On September 30, 2018, the Industrial Activities Board (IAB) of the IEEE Robotics and Automation Society (RAS) organized a Standards Strategy Meeting in conjunction with the Intelligent Robots and Systems (IROS) Conference in Madrid, Spain. The goal of the meeting was to review and refine an overall robotics standards landscape to determine areas in which the IEEE RAS should focus on robotics standards development and determine areas in which IEEE RAS should partner with other standard development organizations. Attendance was limited to 15 people (due to room size and the desire to make it a focused meeting). Attendees included many of the IEEE RAS Working Group Chairs, representatives from ISO, RIA, and ASME, and experts in various robotics fields including autonomous vehicles and industrial robotics. The meeting started with presentations by the participants to provide context, and then moved on to a discussion of IEEE RAS's role in this area. A summary of the presentations (in the order they were presented) is included below:

- "Welcome/Overview/IEEE CORA Standard"
    - Presenter: Craig Schlenoff, Associate VP of Standardization in IEEE RAS
    - Summary: This presentation provided an overview of the meeting's goals, the agenda, a description of the existing IEEE RAS Standards, and a detailed description of the IEEE 1872: Core Ontologies for Robotics and Automation (CORA) Standard. Key characteristics of CORA are:
        - Standardized in April 2015
        - Developed by 175 members representing a good cross-section of industry, government, and academia
        - Won the IEEE-SA Emerging Technology Award and mentioned in former President Obama's "The National Artificial Intelligence Research and Development Strategic Plan"
- "IEEE P1872.1 Robot Task Representation"
    - Presenter; Stephen Balakirsky, P1872.1 Working Group Chair
    - Summary: This presentation described the P1872.1 Robot Task Representation Working Group's efforts, which started in February 2017. The goal is to develop a knowledge representation that addresses robot task structure, with decomposition into subclasses, categories, and/or relations. It includes attributes, both common across tasks and specific to particular tasks and task types. With this, one would be able to provide a common way of representing tasks across domains and sub-domains, addressing both the relationships between tasks and platforms and the relationships between tasks and users.
- "IEEE P1872.2 Autonomous Robotics Ontology"
    - Presenter: Veera Ragavan, P1872.2 Working Group Member
    - Summary: The P1872.2 Autonomous Robotics Ontology is a logical extension to the IEEE 1872 standard, focusing on autonomous robotics, including general ontological concepts and specific axioms, as well as use cases. The group has already address the development of an underlying architecture, the definition of key vocabulary terms, and is in the process of developing ontological concepts to formally define the vocabulary.

- “IEEE P2751 3D Map Representation”
    - Presenter: Francesco Amigoni, P2751 Working Group Chair
    - Summary: The presentation described the existing IEEE 1873 Robot Map Data Representation for Navigation Standard (2015), which provides a specification for representing XML-based two-dimensional metric and topological maps to ease exchanging map data among robots, computers, and other devices. It also described the new P2751 3D Map Data Representation Working Group, which is extending the IEEE 1873 standard to focus on 3D maps, including point clouds, grids such as voxel maps, and polygonal meshes.
- “Ethics in Technology”
    - Presenter: Ali Hessami, Chair and Technical Editor of IEEE P7000 Standards
    - Summary: This presentation gave an overview of ethics as a whole and described the IEEE P7000 standards. The purpose of these standards is to create a shared mission around values, value priorities, and value harms to avoid, as well as to assure, value-based system engineering, by building a bridge between the value mission and the actual development of a system. A working group draft is expected in October 2018.
- “IEEE RAS/SA 7007 – Ontological Standard for Ethically Driven Robotics and Automation Systems”
    - Presenter: Sandro Fiorini, Vice-Chair IEEE 7007 Working Group
    - Summary: This presentation described the IEEE 7007 effort focusing on Ethically Driven Robotics. The standard establishes a set of definitions and their relationships that will enable the development of Robotics and Automation Systems in accordance with worldwide ethics and moral theories, with a particular emphasis on aligning the ethics and engineering communities to understand how to pragmatically design and implement these systems in unison. The standard describes what is meant when one says that something is ethical or not ethical.
- “Intro to P2730”
    - Presenter: Tamas Haidegger, IEEE RAS IAB Associate VP
    - Summary: This presentation described the IEEE P2730 Classification, Terminologies, and Definitions of Medical Robots Standard, which IEEE RAS is co-sponsoring with the IEEE Engineering in Medicine and Biology Society. IEEE RAS joined this effort in September 2018. The standard specifies the category, naming, and definition of medical robots. They are in the process of changing the name to “Medical Electrical Equipment Employing Robotic Technology Terminology and Classification.”
- “ISO and RIA Efforts in Standardization”
    - Presenter: Roberta Nelson Shea, Global Technical Compliance Officer at Universal Robotics, ISO TC299 WG3 Convenor, ISO TC299 SG1 Convenor, ANSI RIA Standards Chair Emeritus.

    - Summary: This presentation described ISO TC299 (Robotics) whose goal is to develop high quality standards for the safety of industrial robots and service robotics to enable innovative robotic products to be bought onto the market. These standards are mostly harmonized standards for Europe, North America and Asia. They tend to have very good global acceptance and are used for asserting conformity to a variety of regions around the globe. Specific efforts include SG1 (Gaps and Overlaps), WG1 (Vocabulary and Characteristics), WG2 (Personal Care Robots), WG3 (Industrial Safety), WG4 (Service Robots), JWG5 (Medical), and WG6 (Modularity for Service Robots). ANSI/RIA efforts were also discussed, including R15.06 (Industrial Robots and Robot System) and R15.08 (Mobile Robots). The scope of ISO TC299 excludes toys and defense (military).
- "ASME Robot Standards Efforts"
    - Presenter: Angel Guzman Rodriguez, Standards and Certification (S&C) Project Engineer, Standardization & Testing Department
    - Summary: This presentation gave an overview of ASME and described the robotics field as one of the five core technologies that ASME wants to focus on in the future. Specific efforts will explore robot arms under the Standards Committee on Manufacturing and Advanced Manufacturing. They also have a new committee on Mobile Unmanned Systems (MUS) for inspection, monitoring, and maintenance of industrial facilities and power plants. A few other related efforts were also described.
- "Robot Standardization: Personal Care, Medical, and Modularity"
    - Presenter: Gurvinder Virk, Technical Director, InnotecUK (among other affiliations)
    - Summary: This presentation described the changing world of robotics, from industrial to service to modularity, as well as the growing safety requirements for closer human-robot interaction, and the growing international standardization efforts for emerging robots. It also described how the robots are changing, from tools to assistants to servants and most recently to companions. Because of this, even the definition of a robot is evolving. Lastly, it described the various working groups in ISO, filling in some areas that were not deeply discussed in Roberta Nelson Shea's talk.
- "Thoughts on Autonomous Vehicle Robot Standards"
    - Presenter: Chris Debrunner, Lockheed Martin Autonomous Systems Fellow
    - Summary: Dr. Debrunner led a discussion on autonomous vehicle technology and what was needed. The focus was on validation of autonomous systems (especially those that learn) and interoperability among vehicles and between vehicles and the environment. He described some autonomous vehicle work that was performed at Lockheed Martin which built on top of the Robot Operating System (ROS).
- "A Perspective on Robot Standards"
    - Presenter: Henrik Christensen, Director of the Contextual Robotics Institute
    - Summary: This presentation gave a high-level overview of the standardization process, with a focus on answering the follow questions:
        - Why are we standardizing? (it is all about money)
        - Who are the players? (industrial companies, trade organizations, etc.)

- When can we standardize? (technology maturity, incentive, longevity)

Some of the main take-aways were the need to leverage technology roadmaps where they exist, the need to create a clear business case, and the need for collaboration among mature organizations.

The presentations can be found at http://www.ieee-ras.org/industry-government/standards/standards-strategy-meeting.

After the presentations, a discussion ensued to determine the areas in which IEEE RAS could have the biggest impact on the robotics standards community, while complementing the efforts from the other standard organizations. A few key areas were identified, including (in no particular order):

- Harmonization of terminology amongst the various standard organizations – The same term is defined differently in different standards organizations, and even among different groups within the same standards organization. IEEE RAS could play a valuable role in harmonizing these definitions.
- Interoperability standards – IEEE RAS has already started down this path with the CORA and Map Data Representation standards. No other standards organization appears to be focusing on this area. This would involve clear terminology definition and possibly interface standards.
- "Under The Cover" Standards - ISO/TC 299 is working in the "here and now." Forward looking activity is not to the far future because standards are written because of known demand and need. Participants tend to be weighted towards industry, manufacturers, integrators and users. In contrast, IEEE appears to be on the research side with close ties to R&D and academia. A partnership could be mutually beneficial.
    - Electronic, electro-technical, software, hardware techniques and innovations that could be leveraged for commercial applications. Roberta mentioned that ISO/TC299 WG3 does not dictate HOW to design or implement a solution, instead their standards state the required end goal of the performance.
- Verification of autonomous systems – This is growing research area, especially focusing on systems that learn. IEEE RAS could be good home for standards and performance metrics to help verify autonomous system performance.
- Robot agility performance metrics – As robots need to adapt to ever changing environment, metrics and test methods are needed to assess their agility performance when confronted with unexpected situations.
- Human-Robot Interaction (HRI) performance metrics – As human-robot collaboration is more prevalent, metrics and test methods are needed to assess the interaction between the human and the robot, considering human factors and the transfer of information. (Note: This is distinct from robot-human contact and the topic of biomechanical limits, forces, speeds and similar, which is already being addressed in ISO/TC199).

The IEEE RAS IAB is exploring all of the suggestions above and will determine the areas that we feel we can have the greatest impact (and have the resources to support). We will then develop a plan for addressing each of them.

IEEE RAS overall seemed pleased with the effort and requested that we continue this interaction for the next two years (with funding provided to make it happen).