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Standard Guide for Unmanned Undersea Vehicle (UUV) Communications[1]

This standard is issued under the fixed designation F2594; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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,
WK11283 Guide for UUV Mission Payload Interface,
F2541 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,

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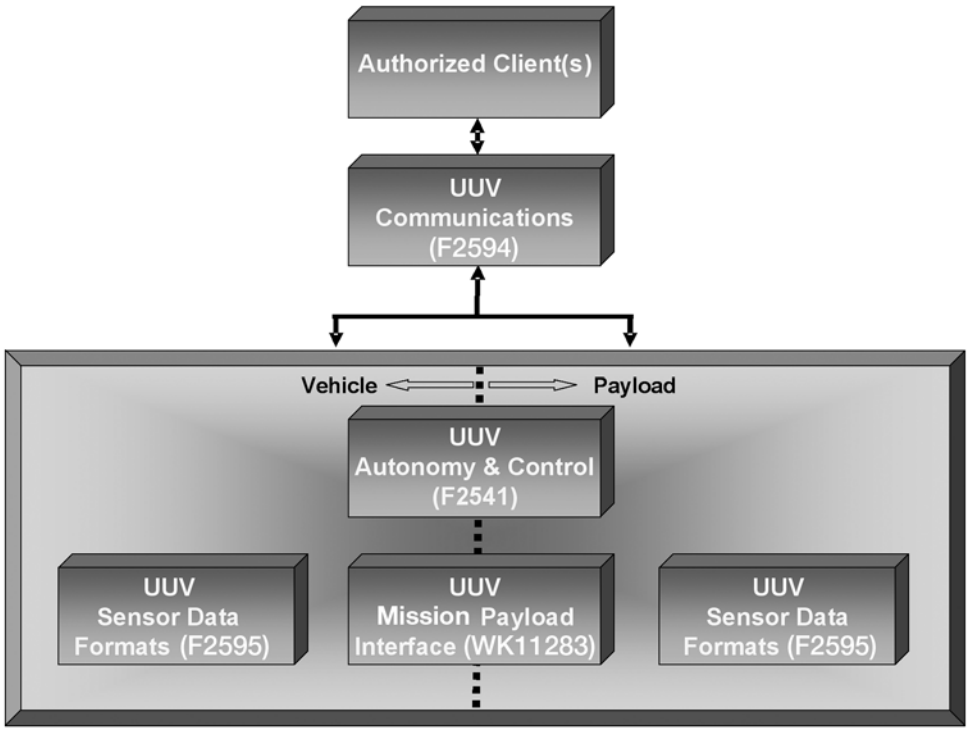

FIG. 1 Notional System Interfaces and Governing Standards

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 appendixes.

WK11283–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. In-as-much-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 appendixes 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

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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. Scope

1.1 This guide establishes the basic communications requirements for Unmanned Undersea Vehicles (UUVs). In its first instantiation, this guide serves as only a guideline, and not a definitive directive on acceptable UUV communication standards. In fact, this initial version is more accurately considered a compendium that addresses myriad communication modalities, where the selection of listed standards is determined after communication requirements are tailored to specific UUV applications and payloads.

1.2 This guide is intended to influence the design and development process for the acquisition and integration of vehicles, payloads, and communication system components, while at the same time to avoid specifying particular solutions or products. In its initial release, an additional intent of this guide is to address the communication standards required for operation of the U.S. Navy's planned 21-in. Mission Reconfigurable UUV System (MRUUVS) which is representative of its heavy weight class of UUVs. Guidance provided by the newly mandated and continually evolving, DoD IT Standards Registry (DISR) in the realm of existing military communication standards is also provided as a reference. Although there is a certain emphasis on U.S. Navy UUV missions, there is broad utility across the spectrum of commercial applications as well.

1.3 The breadth of standards addressed within this guide encompasses widely recognized Network standards and RF communications standards, including line of sight (LOS) and beyond line of sight (BLOS). Discussion of optical laser and underwater acoustic communications standards that are in development is also included. Besides identifying existing communication infrastructure, waveforms, and standards, this guide also briefly addresses related issues, security considerations, and technology forecasts that will impact fleet communication systems in the near future (5 to 10 years).

1.4 For ease in reading and utility, specific recommendations of existing standards are captured in tables segregated by communication domain. In some cases where standards are still under development or do not yet exist, details have been reserved for future revisions to this guide. Similarly, in various sections, elaboration of certain topics has either been determined to be beyond the scope of this guide or more appropriate for forthcoming revisions.

1.5 Readers of this guide will also find utility in referencing the related Committee F41 Guides on UUV Sensor Data Formats, UUV Payload Interfaces, and UUV Autonomy and Control. There is a clear relationship that exists in terms of communication systems, external interfaces, data formats, and information/data exchange which can be applied in context with the standards invoked in those documents.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.*

1.8 *Table of Contents:*