The Physics of Space Weapons

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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 momentum)

• Lack of air (friction) means inertia dominates
  – What goes in motion stays in motion for a very long time
  – Very difficult to change direction

• 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

Motion relative to the Earth

Motion relative to each other
Three general categories of space weapons

- **Ground-based weapons that move through space to get to targets on the ground**
  - Medium to long range ballistic missiles
  - Prompt Global Strike
- **Ground-based weapons that attack targets in space**
  - Direct ascent ASATs
  - Lasers
- **Space-based weapons that attack targets in space, on the ground, or in the air**
  - Co-orbital ASATs
  - Hypervelocity rods
  - Space-based lasers
Ballistic Missiles

Promoting Cooperative Solutions for Space Security

• 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)

• Most do not consider them to be true space weapons, but the principles of ballistic missiles are used in other space weapons

• Usually classified by their range
  – SRBM
  – IRBM
  – MRBM
  – ICBM
• A ballistic trajectory is simply an orbit with a perigee inside the Earth

• Ballistic objects have apogees much higher than most space launches but do not have enough velocity to stay in orbit
Intercontinental ballistic missiles (ICBMs)
• Ballistic missile launched from the ground (or airplane) with an interceptor on top
• Interceptor flies on a ballistic arc that intersects with the orbit of a satellite at a precise time
• No explosives on the interceptor, target is destroyed through kinetic energy (mass times velocity) alone
• No real difference between the core kinetic kill technology used to intercept ballistic missiles and satellites
• Developed by the US, Soviet Union, and China (only Chinese program still active)
Ground-based directed energy weapons

• Lasers and particle beams
• Generally work by increasing the surface heating of the target
  – Can cause rupture and collapse of weak structures under load (like missiles)
  – 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 capabilities
• Destroying or “blowing something up” in space via laser still very much sci-fi
Co-orbital ASAT

• A satellite that is in orbit and maneuvers to intercept another satellite

• 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 and fire thrusters

• A co-orbital ASAT system was developed and tested by the Soviets in the 1960’s and 1970’s but stopped in the 1980’s, assumed canceled
Hypervelocity kinetic bundles

- Heavy metal rods released by an orbital satellite 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
• 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, 1980’s designs called for nuclear explosions to create X-ray lasers

• Systems have been designed but not deployed
Space-based lasers
“The Physics of Space Security”
by the Union of Concerned Scientists
(available for free on the Web)
Questions?

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