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Standard Guide for Unmanned Undersea Vehicle (UUV) Physical Payload Interface¹

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INTRODUCTION

ASTM has prepared this series of standards to guide the development of autonomous unmanned underwater vehicles (UUVs). The standards address the key capabilities that a UUV system must possess in order to be considered autonomous and reconfigurable:

Autonomous—Capable of operating without operator input for extended periods of time. Implicit in this description is the requirement that the UUV's sortie accomplishes its assigned goal and makes the appropriate rendezvous for a successful recovery.

Reconfigurable—Capable of operating with multiple payloads.

The top level requirement is established that the UUV systems will consist of:

Payloads to complete specific system tasking such as environmental data collection, area surveillance, mine hunting, mine countermeasures, intelligence/surveillance/reconnaissance (ISR), or other scientific, military, or commercial objectives.

Vehicles that will transport the payloads to designated locations and be responsible for the launch and recovery of the vehicle/payload combination. While the payload will be specific to the objective, the vehicle is likely to be less so. Nevertheless, commonality across all classes of UUV with respect to such features as planning, communications, and post sortie analysis (PSA) is desirable. Commonality with regard to such features as launch and recovery and a common control interface with the payload should be preserved within the UUV class. In accordance with this philosophy, ASTM identifies four standards to address UUV development and to promote compatibility and interoperability among UUVs:

- F2541 Guide for UUV Autonomy and Control,
- F2545 Guide for UUV Physical Payload Interface,
- F2594 Guide for UUV Communications, and
- F2595 Guide for UUV Sensor Data Formats.

The relationships among these standards are illustrated in Fig. 1. The first two standards address the UUV autonomy, command and control, and the physical interface between the UUV and its payload. The last two ASTM standards address the handling of the most valuable artifacts created by UUV systems: the data. Since there are many possibilities for communications links to exchange data, it is expected that the UUV procurement agency will provide specific guidance relative to these links and the appropriate use of the UUV communications standard. In a similar manner, specific guidance is expected for the appropriate use of the UUV data formats.

F2541 Standard Guide for UUV Autonomy and Control—The UUV autonomy and control guide defines the characteristics of an autonomous UUV system. While much of this guide applies to the vehicle and how the vehicle should perform in an autonomous state, the relationship of the payloads within the UUV system is also characterized. A high level depiction of the functional subsystems associated with a generic autonomous UUV system is presented. The important functional relationship established in this guide is the payload's subordinate role relative to the vehicle in terms of system safety. The payload is responsible for its own internal safety, but the vehicle is responsible for the safety of the vehicle-payload system. Terminology is defined to provide a common framework for the discussion of autonomous systems. System behaviors and capabilities are identified that tend to make a system independent of human operator input and provide varying levels of assurance that the UUV will perform its assigned task and successfully complete recovery. A three-axis sliding scale is presented to illustrate the system's level of autonomy (LOA) in terms of situational awareness,

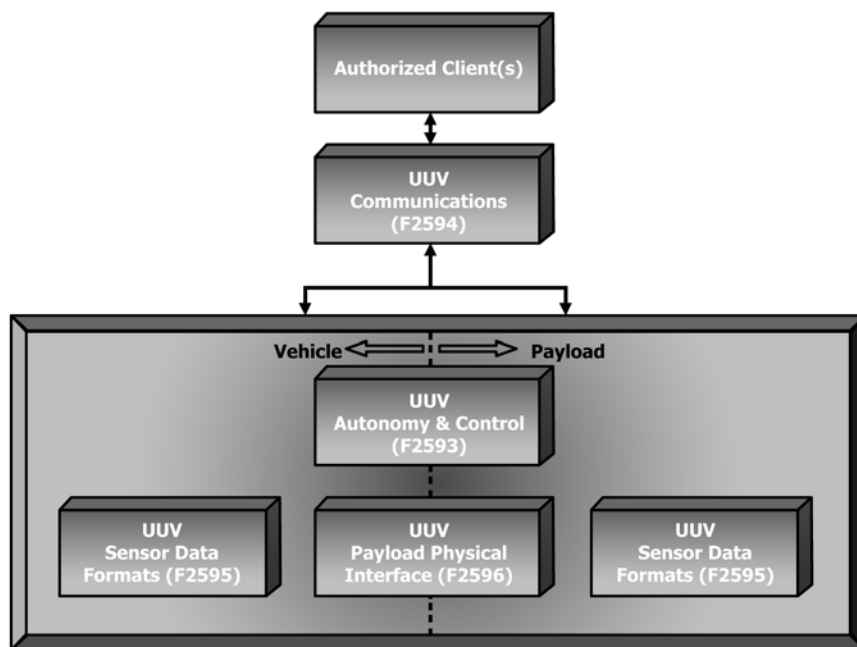


FIG. 1 Notional System Interfaces and Governing Standards

decision-making/planning/execution, and external interaction. The control interface (messages exchanged between the vehicle and the payload) is described and instantiations of this interface for the various classes of UUV are presented in associated appendices.

F2545 Standard Guide for UUV Physical Payload Interface—The UUV physical payload interface guide is a physical and functional interface standard that guides: the mechanical and electrical interface between the vehicle and the payload, and the functional relationship between the vehicle and the payload. Inasmuch as a single physical interface standard cannot address all classes of UUVs, this guide describes the physical interfaces in the body of the guide and provides appendices to guide the instantiation for each of the classes. This guide reinforces the relationship between the vehicle and the payload and confirms the permission-request responsibility of the payload and the permission granted/denied authority of the vehicle.

F2594 Standard Guide for UUV Communications—The UUV communications standard guides the development of offboard communications between the UUV system and the authorized clients, that is, those agents designated by the UUV operational authorities with responsibility for programming, operating, or maintaining a UUV, or a combination thereof. An authorized client may also represent an end user of UUV and payload mission data. Such a standard is required to provide for UUV interoperability with multiple authorized agents and to provide the authorized agents with interoperability with multiple UUVs (preferably across the different classes of UUVs). Optical, RF and acoustic methods of communication are considered. While RF communication is a matured communications mode and existing standards are referenced and adopted for offboard surface communication, underwater acoustic communication (ACOMMS) is an evolving field and interoperability between the different ACOMMS systems is also evolving. Typical ACOMMS systems and protocols are described with typical applications related to bandwidth and range. General comments are provided for optical communication as the use of this mode of communication may evolve in the future.

F2595 Standard Guide for UUV Sensor Data Formats—The UUV sensor data formats guide provides the UUV and payload designer with a series of commonly accepted data formats for underwater sensors. These formats provide the opportunity for two-way interoperability. Their use facilitates the UUV system's ability to process historical environmental data for mission planning purposes. Likewise, use of these formats facilitates the end users' ability to catalog, analyze, and produce recommendations based on current field data. Fig. 1 suggests that both vehicle-specific data as well as payload sensor data should be stored in these data formats.

¹ This guide is under the jurisdiction of ASTM Committee F41 on Unmanned Undersea Vehicle (UUV) Systems and is the direct responsibility of Subcommittee F41.03 on Mission Payload Interface.

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1. Scope

1.1 This guide covers the interface requirements for physical payload interface for Unmanned Undersea Vehicles (UUVs). In its initial release, the purpose of this standard is to specify the physical, electrical, and operational interfaces between the host UUV and the modular payload sections. This guide provides specific requirements for the 21-in. heavy-weight UUV body. Future iterations of this standard will add requirements for additional bodies.

1.2 The desired system is based on the qualitative features defined in this guide and the quantitative requirements as specified in individual performance specifications. Quantitative measures are beyond the scope of this guide. The resulting system is a combination of both.

1.3 This guide is intended to provide the developer with parameters necessary to integrate various combinations of system components and mission payload packages into the UUV, but at the same time not specify particular products. The established standard evaluates several autonomous vehicle architectures, performs a functional decomposition, and identifies key aspects that are common throughout. Through this process, a common architecture standard can be adopted that covers the family of unmanned undersea vehicles (UUVs) and the integration of emerging technologies.

1.4 This guide should be tailored to each application.

1.5 This guide does not attempt to specify a particular version of a commercial product or tool, but it does show examples that might conform. This guide does not address specific system functionality required of UUVs, but focuses on architectural matters.

1.6 The values stated in inch-pound units are to be regarded as standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

F2541 Guide for Unmanned Undersea Vehicles (UUV) Autonomy and Control (Withdrawn 2015)³

F2594 Guide for Unmanned Undersea Vehicle (UUV) Communications

F2595 Guide for Unmanned Undersea Vehicle (UUV) Sensor Data Formats

2.2 Government Standards:⁴

NAVSEA 5855688 Mk 48 Shell Joints Male/Female

NAVSEA 8293251 System Specification for the Mission Reconfigurable Unmanned Undersea Vehicle System (MRUUVS)

3. Terminology

3.1 Definitions:

3.1.1 *application software*, *n*—high-level software that is unique to the application for which the processor exists and represents the major cost driver of long-term development costs.

3.1.2 *application software interface*, *n*—boundary between the application software and the software execution platform.

3.1.3 *autonomy module*, *n*—in accordance with Guide **F2541**, a higher-level controller that interfaces with external systems (that is, mission downloads, mission retasking from platforms, and so forth).

3.1.3.1 *Discussion*—The mission controller tracks obstacle and terrain avoidance inputs and may update or replan the UUV sortie based upon sensor input to meet mission plans and objectives.

3.1.4 *conformance*, *n*—degree by which a design conforms to a particular standard.

3.1.5 *device drivers*, *n*—low-level software that manages the input and output to the various external devices in support of the application software.

3.1.6 *distributed architecture*, *n*—allows for local control of processes and local processing of data, which eliminates the need for passing large amounts of data across networks.

3.1.6.1 *Discussion*—A distributed architecture also allows for the removal or update of a particular function without changes to the rest of the system. The functionality of Forward Look Sonar (FLS) might change, but as long as the output remains constant, there is no need for any additional changes to the system.

3.1.7 *emerging payload*, *n*—payload capabilities that have not been defined at this time.

3.1.7.1 *Discussion*—Section 1.3 of the UUV Master Plan⁵ describes research and development (R&D) enabling technologies.

3.1.8 *event driven*, *adj*—type of architecture in which individual components announce data that they wish to share with other components.

3.1.8.1 *Discussion*—The reporting of the FLS sensor with specific target data is an example of an event-driven architecture. The FLS can send specific messages that cause an action for the vehicle controller.

3.1.9 *heterogeneous*, *adj*—implies that several styles of architecture may be required and are allowed by this standard.

3.1.10 *hierarchical*, *adj*—implies a layered order of control.

3.1.10.1 *Discussion*—For example, a master controller controlling a lower layer of processors.

3.1.11 *interoperability*, *n*—ability of two or more systems to exchange information and use the information that has been exchanged mutually.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from Naval Sea Systems Command (NAVSEA), 1333 Isaac Hull Ave., SE, Washington, DC 20376, <http://www.navsea.navy.mil>.

⁵ Navy Unmanned Undersea Vehicle (UUV) Master Plan, November 2004.