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# IEEE RAS Standing Committee for Standards Activities: History and Status Update

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## 1. INTRODUCTION

Fueled by investments from the defense and industrial sectors, increased computing power, and advances in sensor systems, the development of robotic systems has progressed with a renewed vigor in recent years. In the coming decade, significant progress can be expected in various domains where we will increasingly witness robots becoming part of our everyday lives. Standards are crucial for driving industry innovation and technology transfer. Benchmarking and standardization are vital to the development of robotic and automation systems in already established application areas, and are critical to wider (including societal) acceptance of emerging technologies. It is widely accepted within the robotics and automation community that leaving emerging robotic technologies to proliferate in an unguided direction comes with a high price: synergistic opportunities remain unrealized, lack of cohesion in the community hinders the progress in many domains such as manufacturing, service, healthcare, and security, to name a few [13] [17].

The Standing Committee for Standards Activities (SCSA) under the Industrial Activities Board (IAB) of the IEEE Robotics and Automation Society (RAS) is working together with the research and industrial communities and other Standards Developing Organizations (SDOs) to help develop standards for robotics and automation. The scope of the activities of the IEEE RAS-SCSA is to formally adopt and confirm best practices in robotics and automation as standards. Within this scope, SCSA is pursuing the following objectives [8]:

- promote common measures and definitions in robotics and automation
- promote measurability and comparability of robotics and automation technology
- promote integratability, portability and reusability of robotics and automation technology

Some of the previous work carried out by the Standards Committee can be found in [18] [24].

At the 2010 International Conference on Robotics and Automation (ICRA'10) held in Anchorage, Alaska, SCSA hosted two meetings. One of these meetings was organized by the IEEE-Standards Association (IEEE-SA) to better understand the procedures involved in the standards process. The second meeting was part of the SCSA's regular meeting series which delved into identifying suitable areas for standardization that are both crucial and achievable in the short-term. These meetings served as an excellent forum to discuss and exchange ideas from professionals working on various aspects of robotics and automation and many with previous experiences in standards development. Two follow-up meetings were held at the 2010 International Conference on Intelligent Robots and Systems (IROS'10) in Taipei, Taiwan to further discuss the scope of the study groups and to develop a timeline for the standards-defining activities. Based on the discussions stemming from these meetings and with input and consensus from participating members, two Study Groups (SGs) have been formed. This article discusses work being carried out within the SGs and provides a status report on ongoing work.

This article is organized as follows: Section 2 provides an overview of standardization efforts that are related to ongoing work within RAS-SCSA. Section 3 discusses standards-defining activities within SCSA and current and anticipated progress towards the development of

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standards. Section 4 concludes the article.

## 2. Related and Previous Standardization Activities

The rest of this section provides a brief summary of past and ongoing work as it relates to the focus of the SGs. For an in-depth discussion of existing standards and worldwide efforts, the interested reader is referred to [14].

### 2.1 International Standards Organization

International Standards Organization (ISO) TC184/SC2 relates to robotics. It was created in 1983 and has so far published nine international standards and one technical report. The scope of TC184/SC2 has been properly expanded to reflect the industry trends. At the time of its creation, the main interest was "robots for manufacturing environment", while it changed to "robots for industrial environment" in 2003. In 2006, the TC184/SC2 is concerned with "robots and robotic devices". **Fig. 1** shows the organization of ISO TC184/SC2†.

WG1 is mainly concerned with vocabulary for robotics. It was formed at the June 2007 Washington DC plenary meeting and aims to revise ISO8373:1994 and to develop new terminologies for service robots. As of June 2010, CD (committee draft) voting was finished; it is expected that a new international standard for vocabulary will be published by the second half of 2011. One example of the vocabulary is a service robot, which is defined as "a robot†† that performs useful tasks for humans, society or equipment excluding industrial automation applications".

WG3 has been active for more than ten years. ISO10218 published by WG3 must be satisfied if robotic products are to be exported. ISO10218 has been split into two parts. One part relates to robots and was finished in 2006. It is currently is under revision and covers cableless teaching pendants, simultaneous motion, and collaborative operation. The other part relates to robot system and integration, which is at FDIS (final draft international standard) stage. It deals with safety issues at system integration, for example, location, power, lighting, grounding, and end-effectors.

WG7 started working in the field of personal care robots in June 2006, ensuring consistency with ISO 10218 (industrial robots). Safety issues are being discussed for two kinds of service robots: non-medical personal care robots (ISO13482) and medical care robots. ISO13482 is expected to be published by February 2012. Last September, an ISO call for experts has been announced to deal with issues of medical care robot safety. A couple of WG7 SG meetings were held, including the most recent meeting in June 2010.

WG8 was formed in October 2006 to explore the need for the development of service robot standards. WG8 handles standardization issues related to performance, coordinate system, and robot service contents. Examples of safety measures are obstacle (fixed and mobile) avoidance performance and robot impact force measures. Functional performance measures and applica-

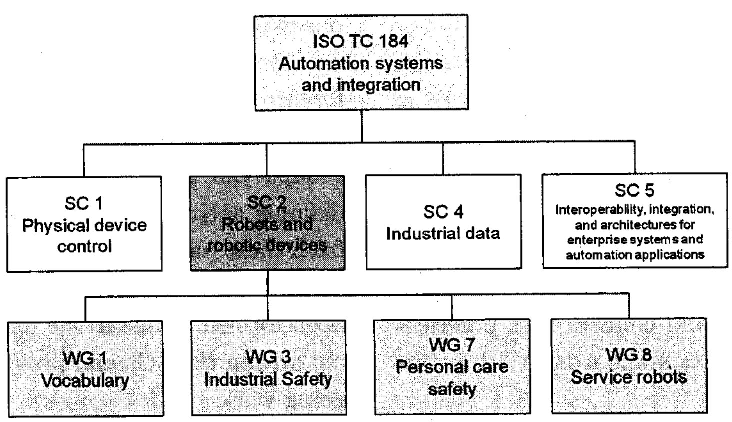


**Fig. 1** Organization of ISO TC184/SC2 (TC: Technical Committee, SC: Sub-Committee, WG: Working Group)

†S. Moon and G.S. Virk, "Survey on ISO Standards for Industrial and Service Robots," ICROS-SICE Int. Joint Conf., Fukuoka, Japan, Aug. 2009.

††WG1 defines a robot as "an actuated mechanism programmable in more than one axis with a degree of autonomy, moving within its environment, to perform intended tasks".

tion specific evaluation measures are also dealt within WG8.

## 2.2 Object Management Group

The Object Management Group (OMG) has had a Robotics Domain Task Force (DTF) [21] since 2005. Its purpose is to develop the specifications necessary to support future markets and businesses based on robot technology. Through the modularization of software components, developers will be able to exchange robot technology components through a market for robot software and hardware with well-defined interfaces. Its first step towards achieving this was the production of the necessary component model itself. The Robot Technology Component (RTC) specification was published in April, 2008 [23].

The RTC specification defines the component model used by a single software component. It particularly focuses on the introspection and execution of software components, preferring to leave the details of communication between components to other projects. There are currently three known major implementations of the RTC specification: the OpenRTM-aist software framework in Japan [15], the OPRoS software framework in Korea [16], and the Gostai RTC implementation in France [11].

The Robotics DTF interacts with other groups both within and external to the OMG as appropriate. For example, the Dynamic Deployment and Configuration for RTC (DDC4RTC) specification currently under development is being done under the auspices of the Middleware and Related Services Platform Task Force (MARS). Working in this way has allowed the Robotics DTF members, who are mostly roboticists, to gain important insight from experts in other domains. The RTC specification, for example, received considerable input from experts in high-performance middleware design, and utilises other OMG specifications such as the Super Distributed Object (SDO) specification.

The Robotics DTF has published one other specification: the Robotic Localization Service (RLS) specification, published in February, 2010 [20]. It is currently working on two other specifications. The first is the DDC4RTC specification, aimed at dynamic deployment and (re-)configuration of RT Components. The second is the Robotic Interaction Service (RoIS) specification, which describes human-robot interface systems.

## 2.3 Robot Engineering Task Force

The Robot Engineering Task Force (RETF) is a new effort started by a loose collection of robotics researchers, in particular Ingo Lütkebohle and Geoffrey Biggs [19]. Its goal is to foster a greater interchange of technical concepts between robotics professionals, including both academic and industry roboticists. One of its methods is the use of Robotics Requests for Comments (RRFCs). These are documents that define how a particular system or idea can be implemented in such a way as to allow independent, compatible implementations.

The RETF is modeled on the Internet Engineering Task Force (IETF), the body that has directed the development of the fundamental technologies of the Internet [12]. However, while the IETF is a formal body with a small group of leaders who's end goal is standards documents, the RETF is a loose collection of contributors and does not aim to produce standards. Rather, it aims at *documentation of common ideas* and relies heavily on the consensus of all interested people. It uses a published process to turn documents submitted by anyone into published reference material. One of the key steps is voting by anyone interested on whether a document is worth raising to the RRFC level. This is what allows the RETF to produce a list of documentation considered worthy of publicising by roboticists.

The RETF hopes that, by lowering the barrier to producing documentation for a wider group of roboticists than those using a single project, there will be an increased interchange of technical concepts. The RETF does not currently intend to produce standards itself; rather, it expects that RRFCs that become particularly popular will be used as a basis on which to produce formal standards through existing standardization organizations such as the IEEE, ISO, and OMG.

## 2.4 Glossary/Ontology

The Robot Standards and Reference Architectures (RoSTa) was a Coordination Action (CA) funded under the European Union's Sixth Framework Program (FP6) that ended in February 2009. The objective of RoSta was to define formal standards and the establishment of "de facto" standards in the field of robotics, especially advanced service robotics. The project was intended to take the initiative in the formulation of standards in selected key topics which are regarded to have high impact on future service robotics research and development. One of these areas was to develop a glossary/ontology for robotic terms [9].

Autonomous Levels for Unmanned Systems (ALFUS) currently resides in the Society of Automotive Engineers (SAE) AS4D Committee focusing on Performance Measures. The ALFUS goal is to specify terms and definitions for the performance of unmanned systems; and establish measures for the performance and characterization of unmanned systems, their components, and their interactions. The terms are defined in a terminology document written in natural language [3].

As noted in Section 2.1, ISO has been focusing on vocabulary for robotics. Other notable efforts include work under ASTM ASTM International focusing on creating terminology for Urban Search and Rescue. some of the related standards are listed below:

- ISO 8373 Manipulating industrial robots – Vocabulary [6]
- ISO 9787 Manipulating industrial robots – Coordinate systems and motion nomenclatures [7]
- ISO 11593 Manipulating industrial robots – Automatic end effector exchange systems – Vocabulary and presentation of characteristics [4]
- ISO 14539 Manipulating industrial robots – Object handling with grasp-type grippers – Vocabulary and presentation of characteristics [5]
- ASTM F2541-06 Standard Guide for Unmanned Undersea Vehicles (UUV) Autonomy and Control [2]
- ASTM E2521-07 Standard Terminology for Urban Search and Rescue Robotic Operations [1]

In addition, there are many small efforts which have attempted to create glossaries for robotics applications. A Google search of "robotics terminology" returns approximately 1,500 hits while a search of "robotics glossary" returns approximately 1,300 more. Almost all of these hits, with few exceptions, come from individual companies that are trying to educate their consumers but only include a handful of concepts that most directly relate to their respective fields. Ironically, it wasn't until the fifth link in the "robot glossary" search that the concept 'robot' was defined.

## 2.5 Unmanned Systems Standards

This section introduces some of the organizations that focus on the Unmanned Systems Standards (UMS), applicable in such domains as homeland security, defense, and law enforcement and covering the space of air, water, and ground.

### 2.5.1 Autonomous Levels for Unmanned Systems (ALFUS)

As robots/UMSs are being fielded in all different domains, including battlefields and homeland emergency responses, practitioners began having great needs of understanding the autonomy and standard definitions with which to communicate about the robot's autonomy. These gave rise to the starting of the ALFUS working group, in 2003. The ALFUS Framework has been evolved around two central issues: term definitions that help practitioners communicate and metrics that help practitioners characterize and evaluate the autonomous capabilities of UMSs. The two current publications are:

- ALFUS Terminology: NIST Special Publication 1011–I.2.0
- ALFUS Framework: NIST Special Publication 1011–II.1.0

In 2008, ALFUS joined Society of Automotive Engineers (SAE) and formed SAE AS-4D Unmanned Systems Performance Measures Committee. The plan is to further develop the two issues, as well as assisting the community with UMS general technical performance issues. AS4D, along with its sister Committees, namely, AS-4A Architecture Framework, AS-4B Network Environmental, and AS-4C Information Modeling & Definition form the AS4 UMS Steering Group, which, itself, is the primary organization under SAE that focuses on the UMS standards. This Group is under SAE Aerospace Council, Avionic Systems Group.

### 2.5.2 ASTM Committees

ASTM contains the following Committees that contain UMS focuses:

- E54 Homeland Security Application: Although the focus of this Committee is rather wide, it contains a Robotics Task Group, designated as E54.08.01. This Group focuses on the performance evaluation of the emergency response robots. Several suites of standard test methods are being developed for all the component and system performance to help users determine whether a robot is suitable for particular emergency response operations.

  Its current standards include:

  –E2521–07a Standard Terminology for Urban Search and Rescue Robotic Operations

  –E 2592–07 Standard Practice for Evaluating

Cache Packaged Weight and Volume of Robots for Urban Search and Rescue

–E 2566–08 Standard Test Method for Determining Visual Acuity and Field of View of On-Board Video Systems for Teleoperation of Robots for Urban Search and Rescue Applications

- F38 Unmanned Aircraft Systems F38 contains Subcommittees of Airworthiness, Flight Operations, Personnel Training, Qualification and Certification, and Executive. It has the terminology standard: ASTM F2395–07 Standard Terminology for Unmanned Air Vehicle Systems
- F41 Unmanned Maritime Vehicle Systems (UMVS) F2541–06 Standard Guide for Unmanned Undersea Vehicles (UUV) Autonomy and Control
- In addition, ASTM E57 3D Imaging Systems Committee (not a robotics committee) has developed ASTM E2544–10 Standard Terminology for three dimensional (3D) Imaging Systems.

## 3. IEEE RAS Standing Committee for Standards Activities: Ongoing Work

### 3.1 Map Data Representation and Fundamental Data Types Study Group

*Map Data Representation and Fundamental Data Types* is one of recently formed Study Groups (SGs) sponsored by IEEE RAS-SCSA. Its aim is to develop a consensus on the needs for common representation for robot map data, including metric, topological, and semantic maps.

As is well known, robot navigation includes determining the position, course, and distance traveled of a mobile robot [10]; and one of the basic requirements of robot navigation is a map within which a mobile robot can perform localization and motion control cush as path planning, tracking, and obstacle avoidance. In order for a mobile robot to operate properly, therefore, a map must be available a priori or constructed during the navigation task. Mapping is the process of interpreting sensor readings about the surrounding environment into machine-understandable environmental features [26]. Robotics has a long history of research in spatial mapping, ranging from manual, CAD-based map drawing to state-of-the-art SLAM (Simultaneous Localization And Mapping) technologies. Whichever is used for spatial mapping, the resulting map should be interoperable amongst various robots or robotic service providers providing the navigation function. **Fig. 2** illustrates some examples of a metric map, a topological map, and a semantic map; the examples have been introduced to help the reader understand the characteristic appearance of each individual map.

This SG will investigate the potential for standardizing fundamental data types for mapping and study existing map data representations from other SDOs including the OGC (Open Geospatial Consortium) and the ISO. As part of its work, it will determine how detailed the standardized data types used in map representation need to be. The study group will set up a long-term roadmap for developing specifications for map data representation and discuss how to represent, encode, and exchange map data for robot navigation, leading to a project authorization request (PAR) to initiate a standardization process within the IEEE Standards Association.

In addition, as part of the task of producing a standard for mapping in robotics, there is the task of identifying the data types involved, including those reaching down to the fundamental level. This stems from the long difficulty in robotics of matching data types used between software existing in separate projects and the need for mapping systems to exchange data with other robotics software. To date, many robot software frameworks have supplied, in some way, a collection of data types for use with the framework. Player, for example, specified the Player Abstract Device Interface [25]. Frameworks as recent as OpenRTM-aist and ROS [22] have followed this course eventually in an effort to prevent fragmentation.

To promote interoperability between frameworks exchanging map data, it may be necessary for the data types involved to be defined down to a fundamental level. Defining the data types involved down to such a low level will not solve the interoperability problem and ensure that map implementations can talk to each other. There are many other issues involved, such as transport protocols and calling conventions. It will, however, ensure that mapping implementations that overcome these other issues will be able to understand the core data involved. The study group will, as part of its investigation of standard map data types, also investigate the potential for standardizing the lower-level data types. Its key goals will be to investigate how

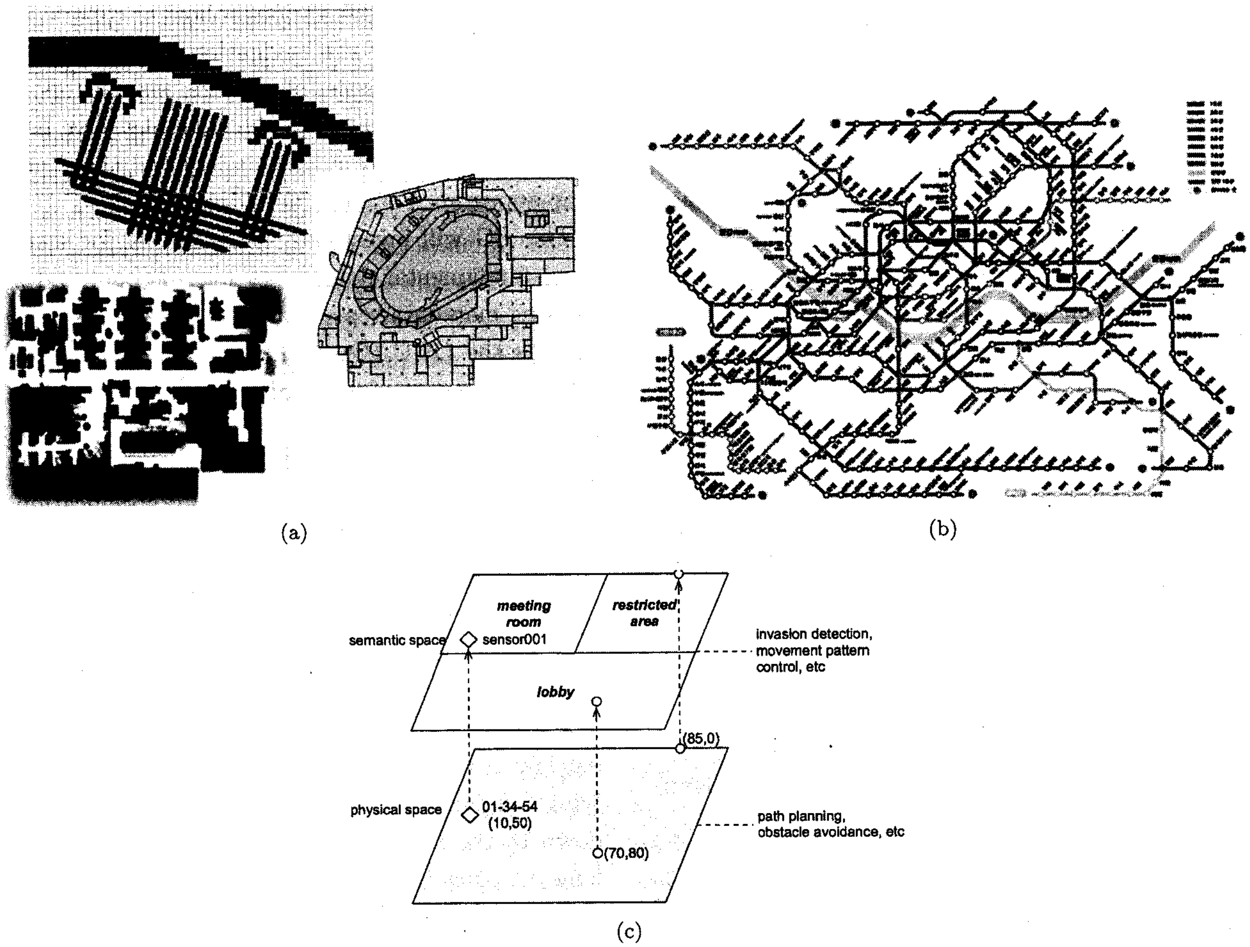


**Fig. 2** (a) Some examples of metric map, (b) (pure) topological map (subway lines of Seoul), and (c) conceptual illustration of semantic mapping between physical space and the corresponding semantic description

low down the data types should go, and if there is any real benefit to standardizing the lower data types at all, versus other options such as data interchange protocols. The information produced will inform the standardization process.

### 3.2 Glossary/Ontology for Robotics and Automation Study Group

The objective of the Glossary/Ontology for Robotics and Automation Study Group is to identify, develop, and document salient terms and their definition so that they can serve as a common reference for the robotics and automation community. The advantages of creating such a glossary/ontology are many, including: 1) ensuring common understanding among members of the community which helps to ensure timely decision-making and minimizes potential confusion and 2) facilitating more efficient data integration and transfer of information among systems. Unlike previous efforts which have attempted to perform similar activities in more specific domains, this study group will take a more all-encompassing approach, focusing on terms that relate not only to the more traditional mobile robotics domain (e.g., service robotics, healthcare robotics, military robotics) but extending it into the automation field which could include terms related to domains such as automated manufacturing shop floor. The exact scope of this effort and the domains that will be addressed will be one of the first orders of business of this study group. Initial efforts will attempt to leverage previous and existing efforts that have tried to address parts of this issue, such as the ones listed in Section 2.4 of this article.

A core issue that will be addresses as part of this effort is how to represent the definition of the terms. Many approaches exist for representing knowledge at different levels of formality, including dictionaries and glossaries, database, and logic-based approaches. All offer their benefits and costs which need to be considered when determining the most appropriate representational approach. A related issue is how to most logically organize the terminology, especially in such a large area with many inter-relationships.

## 4. CONCLUSIONS AND CONTINUING WORK

The progress within RAS-SCSA has been encouraging though a lot remains to be done. It is anticipated that the symbiosis and interaction between these SGs will facilitate better discussions and rapid progress than what would be possible if these groups tried to address these problems in a standalone and isolated fashion. The efforts of each of the SGs has resulted in the drafting of a proposal that is being widely circulated among the community for feedback and comments. The finalized SG document will in turn result in a Project Authorization Report (PAR) towards the formation of a Working Group (WG) that will work closely with the IEEE-Standards Association. The WG document is expected to be available by April 2011. A full-day standards meeting will take place on the first workshop day of both ICRA'11 and IROS'11 conferences to encourage participation of attendees in discussions and as a forum to bring together interested parties.

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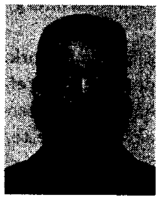

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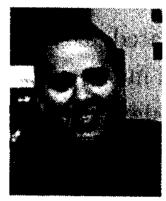
### Geoffrey Biggs

Geoffrey Biggs completed his BE (1st Class) in Computer Systems Engineering at the University of Auckland in 2002. In 2007 he completed his Ph.D. in Electrical Engineering, in the Department of Electrical and Computer Engineering, studying robotics. His research focussed on tools used by developers of mobile robotic systems, an often-neglected field in robotics research, and in particular he investigated the design requirements of programming languages for robots. His research showed that existing programming languages can be adapted to robotics, without the need to create a new language from scratch, but that they also benefit from additions to semantics designed for the unique challenges of programming robotic systems. He is currently at the National Institute of Advanced Industrial Science and Technology (AIST) in Japan.

### Wonpil Yu

Wonpil Yu received the Ph.D. degree from KAIST (Korea Advanced Institute of Science and Technology), Korea. He is currently with ETRI (Electronics and Telecommunications Research Institute), Korea. His research interests include perception for mobile robotics, robot navigation, and computer vision. He's been active in standardization since 2006, contributed to publish the OMG (Object Management Group) RLS (Robotic Localization Service) standard (published as an OMG official specification at 2010). He is currently conducting research on automated robotic vehicle technology and also working to develop a robotic map data standard with IEEE RAS SCSA.



### Craig Schlenoff

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### Hui-Min Huang

Hui-Min Huang is a software/mechanical engineer with NIST for over 20 years and conducts research on performance measures, software architectures, and system analysis and design methods for intelligent systems including unmanned vehicles (UMS) and manufacturing systems. He leads a cross Government and Industry Ad Hoc working group called Autonomy Levels for Unmanned Systems (ALFUS) and is developing performance test standards for Urban Search and Rescue (US&R) robots in a team under ASTM International Committee on Homeland Security Applications and leads a terminology task group. He currently serves on the SAE AS-4 Executive Committee for Joint Architecture for Unmanned Systems (JAUS) and chairs the AS-4D Subcommittee on Performance Measures. He earned a U.S. Department of Commerce Bronze Medal award. Previous employment involved nuclear power plant simulation and watch manufacturing. He has published over 50 papers/book chapters and served on program committees and as session chairs for various conferences.