Feasibility study on LED-based underwater gated-viewing for inspection tasks

1st Jendrik Schmidt
Institute for the Protection of Maritime Infrastructures
German Aerospace Center (DLR e.V.)
Bremerhaven, Germany
Jendrik.Schmidt@dlr.de

2nd Enno Peters
Institute for the Protection of Maritime Infrastructures
German Aerospace Center (DLR e.V.)
Bremerhaven, Germany
Enno.Peters@dlr.de

3rd Maurice Stephan
Institute for the Protection of Maritime Infrastructures
German Aerospace Center (DLR e.V.)
Bremerhaven, Germany
Maurice.Stephan@dlr.de

4th Oliver Zielinski
Institute for Chemistry and Biology of the Marine Environment
University of Oldenburg
Oldenburg, Germany
and *Marine Perception Research Group*
German Research Center for Artificial Intelligence (DFKI)
Oldenburg, Germany
Oliver.Zielinski@uni-oldenburg.de

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***Abstract*—A nanoseconds-pulsed LED illuminator design for underwater vision enhancement by gated-viewing is investigated and discussed in comparison to a state of the art laser source. An initial experiment in a turbid harbour at 2.5 to 3.0 attenuation lengths shows an increase in image contrast by a factor of about 2 to 6 achieved by an LED gated-viewing in comparison to non-gated, active and passive camera systems. In addition, an analysis of beam attenuation spectra in coastal areas of potential operation has been conducted. Different LEDs have been characterised, using a 6 ns electrical trigger pulse width. With this setup, optical pulse energies up to 7.2 nJ per LED at optical pulse widths of 4.6 ns could be achieved. The photon return of an upscaled LED-based illuminator in a coastal environment is estimated and its characteristics, potentials and drawbacks are discussed.**

***Index Terms*—active imaging, gated-viewing, LED illumination, underwater inspection**

I. Introduction

The detection, identification and assessment of discarded military munition and unexploded ordnances has been of interest for many years and its importance will even grow in the future, given the extend of this global risk to marine life and work at sea. It is estimated that there are approximately 1.6 million tons of munition in German marine waters alone. Of this, about 1.3 million tons are assumed to be in the North Sea [1]. Especially in coastal areas with extensive fishery, ship traffic and offshore activities, contact with potentially hazardous munition is likely. The increased use of the seafloor for offshore constructions like cables, wind farms or oil and gas installations rose the awareness of this topic [2], [3]. Nevertheless, remediation of dumped munition on a grand scale in the near future is unlikely, mainly because of the excessive costs of such a project. At the moment, the decision to remove munition from the seabed is made only if there is an acute safety risk [2]. However, findings have to be subject to risk assessment and the state of non-cleared munition has to be monitored. This is especially critical in the case of corroding, potentially leaking chemical munition as their warfare agents directly affect the surrounding marine environment and life [3]. Still, with the risk of uncontrolled explosions or release of toxic explosives, all types of munition can be dangerous in case of direct contact [4].

After detection, which is usually done by sonar scanning to achieve a sufficient high area coverage or magnetic sensors to detect objects within the sediment, the munition has to be identified and assessed in terms of corrosion and leakage of toxic chemicals. Thus, chemical, optical and close range, high resolution sonar sensors are utilised for inspections. Today these works are performed either by divers or with the help of remotely operated vehicles (ROV). During assessment the spreading of potentially contaminated ground sediments has to be prevented, thus inspection from larger distances is preferred.

In coastal areas and waters like the North Sea or Baltic Sea, the turbidity due to sediments, algae and marine life limits the visibility range of optical instruments. However, they offer different imaging characteristics compared to sonar, which makes them a valuable addition in inspection.

At greater depth or within wrecks, where ambient light availability is reduced, artificial light sources are required. However, active imaging is prone to backscatter in turbid waters, significantly decreasing visibility range and image quality. Consequently, throughout the years, many different techniques and systems have been in focus of research and development reducing the effect of scattering through time, space, spectral, polarisation or coherency discrimination [5], [6].