Designation: F2595 – 07

Standard Guide for Unmanned Undersea Vehicle (UUV) Sensor Data Formats[1]

This standard is issued under the fixed designation F2595; 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 less likely to be 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–Standard Guide for UUV Autonomy and Control,
WK11283–Standard Guide for UUV Physical Payload Interface,
F2594–Standard Guide for UUV Communications, and
F2594–Standard 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,

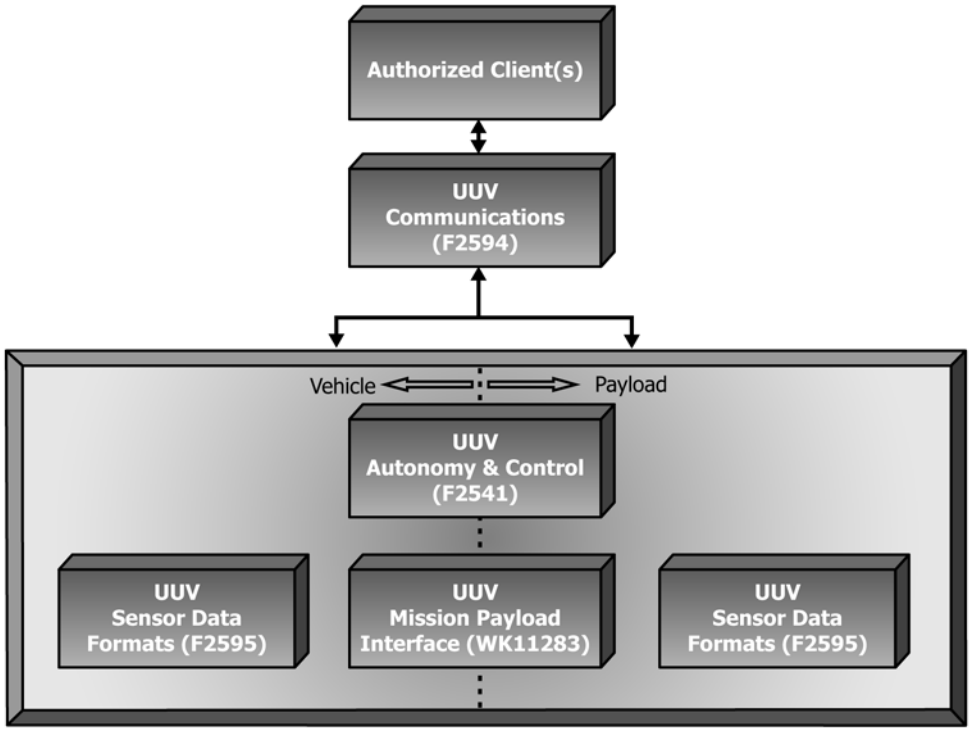

FIG. 1 Notional System Interfaces and Governing Standards

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.

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 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, or a combination thereof, a UUV. 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

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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. Scope

1.1 This guide establishes the basic sensor data format requirements for Unmanned Undersea Vehicles (UUVs). This guide is intended to influence the development process for the acquisition and integration of various sensor packages, but at the same time, not specify particular solutions or products. An additional intent of this guide is to address the data format standards specifically 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. Although this initial release of UUV sensor data formats standards primarily focuses on the U.S. Navy's UUV missions comprising intelligence, surveillance and reconnaissance (ISR), mine countermeasures (MCM), and oceanographic data collection, there is broad utility across the spectrum of commercial applications as well.

1.2 Readers of this guide will find utility in referencing Guides F2541, F2594, and WK11283. There is a clear relationship that exists in terms of data formats, external interfaces, and information/data exchange that can be applied in context with the standards invoked in these documents.

1.3 Technical sections of this guide are broken down as follows:

1.3.1 Section 5, the main body of this guide, provides general guidelines for sensor data, including water column and ocean bottom undersea search and survey (USS) measurements, and above-waterline data. It describes required data records, but does not attempt to specify data recording formats, except as already established in existing documentation. Whenever possible, data recording formats are suggested to conform to existing convention, facilitating data processing and use. This guide references standard U.S. Department of Defense (DoD) formats or *de facto* commercial formats where appropriate, such as widely accepted World Meteorological Organization (WMO) or Intergovernmental Oceanographic Commission (IOC) standards.

1.3.2 Section 6 covers related mission data formats such as timing. It also serves as a placeholder for future discussion of vehicle-specific mission data formats. Navigation, vehicle status, and related vehicle information data formats are expected to be addressed in subsequent versions of this guide. Also included in this section are brief discussions on external interface and command and control formats.

1.3.3 Section 7 introduces the topic of metadata formats. Amplification of this subject is warranted and will be incorporated into future versions of the guide.

1.3.4 Section 8 briefly identifies general data storage issues. Onboard data storage decisions will be driven by power requirements, data volume, and media cost.

1.3.5 Section 9 presents an abbreviated summary of the currently recommended data format standards where they could be identified.

1.3.6 Section 10 exists primarily as a placeholder to address relevant technology forecasts that could impact future data formats.

1.4 Though the general guidelines of this guide apply to most oceanographic sensor data, the data types specifically considered here are limited to: water column measurements (including temperature, salinity, currents, optical clarity, and bioluminescence), ocean bottom measurements (including bathymetry, acoustic images, and sub-bottom), ambient noise, and related geophysical parameters. ISR sensor data and other data collected on or above the surface are addressed by reference to governing U.S. military data standards. Discussion of electromagnetic and electro-optical (EM/EO) data formats (including atmospheric refractivity) is also included.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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

WK11283

2.2 *DoD Documents:*[4]

DoD Bathymetric Library (DoDBL)

DoD Directive 8320.2 Data Sharing in a Net-Centric Department of Defense

2.3 *IEEE Standards:*[5]

ISO/IEC 12207 Standard for Information Technology Software Life Cycle Support

[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 the U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., N.W., Mail Stop: SDE, Washington, DC 20401.

[5] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331.