



# SmarterLink Whitepaper



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# SmarterLink

## Scope

This document provides an introduction to the SmarterLink standard. It provides the purpose, give a general overview of technical implementation and outlines some example use cases

SmarterLink is a structured approach for enabling interoperable communication between industrial systems, devices, and software platforms. SmarterLink is built on MQTT, is intended to support integration across various inspection environments, enabling efficient data exchange, improved traceability, and enhanced system coordination.

## Referenced Documents

The following documents provide supporting and contextual information relevant to this document:

**[mqtt-v3.1.1] MQTT Version 3.1.1** - Edited by Andrew Banks and Rahul Gupta. 29 October 2014. OASIS Standard.

<http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html>.

<http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/mqtt-v3.1.1.html>.

**SmarterLink Protocol Specification** - Status: Draft (pre-release, protocol version 0) Library version: 1.0.0-alpha-07

<https://smarterlink.github.io/>

## Terminology

**SmarterLink** - A standardised communication framework enabling structured data exchange between systems.

**Participant** - Any system, device, or software component that sends, receives, or processes SmarterLink messages.

**Message** - A structured data payload conforming to the SmarterLink schema.

**Topic** - A logical channel or classification used to organise and route messages.

**Producer** - A participant that generates and sends messages.

**Processor** - A participant which receives messages, performs a function on the data and sends out a response.

**Consumer** - A participant that receives and processes messages.

**Broker** - An intermediary responsible for routing messages between participants.

## Introduction

Modern industrial environments require seamless communication between diverse systems, often spanning multiple vendors, technologies, and generations of equipment. Traditional point-to-point integrations can be difficult to scale, maintain, and adapt.

The SmarterLink standard addresses these challenges by introducing a consistent, topic-based messaging approach. It decouples systems, allowing participants to communicate without requiring direct knowledge of each other's implementation details.

While SmarterLink has many possible applications, it has been specifically designed for inspection environments, where there is often diverse equipment, varying operation workflows, and differing specific governing requirements.

Key benefits of SmarterLink include:

- Improved interoperability across systems
- Reduced integration complexity
- Enhanced scalability and flexibility
- Clear separation of responsibilities between components
- Enabling the leverage of internal and external skillsets

By adopting SmarterLink, organisations can modernise their data infrastructure while maintaining compatibility with existing systems.

## SmarterLink for OEMS

Original Equipment Manufacturers (OEMs) play a critical role in enabling interoperable industrial ecosystems. By adopting the SmarterLink standard, OEMs can achieve seamless integration while retaining full control over their data, systems, and innovation.

SmarterLink's self-publishing model allows OEMs to expose structured data directly to the network, eliminating the need for costly, bespoke integrations. Downstream systems can consume this data in a consistent and predictable way, accelerating deployment and reducing support overhead. At the same time, OEMs can preserve the richness and uniqueness of their data.

Key advantages for OEMs include:

**Native Connectivity by Design** – Equip systems with built-in SmarterLink support to enable immediate participation in connected environments, reducing reliance on middleware and simplifying integration for customers.

**Full Control of Data Models** – Define and own message structures that accurately represent the value and uniqueness of your equipment, ensuring clarity while protecting intellectual property.

**Future-Ready System Design** – Build products with secure connectivity, remote configuration, and scalability at their core, aligning with modern industrial expectations and Industry 4.0 initiatives.

**Seamless Interoperability** – Integrate effortlessly with other standards, legacy systems, and customer-specific environments through SmarterLink's flexible, bridge-friendly architecture.

**Stable Evolution Through Versioning** – Introduce new features and enhancements with confidence using controlled versioning, maintaining backward compatibility and protecting existing deployments.

By aligning with SmarterLink, OEMs can deliver more competitive, integration-ready products, reduce engineering overhead, and position themselves at the centre of increasingly connected and data-driven industrial ecosystems.

## SmarterLink for Integrators

System integrators are responsible for bringing together diverse systems, devices, and software platforms into a cohesive and functional solution. SmarterLink provides a common framework that simplifies this process by reducing the need for custom, point-to-point integrations.

Key SmarterLink advantages for integrators include:

**Simplified System Integration** – Combine multiple SmarterLink-enabled participants into a unified architecture with predictable data flows, reducing engineering effort and integration risk.

**Seamless Legacy and Multi-Vendor Connectivity** – Incorporate non-compliant or legacy systems, through a SmarterLink data processor gateway, enabling them to participate in modern, connected environments without full replacement.

**Streamlined Deployment and Operations** – Leverage standardised broker infrastructure, access control models, and configuration patterns to deploy systems quickly, reliably and manage them more effectively.

**Faster Testing and Validation** – Work with consistent message structures and event models, making it easier to validate system behaviour, troubleshoot issues, and ensure reliable operation.

**Scalable, Future-Proof Architectures** – Build solutions that can grow and adapt as requirements change, without the need for extensive rework or re-integration.

By using SmarterLink, integrators can automate workflows, improve system reliability, and deliver solutions that are easier to scale and adapt over time.

## SmarterLink for Users

End users benefit from SmarterLink through improved automation, visibility, and consistency across their operations. By standardising communication between systems, SmarterLink enables users to move from manual, fragmented workflows to integrated and data-driven processes.

SmarterLink is designed to support environments ranging from simple setups to highly complex, automated systems, while minimising the need for direct user intervention.

Key benefits for users include:

**Workflow Automation** - Routine processes can be automated through event-driven communication between systems, reducing manual input and the risk of human error.

**Reduced Operational Complexity** - Standardised interfaces and predictable data structures make systems easier to understand, operate, and maintain.

**Scalability** - Additional equipment or software can be integrated with minimal disruption, allowing systems to grow alongside operational requirements.

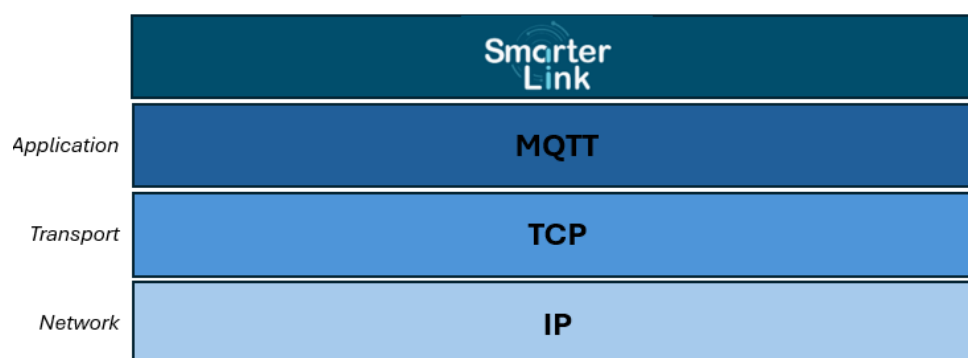
**Improved Traceability and Insight** - Structured data collection enables better tracking of processes, supporting analysis, reporting, and continuous improvement initiatives.

**Leverage of Skills and Resources** - Standardisation allows organisations to integrate and leverage the latest developments and skillsets across different systems and vendors,

By adopting SmarterLink-enabled systems, users can achieve greater operational efficiency, improved data visibility, and a stronger foundation for digital transformation.

## General implementation guidance

SmarterLink is built on top of the MQTT tech stack. Familiarisation with MQTT is fundamental for understanding how SmarterLink works. This section gives a basic overview of the requirements of SmarterLink and how it utilises MQTT components.



When developing a SmarterLink participant, systems should be designed to operate reliably within an event-driven, message-based environment. This includes:

**Structured Data Handling** – The ability to serialise and deserialise structured data formats (e.g. JSON) in line with SmarterLink message conventions.

**Asynchronous Communication** – Support for non-blocking, event-driven communication patterns to enable efficient message publishing and consumption across distributed systems.

Successful implementation of SmarterLink also depends on a supporting technical foundation:

**Robust Network Infrastructure** – A network capable of supporting reliable, low-latency data exchange between participants, with appropriate consideration for scalability and fault tolerance.

**Standards-Compliant MQTT Broker** – An MQTT implementation, including a broker, that meets the conformance requirements defined in MQTT v3.1.1, ensuring reliable message routing and delivery.

Together, these capabilities provide the baseline required for building scalable, resilient, and interoperable SmarterLink-enabled systems.

## Participants & Roles

### Participant Types

SmarterLink defines the following four canonical participant roles:

**Producers** – Acquires and publishes data (images, measurements, etc.)

**Processors** – Consumes and outputs data

**Storage** – Persists data and serves data upon request

**HMI** – Consumes data

Custom roles are permitted but carry no standard event definitions. Other roles that are likely to appear in a SmarterLink network, but which are not canonical and should be considered a derivative of the core 4 roles include:

**Orchestrator** – (A form of storage and processor) This role manages the workflow of messages between participants. Used when formal definition doesn't supply the required flexibility or conditional flows become too complex.

**Supervisor system** – (A form of HMI and processor) Not necessarily requiring understanding of SmarterLink but still an important constituent for logging and security monitoring.

A single application may perform multiple roles depending on the implementation.

## Topic Design

Topics are core part of the MQTT standard and are used to organise and categorise messages, enabling scalable and flexible communication.

SmarterLink topics follow the Universal Namespace (UNS) convention:

**smarter-link/<site>/<area>/<sub-area>/<station>/<role>/<participant-id>/<event-name>**

Level	Name	Description
1	Smarter-link	Fixed protocol root identifier
2	Site	Site or facility identifier
3	Area	Area within the site
4	Sub-area	Sub-area within the area
5	Station	Workstation
6	Role	Role segment
7	Participant-id	Publishing participant's ID prefixed with ~
8	Event-name	Event name in kebab-case

When a level is not applicable to a particular event it is set to \_ rather than omitted. All topics therefore always have exactly 8 levels, which makes subscription filter construction predictable.

MQTT topic paths and must not contain MQTT reserved characters (/, +, #, \$).

Note: Every SmarterLink participant has a **Participant ID**: a plain string that must be unique across the entire SmarterLink network (all sites).

For more information on topics please refer to the SmarterLink Protocol Specification.

**Example:**

smarter-link/site-x/area-1/sub-1/station-a/producers/~cam-01/component-image-acquired

## Message Structure

All SmarterLink messages, except raw file transfer chunks, are JSON objects.

Messages within the SmarterLink standard follow a structured format to ensure consistency and usability.

Every message has two required top-level fields:

**Header** - Encoders data about the message, used to help the system deliver and handle messages. Required fields include, *payloadType* and *protocolRevision*

**Payload** – Contains the message contents, e.g sensor reading, job number, Component ID, data file URI. Etc.

### Standardized workflows

Additionally, SmarterLink defines standardized events that can be used to configure devices to operate along a predefined workflow. Different participant types have access to different events.

Participant	Event
All	activeJobUpdated jobFileAvailable
Producer	componentImageAcquired userInformationAcquired inspectionSystemStatusAcquired
Processor	componentAnalysisUpdated componentReportUpdated

For more information on message structure, required and optional fields, please refer to the SmarterLink technical documentation.

### Custom workflows

A core strength of SmarterLink is its ability to be adopted quickly and configured flexibly around different data outputs and user workflows. To support this, SmarterLink provides a facility for custom payloads for scenarios that don't align with the standard typed event model, such as third-party integrations, application-specific configuration, or application-defined side channels. Wherever possible, publishers should adhere to established SmarterLink conventions.

For further details on custom messages and payloads, refer to the SmarterLink Protocol Specification.

## Security

Because SmarterLink is built on standard MQTT and uses a non-proprietary, human-readable message format, it can leverage well-established MQTT security practices and tooling. This includes transport-layer protection using TLS encryption, application authentication via usernames/passwords and authorization through topic-based access control.

In addition, existing MQTT ecosystem features, such as broker-side access policies, network isolation, and monitoring, can be applied directly to SmarterLink deployments without modification. Where required, applications can implement additional safeguards such as payload validation, custom message signing, or end-to-end encryption for sensitive data.

By aligning with widely adopted MQTT security mechanisms, SmarterLink avoids introducing bespoke security models, allowing organizations to integrate it into their existing security frameworks, operational controls, and compliance processes.

## Example Use Cases

The examples below illustrate a selection of use cases that demonstrate the capabilities of SmarterLink and to highlight the range and flexibility of what SmarterLink can support.

### Centralised inspection parameters

Often inspection departments are managing multiple pieces of inspection equipment, across different inspection techniques, with varying requirements imposed by different customers.

#### *Problem*

This creates a significant management challenge. Operators must manually configure each machine in line with internal procedures, which themselves reflect customer specifications. This setup process can be time-consuming repeat work that requires reference to complex documentation or reliance on individual experience. In addition to the time overhead, there is a heightened risk of inconsistency and human error.

#### *Solution*

SmarterLink enables this process to be standardised and automated. Inspection instructions, parameters, and configuration settings can be centrally managed and distributed directly to equipment, on demand, ensuring consistency across all operations. This reduces setup time, minimises reliance on manual interpretation, makes sure the correct and most recent instructions are followed and helps ensure compliance with both internal procedures and customer requirements.

### Scalable and extensible Automatic Defect Detection and AI integration

The inspection industry is increasingly adopting advanced mathematical methods and AI techniques for tasks such as automated indication detection, pattern recognition, and assisted or fully automated defect evaluation.

#### *Problem*

This rapid growth in AI-driven solutions, which can be provided by both equipment

manufacturers and third-party specialists, has created a fragmented landscape. Many solutions are proprietary, tightly coupled to specific hardware, or difficult to integrate with existing workflows. As a result, organisations face challenges in adopting new capabilities without vendor lock-in, duplicating procedures, or compromising traceability and consistency across systems.

### *Solution*

SmarterLink provides a vendor-agnostic integration layer that enables AI and automated defect detection tools to be seamlessly incorporated into inspection workflows. Different AI solutions, whether embedded within equipment or delivered by external providers, can be connected to and utilised as part of a unified process.

All components can be plugged into the SmarterLink network, enabling scalable deployment and consistent data exchange. Crucially, SmarterLink maintains end-to-end traceability by capturing inspection data, processing steps, and results within a unified framework, supporting auditability, compliance, and quality assurance across the entire inspection lifecycle.

## Distributed inspection and evaluation models

Inspection is typically a two-stage process: first, data is acquired using inspection equipment; second, that data is evaluated to determine the presence of defects or non-conformances. Traditionally, these steps occur in close physical proximity due to communication constraints and system limitations.

### *Problem*

This reliance on proximity restricts operational flexibility. Organisations are unable to fully utilise geographically distributed expertise, for example, having senior or specialist inspectors at one site review data generated at another. It also limits the efficient use of equipment, making it difficult to share high-value inspection assets across multiple locations or projects. These constraints can lead to bottlenecks, increased costs, and underutilised resources.

### *Solution*

SmarterLink enables a distributed model by decoupling data acquisition from evaluation. Inspection data can be securely transmitted in real time (or near real time) from equipment to remote systems, AI processors, or human inspectors anywhere on the network.

This allows organisations to centralise expertise while decentralising data capture. Senior inspectors can review and validate results remotely, multiple sites can share access to specialised evaluation tools, and workflows can be orchestrated across locations without manual intervention. The result is improved resource utilisation, faster decision-making, and greater scalability, while maintaining full traceability and control throughout the inspection process.

## A Standard communication bridge

Across industry there is a growing list of standard standards for communication and data formats. Driven by industry4.0 goals of creating connected "smart factories" that utilize AI, IoT, and data analytics to maximize efficiency, productivity, and flexibility. The inspection sector reflects this trend, with multiple competing standards such as DICONDE, HDF5, QIF, and .NDE.

### *Problem*

While these standards provide structure, they are often complex, rigid, and costly to implement. OEMs and software providers must invest significant effort to support multiple formats, and the proliferation of standards can ultimately undermine interoperability rather than improve it. This fragmentation makes it difficult to integrate systems, share data seamlessly, or adapt to evolving requirements.

### *Solution*

SmarterLink acts as a flexible communication bridge between disparate standards and systems. Through its self-publishing, event-driven architecture, it enables third parties to develop lightweight translation or processing applications that convert data between formats as needed.

Rather than forcing all participants to adopt a single standard, SmarterLink allows systems to communicate in their native formats while translation services operate within the network. This reduces the implementation burden on OEMs, supports coexistence of multiple standards, and enables organisations to evolve their data strategies without costly re-engineering. The result is a more interoperable, scalable, and future-proof inspection ecosystem.

## EU Data act compliance

The EU Data Act (applicable from 12 September 2025) is designed to unlock industrial data by giving users of connected products the right to access and share the data they generate. Its goal is to foster a more competitive and innovative European data economy by reducing data silos and increasing interoperability.

### *Problem*

Many equipment manufacturers are not yet well positioned to meet these requirements. Data is often stored in complex, proprietary formats, tightly coupled to specific systems, and difficult to expose securely. At the same time, no single standard fully addresses the diverse needs of all inspection technologies and use cases. This creates both technical and commercial challenges in making data accessible while maintaining control, security, and context.

### *Solution*

SmarterLink provides a practical pathway to compliance by enabling OEMs to self-publish their data in a structured, accessible, and technology-agnostic way. Through its event-driven architecture data can be made available in real time with minimal changes to underlying systems.

This approach allows integrators and third parties to build translation and analytics applications on top of SmarterLink, converting proprietary data into formats aligned with regulatory or customer requirements. As a result, OEMs can meet data accessibility obligations, reduce reliance on rigid standards, and support a broader ecosystem of interoperable solutions, while retaining control over how and when their data is shared.

## Conclusion

SmarterLink establishes a practical and scalable foundation for interoperable communication within modern inspection environments. By building on proven MQTT principles and combining them with a structured, topic-based approach, it enables diverse systems, devices, and software platforms to exchange data in a consistent and decoupled manner.

Rather than imposing rigid constraints, SmarterLink strikes a balance between standardisation and flexibility. It defines clear conventions for message structure, topics, and roles, while still allowing organisations to adapt the framework to their specific workflows, technologies, and operational requirements. This makes it equally suited to new deployments and the integration of legacy systems.

For OEMs, SmarterLink provides a way to expose high-value data without sacrificing innovation or control. For integrators, it reduces complexity and accelerates system delivery. For end users, it enables more automated, scalable, and traceable operations. Across all stakeholders, it supports a shift away from fragmented, point-to-point integrations toward cohesive, event-driven architectures.

As industrial ecosystems continue to evolve, driven by increasing connectivity, AI adoption, and regulatory requirements such as data accessibility, SmarterLink offers a future-ready approach. It enables organisations to integrate new technologies, respond to changing standards, and unlock the full value of their data without costly re-engineering.

Ultimately, SmarterLink is not just a communication standard, but an enabler of more connected, efficient, and adaptable inspection systems, forming a strong foundation for ongoing digital transformation.

## Acknowledgements

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