# RAMI 4.0 and IIRA reference architecture models

## A question of perspective and focus

Comprehensive use of digitisation and the Internet as the communication system is producing changes to products and their infrastructure and operation that transcend the boundaries of domains. This is also opening up new opportunities in industrial applications and across the entire value stream within the product and production system lifecycle. To capitalise on them, data transmission via Industrial Ethernet in combination with the Internet of Things, Services, People, and Machines makes it necessary to develop smart applications.


Networked systems are already being built as we speak. Sensors in these systems collect data on the physical world and then provide this information across all domains, this being made possible thanks to the system's network capability. Bilaterally agreed communication relationships or the use of industry-specific data transfer standards will act to set the transition from networking to the Internet of Things, Services, People, and Machines in motion. According to several studies [4], over 25 billion 'things' will be connected to the

Internet by 2020 (Figure 1). This is being done for two reasons: firstly, to leverage intelligent networking and the availability of the relevant information to establish the optimum value stream at any given point in time, and secondly, to generate new business models. This requires logical upgrades to components, systems, and solutions with the aim of creating interoperable concepts and radically simplifying the process of engineering and operating them.

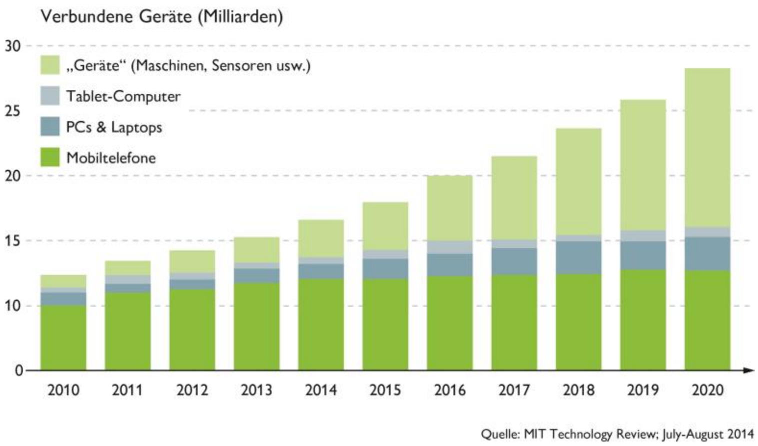


**Figure 1 -** According to various forecasts, roughly 26 billion 'things' will be networked in the Internet by 2020.

**Creating models: a balancing act between providing general descriptions and describing specific requirements**

The description and definition of a reference architecture model serve to break down functions, services, and processes into more manageable sub-processes. What's more, they support the process of implementing the accompanying solutions. The dilemma faced when creating a model typically lies in the fact that it has to provide a generally accepted description based on technical rules and standards while also allowing specific requirements regarding numerous applications and use cases to be described. As such, a model serves as a highly generalised description within defined target parameters. These target parameters are derived from the capabilities of the domain to be described, the model's impact with respect to implementation, and the system boundaries and interfaces that the model has to other models.

Several different consortiums have thus been set up around the world for the purpose of drafting (ostensibly) different reference models from different perspectives and with different focal points. Two key concepts are the Industrie 4.0 reference architecture model (RAMI 4.0) by Plattform Industrie 4.0 and the Industrial Internet Reference Architecture (IIRA) model from the Industrial Internet Consortium. Digitisation and the Internet of Thing, Services, People, and Machines are central components of both models. This raises the question of what parts of the models are complementary (properties) or congruent (properties), and what processes and common features need to be developed to ensure maximum possible benefit for the user. This is not a question of either/or. It is instead a question of the methodical implementation of the overall structures, which are based on Internet mechanisms and include end-to-end digitisation, in coordination between the principle bodies and standardisation organisations. That is critically important from the perspective of the international target users and products used as well as for global companies. Hostile attitudes with a political, regional, or strategic background would slow down or create technical impediments to implementation or generate higher costs.

**Combination of lifecycle, value stream, and hierarchical approach**

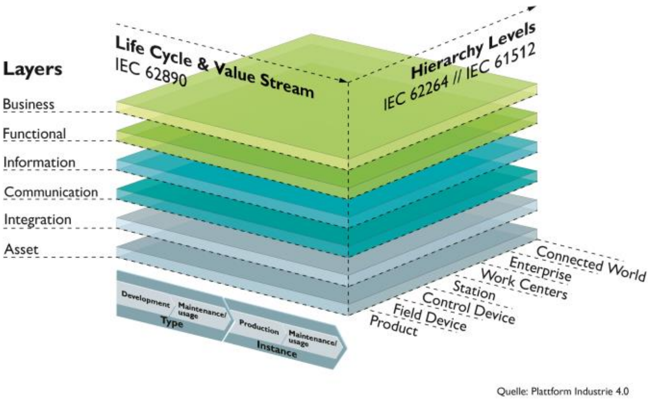


**Figure 2 -** The three-dimensional RAMI 4.0 reference architecture model incorporates the physical world, the lifecycle, and the mapping of IT-based business models.

Industrie 4.0 is a specialisation within the Internet of Things and Services in the 'Production and Product' domain, integrating the engineering of production tools and products along with the service in use. A three-dimensional model describes the Industrie 4.0 space. Layers are used in the horizontal axis to represent various perspectives, such as data maps, functional descriptions, communication behaviour, hardware (assets), and business processes. This corresponds with the IT approach of grouping complex projects into manageable sub-units. Other key criteria are the lifecycle (type) and service life (instance) of products and production systems with the value streams it contains. This is represented along the second axis. Dependencies, e.g., comprehensive data collection across all value streams, can be clearly represented within the RAMI 4.0 model. The third key aspect, represented in a further axis, is the allocation of functions and responsibilities within factories/plants. This represents a functional hierarchy, and not the device classes or hierarchical levels of the classic automation pyramid. The RAMI 4.0 reference architecture model expands the hierarchy levels of IEC 62264 by adding the 'Product' or work-piece level at the bottom, and the 'Connected World' going beyond the boundaries of the individual factory at the top (Figure 2).

The special characteristics of RAMI 4.0 are therefore its combination of lifecycle and value stream with a hierarchically structured approach for the definition of Industrie 4.0 (I4.0) components. The concept allows for the logical grouping of functions and the mapping of interfaces and standards. This provides the conditions necessary to describe and implement highly flexible solutions using the reference architecture model. In this context, investment security is interpreted to mean using existing international standards, where possible, or harmonising compatible standards or agreeing on alternative ones. Standards where they do not exist, as well as the processes to draft them, must be defined by international bodies as a means of ensuring there are no obstacles standing in the way of their speedy implementation and safe adoption. Along with the communication relationship, the semantics and syntax upon which data exchange is based serve as the basis of communication between the various parties involved. Not every domain shares the same language. However, if standardised rules are used, it is possible to transpose (or translate) any differences that may exist between the languages – as in human language – and hence restore communication.

## Consideration for the perspectives of different stakeholder groups

The U.S.-based Industrial Internet Consortium developed the Industrial Internet Reference Architecture (IIRA) model based on the ISO/IEC/IEEE 42010:2011 standard. This international standard outlines the requirements regarding a system, software, and enterprise level architecture. Where practical and feasible, the ISO/IEC/IEEE 42010 standard recommends identifying the perspectives of the various different stakeholders. Stakeholders in this context include system users, operators, owners, vendors, developers, and the technicians who maintain and service the systems. The aim is to describe system properties as seen from their viewpoint. Such properties include the intended use and suitability of the concept in terms of its implementation, the implementation process itself, potential risks, and the maintainability of the system over the entire lifecycle (Figure 3).

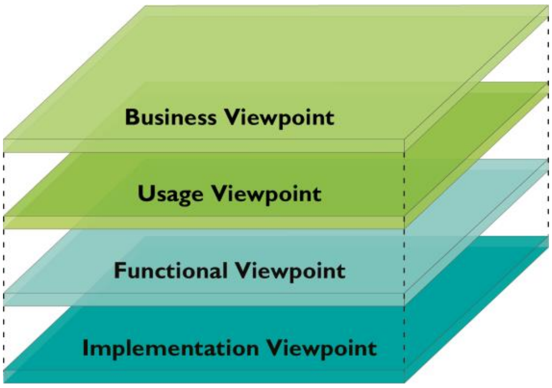


**Figure 3 -** The Industrial Internet Reference Architecture (IIRA) model is based around four viewpoints.

IIRA is a layer model that takes into consideration four different viewpoints (business, usage, functional, and implementation). It focuses on the capabilities from the perspective of the software and their business processes. Each of the four viewpoints outlined in IIRA can be compared with the respective layers on the vertical axis of RAMI 4.0; RAMI 4.0 supplements the model with the axes 'Lifecycle' (with types and instances) and 'Hierarchical Levels.' Furthermore, the relationship to the world of things is elementary. This is specified as an Industrie 4.0 component in the reference architecture model and includes, as indicated above, a description of communication in syntax and semantics in an administration shell (Figure 4).

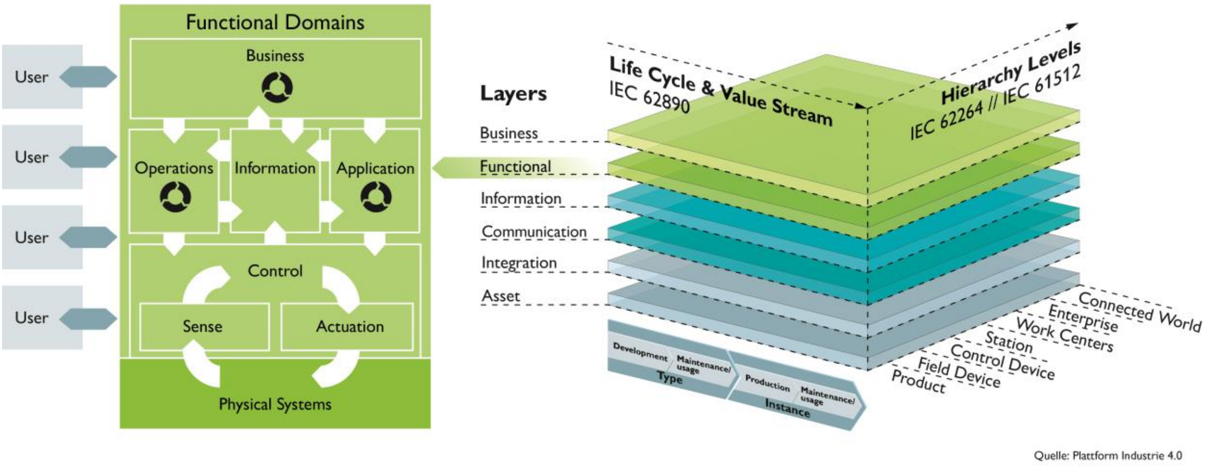


**Figure 4 -** The viewpoints of the IIRA can be represented in the corresponding layers in the RAMI 4.0 model.

### Data model and engineering language as a digital 'link' between domains

With RAMI 4.0 and the Industrie 4.0 component, Plattform Industrie 4.0 has defined an architecture that makes production, products and services, and their usage and complexity manageable from an industrial perspective. The architecture also aims to reduce the variety of interfaces in practice in the Internet of Things, Services, People, and Machines as well as to standardise the engineering language. The administration shell of the Industrie 4.0 component thus forms the link between the shop and office floor and to other models and viewpoints. The stakeholders from the different consortiums now have to work together to identify the models (IIRA, RAMI 4.0) and promote the implementation in products, systems, data, and services. The aim is to generate one or more harmonised reference models that create the investment security for implementation of properties (with harmonised meaning key aspects are identical). This is driven by the fact that interoperability is necessary to deliver Industrie 4.0 solutions that offer identifiable benefits to users.

References:

[1] Plattform Industrie 4.0 (pub.): Industrie 4.0 Implementation Strategy; V1.0; last updated: April 2015

[2] VDI – Verein Deutscher Ingenieure e.V., VDI/VDE Society Measurement and Automatic Control (GMA, ZVEI – German Electrical and Electronic Manufacturers'

Association Automation Division (pub.): Reference Architecture Model Industrie 4.0 RAMI 4.0; last updated: July 2015

[3] Industrial Internet Consortium (pub.): Industrial Internet Reference Architecture V1.7

[4] MIT Technology Review: Business Report – The Internet of Things; July–August 2014; www.technologyreview.com

[5] ISO/IEC/IEEE 42010 Systems and software engineering — Architecture description; Retrieved: 2013-08-0; www.iso-architecture.org

Further links:

[www.phoenixcontact.com](http://www.phoenixcontact.com)
[www.plattform-i40.de](http://www.plattform-i40.de)
[www.iiconsortium.org](http://www.iiconsortium.org)

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**Four example applications on the online roadmap**

The 'Industrie 4.0' online roadmap, published by Plattform Industrie 4.0, contains a list of roughly 200 example applications and test-beds with the aim of providing small and medium-sized enterprises with access to new technologies. Phoenix Contact is one of the pioneers of this forward-looking project and contributed four examples to the online roadmap.

The 'Automation for Versatile Production Technology (AWaPro)' innovation project was among these applications. The 'it's OWL' top cluster is researching and developing the end-to-end digital planning of the electrical system for a machine or system that will facilitate the customised manufacturing of products. The result of the engineering process is a digital article. This also forms the foundation of the 'Smart Engineering and Production 4.0 (SEAP)' joint project between Eplan, Phoenix Contact, and Rittal. SEAP 4.0 demonstrates how a specific control cabinet can be built in a cost-effective way with uniform, standardised data and data formats and interfaces for engineering tools.

Further Industrie 4.0 concepts have already been deployed in the first applications. For instance, a production control system designed by Phoenix Contact enables the parallel production of different versions of a product, simple configuration of version-specific process flows, and the support of manual steps by means of easy-to-use wizard functions. End-to-end recording of the manufacturing history ensures long-term quality documentation. In toolmaking, mixed-method, automated process sequences help reduce idle time because tools can be uniquely identified and localised at any time anywhere in the world. Digitisation of all relevant data therefore taps the potential for improving efficiency, making it possible to manufacture batches of one at the same cost it would take to mass-produce the product.