Industry standards for the X-ray inspection of cargo

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Innovative technology for the non-intrusive inspection of cargo and vehicles has rapidly emerged over the last decade to become a significant factor in port and border protection and homeland security. Several hundred high-energy mobile and fixed-site X-ray inspection stations are deployed throughout the world to examine passenger cars, trucks, trains, and shipping containers that transport goods bound for international destinations. Behind the scenes, cargo screening technology continues to be a story of innovation and change, driven by keen competition and a common mission to improve global security.

Evolution of systems

Early cargo screening systems were relatively slow and expensive to operate. They produced a limited resolution single-energy X-ray image, often using an isotope source such as Cobalt-60. The imaging software was rudimentary, and limited to simple controls such as pan and zoom, while computer processing speeds significantly limited inspection throughput. By contrast, most systems today are accelerator-based, which allows for higher energies, faster operation, and more precise controls. These systems incorporate software that takes advantage of improved computing platforms and features increasingly sophisticated analytics. Figure 1 illustrates how this power has paved the way for the use of dual-energy accelerator sources and advanced detectors to facilitate material discrimination, enabling inspectors to identify threat objects more quickly, based on their composition. For example, this truck cab is imaged by a manufacturer's proprietary dual-energy system that classifies materials of interest by color and provides other advanced imaging features.

Likely progression

Future developments in cargo screening are likely to follow a common innovation trajectory that is fostered by market needs and new technology, while being strengthened by existing intellectual property and evolving industry standards. Figure 2 provides a simplified view of this model, where each color represents a distinct contribution to the innovation process

The top section (see Figure 2 - in green) illustrates that innovation is often perceived as a circular path beginning with customer needs that are identified by a technology developer. The developer then creates application technology in the form of products to meet those needs. With numerous competitors in the market, suppliers are motivated to continually improve their products. However, a more nuanced understanding incorporates the role of component technologies (see Figure 2 - in red) and

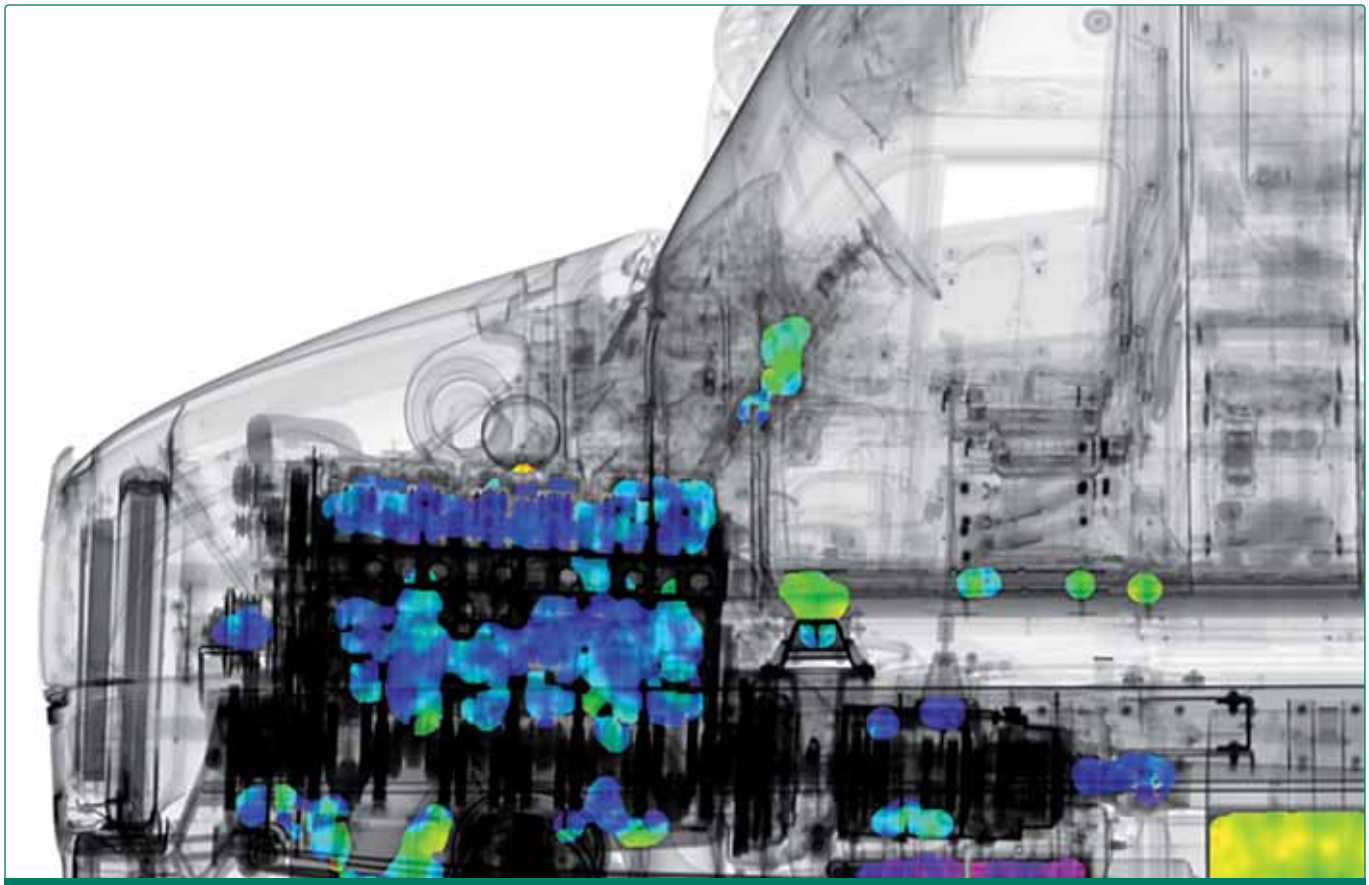

Figure 1: Material discrimination image.

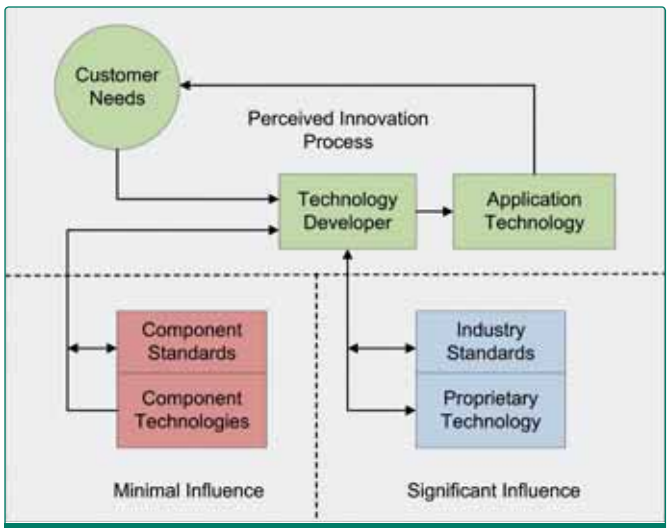

Figure 2: Simplified innovation process.

the core capabilities of the technology developer (see Figure 2 – in blue). Each of these constituents influence and are influenced by their respective technology and regulatory standards, which then ultimately impact the products available to the customer.

Component technologies and their standards are often driven by the needs of other markets and may only be tangentially connected with the market of interest. Consequently, developers often have minimal influence on these technology standards but will benefit by leveraging the investments already made by other organizations. 'Components' may be subassemblies (such as a computer graphics card) or entirely separate systems (such as a cloud computing service) that can be incorporated into a screening system to provide a complete customer solution. System providers benefit from these parallel technologies and component standards because they provide innovative insights and functional capabilities, such as interoperability, interchangeability, and known performance characteristics. In the case of cargo screening, there are many component technologies that are potential sources of future innovation. A few notable examples are described later in the article.

Because cargo screening is a youthful market with changing customer requirements and technology that is evolving to meet those requirements, existing industry standards are still in flux. This is beneficial for the cargo screening industry in that it provides ample room for innovation and development. As cargo screening technology continues to evolve and mature, the community will develop consensus in more areas and create additional standards. However, the standards process is slow and seldom speaks to the most current technology issues in an industry. For example, material discrimination is an important new feature offered by many cargo screening systems, yet there is little guidance from current industry standards to assess the performance of this technology.

Evolving component technology and standards

As the trend continues for cargo systems to address more customer needs, a number of emerging component technologies could become important adjuncts to cargo systems. Each of

these examples is characterized by evolving standards that will influence their potential adoption.

Big data

Cargo screening results in high resolution images with unique data attributes specifically tailored for law enforcement purposes. For example, a typical scan and related data may comprise 50-100 megabytes of data. Depending on utilization, the data collected at a site could exceed 300 terabytes per month. The challenges for coping with big data include storage structures, data latency, reliability, and security. Industry standards are just beginning to emerge as organizations wrestle with incorporating 'big data' into their IT systems.

World Customs Organization (WCO) data model

The WCO has established a data module to standardize electronic data used between governments to identify cargo that is transported across borders. For interoperability, this is being harmonized with other standards such as the United Nations Trade Data Elements Directory (UNTDED), and UN/CEFACT's Core Component Library (CCL). In The United States, the 'Security and Accountability for Every Port Act of 2006' (SAFE Port Act) included a provision to electronically collect import and export data. This system, known as the 'International Trade Data System' (ITDS) is to be operated by the United States Customs and Border Protection. It also requires that the ITDS data requirements are compatible with the WCO Data Model (ITDS report to congress, December 2011).

Cloud Computing

The US National Institute of Standards and Technology (NIST) defines cloud computing as 'a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources – for example networks, servers, storage, applications and services – that can be rapidly provisioned and released with minimal management effort or service provider interaction.' (NIST 800-146). Cloud computing is intended to provide a wide range of features that could be useful to cargo screening facilities, especially in the management and sharing of 'big data'. These include real-time, on-demand data and the potential for more comprehensive and robust analytics that can be made available from a central facility on an as-needed basis. NIST has established the draft Special Publication 800-146, 'NIST Cloud Computing Synopsis and Recommendations' to explain cloud computing technology and provide practical guidance for its use.

Wireless Communications

Wireless communication continues to drive technical capabilities for a number of products. As the security, reliability, and speed of these networks continue to improve, future cargo screening facilities may take advantage of more wireless connectivity. The most likely new standard is IEEE 802.11ac, which is sometimes referred to a '5G Wi-Fi' because it is the fifth generation of this technology. This standard promises a peak speed of nearly 7 gigabits per second (Gb/s) and utilizes the 5GHz radio spectrum. While sustained throughput is likely to be considerably slower at perhaps 1 Gb/s, this new standard will make wirelessly transmitting high resolution images over Wi-Fi more practical.

Personal Identification

Cargo screening typically involves a driver or other individual who must be identified and matched to the shipment. To meet these needs, Smart Card technology is growing in popularity because of its secure authentication capabilities. While Smart Cards have been available for some time, NIST has just released a new standard designated as the US Federal Information Processing Standard (FIPS) 201-2. This version was revised and upgraded to include additional information and biometric features such as iris recognition and on-card fingerprint comparison. For more information, see the related NIST draft Special Publication 800-76-2, 'Biometric Data Specification for Personal Identity Verification'.

Summary

The combination of sustained innovation and established technology standards have resulted in today's robust, reliable, and effective high-energy X-ray cargo screening systems. Future systems will continue to evolve; offering exciting new features and providing more complete solutions to port and border security. The innovation process necessarily will be guided by numerous component technologies and their associated standards, in conjunction with proprietary development expertise and intellectual property. However, the most important source of innovation insight will continue to be the clear mission requirements articulated by a diverse global customer community.

ABOUT THE AUTHOR

Dr Reed is the commercial manager for Varian Medical Systems' Security and Inspection Products Group. He has extensive experience in both engineering and business development for security equipment manufacturers and has authored numerous papers on technology innovation topics. He also holds both US and international patents for the design of industrial security products.

ABOUT THE COMPANY

Varian Medical Systems, Inc., Security & Inspection Products, is the market leader for high energy X-ray linear accelerators, imaging software, and matching detector arrays. With over 35 years of experience in manufacturing industrial products, Varian has produced over 500 linear accelerators for the cargo inspection market and maintains sales and support offices worldwide.

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