Low Mirror Count Tactical High Energy Laser (HEL) Beam Control Architecture

Background and Technology Need

High energy laser (HEL) weapons, such as the Airborne Laser (ABL)[1], have high power optical trains containing more than a dozen mirrors. Tactical weapons, however, need to be far more compact with minimal high power trains.

Tactical high energy lasers (HEL) require sophisticated beam control systems. As tactical applications employ smaller HEL systems, the size, weight and complexity of the accompanying beam control system must come down as well. The typical tactical HEL beam control system includes (i) a gimbaled beam director, (ii) tracking and pointing functions, (iii) adaptive optics, (iv) acquisition sensors, and (v) target illuminators. Any solution that drives towards a smaller lighter and simpler beam control system has to consider the entire end-to-end system architecture.

Existing beam control solutions are robust but large and complex. The technical strides achieved in the past 20 years in wavefront sensing, aperture sharing elements, beam tracking and beam correcting give us the tools to offer a simplified low mirror count beam control system while retaining the ruggedness of function so necessary for a tactical laser weapon.

Technology Highlights and Status

Under the SBIR Phase I project sponsored by the Air Force, Optical Physics Company (OPC) has verified at TRL 3 the feasibility of a novel HEL beam control architecture that offers reduced complexity and component count and combines many functions into a compact arrangement. The HEL architecture's key features are:

- End-to-end boresight tracker with 0.1 microradian rms accuracy at 10 KHz
- No Beacon Illuminator Laser (BILL) required
- Real-time BQ measurements on target during each engagement
- Extremely compact and lightweight beam train suitable for flight
- Primary mirror which is also a Deformable Mirror (DM) and a Fast Steering Mirror (FSM)

In summary, this new architecture has only the HEL module and the beam director. All the measurement and correction functions have been integrated into the beam director without increasing the number of high power components usually required in a Coude path.

Each of the three key advantages is discussed in more detail below.

<u>1. Minimizing complexity and component count</u>:

The optical control architecture has **only six mirrors plus a turret window and two polarizers between the HEL module and the target**. The resulting beam line is considerably simpler, smaller and lighter than current architectures. Almost every component in the beam line performs multiple functions, thereby dramatically reducing the component count. There is only one Long-Burn Deformable Mirror (DM), one Coarse Steering Mirror (CSM), one Fast Steering Mirror (FSM) – and all of these are integrated into the beam director. This approach also packages all beam control sensors, processors and drivers into the turret assembly.

<u>2. End-to-End Boresight and High Bandwidth Tracking</u>:

In this design, the HEL and Track Illuminating Laser (TILL) trackers are integrated onto the same focal plane and are controlled by a single fast steering mirror – which is also the primary mirror and DM. This eliminates the traditional split between local and target loop stabilization, combining both into a single controller. This is accomplished so that the high power path is minimized to its fundamental limit of six mirrors, which are necessary to get the beam from the HEL module up the Coude path and out through the telescope.

[1] http://www.airforce-technology.com/projects/abl/

3. Eliminating the BILL:
The BILL is a solid-state, kilowatt-class laser that measures atmospheric conditions, allowing the beam control/fire control system to compensate for atmospheric turbulence that the HEL would encounter in its path to a target. The beam from the BILL bounces off the target and returns to the HEL source, where optical and software equipment measures the amount of distortion in the atmosphere between the HEL source and the target. The HEL AO system then compensates for the distortion using a deformable mirror. Eliminating the BILL is an important step towards taking tactical lasers into the mainstream of weapons available for air-to-air, air-to-ground and ground-to-air engagements.

OPC's design has been selected for progressing onto the next phase of the SBIR (Phase II).