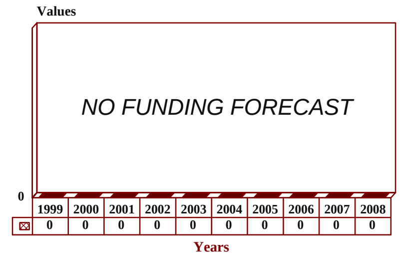
Submarine Laser Communications - Archived 09/2000

Outlook

- This report is being archived in September 2000
- Although technically successful, program was terminated in 1993
- Possibility of this effort being revived sometime in the future
- Report kept active due to its unique technology and implications
- Should this project come back to life, and evidence suggests it is more in limbo rather than dead, it will be updated and issued accordingly

Forecast Funding Levels
1999 - 2008



Orientation

Description. Concept development of a laser communications system originally intended to be used with submarines.

Sponsor

US Advanced Research Projects Agency (ARPA)
Washington, DC
USA

Los Alamos National Laboratory
Los Alamos, New Mexico (NM)
USA

US Navy
Naval Air Development Center
Warminster, Pennsylvania (PA)
USA

US Naval Command, Control & Ocean Surveillance Ctr
RDT&E Division
San Diego, California (CA)
USA

US Naval Ocean Systems Center
San Diego, California (CA)
USA

US Naval Underwater Systems Center
New London, Connecticut (CT)
USA

US Office of Naval Research
Arlington, Virginia (VA)
USA

Contractors

General Dynamics Corp
Space Systems Division
Laser Systems Laboratory
PO Box 85990
San Diego, California (CA) 92186
USA
Tel: +1 619 573 8000
Fax: +1 619 574 9004

GTE Corp
GTE Government Systems Corp
Electronic Defense Division
PO Box 7188
Mountain View, California (CA) 94039
USA
Tel: +1 415 966 2000
Fax: +1 415 966 3401

Lutronix Corp
1940 Seaview Avenue
Del Mar, California (CA) 90214
USA
Tel: +1 619 259 1006
(Subcontractor to ONR)

McDonnell Douglas Corp
McDonnell Douglas Electronics Systems Co
McDonnell Blvd MC 306242
St Louis, Missouri (MO) 63042
USA
Tel: +1 314 232 0232

Status. The Submarine Laser Communications program was canceled in 1993 while in the research and exploratory development stage.

Total Produced. At the time of termination, this program was experimental, with only a single prototype system being built.

Application. To provide a secure communication link with submerged submarines that does not require that the submarine reveal its position to hostile anti-submarine warfare (ASW) forces.

Price Range. Indeterminate due to developmental nature of the program.

Technical Data

Design Features. Submarine Laser Communications (SLC), was intended to be implemented on one of two possible platforms, either a space-based or airborne system. The space-based SLC concept would utilize satellites able to transmit high-data-rate emergency action messages and other types of communications to deeply submerged fleet ballistic missile submarines via a laser beam in the blue-green (visible) frequency spectrum. The SLC space-based architecture under consideration envisioned two to four geosynchronous satellites and receivers in ballistic missile and attack submarines.

A xenon chloride (XeCl) excimer laser downshifted to the blue-green frequency spectrum by lead vapor and coupled with a cesium vapor receiver filter was considered to be the most efficient SLC candidate. This laser beam would be detected by an optical receiver onboard each submarine. Initial transmission of messages to the satellite for re-transmission to the submarine fleet would be achieved through existing conventional ground and airborne communications systems (i.e., TACAMO aircraft and ELF/VLF shore-based communications).

A second SLC (airborne) configuration was examined under ARPA's Tactical Airborne Laser Communications (TALC) project based on the successful test of blue-green lasers for submarine communication on a P-3C aircraft (see below). SLC has several advantages over existing communications systems, including the ability to penetrate seawater and transmit messages at a relatively high rate of speed. The TALC concept demonstration program used a blue laser uplink matched to a cesium atomic line resonance receiver at 455.6 microns. The downlink was a green, diode-pumped laser compatible with existing submarine receivers at 532 microns. This translates to between five and six degrees of latitude of coverage. The laser would also be frequency agile.

The three basic benefits claimed for submarine laser communications are: 1) the reduction of the present-day reliance on towed buoy receivers, 2) improved certainty and data-throughput rate of communications connectivity with strategic submarines, and 3) enhanced tactical antisubmarine warfare coordination for attack submarines.

Variants/Upgrades

There are no known variants or upgrades.

Program Review

Background. Research into SLC concepts began in the early 1970s, with the Advanced Research Projects Agency (ARPA) funding work by the Naval Ocean Systems Center and several contractors. These included GTE, Northrop and Helionetics (now HLX Lasers, which is owned by General Dynamics). Under Project OSCAR (Optical Submarine Communications by Aerospace Relay), GTE developed and evaluated optical communications concepts for communicating with submarines.

The first successful aircraft-to-submarine tests of SLC technology were conducted in May 1981. In that test, a frequency-doubled Nd:YAG laser mounted on an aircraft flying at 40,000 feet. was aimed through clouds and ocean water to a submarine cruising at operational depth. The submarine detected the beam with a special optical receiver and decoded the message with conventional electronic processors. These results made scientists optimistic about the feasibility of a blue-green optical frequency communication system.

To support further airborne tests of the SLC, the FY83 effort focused on development of two receivers, one based on quartz and the other on cadmium sulfide filters which could be simply installed on test and operational submarines. ARPA, in FY83, worked on technology development, experiments and designs for tests of three candidate systems; airborne SLC, laser satellite and mirror satellite approaches.

In May 1984, ARPA announced it was concentrating on satellite lasers instead of mirrors. ARPA had been considering whether to put laser transmitters on satellites, or to keep the lasers on the ground and reflect the signals off mirrored satellites. ARPA did not indicate whether more efficient transmitters, more sensitive receivers or a combination of the two were what established the laser satellite approach. It did report progress on Raman-shifted xenon-chloride lasers.

In September 1984 Lockheed won a US$7.8 million contract to design a laboratory test module of a space-qualifiable XeCl laser based on the Northrop/ Helionetics design. Losing bidders for the contract were TRW and GE Space Division. Breadboard and lead-cell devices were built in FY85 and output matching of the cesium filter was demonstrated, with life-testing exceeding 100 million shots. ARPA stated at that time that an airborne SLC, with laser transmitters in a variety of carrier-based and land-based aircraft, was a near-term possibility for areas in which the US controls the air. However, this approach was likely to compromise submarine security. Laboratory versions of a cesium atomic resonance receiver were tested, and a design for a submarine test model was chosen.

During FY85, most of the efforts of the program were geared toward a smooth transition of the program from ARPA to the Navy. ARPA continued the design and fabrication of the space-qualifiable Laboratory Transmitter Module (LTM). Life testing of a laser device using the same xenon-chloride, Raman-shifted technology as LTM was completed. Reliability and degradation data over more than a billion pulses were taken and applied to the LTM project.

A P-3C aircraft equipped with a blue-green laser beamed a signal to a submarine operating beneath the ice pack in 1986. FY87 accomplishments in SLC included the fabrication of an experimental airborne XeCl laser and atomic resonance filter blue receiver.

Late in 1988, the General Dynamics Laser System Laboratory completed proof-of-concept tests of a blue laser system. Under Project Y-Blue, a laser was installed on a Navy P-3 aircraft. In a preliminary flight test, the P-3 aircraft used the laser to send encoded messages to surface receivers and a submerged submarine.

The US Navy and ARPA signed an agreement in 1989 for the establishment of a joint program to conduct research in, and to demonstrate improved submarine communications between, airborne or space-based platforms and submerged submarines. The ARPA program consisted of four major elements: 1) development of an aircraft transmitter/receiver for an Unmanned Air Vehicle (UAV), 2) development of a submarine transmitter/receiver, 3) concept exploration of a low-probability-of-intercept uplink system, and 4) modification and integration of a high-altitude long-endurance UAV for the mission.

By 1990 the outlook for the technological feasibility of laser communications improved significantly. Up to that time, a shortfall in laser communications development was the fact that lasers did not have a sufficiently long operational life, especially where gas laser technology was concerned. The development of solid-state lasers meant that a longer life could be expected now that reliability and efficiency were increased. The lower cost solid-state lasers also provided a significant weight savings which enhanced their potential for space application.

In 1991 the final design of the metastable atomic resonance filter was completed. The submarine, USS Dolphin, subsequently conducted successful testing of the two-way laser communications between a submerged submarine and an aircraft.

The FY92 budget authorization by the House Armed Services Committee directed demonstration of a near-term, space-capable, blue solid-state laser prototype. The Committee also required the conduct of experiments designed to resolve key technology issues associated with low probability of intercept (LPI), the provision of a laser uplink from a submerged submarine to a satellite and the examination of new technologies to improve blue laser efficiency and to develop robust laser uplinks. Efficiency was a major concern since low efficiency increases weight as well as fuel requirements.

Also in FY92, the USS *Dolphin* continued its experiments, this time to achieve high data rate communications via a green laser with ARPA's UUV while submerged. The submarine also tested the ability to control the UUV while submerged.

During the FY93 budget debate, funding for submarine laser communications development was denied by both the House and Senate Appropriations committees on the grounds that the Navy had showed a lack of commitment to the program, that the DoD was not properly managing the program, and that the direction had changed toward emphasis on satellite-based laser communications with submarines, a direction likely to substantially increase costs. The House committee felt that while the aircraft based version deserved funding, neither a requirement nor adequate funding had been demonstrated for the satellite-based version. The

Senate committee stated that the Navy had demonstrated a lack of interest in the program, including not making a FY93 funding request or fielding a prototype system even after spending US$200 million over 12 years.

Early in 1993, the US Navy discontinued the Satellite Laser Communications program. Budget constraints, technical problems, and a shift away from the Cold War mission were all cited as reasons for the program's termination. A spokesman for the US Navy stated the technology would be continued as part of the service's basic research efforts and that just the high-level demonstration program had been canceled.

Funding

Funding information has always been difficult to determine for certain aspects of laser communications work. It is known that US$20 million was originally appropriated for ARPA work to develop a two-way, blue-green laser. The level of interest increased, with the House Armed Services Commission increasing FY92 funding by US$15 million, and FY93 funding by US$15 million. However, FY93 funding was cut off by both the House and Senate Appropriations Committees. There has been no further funding since the US Navy announced it was not continuing the program.

Recent Contracts

No recent contract awards have been identified.

Timetable

Month	Year	Major Development
early	1970s	Research into SLC concepts begun
May	1981	First successful aircraft-to-submarine tests of SLC technology
May	1984	ARPA announces it will concentrate on satellite-based lasers instead of mirrors
	1986	P-3C equipped with blue-green laser beamed a signal to a submarine operating beneath the ice pack
late	1988	GD completes proof-of-concept tests of blue-green laser system
	1989	ARPA launches development project designed to prove the concept of laser two-way communications between submerged submarines and high altitude long endurance. Memorandum signed between Navy and ARPA for a baseline laser communications program
May	1991	TALC successfully tested at sea
	FY91	Final design for the metastable atomic resonance filter for submarine laser communications completed
	FY91	Successful submarine testing of two-way laser communications
Mar	1993	US Navy cancels program as being too difficult and not cost-effective

Worldwide Distribution

As far as is known, this was a **US** developmental effort only.

Forecast Rationale

A careful assessment suggests that some aspects of laser communications technology will be kept alive and buried in other programs until the time is right to revive it. With research spanning nearly 15 years, over US$200 million in cost, and some rather promising early results, the concept of laser communications is unlikely to be thrown away.

Politics, as well as technical difficulties, can also be blamed for the program's termination. The US Navy had all along displayed a lack of commitment to the program. This was particularly true of the submarine community, which has tended to dominate the upper echelons of the organization and which had long opposed the effort for fear the laser system would help the enemy detect stealthy submarines. The cost of fully developing and then maintaining such a system would also be quite high, something the Navy most likely did not wish to deal with in this era of defense drawdown and budget cuts.

This reluctance by the Navy was cited as a major factor in FY93 funding being cut off by the Senate and House Appropriations Committees. The Senate committee in particular was specific in its sentiment. It stated that if the Navy was serious about developing the laser communications technology, it would have allocated funding for an acquisition program in the FY93-98 future years defense program.

While this effort in submarine laser communications has been terminated for political and strategic reasons, the technology concept did prove successful. Other nations are pursuing the same ideas, and any success they achieve is likely to springboard additional US efforts. Since there is a remote possibility this program will be revived and because it represents a very unique technology, this report will be kept active.

Ten-Year Outlook

No funding is forecast at this time. This report is being maintained due to its unique technology subject matter. Should this project come back to life, and evidence suggests it is more in limbo rather than dead, it will be updated and issued accordingly. This report is being archived in September 2000.

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