbit altitude will have the same speed (but one has a lot more \textit{momentum})

• Lack of air (friction) means \textit{inertia dominates}
  – What goes in motion stays in motion for a very long time
  – Very difficult to change direction, cannot “maneuver” in space like in air

• At very high speeds, solid objects tend to behave like liquids when they collide
  – Think crossing two high pressure sprays from hoses
  – Resulting pieces end up in similar orbits as parents (with some changes)
Examples of unique space physics

- Standing on a satellite and throwing an object “down” will result in the object drifting away and coming back to your hand one orbit later.

- A satellite does not orbit “around” another satellite
  - Both objects are in orbit around the Earth, but appear to move around each other.
Nuclear weapons in space

• Nuclear weapons do not behave in space as they do on the Earth
  – The lack of an atmosphere means a nuclear detonation will not produce a blast wave or blast effects
  – Less thermal energy is emitted and much more high frequency (X-ray and Gamma Ray)
  – Much greater release of prompt radiation

• Other significant effects
  – Electromagnetic pulse (EMP)
  – Short term interference with radar and radio communications
  – Long term damage through capture of charged particles by Earth’s magnetic field, creating artificial radiation belts, and excitation of Van Allen belts
Three general types of space weapons

• Earth-based weapons that move through space to get to targets on the ground
  – Medium to long range ballistic missiles

• Earth-based weapons that attack targets in space
  – Direct ascent ASATs
  – Lasers and directed energy weapons

• Space-based weapons that attack targets in space, on the ground, or in the air
  – Co-orbital ASATs
  – Hypervelocity rods
  – Space-based lasers
EARTH-BASED SPACE WEAPONS
• First ballistic missile was the German V-2 rocket during WWII

• Seized upon in the 1950’s as a way of delivering nuclear weapons long distances in very short times (compared to bombers) and were difficult to intercept

• Most do not consider them to be true space weapons, but ballistic missiles can be the basis for other space weapons

• Usually classified by their range (greater than 5500 km range are considered Intercontinental Ballistic Missiles)
A ballistic trajectory is simply an orbit with a perigee inside the Earth.

Ballistic objects have higher apogees (point furthest away from Earth) than many satellites but do not have enough velocity to stay in orbit.
• At a fundamental level, the only difference between a ballistic missile and a space launch vehicle is energy and payload
  – Ballistic missiles accelerate a payload to enough velocity to coast on an arc that re-enters the Earth’s atmosphere
  – Space launch vehicles lift a payload to the desired altitude and accelerate it so it has enough velocity to remain in orbit

• Generally, any ballistic missile can be used as a launching platform for certain types of anti-satellite weapons
  – The altitude to which the missile can reach is roughly half its missile range
  – Needs to be mated with an interceptor which can perform the tracking and terminal guidance functions
Direct ascent space weapons

- Ballistic missile launched from the ground, aircraft, or naval vessel with an interceptor (“kill vehicle”) on top

- After missile burnout, interceptor flies on a ballistic arc that intersects with the orbit of a satellite at a precise time
  - Interceptor must provide tracking of target, terminal guidance, and capability to maneuver for course corrections

- Usually no “warhead” is present on the interceptor, target is destroyed through kinetic energy alone
  - Some concepts have considered using nuclear warheads
Earth-based directed energy weapons

- Generally work by increasing the surface heating of the target
  - Can cause rupture and collapse of weak structures under load (like missiles) if held on the target for some period of time (seconds)
  - Can blind and damage sensitive optics

- Travel to target “at speed of light” (dodging is virtually impossible), can only target “line of sight”

- Dazzling and blinding are proven, destroying or “blowing something up” via laser still not operationally feasible
  - Depends greatly on the material and construction of the target
  - Painting something white or reflective can degrade the capability of the laser severely
SPACE-BASED SPACE WEAPONS
Co-orbital space weapons

• An object that is already in orbit that conducts a series of maneuvers to intercept another satellite
  – Could also lay in wait for target satellite (“space mine”)

• Could rely on kinetic energy (collision) alone for destruction, but more likely to use other means
  – Release a cloud of metal pellets (“shotgun blast”)
  – Deliver an electromagnetic pulse
  – Explosive charge
  – Attach to target and fire thrusters
Hypervelocity kinetic weapons

• Heavy metal rods released by an orbital platform that re-enter the atmosphere

• Rods have no explosive warheads, damage target through immense kinetic energy alone

• System has been discussed in theory but never developed, tested or deployed
  – Implementation poses significant technical challenges
Space-based lasers

• Satellites with lasers on-board that are used to destroy ground targets, other satellites, or nuclear warheads on ballistic arcs

• Requires extraordinary amount of power to generate
  – Some designs called for nuclear explosions to create X-ray lasers
  – Current research is attempting to develop chemical laser sources

• Systems have been theorized with some design work, but not built, tested, or deployed in space
  – Significant technical challenges still remain for operationally useful systems
The grey areas

• Any antenna can be turned into a jammer, which can then be used to negate or severely hinder a satellites’ ability to broadcast or communicate
  – Difficult to entirely prevent or determine un-intentional interference, especially in the geostationary belt

• Many missile defense technologies have a dual-use as a potential space weapons
  – All kinetic hit-to-kill technologies are similar, and differ mainly in maneuverability and tracking capability
“The Physics of Space Security”
by the Union of Concerned Scientists
(available for free on the Web)
Thank you for your time.
Questions?

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