# APPENDIX C: OTHER APPLICATIONS OF DIRECTED ENERGY WEAPONS

This Background Paper treats only one–and probably one of the most difficult-military application of directed energy. Many other applications of widely varying plausibility vie for funding and attention. An assessment of all these **schemes** is well beyond the scope of this Paper, but the list below is provided for reference. Mention of a scheme does not imply that it has any technical or military promise; this question would have to be properly studied.

***Anti-satellite (ASAT).*** Directed energy attack on satellites from space-, air-, or ground-based weapons is substantially easier than boost phase BMD. A satellite's orbit is completely predictable, making it in effect a fixed target. Long dwell times and low fluences suffice for ASAT attack on unshielded satellites. For instance, long illumination at just a few watts/$cm^2$ (several times **the sun's normal irradiance** in space) could upset the thermal control systems that allow spacecraft to endure the extremes of heat and cold in outer space. Substantial hardening of large and complex satellites (including sensors) to directed energy weapons from all directions at all times is impractical. Unlike BMD, which must handle thousands of boosters in a few minutes, ASATs would have fewer targets and longer attack times. Last, BMDs must operate under the most hostile circumstances imaginable, whereas the superpowers might use ASATs in scenarios short of nuclear war.

This Background Paper has stressed (see Section 5.1) that maturation of the same technologies involved in boost phase BMD virtually assures potent ASATs. The so-called "Star Wars" systems could well be their own worst threats. Besides the intrinsic ease of ASAT over BMD, a Soviet defense suppression ASAT attack on U.S. defensive battle stations would have three key factors working in its favor: 1 ) The Soviets would pick the time and sequence of attack on the U.S. BMD system and launch of their ICBMs; 2) The Soviets need not destroy the entire defensive constellation, but only "punch a hole" for their ICBMs to pass through; 3) The attack would take place over Soviet territory.

Ground-based laser ASATs, presumably using excimer or free-electron lasers for best atmospheric propagation, would have the advantages of large size and power supplies. Airborne lasers could avoid some of the propagation disturbances introduced by denser air at low altitudes, but turbulence around the airplane skin could require adaptive beam compensation.

Space-based directed energy ASATs are the most interesting category of all, since they would be, in effect, long-range space mines, Rather than positioning itself next to its quarry like an ordinary space mine, a **laser** could be thousands of kilometers away and still be able to strike within milliseconds upon receipt of a radio signal from the gound.

***Strategic offense.*** **If** they mature, the directed energy devices discussed for BMD might turn out to have been better termed "offensive breakthroughs" than "defensive breakthroughs." Consider, for example, a fleet of Soviet x-ray lasers launched simultaneously with (or minutes before) a Soviet first-stike ICBM attack. The pop-up x-ray lasers' job would be to intercept any U.S. ICBMs launched before arrival of Soviet silo-killing **RVs. The Soviet x-ray lasers would therefore** deprive the U.S. of its option for launch under attack. Microwave generators might be used for EMP-like attack on the U.S. command and control system. Another example of offensive use of beam weapons would be Soviet ASAT attack on U.S. warning, communications, nuclear detonation detection, or navigation satellites important to the U.S. retaliatory capability. Yet another example would of course be suppression of any U.S. BMD that used space-based weapons or sensors.

***Bus intercept.*** This Background Paper has focused on intercept of ICBMs before booster burnout. Intercept of the bus or post boost vehicle poses a rather different challenge. Post-boost phase for today's ICBMs is rather long (several minutes) but could be shortened drastically on future ICBMs. Bus tracking requires a different sensor than booster tracking, since the bus plume is much less conspicuous, and the bus rocket motor may not operate continuously. The bus is a target of declining value as it dispenses its RVs. Interruption of bus operation would not prevent the bus and its contents from continuing their ballistic flight to the target country, though the aim might be very wide of the target. Operating above the atmosphere, the bus can deploy lightweight shields, decoys, and sensor countermeasures (e.g., corner reflectors). On the other hand, x-ray lasers and neutral particle beams that cannot penetrate the atmosphere can attack the bus in space.

***Anti-SLBM.*** A number of schemes have been suggested for using directed energy weapons against SLBMs, besides the obvious extensions of ICBM defense. Thus pop-up x-ray lasers could be positioned on U.S. coasts or ships at sea to intercept SLBMs launched from nearby Soviet submarines. Aircraft patrolling coastal waters and carrying lasers could attack ascending SLBMs in their area.

***Anti-IRBM.*** Intermediate range ballistic missiles (IRBMs) have short boost phases and potentially low trajectories, making anti-IRBM defense rather different from anti-ICBM defense and perhaps better accomplished with ground-based terminal BMD systems deployed in the theater.

**Defense of satellites *(DSAT).*** Low-power wide-divergence (small optics) laser satellites (perhaps HF for high specific energy) could serve as "escorts" for other satellites, defending the other satellites from hostile objects—mines, ASAT missiles —approaching within a given range.

***Anti-aircraft.*** At least four schemes have been broached for using directed energy weapons against aircraft or cruise missiles. The most ambitious would involve a worldwide constellation of trackers (possibly LWIR) and beam weapons (possibly DF or short wavelength lasers) to attack Soviet Blackjack strategic bombers, Backfire bombers attacking U.S. aircraft carriers, Soviet airborne command post "Doomsday planes, " Soviet AWACS radar planes, and so on. In a second scheme, B-1 or B-52 bombers would be outfitted with lasers (possibly DF) to protect them from Soviet fighters, surface-to-air missiles (SAMs), and air-to-air missiles. A third scheme equips carrier battle groups with lasers or particle beams to defend themselves against cruise missile attack. Fourth and last, ground-based beam weapons might replace surface-to-air missiles for local air defense.

***Midcourse and terminal BMD.*** Intense electron beams have long been studied as replacements for interceptors in reentry BMD. In midcourse BMD, beam weapons might not only destroy RVs, but aid discrimination of RVs from lightweight decoys: lasers, particle beams, or x-ray lasers would illuminate approaching objects, and sensors would use the response of each object as an extra piece of data to judge whether it was a true RV (see Section 6).

***Submarine communications.*** This scheme would use a blue-green laser to communicate with submerged submarines. Seawater is opaque to all but VLF and ELF radio frequencies, used for submarine communications today, and to the blue-green portion of the visible light spectrum. A blue-green laser beam originating on a satellite, reflected from a space-based mirror, or carried by an airplane would be modulated in accordance with the message to be transmitted and directed at a given spot on the ocean. After transmission of the full message, the beam would dwell on a neighboring spot and transmit again, and so on, eventually covering all submarine patrol areas. Optical sensors on the submarine hull would detect the message.

***Blinding sensors and seekers.*** Analysts have studied a wide range of tactical applications for lasers, involving blinding of battlefield sensors, missile seekers, and even human beings.