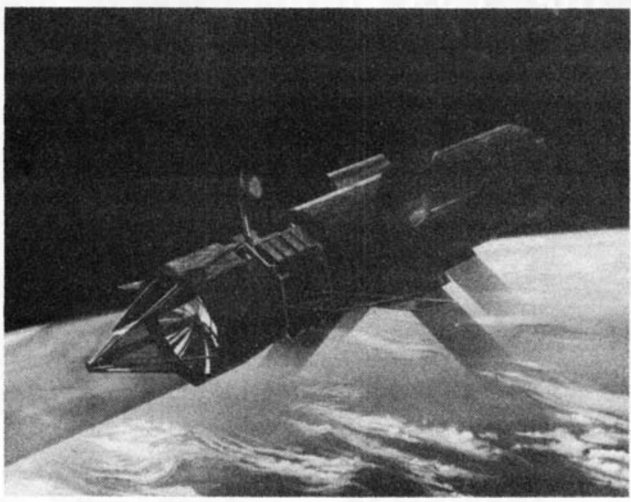
Zenith Star: an SDI demonstration

by Charles B. Stevens

On Nov. 24, 1987 during a visit to the Denver-based Martin Marietta Astronautics factory, President Reagan revealed for the first time the full dimensions and advanced status of the Zenith Star space-based laser demonstration project, a model of which is pictured on this page. Zenith Star is the Strategic Defense Initiative (SDI) continuation of the Defense Advanced Research Projects Agency space-based chemical laser program. The two major elements of Zenith Star are the LAMP mirror and the Alpha chemical laser, both of which elements have been demonstrated in laboratory experiments shown in the photographs.



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This Martin Marietta artist's concept depicts a space-based laser demonstration that would be conducted as part of the Strategic Defense Initiative program. Called Zenith Star, the program would consist of a flight experiment to demonstrate the operation of a medium-power chemical laser in space, and investigate how it would acquire, track, and point at a target. Martin Marietta Space Systems company in Denver, Colorado, has a $10.8 million contract from the SDI Organization to design the flight experiment.

The SDIO has already awarded Martin Marietta, together with its primary subcontractors, Lockheed Missiles and Space Company and TRW, a Phase II contract for demonstrating the feasibility of a space-based laser experiment.

The Alpha laser program is the most mature of the SDI's directed energy technologies. It is developing and validating key critical technologies needed to establish the feasibility of space-based ballistic missile defense.

The simplicity of Alpha's construction and operation makes it a strong candidate for strategic defense. The Alpha laser system is constructed primarily of extruded aluminum, and derives its beam from a purely chemical reaction, which is also the primary source of energy for the laser. Tests have established that Alpha can provide the technology to realize sufficiently high power chemical lasers for strategic defense.

The Alpha is the follow-on to the MIRACL (Mid-Infrared Advanced Chemical Laser). On Sept. 6, 1985 the MIRACL laser destroyed the second stage of a Titan I booster in tests conducted at the High Energy Laser System Test Facility at the White Sands Missile Range in New Mexico.

The Alpha program is managed for the SDIO by the Air Force Weapons Laboratory. The prime contractor is TRW, Redondo Beach, California.

The second major element of Zenith Star is LAMP (Large Advanced Mirror Program), shown in the third photograph. This program has demonstrated mirrors which are light enough to deploy in space. LAMP is the culmination of a decade and a half of R&D effort.

The LAMP mirror is being used to study technology issues involved in utilizing large optics for strategic defense applications. Performance tests of the LAMP mirror will be completed in early 1988. The successful demonstration of this segmented LAMP mirror removes one of the major technology barriers to developing directed energy weapons.

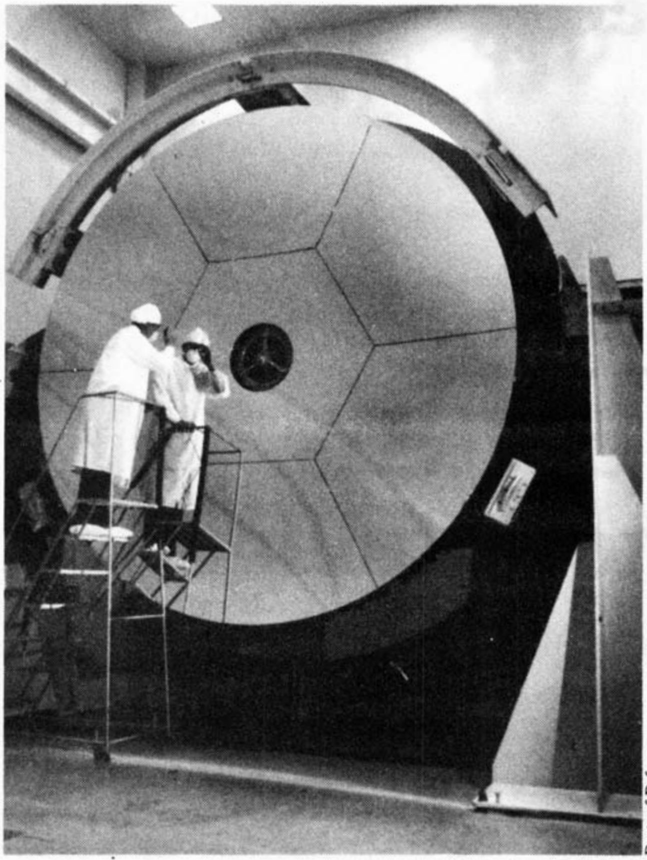
The LAMP program element is managed by the Rome Air Development Center. The prime contractor for the project is ITEK Corporation. Eastman Kodak fabricated the LAMP mirror's center segment.

Background and prospects

As originally conceived, the Zenith Star project was to have demonstrated the essential elements of space-based laser missile defense before the end of 1988. But congressional budget cuts in the SDI program, and the space shuttle Challenger disaster, have delayed the program up to several years.

While the Zenith Star space flight test will demonstrate all of the combined technology elements for space-based laser missile defense, the system itself is not capable of effectively taking action against ballistic missiles. But studies carried out over the past several years at TRW, and laboratory experiments on phase arrayed lasers at the Air Force Weapons Laboratory, show one interesting way in which Zenith Star could be directly scaled to achieve such a goal.

Before going into this, though, it must be understood that



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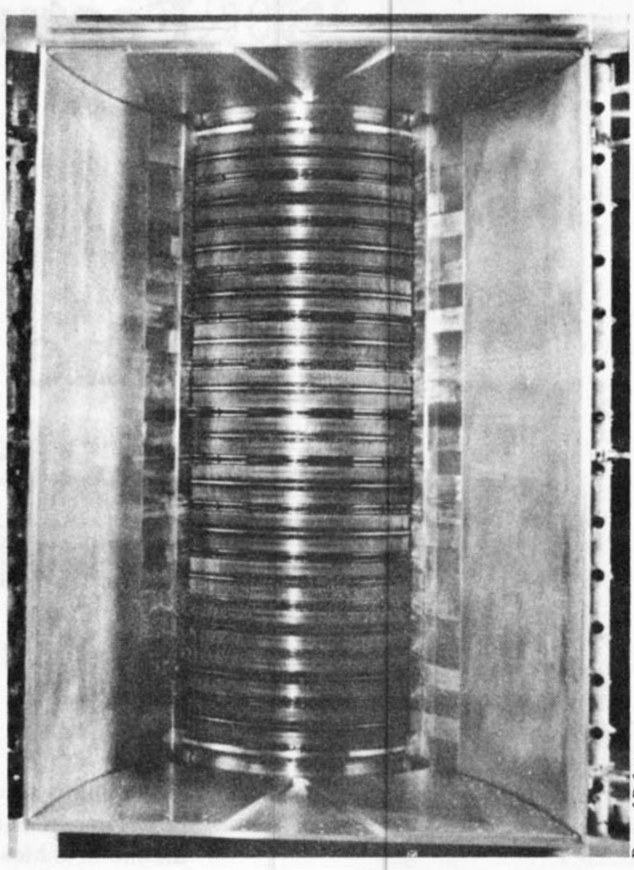
The LAMP mirror is an adaptive, segmented mirror currently in final stages of acceptance testing by ITEK Corporation of Lexington, Massachusetts. Here a technician checks the mirror surface after the seventh and final segment is in place on the supporting backplate. The extremely precise figure (shape) and alignment of the mirror's lightweight facesheets are controlled by actuators attached to the rear surfaces. The overall diameter of the fully assembled mirror is four meters.



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The cylindrical gain generator of the Alpha chemical laser is prepared for installation and testing at TRW's Capistrano Test Site. Alpha uses atomic fluorine and hydrogen to form the hydrogen fluoride lasing medium. The device then uses cylindrical mirrors to extract a 2.7 micrometer wavelength high-power laser beam. Alpha is the key component in the concept design for the SDIO's Zenith Star experiment.

the Zenith Star laser would carry out two distinct missions as part of a missile defense system. The first, which could be attained with a single module system, would utilize the Zenith Star to aid other types of missile interception systems through actively locating warheads in space and discriminating between decoys and real re-entry vehicles.

The second mission is that of intercepting ballistic missions in their vulnerable boost phase. This would require much higher laser power levels and larger mirrors than are represented by a single Zenith Star module. But the work at TRW and the Air Force Weapons Lab shows how this deficiency could readily be overcome.

TRW demonstrated that the technology already exists for constructing and operating extremely large mirror arrays in space. The idea is that many small mirrors can be ganged together in a phased array to act like a single large mirror. The small elements of the phased array can be mass produced and are therefore quite cheap. Systems acting like 100-meter-diameter mirrors are quite feasible. As TRW studies note, this virtually removes all limits on the power and brightness achievable with lasers.

A complementary development at the Air Force Weapons Laboratory is that of phase arrayed lasers. Experiments at this laboratory showed that many individual laser systems could be made to operate as a phased array. The result is that the combined output laser beam has an effective power density equal to that of the square of the number individual laser utilized. In other words 10 small lasers, when ganged in a phased array, would have the effective firepower of a single laser 100 times more powerful than the single small laser.

Potentially, the net effect is quite dramatic. Many small laser modules, such as Zenith Star, could be operated as a phased array. By utilizing large phased array mirrors in geosynchronous orbit, orbiting lasers throughout the world could combine their firepower to achieve effective output levels for intercepting missiles anywhere.