# Executive Summary

The overwhelming advantage enjoyed today by U. S. forces comes about in part through U.S. use of space. The U.S. military uses satellites for traditional support functions, such as intelligence, communication, and navigation, and to support new military capabilities, such as guiding precision munitions and enabling "network-centric warfare" through remote command centers and live video links from the battlefield. How best to maintain these advantages is a key question facing the U.S. military. In January 2001 the Rumsfeld Commission asserted that "the U.S. must develop the means both to deter and to defend against hostile acts in and from space. This will require superior space capabilities." Some have taken this to mean that the United States must develop space weapons.

Agreeing that it is critical that the U.S. maximize the security of its space assets, the Panel considered the key threats to U.S. space systems over the next five to ten years and examined the best counter to each threat (See Tables A and B). In particular, the Panel sought to determine whether deploying weapons in space was the best counter to any plausible threats. After considering a wide range of vulnerabilities of U.S. space assets and the capabilities of various space-based weapons, the Panel unanimously concluded that it was not in the security interests of the United States to place weapons in space in the next five years.

The Panel also considered the usefulness of utilizing space weapons to attack ground targets. It was unanimous in concluding that ground-based weapons are more effective, more technically feasible, and carry a lower financial and political cost than do space-based weapons.

While the Panel emphasized the technical aspects of space weaponization, it also considered the political implications of placing weapons in space. It concluded that in cases where ground-based weapons offer equivalent capabilities, then U.S. strategic interests are better served by avoiding placement of weapons in space.

The Panel's findings are summarized in the pair of tables below. Table A represents significant threats to U.S. space systems in the near term, that conceivably could be countered by weapons deployed in space. Table B describes threats to space assets that cannot be mitigated by space weapons. The Panel agreed that, even for threats that could in theory be countered by space-based weapons, they are not the most effective means.

The Panel did not assess either space-based interceptors or space-based directed energy weapons fielded by a nation hostile to the United States, because, within the time frame of five to ten years, it concluded that no foreign country is likely to deploy space-based interceptors or directed energy weapons. However, because one cannot preclude the future emergence of such threats, the Panel recommends that R&D on such weapons should continue, though not at a level commensurate with early deployment.

## Table A: Threats possibly countered by space weapons

| Threats in order of decreasing detection difficulty | Threat maturity | Impact | Best mitigation strategy |
|---|---|---|---|
| Small satellites/ space mines | Co-orbital space mine technology not yet available to threat countries | Damage to one or more satellites in GEO. Resulting debris may damage many satellites. | International treaty governing "rules of the road" in space. Improved space surveillance for verification and enforcement. |
| Ground-based directed energy ASAT | Can hit satellites in LEO. | Temporary or permanent damage to vulnerable satellites, particularly reconnaissance satellites. | Installation of detection sensors, protective circuits and electro/optic systems. International treaty banning ASAT. Retaliatory steps, sanctions. |
| Ground-based kinetic energy anti-satellite weapon (ASAT) | Can hit satellites in LEO. | Each launch can damage a single satellite. | Quick launch of replacement satellite, if critical. Conventional attack on launch site. International treaty banning ASAT. |
| Nuclear explosion in space | Countries with SCUD-type missile can damage LEO satellites. | Immediate damage to satellites in line of sight. All LEO satellites over a period of weeks to months | Improved models to help estimate appropriate radiation hardening levels. Radiation-hardened military satellites. Quick launch of replacement satellites. |

## Table B: Threats that cannot be addressed by space weapons

| Threats in order of decreasing likeli- | Threat Maturity | Impact | Best mitigation strategy |
|---|---|---|---|
| Jamming of GPS signals | Localized jamming available | GPS system quite robust. Effect of local jamming small. | GPS guided weapons are being made robust. Sanction offenders in peacetime. |
| Jamming of satellite links | Wide band jammers available | Commercial satellites susceptible | Enforcement through international norms and sanctions, and eventual threat of military action. |
| Orbital Debris | N/A | Orbital debris from space weapons in LEO not now a serious problem. Could be serious in GEO. | Better surveillance, international control of disposal of rocket components, penalties for littering in space. |

Because of the especially important role played by the Global Positioning System (GPS) constellation of satellites, a section of this report is devoted to threats to the GPS. Analysis showed that the system is relatively well-protected, because it can sustain the loss of up to four satellites without losing coverage. Furthermore, the fact that GPS satellites are at high altitude drastically lowers the number of countries that could take direct action against them. The Panel recommends U.S. development of a quick-launch capability to be able to further protect the GPS and other critical space systems if they come under threat.

The Panel's conclusions and recommendations follow.

- Space weapons do not constitute the best mitigating strategy to any of the perceived threats to space assets: ground-based anti-satellite weapons, jamming, space mines, orbital debris, or a high-altitude nuclear explosion.
- No space weapons should be deployed by the United States in the next five years, although R&D should continue at an appropriate level so that the United States is not caught by surprise.
- The U.S. should ensure that critical space systems are redundant and placed in multiple orbital planes to reduce the damage caused by losing an individual satellite.
- Critical military infrastructure in low earth orbit should be hardened against radiation to increase survivability in the event of a high-altitude nuclear explosion.
- Quick launch capabilities should be developed in order to replace critical space infrastructure if it is threatened or disabled.
- The U.S. should take the initiative to secure verifiable international agreements, including "rules of the road" that make clearer what is considered threatening activity in space.
- The U.S. should continue to improve its space monitoring capabilities and space situational awareness to prevent stealthy hostile actions and further reduce the threat posed by background orbital debris.

- The threat posed by small satellites is not well understood. A thorough technical study should be undertaken to assess the magnitude of this threat over the next ten years. In particular, the study should investigate the minimum requirements in fuel and mass for various orbital maneuvers, how much support from ground stations they would require, and the homing and stealth capabilities of small satellites.
- The panel developed a rigorous analytical model of the hazard posed by orbital debris. Based on this model the panel determined that suborbital and low earth orbit explosions will not generate debris fields that are significant hazards to space infrastructure. Such debris fields could result from the interception of ballistic missiles in space or from the direct destruction of satellites. Assets in geostationary orbit, however, are much more closely packed and explosions at or near this orbit could potentially cause debris fields that would be extremely dangerous to military and commercial assets.
- To improve confidence in models of the debris problem, the panel recommends that the appropriate government agencies undertake or commission studies to better correlate the current fragmentation models with more precise measurements.
- The panel recommends that a similar study be commissioned in five years to assess how changes in the political and technological landscape may have altered the arguments for and against space weaponization.