LASER BEAM PERFORMANCE

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ABSTRACT

Given some lasers, perform an experiment that will measure how much a laser beam will propagate and broaden in a maritime environment and write about that practical use of a laser as a targeting and weapons system in modern warfare based on the results.

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PURPOSE

To qualitatively understand a laser targeting system and the associated challenges of operating a laser and accurately illuminating a target.

SETUP

Two lasers were used in this experiment, both using 2 milliWatts of power to operate the lasers, with power provide by a gas powered generator. Location for the experiment is the United States Naval Academy whose location meets the experimental needs for a maritime environment, with the experiment taking place at sea level near the water. The lasers were both setup on tripods with mounts that allowed for adjustments to the lasers direction and elevation. One laser is going to be outputting a standard beam to the target; however, the other laser will have a diffractor that will modify the beam. The cameras that were used were also placed on tripods and used a variety of filters to block out the light from the sun, allowing the light from the laser to be seen. The laptops used to record the data were placed on a folding table, powered by their batteries, and connected to the cameras using a special USB cord.

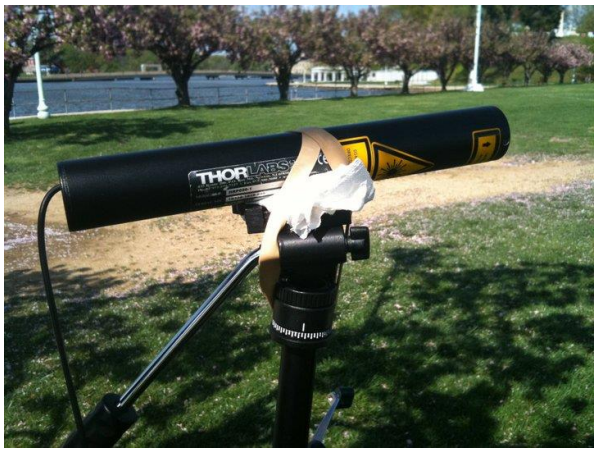


Figure 1: The laser without modifications

PROCEDURE

1) Setup all the equipment onto tripods and tables. Measure out the first distance and set up the cameras and laptop at that distance.
2) Start up the generator by following the instruction included with the generator.

   CAUTION: Exhaust from the generator will be hot and so will the exhaust pipe. Do not touch it or you may be burned.
3) Plug in all items that require an external power source, one being the lasers. WARNING: Do not look into the laser or point the laser at anybody's eye. Even though these are low powered lasers, damage to vision can still occur.
4) Carefully align the laser to point at the camera. Use any method you wish, once suggestion being that you use white poster board and walk the laser to the camera. Once at the camera, adjust the camera to meet the laser.

Figure 2: Aligning the Laser

5) Adjust the filters so that the cameras see only the laser light.
6) Record the data of the laser on the camera, such as recording the camera picture on the laptop and measuring the width of the laser beam by using graphing paper as an estimate.

7) Reposition the cameras at the new distance and repeat from step 4 till complete.

RESULTS

5 meters:

At 5 meters from the laser, aiming of both lasers were easy, though it took more time to work out the second one as the beam was so dim in the sunlight, the methods to aim the beam had to be made up on the spot which was then included in the procedure. Getting the cameras to work took quite a bit of time since the filtering level had to be just right in order for the cameras to catch the light from the laser and not the sun. In addition, the program used to capture to laser light was experiencing problems that slowed the process down. The results we received were as expected; the size of the unmodified laser was less than 5 mm in diameter at 5 meters, while the modified laser was at about 10 mm in diameter. And the concentration of light in the unmodified beam was higher than in the modified beam, as well as the unmodified beam experiencing less distortion from the atmospheric effects.

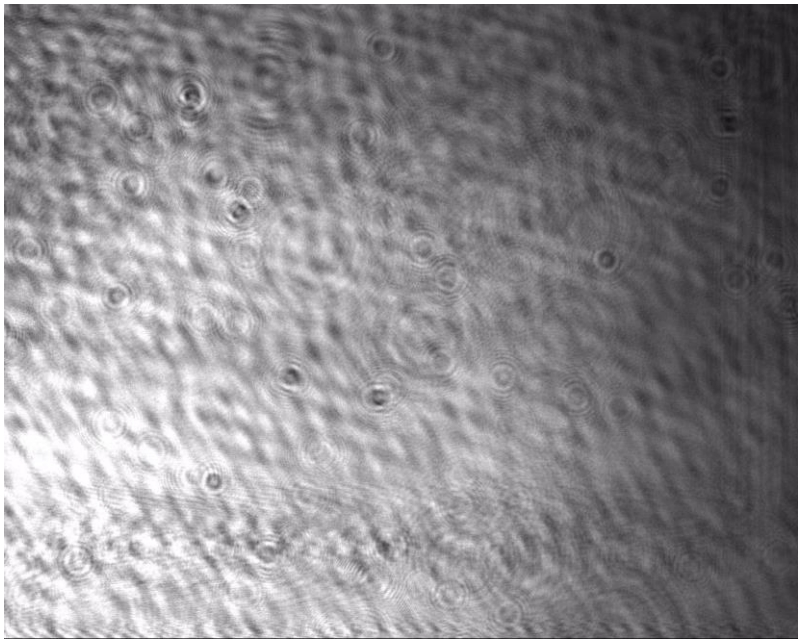


Figure 3: Picture from the Modified Laser at 5 meters

10 meters:

Aiming the lasers at 10 meters was still relatively easier, although it became harder to do on the modified laser since it was nearly impossible to see in the direct sunlight and artificial shade had to be made in order to align the camera to the laser. The spread of the normal laser had increased in diameter to about 5 mm while the modified laser remained at 10 mm in diameter. The concentration of light from the unmodified laser was less at 10 meters than at 5 meters but it was barely noticeable. The modified laser lost some light concentration but the spread remained the same where as the unmodified laser lost power and had a wider beam. Also the effects of distortion such as the blowing wind and rising heat off the ground were more noticeable as the beam was bouncing around the camera picture much more.

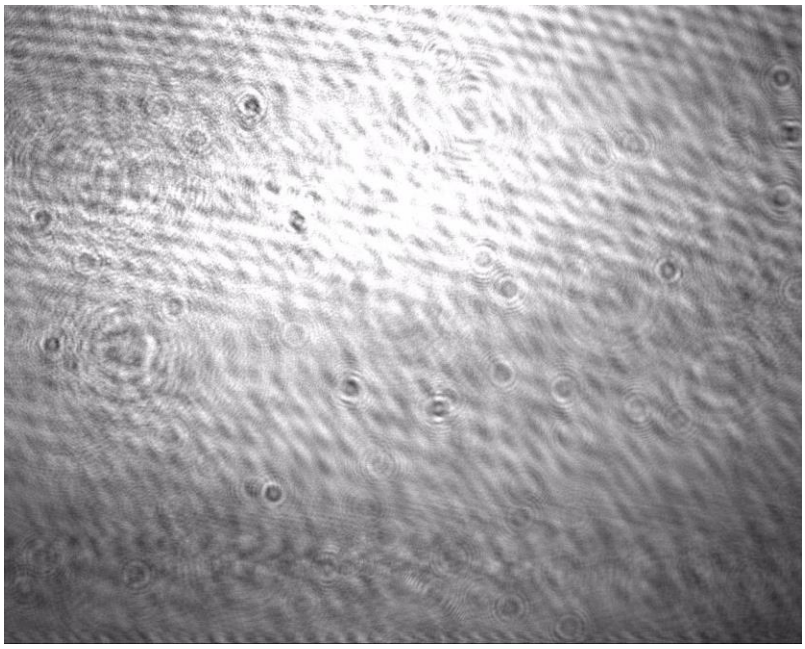


Figure 4: Picture from the Modified Laser at 10 meters

100 meters:

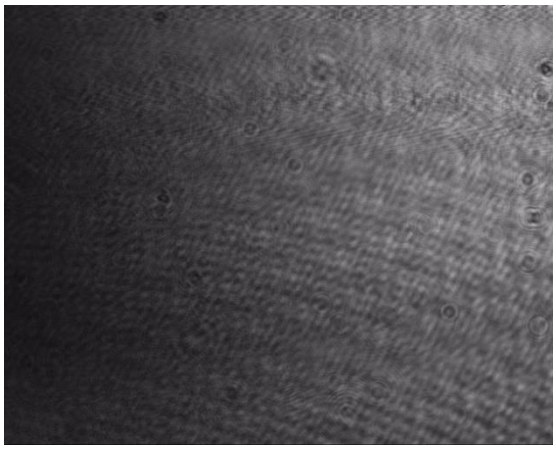
Aiming the lasers at 100 meters was difficult. The unmodified laser would not reach out that far in direct sunlight and we lost sight of the laser at around 88 meters. The modified laser reached out to 100 meters and surprisingly remained at around 10 mm in diameter and experience some loss in power concentration, other than that, the laser was still viewable on the camera. Distortions of the beam were noticeable on the camera and while using the color camera which displays the light concentration on the laptop screen as a color, the edges of the laser were seeing the effects of the environment on the beam. Unfortunately, the power was cut to the laser before a picture could be taken the effect of the environment on laser beams was clear at that point. 

Figure 5: Picture from the Modified Laser at 100 meters

CONCLUSION

From the results of the test, use of a laser targeting system while difficult, is a very real possibility. To make targeting more accurate, either a computer must be used with a system that can track objects quickly depending on its mission, or have a beam powerful enough that it is visible in the daylight so that troops using it can see where the beam is going to land. Use of the laser in air, ground, and sea targeting systems is already in use today, though the lasers used today are purely for marking of the target and are highly advanced in their construction and

operation. The use of lasers as a weapon is going to require some heavy modifications to the existing systems. First the power output of weaponized lasers is going to have to be 10 fold the power of what we were using today, requiring much more power and complex assembly. And as shown by the experiment, an unmodified laser, while powerful at closer ranges, falls off at distance, so some sort of focusing lens will be required to focus the beam into a small target area to produce enough thermal energy to destroy or disable the target. The tracking systems of such lasers would have to be linked to computers to compensate for a number of environmental factors, such as the ships moving in the sea, ground effect, heat rising, wind, temperature, pressure, etc. Such advanced systems would be expensive to build and operate, however the benefits of a laser weapon system allow of a number of new options in defensive and offensive capabilities for US forces ranging from destroying tanks to destroying ballistic missiles.

RECOMMENDATIONS

For future test, a better way to aim the laser would be beneficial and save a large amount of time. Also, sorting out the problems with the computer program will speed the testing process up so we can gather more data in the limited time that was available to us. Another way to improve the experiment is to use of a more powerful laser that would allow us to see the laser better and to collect data from it easier as the beam would be easier to see by the cameras.

CREDITS

Professor Svetlana Avramov-Zamurovic for assisting in the running of the experiments by providing oversight and guidance in addition to providing the supplies to run the experiment.

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