

High Power, High Repetition Rate, Pulsed, Blue Laser for ASW Purposes

JP Innovations, LLC

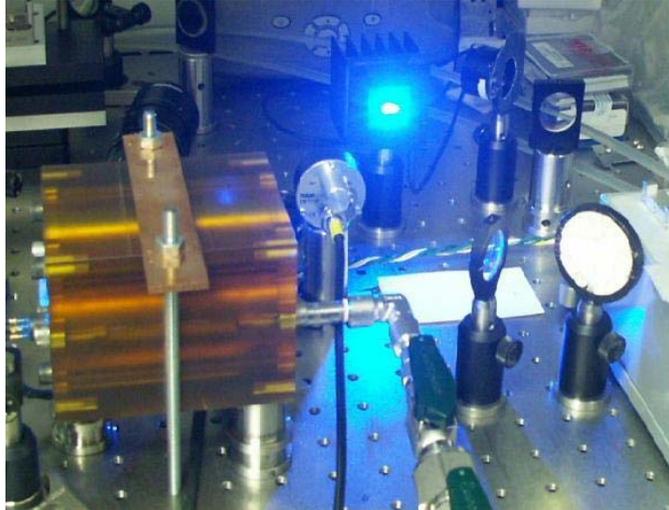
101 East Main St., Suite 207
Monroe, WA 98272

Mr. Jeffrey Pierce

Phone: (360) 805-3124
Fax: (360) 805-3126
Email: jpierce@jpinnovations.com
Website: www.jpinnovations.com

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PROBLEM STATEMENT

The Navy is investigating lasers with very particular performance characteristics for the Anti-Submarine Warfare (ASW) application; that is detection, location, and characterization of submarines traveling at depth and speed in deep ocean water. Detecting underwater objects such as mines, cables, and other potential hazards is also of interest. For this particular application the laser wavelength must be in the blue region of the visible spectrum, from about 450 nm to 490 nm, as was indicated in the SBIR Phase I solicitation. This laser can be used to locate objects in the ocean from an airborne platform – both “deep” ocean water and littoral water.

The technology under development consists of a novel design for a blue wavelength laser that can meet ASW requirements. The current technology that works well only in littoral water is green lasers operating at 532 nm. But the green wavelength is rapidly attenuated in deep ocean water, rendering the currently available laser technology unsuitable for the ASW application.

This use of a laser is known as Bathymetry – a short pulse laser beam is directed into the water, typically from an airborne platform, and a return signal from an object of interest is detected by a receiver in the aircraft. Of course the return signal is very weak, so minimizing the attenuation of the water is very important. The blue laser under development operates at a wavelength of 473 nm, which is near the optimum wavelength to be used in both deep-ocean and littoral waters. This means that the Navy can use this laser in a sensor system that will cover the broadest possible range of operational scenarios.

The initial deployment of this laser is anticipated to be in helicopter platforms. The laser can be installed in a pod carried outside of the helicopter. In the future the Navy may consider use of this laser in Unmanned Aerial Vehicle (UAV) platforms, if the size, weight and power consumption of the laser can be made compatible with suitable UAV platforms.

WHO CAN BENEFIT?

The technology under development for blue lasers is specifically oriented to the ASW application for the Navy. However, the fundamental technical approach can also be used to make 532 nm green lasers with higher average power, better beam quality, and in smaller and lighter packages than current technology being used for other Department of Defense (DoD) applications, such as the Airborne Laser Mine Detection System (ALMDS). There are also commercial applications of this technology once it has been fully developed.

BASELINE TECHNOLOGY

At the moment there is no laser based, active LIDAR program of record for the ASW application. The closest technology that could be called “baseline technology” is the ALMDS program for detecting mines and other objects in littoral waters. This program uses a green (532 nm) laser in a pod mounted to a helicopter platform. The green wavelength works well in littoral waters, but is not suitable for the ASW application in deep ocean water.

It is much easier to make a green laser than a blue laser – nature has not provided a simple solution to making the blue laser wavelength, whereas green lasers are common. This is the primary reason that green lasers are being used in airborne Navy platforms – a laser with suitable performance is available and can be purchased. The primary effort of this program is to make blue lasers of appropriate performance available to increase the range of possible applications.

The Blue laser can potentially be substituted for the green laser into existing Navy platforms, reducing the cost of transition to the new technology which will provide superior performance.

TECHNOLOGY DESCRIPTION

The most important feature of this technology is producing the blue output wavelength of 473 nm with substantial pulse energy and high repetition rate. This laser source will improve detection capability of an active ASW program. Substantial blue pulse energy is required to be able to detect submarines in sufficiently deep water to make the sensor system widely useful.

Further, the laser must operate at high pulse repetition rate, from 100s of pulses per second up to 1000 pulses per second. This will make a practical sensor system that can cover a large area with a single airborne platform.

JP Innovations is currently developing a green laser for the Coastal Zone Mapping Imaging Lidar (CZMIL) system which will operate in a small aircraft. The blue laser will be fabricated with similar manufacturing assembly technology so the system will be ready to be tested in an airborne environment.

The following is a Features, Advantage, Benefit table which discusses the primary benefits of the new technology.

Feature	Advantage	Benefit
Blue Wavelength (473 nm)	Best transmission in ocean water over a wide range of ocean conditions	The Navy will be able to sense submarines and other objects of interest in much deeper “blue” ocean water than is possible now. This wavelength is also favorable for operation in littoral waters so the same sensor system can be used for both regions of the ocean, reducing total system complexity and cost.
High Pulse Energy (10 mJ)	System can detect objects in deeper water	Offers a new detection capability to the Navy that is not currently available
High Pulse Repetition Rate (up to 1 kHz)	Rapid data collection	Wider area coverage with a single system, reducing platform cost and redundancy
Compact Size	Can be integrated easily into various airborne platforms	Different airborne platforms – helicopter, UAV, etc. can possibly be used, increasing utility
Designed for airborne environment	Manufacturing processes have already been developed by JP Innovations for other airborne lasers	Lower development cost for laser system, higher reliability in operational environments, and lower deployment costs
Scaleable design	Pulse energy can be increased	Potential use of technology for other applications
Technology can be modified to use for different wavelength applications	A broad range of laser applications for the DoD can be addressed	Common design features simplifies systems and reduces development costs and time

The laser shown in the photograph of Figure 1 is a 20 mJ “eye-safe” laser operating at a wavelength of 1.57 microns manufactured by JP Innovations. It is used for ranging and infrared illumination applications on aircraft test ranges. This laser has been environmentally tested and operates over a temperature range of -20C to + 45C. It is used on a high speed tracking Lidar system, so it operates in an environment of shock and vibration. Multiple units are in the field and have been running now for several years.



Figure 1 – Photo of JP Innovations, LLC eye-safe laser head that has been environmentally tested and operates over a wide range of temperature conditions on a mobile platform. The blue laser under development will have a similar size and geometry to this laser.

The blue laser package will be similar to the photo shown in Figure 1 of the eye-safe laser system.

The value proposition for the Navy is to realize a LIDAR system that can see deeper into the ocean to better protect ships at sea. This laser is just a part of such a system, and it is anticipated that the cost of this laser will be < \$200k per unit in moderate quantities.

CURRENT STATE OF DEVELOPMENT

To date we have developed two critical technologies to make this blue laser system possible. The first major accomplishment was to create a new diode bar stack mounting and cooling technology that makes it possible to run the Quasi-CW (QCW) pump diodes at the high pulse repetition rate and on-time “duty factor” that will be required for this application. This diode stack mounting technology has been developed and demonstrated under this SBIR Phase II contract by our subcontractor, EOTRON, Inc. of Carlsbad, California.

The second critical technology was mounting and cooling technology for the laser crystals operating at 946 nm. This laser wavelength imposes extreme requirements on the pump and cooling geometry of the laser crystal, and we have successfully developed and demonstrated cooling technology that makes it possible for this laser wavelength to operate efficiently at significant pulse energy and high pulse repetition rate.

JP Innovations is conducting breadboard experiments to develop the blue laser system using these new components that have been designed, fabricated and assembled during the first year of the Phase II program. This breadboard work is ongoing and we will learn much about the physics of this difficult laser system.

After the laser parameters are successfully determined by breadboard experiments, then an environmentally sealed laser head package will be designed and assembled. The approximate anticipated dimensions of the blue laser head are L: 11" x W: 7.5" x H: 4.5". That packaged laser will then be environmentally tested and eventually delivered to the Navy for evaluation by the end of the Phase II program.

Milestone	TRL	Measure of Success	TRL Date
Breadboard demo of Blue laser	4	8 mJ of blue produced at low PRF	02-Apr-08
Packaged laser paper design	4	Design reported	08-Jun-09
New approach components ready for experiments	4	Experiments in progress	01-Aug-10
Prototype laser assembled	5	Laser package fabricated	21-Jan-11
Prototype laser tested and complete	5	Prototype laser delivered	01-Jul-11

REFERENCES

At this time JP Innovations has not discussed the laser performance with anyone but the TPOC's assigned to this SBIR Phase II contract:

TPOC – (301) 757-5735

TPOC – (301) 342-2034

WHEN THE TECHNOLOGY WILL BE READY FOR USE

At the present time the laser technology is at TRL 4. We have components of the laser system that have been specifically designed and developed for this laser, and we are now using these components on a "bench top" setup to determine and optimize overall laser performance. These newly developed components are at TRL 5 as they are manufactured with production techniques, but the laser system is presently at TRL 4.

Once we have characterized and optimized the laser performance with the breadboard setup, then a laser package suitable for airborne operation must be designed and

fabricated. Then the laser system will be assembled into the package which will result in the first blue laser of this type. At that point the laser system will be at TRL 5.

After the laser is packaged, the next step is to do environmental testing on the laser unit. This will involve temperature cycling, and shock and vibration testing. Issues discovered during the testing will need to be corrected, and then the testing repeated. After a few cycles of such testing, the laser will be ready to test in a real operating environment, and should qualify for a classification of TRL 6. It is anticipated that this environmental testing will occur on the Phase II option which is established in the contract but needs a funding decision.

After initial environmental testing, a concerted program will be required to move this laser technology into an "air-worthy" condition with the goal of eventual air qualification certification. This step will require additional support from the Navy program office, as airworthiness certification is a rigorous process. After this additional funding and continuing development, the laser technology will be approaching TRL 7 and will be ready for deployment in active Navy imaging systems.

ABOUT THE COMPANY

JP Innovations, LLC, now in our tenth year, is a small commercial manufacturer of diode pumped lasers and non-linear optical systems. We currently manufacture compact and portable pulsed diode pumped Nd:YAG lasers for laser induced breakdown spectroscopy (LIBS), 1064 nm target designator lasers for special applications, pulsed eye-safe lasers (1.57 um) for range finding and imaging applications, and short pulse high repetition rate green lasers for coastal mapping and bathymetry. We have developed many custom laser and non-linear optical systems over the past 10 years, and have delivered many solutions to our various customers. JP Innovations specializes in development of difficult and unavailable lasers for our customers to enable new and emerging applications, with a wide range of operating wavelength, pulse energy, repetition rate, and beam quality requirements.