Relay systems for effectively deploying tactical laser weapons in urban warfare

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Ground-based solid-state laser weapons could be capable tools in the warfighter’s response to asymmetric threats in urban warfare.

Conducting defensive warfare in an urban environment is seriously complicated by the need for rapid and precise response to distributed threats that are frequently dispersed within the local population. Today, protecting friendly noncombatants without putting them at unnecessary risk is a difficult but inescapable military task. Recent experience in both Iraq and Afghanistan has shown that integration of persistent intelligence, short reaction times, precision engagement, and measured, predictable effect are all keys to successfully countering emerging asymmetry in contemporary urban warfare. Ground-based tactical high-energy laser (HEL) systems, augmented by airborne relay platforms, can be highly effective in providing these capabilities.

Laser-relay weapons consist of one or more fixed or mobile ground-based lasers of 25–100 kW output, airborne dual telescope relays located on stationary or mobile platforms at altitudes from 500 to 3000 m, and associated operational control elements (see Figure 1). Laboratory versions of weapons-class solid-state lasers are in development and have already shown high brightness performance at powers above 25 kW. Output goals above 100 kW are expected by 2008. The elements that will make up the future laser weapon system should reach technical maturity before the end of the decade.

At Boeing Directed Energy Systems (DES) we have been engaged in a five-year quest to understand and demonstrate entry-level optical relay systems. We believe that, through the efforts of Boeing’s own research, together with the aid of government-funded contracts, tactical relays are now readily achievable and will enable or enhance many of the capabilities with which moderately powered laser weapons can equip the warfighter.

A laser-relay system consists of two independently gimbaled beam directors, an optical transfer subsystem for ‘cleaning up’ and moving the captured beam between the relay receiver and transmitter telescopes, a suite of multiband sensors, and the control electronics and software necessary for managing all onboard systems (see Figure 2).

For the so-called ‘fixed’ coverage laser-relay system, the relay payload is suspended beneath a tethered aerostat. In the mobile version, the system can be configured as an underwing pod on a remotely piloted aircraft, such as a Predator. In either configuration, the gimbals must be able to establish a precise optical line of sight with the source laser (uplink) and, simultaneously, with the target (downlink). In addition to providing sub-microradian pointing precision for two independent lines of sight, the payload optical system must capture and relay the high-power beam with minimal loss. Understanding and addressing these challenges, known as dual line of sight (DLOS) and energy throughput (ET), have been the technical focus of Boeing’s development efforts to date. Through a graduated program of modeling and analysis, simulation, and hardware development and testing, we have demonstrated that DLOS pointing and ET can be

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achieved with acceptable risk levels that exceed those required for a 25–100kW tactical laser-relay system.

To illustrate Boeing’s efforts to better understand the technological challenges of relays, the current DLOS mobile platform is shown in Figure 3. It is a fully functional half-scale relay package mounted in upright configuration on a mobile (towed) trailer base. The payload includes a full suite of control and sensing electronics, sensor subsystems and multiple low-power laser beacon sources. All trackers are hosted in on-board high-performance processors, and the entire system is linked through on-board fiber and off-board wireless communication protocols. Two-way remote operations, tracker video ‘down’ and command links ‘up,’ are tied into a PC-based ‘gunner’ and laser operator console. DLOS has proved a highly successful laboratory and field workhorse, used to validate complex system mode logic while exercising the full range of tactical laser source-payload-target interface challenges, albeit at low power.

Lessons in the field from the initial DLOS experience have been invaluable in planning future relay system development. To further enhance the learning value of the dual-gimbal DLOS payload, Boeing will continue to evolve the hardware and software toward fully autonomous performance capability while suspended, inverted, from an airborne carrier or crane. For more realistic short-range field demonstrations, we are also considering hardware modifications to permit augmentation of power sources by several kilowatts.

**Figure 2.** The relay payload constitutes an all on-board system.

**Figure 3.** This dual line-of-sight (DLOS) mobile payload is half-scale and fully functional.

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