

ISA-95 Today: Enduring Concepts, Models Worth Revisiting

A reading of the reference model in light of current architectures and representation needs

Jean Vieille

8 October 2026 · Version 1.0 — English version

DOI: 10.5281/zenodo.23233104

French original: DOI 10.5281/zenodo.23220063

© 2026 Jean Vieille. Licensed under the Creative Commons Attribution 4.0 International licence (CC BY 4.0).

The pump serving the functional position tagged P101 fails. It is replaced by an equivalent pump with a different serial number.

For operations, P101 still exists: the function performed in the process has not changed. For maintenance, however, the former asset must retain its history while the new one starts its own. The control system, CMMS, MES or an OPC UA server may therefore speak about “the same equipment” while referring to different realities.

This simple case concentrates several questions that ISA-95 has addressed for more than thirty years: how should resources used in operations be described? How should functional role and physical asset be distinguished? How can the same reality be recognised and related across several systems? And how should information circulate between them?

Since the first ISA-95 work in the mid-1990s, technologies have changed profoundly. OPC UA exposes information models that applications can use directly. MQTT and Unified Namespace architectures facilitate the distribution of events and states. APIs, data platforms, edge and cloud architectures multiply the ways in which functions can be distributed. AI can now exploit representations that have never been explicitly aligned.

In this context, rereading ISA-95 helps distinguish three planes: the industrial concepts it helped stabilise, the particular models that organise those concepts, and the way in which multiple representations of the industrial system can be related and kept coherent.

This reading highlights both the strength of part of the standard and some limits in the way it has been constructed.

The industrial system, its representations and computing

An industrial system is not made up of a “real” system to which an information system is added in order to represent it and support its operation.

Information is a constitutive dimension of the industrial system. Orders, procedures, models, measurements, decisions, documents and knowledge all participate in its activity. The computing means that create, store, transmit or exploit this information are themselves part of that system: they observe, calculate, coordinate, act, record and contribute to decisions.

We build representations of the industrial system. Computing artefacts — software, devices, databases and services — carry or exploit some of those representations. Their architecture describes how those artefacts are organised and related.

Representations of the industrial system and the computing architecture are related, but nothing requires them to share the same structure.

Functional levels, applications and architecture

The representation in levels 0 to 4 comes from the Purdue Reference Model.

Level 0 is the physical process. Levels 1 and 2 concern observation, action and control of the process. Level 3 corresponds to the management of operational activities; level 4 to broader enterprise management functions.

ISA-95 was notably built around the boundary between operational activities and enterprise functions, that is, between levels 3 and 4. The boundary between these levels is functional, not technological. Activities on either side differ notably in their time horizons, responsibilities and requirements for availability, security, quality, reliability or compliance.

But a functional level is not an application category.

The simplified association:

ERP = level 4

MES = level 3

SCADA / automation = levels 2 and 1

can provide a rough map of an application landscape, but it is not an architecture prescribed by ISA-95.

A level 3 activity can be performed in an MES, a specialised application, an ERP, an intelligent device or several cooperating services. Conversely, an MES may cover activities that go well beyond a narrow reading of level 3 — for example, managing weighing operations or contributing to production rescheduling.

The useful question is therefore less:

“Which level does this application belong to?”

than:

“Which activity does it perform, what information does it consume and produce, what resources does it mobilise, and what constraints apply to its execution?”

Distributed architectures, OPC UA, MQTT or the cloud change the paths followed by information. They do not remove the functional differences for which the levels provide a reference.

Part 5 already defined pull, push and publish transaction models; Part 6 extends them with a Messaging Service Model independent of the underlying communication mechanism, based notably on request/response and publish/subscribe modes.

Two representations of equipment

Alongside this functional hierarchy, ISA-95 provides two different viewpoints on equipment: the Role based equipment model, organised according to the Role based equipment hierarchy, and the Physical asset model, organised according to the Physical asset equipment hierarchy.

The Role based equipment hierarchy:

Enterprise / Site / Area / Work Center / Work Unit

organises equipment according to its functional role in operations, represented here by the P&ID tag P101. Work Centers and Work Units take different meanings depending on the type of production, so the structure is not devoid of functional content. But in ISA-95 models, it serves primarily to locate an object or information within a scope, notably through the hierarchy scope. It therefore provides a convenient means of localisation, for example when structuring some Unified Namespaces:

Enterprise / Site / Area / Line / Equipment / ...

Such a path helps locate information. By itself, it neither describes nor relates nor constrains the objects it locates.

The Physical asset equipment hierarchy takes another view of equipment: that of the tangible physical object.

Returning to P101, this tag denotes a relatively stable function in the installation. The pump that actually fulfils that function is a physical object identifiable by its manufacturer, model or serial number. It can be replaced without P101 disappearing.

ISA-95 explicitly distinguishes these two representations and allows their association to be maintained. The OPC UA ISA-95 Companion Specifications also reflect this distinction: the equipment can remain stable while the physical asset that fulfils it changes.

The standard therefore recognises that the same industrial system may legitimately be described from several viewpoints.

ISA-95 and ISA-88: shared heritage, different roles for hierarchies

Comparing ISA-95 with ISA-88 helps clarify the different roles played by these hierarchies.

The two standards share part of their history and many concepts. ISA has also published Technical Report ISA-TR88.95.01 specifically on using them together.

But from the Work Center — the Process Cell in the batch case — the ISA-88 physical hierarchy plays a much more structuring role.

Process Cell, Unit, Equipment Module and Control Module are not merely levels for locating information. They organise the operational capabilities and control of the installation.

The equipment procedural model is embedded in this structure: a Unit carries its Equipment Unit Procedures, Equipment Operations and Equipment Phases; a Process Cell carries its Equipment Procedures. When an equipment entity is reused or moved, these procedural elements, which express part of its control capabilities, move with it.

ISA-95 equipment hierarchies structure the meaning and behaviour of the objects associated with them much less strongly.

This difference matters when a Role based equipment hierarchy is used as a UNS tree: it provides an excellent localisation framework, but does not thereby become a semantic model of how the installation operates.

The same pump across several systems

The P101 example can be taken further.

The control system knows the pump through its variables and technical modules. OPC UA can expose it as an object with properties and relations. The MES can treat it as a resource assigned to an activity. The CMMS follows the physical asset, its interventions and its history. An ERP may reference it for other purposes. A Unified Namespace may publish some of its states under a path derived from its location.

These representations serve different needs.

The difficulty appears when they must be related.

Does the OPC UA object represent P101, the physical asset currently assigned to P101, or both? When the pump is replaced, which identifier should remain stable? Which applications need to know about the change? Do two identifiers denote the same object, or different objects linked by an explicit relation?

Part 7, Alias Service Model, addresses part of this problem by defining services for establishing correspondences between identifiers and their context.

It also exposes the boundary between two different problems: maintaining correspondences between identifiers and building a sufficiently general semantic representation to express the nature and relationships of the objects concerned.

The second problem extends well beyond ISA-95. It is also addressed today, from different perspectives, by OPC UA information models, the Asset Administration Shell, master data management, knowledge graphs and ontologies.

Enduring concepts, imperfect factorisation

Beyond the first three parts, the ISA-95 corpus expanded to information models for Manufacturing Operations Management, transactions, messaging services, aliases and information exchange profiles. B2MML provides a complete XML implementation of ISA-95 models, whereas the OPC UA ISA-95 Companion Specifications project only subsets of them into a different modelling and exposure environment.

Committee work is also continuing through recent revisions — Part 1 in 2025, IEC 62264-2 in 2026 — and Technical Report projects, notably around Smart Manufacturing and the extension of activity models towards levels 1 and 2.

ISA-95's fundamental distinctions remain highly relevant.

A definition is not its execution. A request is not the response describing what was actually performed. An available resource is not necessarily capable of carrying out a given task. Equipment considered by its operational role is not the physical asset currently fulfilling that role.

These concepts do not depend on the protocol used to represent or exchange them.

Their organisation, however, results from the standard's progressive construction, part by part, in response to different industrial problems. It was not derived from a reduced set of meta-concepts that were then specialised systematically.

Part 4 makes this issue particularly visible. At another level of granularity, it introduces Work Master, Work Schedule, Work Capability, Job Order, Job Response and associated objects around a conceptual pattern close to one already present in the Operations models: describing what can be done, what must be done and what has actually been performed.

Operations Definition and Work Master, or Operations Request and Job Order, are therefore not identical objects: they address different contexts and levels of granularity. But their proximity highlights a modelling choice: creating families of objects tailored to each context rather than explicitly factorising a more general pattern and then specialising it.

ISA-95 itself has followed a generalisation logic elsewhere. Models for Production, Maintenance, Quality and Inventory, initially developed with substantially different structures and levels of detail, were later brought together under the more generic and consistent concept of Operations.

The same reasoning can be taken to a more abstract level. Many objects in the standard can be read through a few recurring distinctions: Process, Definition, Capability and Execution.

Such factorisation would make a conceptual coherence that remains partly implicit in the native models more explicit and would substantially simplify the standard.

The same phenomenon appears when ISA-88 and ISA-95 are brought together: their concepts are largely compatible, but expressed with different vocabularies, structures and levels of abstraction.

The issue is therefore not the age of these concepts, but how their different expressions could now be brought closer together and made more semantically coherent.

From information exchange to coherence between representations

ISA-95 has historically focused extensively on the information required for exchanges between functions and applications.

Current architectures raise a complementary question: how can coherence be preserved when several applications simultaneously hold partial representations of the same industrial system?

With OPC UA, information is no longer only contained in a message: it can be part of a navigable model of objects, properties and relations. The ISA-95 Companion Specifications therefore project some abstract models from the standard into ObjectTypes, Variables, DataTypes and References that can be used directly in the OPC UA address space.

With a UNS, several consumers can receive the same events directly without going through a chain of point-to-point interfaces.

With the AAS or a knowledge graph, relations and semantic references can themselves become explicit elements of the representation.

The problem is therefore no longer only to determine which data should be exchanged. It is also necessary to know what they refer to, how their objects are related, and which representations can be considered coherent.

What AI adds

ISA-95 Part 2 already distinguishes role-based equipment from physical assets and provides for the association between them.

Part 7 addresses another aspect of the problem by supporting mappings between identifiers used in different application namespaces.

In practice, however, those relationships are not always explicitly represented or consistently available across the systems an AI agent may access. An agent encountering P101 in the control system, EQ-4732 in the CMMS and related operational data may infer that, during a particular period, physical asset EQ-4732 fulfilled the operational role P101.

Such an inference may be useful, but it does not establish the relationship as an authoritative fact. The agent cannot, from inference alone, determine that the assignment has been formally recognised, its exact period of validity, or which source has authority over it.

AI can therefore help discover or reconstruct relationships across heterogeneous representations. It does not remove the need to represent and govern those relationships explicitly when operational decisions depend on them.

AI tolerates heterogeneous representations better. The remaining question is which representation or relationship is considered valid, in what context, at what time and under whose authority.

What should we retain?

This rereading brings out three aspects.

The first concerns industrial concepts. Many remain remarkably robust: resources and capabilities, definitions and executions, requests and responses, operational activities, functional role and physical asset. They still provide a solid basis for reasoning about industrial operations.

The second concerns the models that organise these concepts. They reflect the needs successively addressed by the standard. Their diversity adds richness, but it also reveals similar conceptual patterns expressed in multiple forms and at multiple granularities, making the standard harder to read and implement.

The third concerns coherence between representations. Current technologies allow several systems to produce, expose and exploit different viewpoints on the industrial system simultaneously. The need is not necessarily to make them uniform, but to know how they correspond, what relations they express and which sources are authoritative.

ISA-95 is neither a computing architecture to reproduce nor a general ontology of industrial systems. It is a particularly rich body of concepts and reference models built from several decades of industrial experience.

Returning finally to P101: the function remains when the pump is replaced; the asset changes, the histories separate, and several systems may legitimately retain different representations of them. ISA-95 provides several of the distinctions needed to avoid confusing them. It does not, by itself, constitute the general model required to make all these representations coherent.

Further reading:

- ISA — ISA-95 series, Enterprise-Control System Integration: [series overview](#)

- ISA-TR88.95.01 — Using ISA-88 and ISA-95 Together: [ISA-88 / ISA-95](#)
- IEC 62264-2:2026 — Object models and relationships for interfaces between manufacturing operations and business functions: [IEC 62264-2:2026](#)
- OPC Foundation — OPC 10030, ISA-95 Common Object Model: [OPC 10030](#)
- OPC Foundation — OPC 10031-4, OPC UA for ISA-95 — Part 4: Job Control: [OPC 10031-4](#)
- Industrial Digital Twin Association — Asset Administration Shell specifications: [AAS specifications](#)

Note on the use of AI tools

Generative AI tools were used to support editorial drafting, structured critique, consistency checking and the examination of alternative formulations. OpenAI GPT 5.6 Sol was used throughout drafting and revisions; Anthropic Claude Opus 5.5 was also used for critical review of intermediate versions. All suggestions were evaluated by the author, who determined the positions adopted and remains solely responsible for the final text.