# CPS: Synergy: Collaborative Research: DEUS: Distributed, Efficient, Ubiquitous and Secure Data Delivery Using Autonomous Underwater Vehicles

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Project Details

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| **Performance Period:** | 08/31/18 - 12/31/19 |
| **Institution(s):** | Lehigh University |
| **Sponsor(s):** | National Science Foundation |
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**Abstract:** Ocean Big Data (OBD) is an emerging area of research that benefits ocean environmental monitoring, offshore exploration, disaster prevention, and military surveillance. It is now affordable for oil and gas companies, fishing industry, militaries, and marine researchers to deploy physical undersea sensor systems to obtain strategic advantages. However, these sensing activities are scattered, isolated, and often follow the traditional "deploy, wait, retrieve, and post-process" routine. Since transmitting information underwater remains difficult and unreliable, these sensors lack a cyber interconnection, which severely limits ocean cyber-physical systems. This project aims to providing a viable cyber interconnection scheme that enables distributed, efficient, ubiquitous, and secure (DEUS) data delivery from underwater sensors to the surface station. The proposed cyber interconnection scheme features cheap underwater sensor nodes with energy harvesting capability, a fleet of autonomous underwater vehicles (AUVs) for information ferrying, advanced magnetic-induction (MI) antenna design using ferrite material, distributed algorithms for efficient data collection via AUVs, and secure data delivery protocols. The success of this project will help push the frontier of Internet of Things in Oceans (IoTO) and OBD, both of which will find numerous underwater applications in offshore oil spill response, fisheries management, storm preparedness, etc., which impact the economy and well-being of not only coastal regions but also inland states. The project will also provide special interdisciplinary training opportunities for both graduate and undergraduate students, particularly women and minority students, through both research work and related courses on underwater wireless communication, network security, and AUV designs. The DEUS project provides a viable cyber interconnection

scheme that enables distributed, efficient, ubiquitous, and secure data delivery in underwater environment via four synergistic thrusts: (1) integration of underwater wireless sensor and communication systems, which will enhance the current MI and light communication means of underwater sensors, integrate acoustic transmission systems for long-range communications between anchor nodes and AUVs, and design energy harvesting and replenishment solutions to prolong the lifetime of underwater sensors (30+ years); (2) distributed and ubiquitous data delivery via multiple AUVs, which aims to collect the distributed data and deliver them ubiquitously throughout the underwater network by employing ferrite material and triaxial induction antennas and mounting them outside of the AUV body for MI enhancement, and developing algorithms of multiple AUVs' path-planning, trajectory optimization, etc. under dynamic network conditions; (3) efficiency and security in data delivery, which designs network algorithms to improve the efficiency and security of data delivery. Instead of collecting data from every sensor via acoustic communications, the AUVs choose some sensors to collect data with the high data rate transmission mode in near field (e.g., light), and allowing the sensor far away from the AUVs to send its data either directly to AUVs via acoustic wave or to its nearby chosen sensors via MI/light communications. A secure data delivery scheme will also be developed to not only secure the data delivery against typical malicious attacks and guarantee the integrity of collected data, but also allow the data aggregation of one business entity without knowing others' private business information; (4) experimental validation and testing, which will verify the proposed data delivery schemes, and quantitatively present the performance gains through simulations, experiments and field test, based on existing facilities.