Remarks to the Open-Ended Working Group on reducing space threats through norms, rules, and principles of responsible behaviours
Topic 4: Current and future space-to-earth threats by States to space systems

September 15, 2022

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Thank you very much for the invitation to brief you on some important issues regarding space and earth security. I am pleased to speak with you and am grateful that you are all engaged in the important work of the OEWG, which is so timely. My apologies for not being able to make the journey in person, but I would be happy to continue discussions with any members and encourage you to contact me if you feel I could be helpful. My email address is available from our hosts.

I am a researcher for a nongovernmental organization. We see our role as supporting informed dialogue; identifying new paths to a safer, more sustainable and equitable world; and advocating that actors to walk forward on these paths. My organization, the Union of Concerned Scientists, recently celebrated its 50th anniversary. We have been working on space security issues for all of these fifty-plus years. However, the opportunities for progress wax and wane, and I think that we have a moment of opportunity in front of us and urge us all to take it very seriously.

My overall remarks on the topic of space to earth weapons consists of three main points: one, that while they are perhaps the most alarming and provocative to think about, they are also militarily not very useful and are the least likely to be pursued in the foreseeable future. Two, any such specifically-designed weapon is likely to be recognizable, and for that reason limits on them are quite possible given the sufficient interest and political will and would be verfiable. And three, despite these facts, there are quite pressing immediate issues that could use your attention at the moment, issues of great importance, and so I would not want concerns about these weapons to get in the way of that work.

First, I will briefly talk about the technical reasons why earth-targeting space weapons have strong limits on utility. This will separate “is it possible to target earth from space?” from “is it likely or advantageous?” Secondly, I’ll describe some of the types of systems that have been proposed in the past and why we have not seen them put into practice. Third, I’ll talk about whether such systems would be recognizable, verifiable, whether limits on them would be feasible and desirable. These will be brief, of course, as a full discussion would take quite some time.

First: a reminder that while space is a place, orbit as a condition, one that takes an enormous amount of energy to achieve. Objects must not just be lifted up to a height above earth, they must have a speed relative to the surface of the earth sufficient to keep them there. This speed, at

orbits close to the earth, are about 30 times the speed of a jet plane. This takes an enormous amount of energy. Imagine a large space rocket such as an Atlas 5 rocket. Almost this entire Atlas rocket is fuel, and only 3-4 percent of its mass is actually payload. it takes 45 tons of fuel to put a one-ton satellite into orbit. It is also expensive to put things in space ($15-20,000/kg), so there does need to be a compelling rationale to put an object in space rather than somewhere else.

You can think of a satellite in orbit as more similar to a car going around a racetrack rather than an airplane that maneuvers by aerodynamic forces or a science fiction spacecraft going around like an X-wing fighter using some unknown kind of physics. Once you are in an orbit, it takes significant amounts of energy to jump to a different racetrack or to get off the racetrack completely.

For this reason, a weapon doesn't just drop back down to earth – weapons dropped from an airplane is not the right analogy. It takes significant energy to get it an orbiting object to slow back down enough to drop back to earth quickly enough to be relevant as a weapon, and that fuel has to be carried up with that satellite at launch. Putting weapons in orbit to prepare to use them to target the ground is therefore very costly. They take an enormous amount of energy to put into space and to bring back down. This extraordinary expense must be justified in light of other ways to accomplish a similar purpose, and generally are much less efficient than other options. While these objects are at a high altitude, this doesn't confer a "high ground" advantage. The transport of mass back and forth from orbit is very challenging--- this is why space operations are focused on the transmission and receipt of electromagnetic signals.

Additionally, for a space-based weapon to reach an appointed target on the ground at the high speeds characteristic of re-entry requires dedicated technology; an average satellite designed for another purpose will not have sufficient fuel to make a rapid descent back to earth nor the ability to direct itself with precision to a target. An average satellite cannot be repurposed into a ground-attack weapon.

Some commentators have also expressed concern about space-based directed energy weapons, in particular lasers. These are also very challenging technically—the atmosphere absorbs and scatters light, and cloud cover can be devastating as would the defense's introduction of aerosols, dust or other absorbing materials above important targets. The laser systems need to carry their own fuel, and would be necessity be large, technically very sophisticated, and expensive. They could not be maintained and repaired easily.

Another issue with space to earth weapons is that objects in space are moving rapidly with respect to the ground, and so tend not to be where you want them when you want them, it's not like flying an airplane to a target on demand. This is the "absenteeism" problem. So if you have a need for a weapon or surveillance asset to be available promptly, you will need multiples, and this gets expensive rather quickly.

The absenteeism issue is also a critical flaw in plans to put weapons in space that need to have a rapid response, such as space-based ballistic missile defenses which are meant to target nuclear-weapon carrying ballistic missiles as they are launched. The launch phase of an intercontinental ballistic missile (ICBM) is 3-4 minutes or shorter. In order to have a defense against a single

liquid fueled ICBM, one would need to have several hundred satellite-based weapons. To defend against ten simultaneously launched liquid-fueled missiles would require around 4,000 weapons in space to ensure that each of those ten missiles would have a missile defense interceptor assigned to them. Even making the most optimistic assumptions about space launch getting less expensive, even the least capable of such a system would cost $100 billion to $180 billion.

Beyond the high costs, an additional disadvantage of putting weapons in space is that as space objects visible to the ground they would be vulnerable to interference, damage, or destruction by anti-satellite weapons, including ground-based antisatellite weapons, and rendered ineffective. The ability of such a system to protect itself would likely be limited. This is a key and mostly unchangeable characteristic of space-based weapons. Thus space to ground weapons are sure to be extremely expensive and quite vulnerable, and ultimately probably useless.

While the prospect of the United States building a space-based missile defense has generated great concern in some quarters, space-based missile defense is not popular in the Pentagon; the most recent Director of the US Missile Defense Agency has stated that he has doubts about the cost-effectiveness and technical prospects for such a system. No system has ever been built, even in a test mode. But it continues to be discussed mainly due to a small number of Congressional champions. In the US political system, it would be extraordinarily difficult to get funding to build a fully-realized system, which would cost tens or hundreds of billions of dollars even to defend against a few missiles launched at a time. However, in the US political system it is also very difficult to get a firm “no” that would decisively close the door on the issue.

In summary, space physics disfavors missions that require the rapid transfer of mass into and out of orbit, missions that require a rapid response, missions that require safe basing. What space is excellent for is earth-observation and for the broadcast and receipt of electromagnetic communications. Space-based weapons designed to target terrestrial targets are unlikely to be a serious pursuit in the foreseeable future. They are uncompetitive with other means of achieving the same objective, and space-based weapons are just as vulnerable to anti-satellite weapons as satellites are. No country seems to have seriously pursued such systems and in my judgment are unlikely to do so in the foreseeable future.

Because any effective space to earth weapon is going to be technically sophisticated and require some significant amount of energy or fuel to accomplish its mission, they are likely to be recognizable upon inspection. The equipment to rapidly de-orbit a significant mass, the carrying of large mirrors for a laser, these would be easily recognized. Additionally, space-based weapons would need to be tested in order for their sponsors to have any confidence in them; such tests would be observable. We can have a great deal of confidence that these systems are not deployed today. Of course as systems were planned with more sophistication or to be concealed, increased confidence can be gained from increasingly intrusive inspection methods.

Given that these weapons are impractical, expensive, and difficult to defend, they unlikely to confer a lasting advantage and declarations not to be the first to deploy such weapons are welcome and I believe would be ultimately verifiable. However, the possibility of space-to-ground weapons becoming an important issue in the near term is remote and there are many

urgent space security issues which deserve significant attention in the deliberations that you are undertaking. I understand that progress in multilateral fora can be slow and frustrating, but I do hope that you find a way to make the most of this time as these issues are so urgent. We need agreements, guidelines, and rules to defuse a slow but progressing arms race, to defuse the risk of space operations sparking or exacerbating a crisis, particularly between major powers, and to protect the space environment so that it may be used to benefit all humankind.