This is what “war in space” probably would look like in the near future

Enlarge / Anti-Satellite Weapons from Mission Shakti are displayed during Republic Day Parade on January 26, 2020 in New Delhi, India.
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The creation of the US Space Force has conjured up all manner of fanciful notions about combat in space. Will military satellites act like X-wings and Tie Fighters, zipping around and shooting at one another? Or perhaps will larger ships akin to the USS *Enterprise* fire photon torpedoes at enemy warbirds?

Hardly. But even those with more realistic expectations for what could happen if nations went to war in space—perhaps satellites using orbital kinetic weapons to attack other satellites?—may not fully appreciate the physics of space combat. That’s the conclusion of a new report that investigates what is physically and practically possible when it comes to space combat.

Published by The Aerospace Corporation, *The Physics of Space War: How Orbital Dynamics Constrain Space-to-Space Engagements* lays out several basic concepts that are likely to govern any space combat for the foreseeable future. All of the physical constraints suggest battles will need to be planned far in

advance.

Unlike a war on Earth, which typically involves an effort by opposing forces to dominate a physical location, satellites in orbit do not occupy a single location. Therefore, the report authors Rebecca Reesman and James Wilson write, controlling space does not necessarily mean physically conquering sectors of space.

Rather, control over the high ground involves reducing or eliminating adversary satellite capabilities while ensuring one retains the ability to freely operate their own space capabilities for communications, navigation, observation, and all the other increasingly essential ways in which militaries rely on space.

When considering how to control space, the authors lay out the ways in which space combat is counter-intuitive for policymakers and strategists.

- **Satellites move quickly, but predictably**: Satellites in commonly used circular orbits move at speeds between 3km/s and 8km/s, depending on their altitude. By contrast, an average bullet only travels about 0.75km/s. They are here, and then gone.
- **Space is big**: The volume of space between low-earth orbit and geostationary orbit is about 200 trillion cubic kilometers. That is 190 times larger than the volume of Earth.
- **Timing is everything**: Within the confines of the atmosphere, airplanes, tanks, and ships can nominally move in any direction. Satellites do not have that freedom. Due to the gravitational pull of Earth, satellites are always moving in either a circular or elliptical path, constantly in free-fall around the Earth. Getting two satellites in the same spot is not intuitive. Therefore, it requires careful planning and perfect timing.

- **Satellites maneuver slowly**: While satellites move quickly, space is big, and that makes purposeful maneuvers seem relatively slow. Once a satellite is in orbit, it requires time and a large amount of delta-V to perform phasing maneuvers.

Given all of this, for engagements in space, maneuvers and actions will have to be planned far in advance, Reesman said in an interview. “Any conflict in space will be much slower and more deliberate than a Star Wars scene,” she said. “It requires a lot more long-term thinking and strategic placement of assets.”

In a perfect world, space might be viewed as a sanctuary. But since the mid-1970s and the advent of anti-satellite weapons in the Soviet Union and the United States, space has been treated as a contested domain by the United States, the Soviet Union, and other emerging powers. While no shooting wars have broken out in space, the ability to take down space weapons has been seen by new powers such as China (in 2007) and India (in 2019) as a means to demonstrate their capabilities.

In addition to ground-based missiles, the report identifies several ways in which satellites might be attacked. Radio signals can be used to jam an opponent’s satellites, or spoof them by sending harmful commands. This would be an extension of electronic warfare already used in naval and air battles.

Some nations, such as France, have gone so far as to talk about deploying weapons in space to protect their own satellites. However, the authors suggest that satellites using kinetic weapons to shoot down opposing satellites seems unlikely for now, given the extraordinary energy required to maneuver an orbital weapon into a proper trajectory. More likely would be a “T-bone” collision between satellites, which does not require plane matching but rather occurs when two orbits cross.

Nations do have a strong incentive to not destroy other satellites because of the potential to create hazardous debris that would potentially affect all nations' assets in space—and debris generated in space has a lasting effect. However, in the immediacy of war, a nation may decide it is worth permanently losing access to some slots in geostationary orbit, due to debris, in order to win a ground-based war.

And what about the Moon? In the television show on Netflix, *Space Force*, US and Chinese troops get into a ground-based combat on the surface of the Moon. It all seems pretty ridiculous, considering the expense of transporting all that material to the lunar surface. And yet—*and yet*—from a geopolitical standpoint it does seem plausible that we could see humans fighting over the Moon in the not-too-distant future.

So what do the study authors think about hand-to-hand fighting on the Moon, with its low gravity and vacuum? "I would think you're more likely to take out the rockets on the way up," Wilson said.

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