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Disruptive High-Energy Laser Technology

Eighty-eight years ago, Albert Einstein conceived of stimulated emission, the basis of the laser. Forty-two years ago, the first laboratory experiment confirmed lasting lasing light generation. That, in a nutshell, is the history of the laser. But what about its future? I believe we need not wait another 88 years, or 42 years, or even 10 years, before we see military lasers live up to their potential in the field. I believe the age of the military laser is about to arrive.

We are keen to find ways to accelerate the development of lasers and get them into the field. We believe the efficiency gains are at hand. We believe we can soon make high-energy laser weapons and battlefield power sources a reality. We believe all this because DARPA high-energy laser technology programs are beginning to prove it.

Consider: In recent years, the rapid commercial development process resulted in common, everyday applications for the laser. We use lasers as pointers, as levels to check for plumb, as supermarket scanners, as the "needles" in CD players, as scalpels in eye surgery. The breakneck commercial development of the laser from exotic science to an everyday, pocket-protector device suggests this is a young technology just beginning to be useful, and that it can be pushed to higher powers and more versatile uses.

The current state of military laser technology falls far short of its potential. Using lasers to paint targets and guide ordnance is like using a supercomputer to balance your checkbook. We can do much better than that. We can do much better than even the most recent advances in technology and achieve revolutionary gains in high-energy lasers.

When I was a boy, weapons that shot beams of light were the stuff of pulp magazines and Saturday morning serials. While I hesitate to admit that I am a Buck Rogers or Star Trek fan, I have to say it is fascinating how science fiction can anticipate reality. The potential exists for a weaponized laser to be carried on a Humvee, if not by a single Soldier.

In short, the time has come to push novel approaches that can drive factors of 10, or even more, gains in the field. We need laser weapons that are small enough, light enough, and power-efficient enough to make sense on the battlefield. Neither chemical nor solid-state lasers have reached the efficiency levels needed for true battlefield deployment and combat readiness.

The fact remains that chemical lasers have to lug a portable chemical plant into the field.

The fact remains that solid-state lasers require too much power and "coolant" to be practical in combat.

We need new laser technologies that are truly disruptive, that push the laser to dramatically higher levels of efficiency. That's the only way we're going to have realistic weapons.

We also have to consider very carefully how we will use high-energy lasers in the battlefield. For all the talk of lasers as a speed of light weapon, it takes time to manage the movement and servicing of a laser power plant. It also takes time to position a laser and track a target, and it takes time to kill the target. In the end, a laser is only as fast as the technology and machinery that supports it.

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I think the potential for disruptive technologies are at hand. DARPA's high-energy laser programs recently made breakthroughs in these directions with liquid, fiber, and even air lasers. We have made breakthroughs as well in critical enabling technologies for high-energy lasers, such as high-efficiency laser diode pumps and MEMS-based spatial light modulators. These advances hint at the technologies that will enable "killer applications" in the battlespace of the near future.

Getting high-energy lasers and their enabling technologies out of the lab and into the field will be a huge step toward pushing them forward and getting into the field the kinds of weapons our military needs; however, all these existing technologies are evolutionary. As promising as they are, we are even hungrier for laser technologies that are truly revolutionary and disruptive.

Efficiency is the key—the way to reduce volume and mass. To be effective weapons, lasers must attain much higher levels of efficiency. DARPA believes we can already coax 5 kilograms of mass to produce 1 kilowatt of power. Think of what will be possible when we develop a high-energy laser that can deliver, instead of 5 kilograms per kilowatt, 5 kilowatts per kilogram. If someone today has an idea how we can achieve that goal without violating the laws of physics, you have what we need to launch a real and very promising DARPA-hard program!

We're determined to make high-energy lasers more rugged and to produce beam directors with dramatically lighter mass. A battlefield laser could probably use a beam director with an aperture of up to 1 meter. Can you suggest a way to design a 1-meter beam director subsystem, including all the options, that weighs less than 100 kilograms? Less than 50?

If we can do these things, the first killer applications I can think of are the applications that kill. Weaponized lasers in the hands of US Armed Forces could one day be as common as commercialized lasers in the hands of your local grocery store clerk. In the field, such weapons would be as effective a deterrent as one can imagine.

Another application is tantalizingly conceivable: Can lasers become a power source for the battlefield? If we can replace copper wires with fiber and electrons with photons, we will drop loads of mass off military planes, making them more maneuverable. Ships can become less vulnerable. All our assets can become stealthier and more jam resistant.

The chance exists that we might actually be able to use lasers to move power through the air. Imagine an unmanned air vehicle (UAV) powered by ground-based lasers. Such a capability would add exponentially to the flexibility of our forces in the field. Whether that is a real possibility or so much photonic pie in the sky, the fact remains that laser power is sure to revolutionize the capabilities of our battlefield assets.

In conclusion:

- We need to make lasers more efficient weapons and power sources—with batteries included.
- We need to drive new efficiencies in diode-laser pumps.
- We need to apply new physics beyond solid-state and chemical lasers and convert from voltaic to optical power sources. It is going to take photons, not electrons, to enable new high-power military applications of the future.

I freely admit we are pushing against the edges of what is currently known. We are challenging known physical limits. But it is precisely this sort of thinking that created the laser in the first place. Charles Townes, who shared a Nobel Prize for the invention of the laser, once thought the Second Law of Thermodynamics made stimulated emission impossible. One morning, while walking through Franklin Park in Washington, DC, Townes had an "aha" moment. He realized he did not have to worry about achieving thermal equilibrium. He immediately started jotting down calculations on the back of an envelope—and the work began.

Charlie Townes simply refused to accept the barrier in front of him—not even one as authoritative as the Second Law of Thermodynamics. He saw that there is always a way around a barrier, or over it, or through it. Somewhere, one of us is going to have such an "aha" moment. And when that happens, we are going to see:

- Efficiencies pushed to undreamt of levels. Laser diodes with efficiencies of 80 percent or more.
- Five kilograms of mass, batteries included, producing more than 1 kilowatt of power.
- Lasers transforming the power system of the battlefield, making our forces lighter, stealthier, and safe from interference.
- Many more applications we cannot even imagine.

The inventors of the laser could not envision all the commercial, medical, and industrial applications of their brainchild. No doubt, we are in the same position, unable to see the full potential of the breakthroughs we're making, but we are prepared to be astonished!

That's the beauty—the payoff—of science. That's why we're in this game. For myself, I can't imagine doing anything else. I look forward to meeting with you and hearing your best, your most disruptive, ideas.