FACT SHEET

UNITED STATES AIR FORCE

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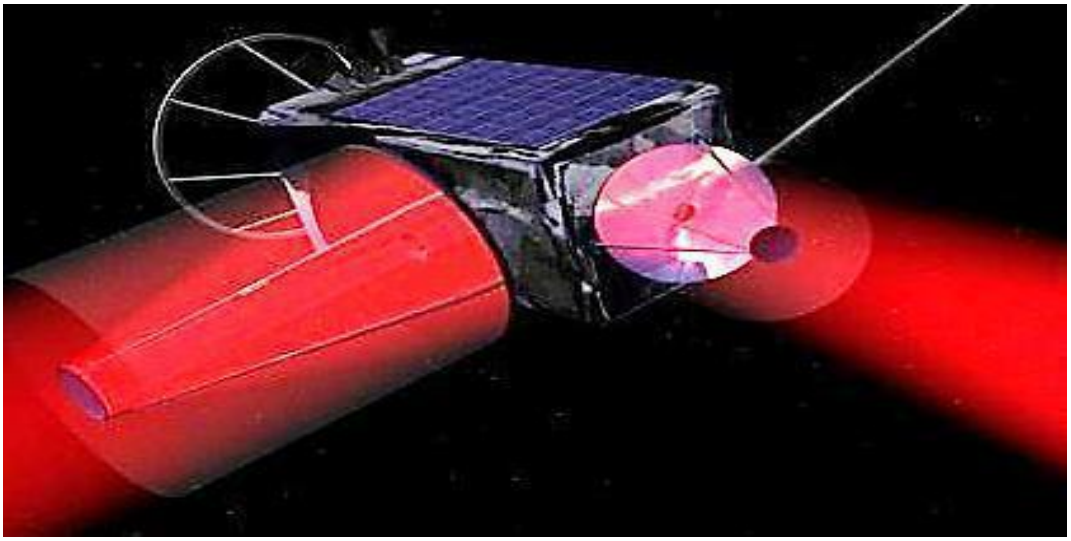
RELAY MIRROR TECHNOLOGY



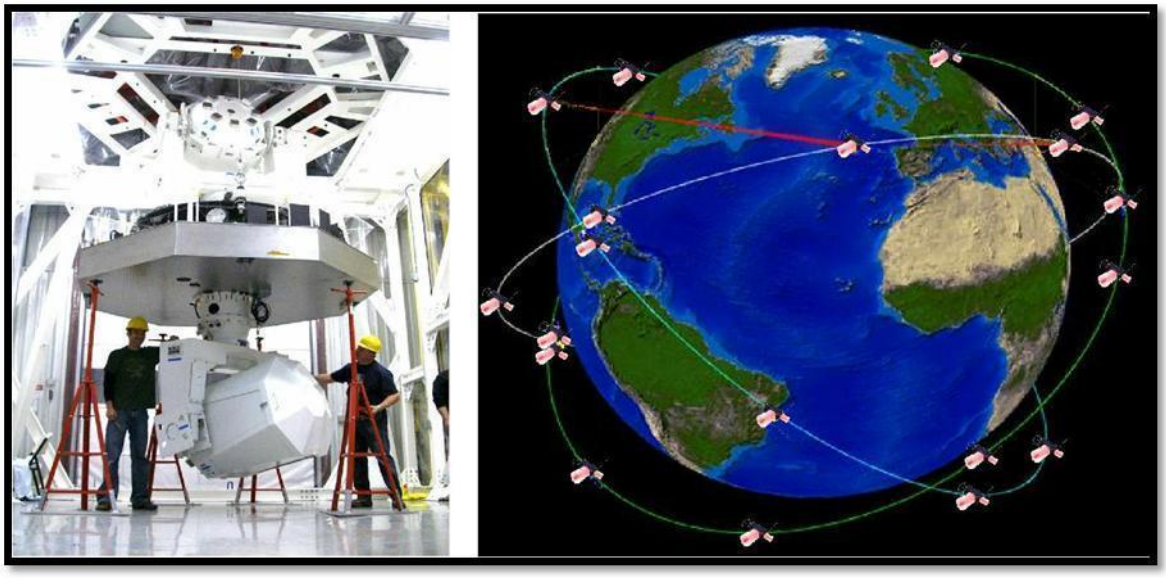
Relay Mirror Technology, under the Air Force Research Laboratory's Directed Energy Directorate at Kirtland Air Force Base, New Mexico, is looking at using a dual-mirror instrument in the air or in space to transfer laser energy from one part of Earth to another. Initially known as EAGLE, or Evolutionary Aerospace Global Laser Engagement, this technology is also exploring the potential for developing a constellation of large aperture satellites around the Earth.

These low-Earth-orbit relay-mirror satellites would be used to relay laser energy from one point to another, providing a worldwide speed-of-light capability to the warfighter. In a typical application, a laser beam would be directed at a "receive mirror." That mirror would collect the beam, then pass it to a beam control system, which would "clean it up" optically, then refocus and retransmit from a second mirror. This would be a practical application for moving laser energy from one part of Earth to another – extending laser energy beyond the horizon, beyond the limiting confines of the Earth's curvature.The goal of the program is to identify and develop key technologies needed to produce a relay mirror demonstration in the near future. The emphasis is on the relay mirror technology and technical synergy with other airborne or space-based directed energy systems, not on laser source development.

In attaining this goal several critical technologies must be examined. They include space vehicle design, vibration and thermal management, attitude control, large angle slewing and momentum control of a multi-body system (two mirrors, optical bus and space bus). In terms of optics, the system must be able to precisely point, acquire and track the laser source and the targets, requiring line-of-sight maintenance for both mirrors. Finally, large, lightweight (potentially deployable) mirrors must be developed as well as optical coatings and tech- niques for controlling jitter and optical aberrations.

The Directed Energy Directorate is developing a subscale relay mirror payload to reduce program risk and demonstrate critical technologies. Known as the Aero- space Relay Mirror System, or ARMS, the project will utilize two 75-centimeter telescopes to redirect laser energy from the ground to objects in the air or space.The product of the ARMS program will be an upgradeable relay mirror testbed that demonstrates traceable performance to that of potential airborne and space based operational systems.

Some of this research builds on the Directorate's Relay Mirror Experiment, conducted in the late 1980s and early 1990s. This was an experiment to deter- mine the precision upon which scientists could fire a ground-based laser to an orbiting mirror passing overhead, and bounce – or relay – that laser beam from that mirror to a target board on the ground several miles away. The experiment, which was repeated many times using Air Force facilities in Maui, Hawaii, proved this could be done successfully.



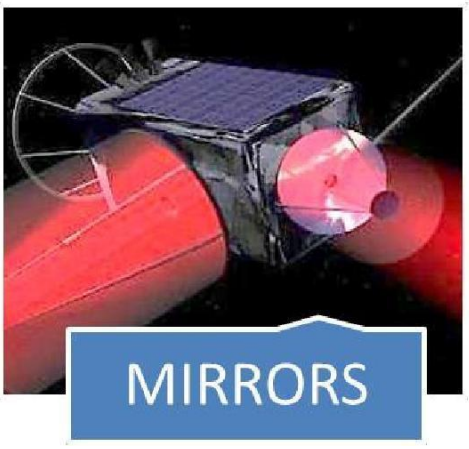
Current as of April 2006

BOEING-SVS Technician Reflected in the Airborne Relay Mirror System (ARMS)

In May 2006, the Laser & Electro Optical Systems (L&EOS) unit of Boeing Missile Defense Systems (MDS) received a contract potentially worth more than $400 million to continue supporting two U.S. Air Force laboratories engaged in cutting-edge research on high energy laser and satellite tracking technologies. Under the Air Force Research Laboratory's Innovative

Research and Optical Support Services (IROSS) contract, Boeing Laser & Electro Optical Systems will provide technical support services at the Maui Space Surveillance System (MSSS) in Hawaii and the Starfire Optical Range (SOR) at Kirtland Air Force Base in Albuquerque, N.M - Boeing and the U.S. Air Force announced in 2006 that they successfully redirected a laser beam to a target using their Aerospace Relay Mirror System (ARMS).

This demonstration was a major step in the development of relay technology because it showed that a relay mirror system can receive laser energy and redirect it to a target, extending the laser's range. The Air Force plans to use the ARMS hardware to establish a permanent test bed for relay system technology development. Relay mirror systems will greatly enhance the performance of laser weapon systems by reducing the atmosphere's effects on laser beams, extending their range beyond line of sight and expanding potential laser engagement geometries…



LASERS in 80s = BATTLE MIRRORS and PEBBLES

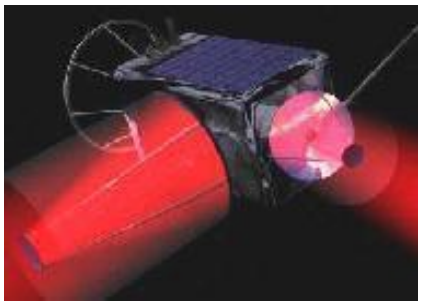
By BRYAN BRUMLEY
LIVERMORE - CALIFORNIA

In a industrial park amid the vineyards east of San Francisco, some of the worlds TOP SCIENTISTS are designing weapons to defend the USA against a missile attack from Space. As with the makers of fine wines, their work will not show itself soon.

The researches are nurturing concepts, that will not bear much fruit before the 21. Century. The crop includes the machinery of STAR WARS: x-ray lasers, high – technology Battle mirrors, charged particle beams (president Reagan Defense Intiative). Government scientists at the Lavrence Livermore NATIONAL LABORATORY are circumspect about their work, which is carried out in a COMPLEX of brightly colored aluminum ware houses surrounded by high fences and armed guards. The first element of STAR WARS that could fly is the anti – missile missile, which was developed els-where and is not so esoteric as the 21 century, weapons under study at Livermore. The Pentagon already has successfully tested some versions.These … "boost -phase kill" weapons are intended to stop enemy in the first moments of flight, before they release their thounsadns of arheads and tens of thousands of decoys, over helming later defense.

BATTLE MIRRORS

The most promising of these weapons, according to AIR FORCE (general James Abrahamson) who heads the Staregic Defense Intitative is the freee-electron laser. These lasers, based on Earth would bounce intense, high – energy light beams off orbiting space mirrors and destroy enemy missiles moments after lift- off. Prototypes lasers combine break throughts in several fields to prode a BEAM, that can be "tuned" to most effectively penetrate the atmosphere and travel to targets half a world away. So far, that wiggier has been able to tune 40 % of beam energy, but it has not been tested as FR /frequency that can pass through the atmosphere.Current designs envision bouncing beams from ground – based lasers off Mirrors parked in Station-ary ORBIT,, some plans call for putting the mirrors halfaway to the moon, to protect them from enemy attack satellites. Briggs foresses 5- 7 laser centers with about 10 lasers per site (100-1000 megawatts of power).



Relay Mirror Technology, under the Air Force Research Laboratory's Directed Energy Directorate at Kirtland Air Force Base, New Mexico.

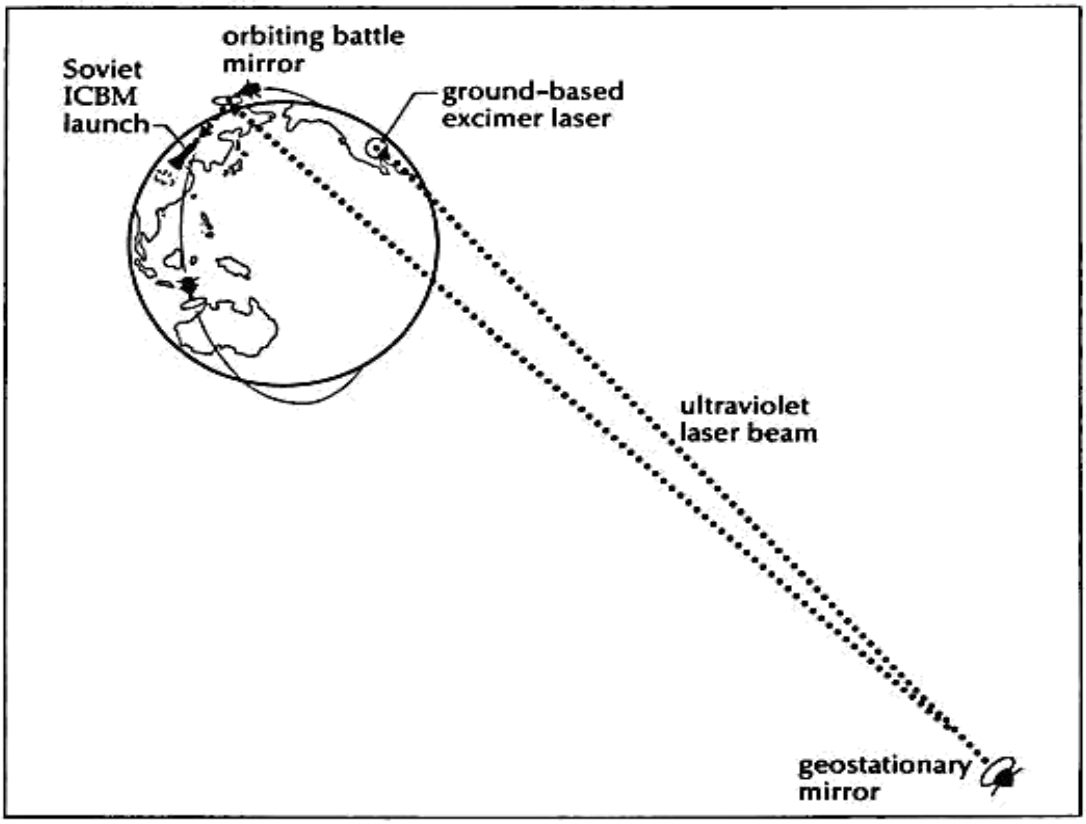


Figure 8.2 Geostationary Relay of Short-Wave Laser Weapon
Source: French, 1985. Reproduced with permission.

Another option generally favoured by proponents of this concept, like the former Presidential Science Adviser George Keyworth, is to have low-orbit 'mission mirrors' to track the ICBMs and redirect the beams sent down to them from GEO (figure 8.2). These would suffer from the absentee problem, but each could be cheaper and lighter than a chemical laser battle station.

The feasibility of such a system is hard to judge because the concept is not yet clearly defined and a number of technological problems are still some way from resolution. Multi-megawatt excimer or free-electron lasers, large space-based mirrors capable of handling high-power short-wave beams, and the necessary atmospheric propagation techniques have all yet to be developed. However, the theoretical power requirements for a system using such ground-based lasers suggest that the cost would be high.[10] Again the cost of developing, building and deploying such a

KIRTLAND AIR FORCE BASE, N.M. – Shown here is the Defense Department's largest mirror coating chamber, open at center. It was installed recently at the Air Force Research Laboratory's Starfire Optical Range. (Air Force photo by 1st Lt. Wellington Phillips)

Starfire Optical Range telescope

Air Force Research Laboratory Directed Energy Directorate's Starfire Optical Range 3.5-meter telescope. The world-class adaptive optics telescope is the second largest telescope in the Department of Defense.

ENABLING BATTLESPACE PERSISTENT SURVEILLANCE: THE FORM, FUNCTION, AND FUTURE OF »SMART DUST«

SCOTT A. DICKSON, Major, USAF, April 2007

Blue Horizons Paper /Center for Strategy and Technology /Air War College

Fund or conduct more ingestion experiments to confirm, deny, or alleviate the toxic effects of nanotechnology

In 2025, the military's need for persistent surveil lance applications will extend beyond current airborne platforms such as Global Hawk and Predator. The future of 2025 contains potential enemies with a material and information focus capable of conducting regular and irregular warfare on foreign lands as well as the continental United States. The US military must invest their energy and money today into researching enabling technologies such as nanotechnology, wireless networks, and micro - electromechanical systems (MEMS) to develop persistent surveillance applications such as Smart Dust for the future. *The Phantom Menace* A state actor attacks the United States using irregular warfare with information-oriented weapons through the electronic or electromagnetic spectrum.

1) **Support and fund research into nanotechnology measurement and manufacturing**
2) **Continue funding research and manufacture of nanoscaled sensors**
3) **Develop new antennas capable of larger gains to offset the reduction in size**
4) **Support and fund research to nanoscaled power supplies**
5) **Encourage and fund research into alternative methods to increase the transmission reliability of wireless networks**
6) **Encourage and fund research into creative solutions to the race conditions of networks**
7) **Support further research into the tradeoffs between false alarms and network latency**
8) **Develop and research alternative solutions to minimize the effects of environmental obstacles**
9) **Ensure the use of persistent surveillance data is for the public good rather than its detriment**
10) **Measure public reaction to these technologies, especially nanotechnology, through sponsored surveys every five years to redirect research and public educational efforts**
11) **Research and identify the true environmental concerns for nanotechnology**
12) **Educate the public on the benefits of Smart Dust to their way of life**
13) **Develop frequency-agile Smart Dust to defeat enemy jamming efforts**
14) **Fund or conduct more ingestion experiments to confirm, deny, or alleviate the toxic effects of nanotechnology**