At the 1993 World Standards Day reception, the first Ronald H. Brown Standards Leadership Award was presented to I. MacAllister Booth, who was the Chairman and Chief Executive Officer for the Polaroid Corporation. During his acceptance speech, Mr. Booth noted that Edwin Land, the brilliant inventor and co-founder of the Polaroid Corporation, didn’t appreciate the importance of standards, especially when it came to innovation. In fact, Edwin Land supposedly remarked that “standards are to innovation like fleas to a dog; a nuisance that doesn’t do the dog any good.”

Edwin Land’s negative attitude toward standards was not unique when it came to innovation. Even today, a quick Google search reveals widely held views that standards stifle innovation. While examples can be found where the overzealous use, misapplication, or premature application of standards has impeded progress, on the whole, standards have a positive impact on innovation. A review of the literature on some game-changing technologies, such as quantum computers, nanotechnology, smart grids, internet of things, smart cities, healthcare information technology, additive manufacturing, smart cars, and a litany of other lead-edge areas, all suggest that one of the most significant barriers to innovation and the consensus needed to reduce risk and create consumer confidence is a lack of standards.

The purpose of this paper is to look at some of the most common ways standards enable innovation, and answer the age-old question, “Are standards to innovation like fleas to a dog?”

**Innovation Requires a Common Language**

In Lewis Carroll’s *Through the Looking Glass and What Alice Found There*, Humpty Dumpty said, “When I use a word, it means just what I choose it to mean — neither more nor less.” To which Alice responded, “The question is whether you can make words means so many different things.”

Alice understands if words can mean anything, then people will not understand each other. People have to agree on shared definitions and meanings for communication to be possible. Alice would also recognize that for innovation to take root in an emerging global technology first requires a consensus on terms and their definitions.

No better emerging technology to illustrate the need for definition standards than quantum computers, which are being touted as the next great technology disrupter that will transform entire industries. The Chinese
government has invested billions of dollars for quantum research. The United States Congress is considering the Quantum Computing Research Act of 2018, which would fund a federal research consortium to form a partnership between industry and government.

While we are probably years away from the first use of quantum computers for practical purposes, the groundwork has been laid by the approval of a project to develop, IEEE P7130, Standard for Quantum Computing Definitions. Without such definition standards, consistent and widely-accepted nomenclature and terminology is not possible. The risk of interpreting such terms as quantum tunneling, super position, quantum entanglement, and other terms differently could delay innovation or fragment it in ways that undermine its potential usefulness and interoperability. As noted by William Hurley, Chairman of the IEEE Quantum Computing Working Group, this proposed definition standard “marks an important milestone in the development of Quantum Computing by building consensus on a nomenclature that will bring the benefits of standardization, reduce confusion, and foster a more broadly accepted understanding for all stakeholders involved in advancing technology and solutions.”

**Innovation Needs Measurement**

Once you have the basic terminology needed to ensure that ideas are communicated correctly and consistently, measurement and testing standards are needed to advance innovation. In a 2006 study, An Assessment of the United States Measurement System: Addressing Measurement Barriers to Accelerate Innovation, the National Institute of Standards and Technology (NIST) concluded that new measurement tools and standards will be critical to technological innovation in nearly all industry sectors. In a review of 164 industry technology roadmaps, NIST found that a “lack of standards was noted as an impediment to technological innovation in nearly every economic sector covered in the technology roadmaps,” and that “82 percent identified measurement problems that pose barriers to technological innovation.”

One area where industry has been especially active in developing measurement and testing standards to foster innovation is nanotechnology. Considered by many as the next great technological revolution, nanotechnology is the ability to manufacture by manipulating single atoms or molecules. The big challenge is to

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develop new measurement tools and standards to detect, analyze, and assess such infinitesimally small materials. The need for the measurement of new sample structures and characteristics far exceeds the capabilities of current measurement science. Some important standards which are yet to be established are standards for measuring thickness of thin films or layers, characterization of surface features, standards for force measurement at nanoscale, standards for characterization of critical dimensions of nanoparticles and nanostructures, and standards for measurement for physical properties, such as conductivity and elasticity. Recognizing the need for measurement and testing standards for future innovation, these are the type of standards where industry has focused its initial efforts. The American National Standards Institute (ANSI) Nanotechnology Standards Database identifies 148 nanotechnology standards and associated documents, of which 86 documents pertain to measurements and testing.³

While nanotechnology is moving at what appears to be a blistering pace, there is a worrisome element on the horizon. The health, safety, and environmental implications of nanotechnology are largely unknown. This an area of concern. To a large extent, there are no standard methods for human exposure to nanoparticles, and there is some question about the effectiveness or existence of standards to conduct risk assessments, toxicological assessments, and life cycle analysis of products containing nanomaterials. This is not to say that there aren’t any standards in this area. The ANSI Nanotechnology Standards Database identifies 74 documents related to health, safety, and environment. But a health or ecological disaster associated with nanomaterials could have a negative impact on the future of nanotechnology. For this innovative technology to grow safely will require standards to ensure the proper evaluation of the toxicological and ecological effects of nanotechnology.

**Interoperability Standards Are Essential to Innovation**

In today’s digital information world, interoperability between systems, devices, and other equipment is essential for an organization to succeed and be more effective and efficient. Often, one of the most significant barriers to interoperability and innovation is the lack of standards. Perhaps no other sector has been affected more by a lack of interoperability standards than the healthcare industry.

The Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 legislated for the meaningful use of interoperable health records to improve patient care with better access to a patient’s

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³ ANSI Nanotechnology Standards Database, nanostandards.ansi.org, viewed June 20, 2018.
medical records. A major part of the legislation called for the development and implementation of standards to foster interoperability to permit the seamless exchange of Electronic Health Records (EHR).^4^

Despite many best efforts, true interoperability remains the EHR unfulfilled holy grail. With thousands of legacy systems containing medical information in many different formats, including paper, the challenge of integrating these records and making such information available to medical providers in a meaningful way is huge. Interoperability isn’t just about exchanging information. It’s about the ability to use the information as well.

Standards are needed that approach these medical records as structured pieces of data that will be managed as data rather than documents. Perhaps something similar to the private/public-sector initiative called the Semantic Web for Interoperable Specifications and Standards (SWISS) that will transform standards into digital models and allow information to be fully and more easily integrated into design, manufacturing, and sustainment processes and to provide for cross-platform interoperability.^5^

Progress, however, is being made towards EHR interoperability. The Consolidated Clinical Document Architecture (C-CDA) developed by Health Level 7 International, an ANSI-accredited standards developing organization, provides a collection of templates to standardize file formats that define the structure of certain medical records, such as discharge summaries and progress notes, as a better way to exchange this information between health providers and patients. Progress, yes, but better standards and new interdependent technologies will be needed for the innovations that will allow medical information to travel seamlessly with patients in the healthcare system.

Often times, the innovation allowed by interoperability standards does not relate to the item covered by the standard, but with associated accessory items. Standards can help introduce innovative products by providing interoperability between new and existing products and a technological platform on which innovation can take place.

For example, in 1995, the United States Army’s Picatinny Arsenal issued MIL-STD-1913 for an accessory mounting rail for small arms weapons. Originally, the standard was intended to establish the interface between the mounting rail atop larger caliber rifles and scopes. But the success of this standard soon encouraged innovation for

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numerous other accessories that could be mounted on rifles and pistols, including tactical lights, lasers, night vision devices, reflex sights, and other items. As recently as 2017, the United States Marine Corps developed an expended ammunition rounds counter that could be attached the standard mounting rail to let the warfighter know how many rounds were left. This innovation greatly contributes to the warfighter’s situational awareness during combat when the last thing on anyone’s mind is how many rounds remain in a weapon.\(^6\)

The MIL-STD-1913 mounting rail innovations isn’t limited to the military. In the commercial world, this mounting rail is called “the Picatinny rail.” In addition to hunting rifles, the Picatinny rail provides a standard mounting interface for innovative accessories for paintball guns, airsoft guns, crossbows, and other equipment. In fact, a search of the Amazon website shows over 5000 results for the Picatinny rail. Lots of innovation still taking place thanks to an interface standard over 20 years old.

**Standards Disseminate Knowledge for Innovation**

The knowledge that standards capture and disseminate widely are important catalysts for the spread of technologies and innovation. While the internet may seem to many to be a technology that rose from the ground overnight, it actually was a very long time coming. The Internet Society provides a useful brief history of the internet that underscores the importance of standards for spreading knowledge necessary for innovation.\(^7\)

The concept and early development of the internet began in the 1960s with the government’s Advanced Research Project Agency (ARPA) (later renamed the Defense Advanced Research Project Agency (DARPA)). The idea was to create a network of globally interconnected computers through which people could quickly access data and programs from any site. The first public demonstration of this new network technology took place in October 1972 at the International Computer Communication Conference with the sending of an email message.

During the 1970s, DARPA developed a protocol would eventually be called the Transmission Control Protocol/Internet Protocol (TCP/IP) to specify how data was to be exchanged over what was called the ARPANET, the predecessor to the internet. In 1982, the Department of Defense designated TCP/IP as the standard for all military

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computer networking. Within a few years, industry recognized the huge potential importance and commercial value of the internet. The TCP/IP standards were transitioned to the Internet Engineering Task Force in 1985, and this marked the start of the internet explosion.

Beginning with the TCP/IP protocol, standards sparked much of the innovation that transformed the internet, ranging from Hypertext Transfer Protocol (HTTP), which is the foundation of data communication for the World Wide Web, to the Simple Mail Transfer Protocol (SMTP), which is an internet standard for electronic mail (email) transmission. A key to the rapid growth of the internet was the free and open access to the basic standards that documented and disseminated knowledge that would revolutionize computers and communications.

Standards Bridge the Gap Between Invention and Innovation

Many people use the words “invention” and “innovation” interchangeably. Debatably, there are some important, subtle distinctions. Invention means creating something new. Innovation means taking an invention and taking actions to ensure its acceptance by the marketplace. To quote Watts Humphrey, who is considered the father of software engineering, “Innovation is the process of turning ideas into manufacturable and marketable form.”

There are many inventions that were never accepted and have long been forgotten. To transition from invention to innovation can be attributed to many possibilities, including good marketing, right idea at the right time, urgent needs, and other factors. Standards too help bridge the gap between invention and innovation by giving users the needed confidence to trust newly developed products and technologies.

Additive manufacturing (AM), or 3D printing, which uses computer-aided design to build objects layer by layer as opposed to subtractive manufacturing fabrication is an example of an invention that will need standards to drive innovation. AM has the potential to transform logistics and manufacturing. Instead of keeping an inventory of parts to repair or maintain equipment or waiting for a part to arrive from a supplier, AM allows users to manufacture parts on the spot, as needed. AM can significantly cut manufacturing costs since AM allows only the material necessary to be used, thus reducing wasted materials associated with traditional fabrication methods.

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Despite the promising opportunities AM offers, its diffusion has been hampered by such challenges as production time, consistent production outcomes, reliability, and safety. For example, in critical aircraft engine applications, how do you know an AM part has the same strength, durability, and reliability as the traditionally manufactured part its replacing? In medical equipment, how do you know whether an AM part isn’t toxic or won’t present a hazard to patient? These are just a few of the many questions.

Today, most AM standards in use are proprietary with each company developing its own specifications. For AM technology to be accepted widely and allow for rapid innovation will require a variety of consensus standards. To meet the standards challenge, ASTM established the F42 committee on additive manufacturing technologies to develop a set of AM standards that will be recognized worldwide. F42 committee has an ambitious roadmap to identify standards-related gaps and needs, and has already laid the groundwork by issuing several terminology standards. In the near future, AM technology will be as commonplace as the internet, and standards will have played a major role in this remarkable innovation.\(^9\)

**Fleas on the Dog?**

So do standards foster innovation, or as Edwin Land suggested, are standards like fleas on a dog, and constrain innovation?

There is a dearth of macro-economic studies to assess the value of standards to innovation. In 2005, the United Kingdom Department of Trade and Industry (DTI) published a paper that tried to determine the extent standards enable innovation. Not surprisingly, the DTI found evidence from other studies and the European Union Community Innovation Survey (CSI) that standards both enable and constrain innovation. On the positive side, the DTI concluded that standards are an important part of the international technology transfer process and function alongside new technology in facilitating technological progress across countries and across manufacturing sectors. Based on data from the CSI survey, the DTI determined that of the eighteen identified sources of information to promote innovation, technical standards ranked seventh on the list with about 60 percent of the company respondents identifying standards as an important source of information for their innovation activities. On the negative side, companies reported standards constrained innovation when they were developed or applied too

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prematurely, not current, and if there were too many. In the end, the DTI paper concluded that while you cannot make the unqualified claim that standards foster innovation, on balance, standards are an important enabler of innovation.10

While definitive research is lacking, anecdotal evidence strongly supports the importance of standards to innovation. Establishing a common language for the exchange of ideas and technology, creating methodologies and testing to create baselines and measure capability and safety, ensuring that new technologies are interoperable, disseminating knowledge, and allowing for marketplace growth by contributing to consumer confidence in a product’s performance and safety are just some of the ways standards have and continue to foster innovation.

So are standards to innovation like fleas to a dog? Maybe sometimes. But generally, standards are like a chew toy to an innovative dog.