

FUNCTIONAL SAFETY (FUSA)

The Foundation for Safety-Critical, Intelligent Systems*

EXECUTIVE SUMMARY

Functional Safety (FuSa) is a foundational requirement for applications deployed in safety-critical environments — including industrial automation, robotics, transportation, and avionics. As systems become more autonomous, software-defined, and intelligent, ensuring predictable and safe behavior under fault conditions is no longer optional.

FuSa exists to remove unreasonable risk of harm to people, protect valuable assets, and enable safe and continuous operations. Achieving these objectives requires compliance with international safety standards and system architectures that deliver determinism, reliability, and performance at scale.

As intelligence moves closer to the physical world, safety becomes the foundation that enables innovation to scale responsibly.

**This paper is intended for system architects, safety engineers, and technical leaders designing safety-critical, intelligent systems.*

What Functional Safety Requires

Functional Safety is not a single component or feature. It is a system-level discipline that spans the full lifecycle of a product—from concept and design through deployment and operation.

At a high level, Functional Safety requires:

- Clearly defined safety goals and safety functions
- Fault detection, isolation, and controlled transition to a safe state
- Bounded and deterministic response times
- Rigorous development, verification, validation, and lifecycle traceability
- Ongoing compliance across system updates and lifecycle changes

These requirements must be met consistently, even as systems integrate higher-performance compute, advanced perception, and AI-driven workloads.

Functional Safety is therefore architected into the system from the beginning - adding it later in the design process may prove to be very challenging or impossible.

The Functional Safety Standards Landscape

Functional Safety is governed by a family of international standards that address different industries and application domains.

At the foundation is IEC 61508, the cross-industry standard for electrical, electronic, and programmable electronic safety-related systems. From it, industry-specific standards are derived, including:

- ISO 13849 for industrial machinery
- ISO 26262 for automotive systems
- DO-178C / DO-254 for avionics

Understanding how these standards apply - and how they relate to one another - is essential for

designing systems that can be certified efficiently and reused across multiple products and markets.

Market Drivers and Challenges

Certification Pressure and Time-to-Market

Organizations face increasing pressure to meet safety certification requirements while maintaining competitive development timelines. Certification processes often introduce additional design complexity, validation effort, and documentation overhead.

Growing System Complexity

Modern safety-critical systems integrate control, perception, networking, analytics, and increasingly AI workloads. Performance demands are rising, while safety requirements remain uncompromising.

Legacy Infrastructure

Many industries rely on long-lifecycle equipment and legacy components. New safety-certified systems must coexist with existing infrastructure and support incremental modernization without operational disruption.

AI Meets Functional Safety

AI introduces new challenges for Functional Safety, including non-deterministic behavior, explainability, and certification of learning-based systems. AI does not replace Functional Safety; it must be bounded, supervised, and architected within certified safety frameworks.

Why Functional Safety Matters Now

Functional Safety has evolved beyond isolated safety controllers. As human-machine interaction increases and autonomy expands, FuSa has become a business-critical enabler across industries.

It is essential not only for regulatory compliance, but also for establishing trust in intelligent systems, enabling scalable deployment, and ensuring safe collaboration between humans and machines.

From Requirements to Real Systems: Intel's Approach

From Isolated Safety to Mixed-Criticality Systems

Modern platforms increasingly consolidate multiple workloads — including safety-critical functions, real-time control, AI inference, and connectivity — onto shared compute resources.

This shift introduces the challenge of mixed-criticality systems: ensuring that safety-related workloads remain isolated, deterministic, and certifiable, even when coexisting with non-safety workloads.

Meeting this challenge requires strong architectural separation, predictable timing behavior, and hardware-assisted integrity mechanisms.

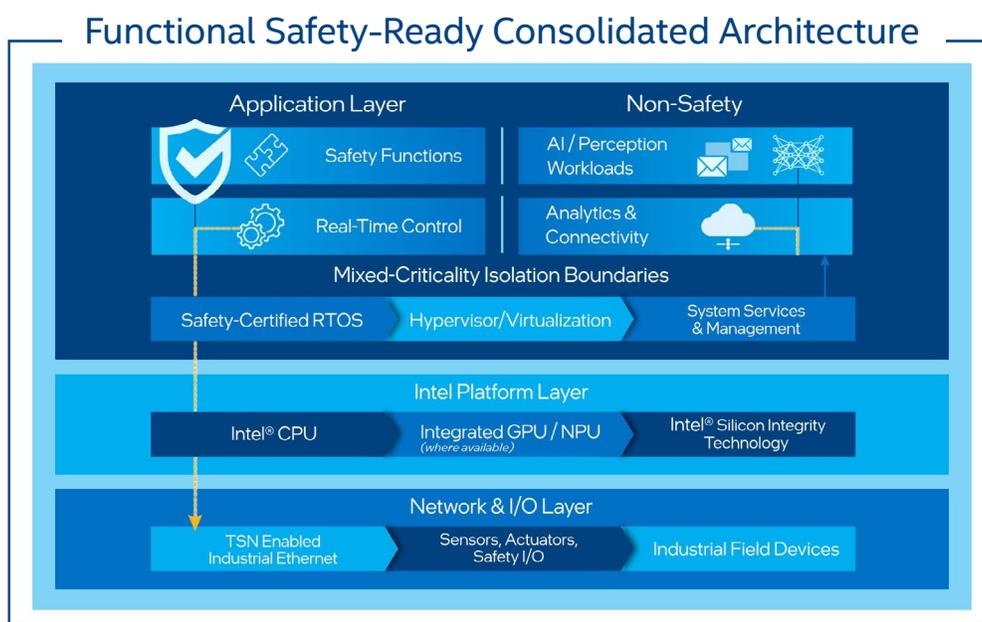
Intel Platforms for Functional Safety-Ready Designs

Intel enables Functional Safety-ready system architectures through scalable compute

platforms designed to support determinism, consolidation, and long-term certification strategies.

Key capabilities include:

- **Platform integrity and trust**
Intel® Silicon Integrity Technology helps protect the platform hardware and is the foundation of safety.
- **Deterministic performance**
Intel® Time Coordinated Computing (Intel® TCC) and Time Sensitive Networking (TSN) support bounded latency and predictable real-time behavior.
- **Heterogeneous compute**
CPU, integrated GPU, and integrated NPU (where available) enable consolidation of control, perception, and AI workloads.
- **Virtualization, security, and manageability**
Supporting isolation and mixed-criticality system designs.
- **Open ecosystem**
A broad network of software and hardware partners accelerates certification and deployment across industrial, transportation, and emerging markets.



A mixed-criticality system architecture that isolates safety-critical workloads while enabling deterministic real-time control, AI, and analytics on a shared Intel® platform.

Use Case Snapshots

Industrial Robotics

Industrial robots must operate safely alongside human workers, detecting faults, limiting motion, and transitioning to safe states under defined conditions.

Autonomous Mobile Robots (AMRs)

AMRs require deterministic perception and navigation to safely operate in dynamic environments shared with people and equipment.

Avionics

Avionics systems demand deterministic, fault-tolerant behavior and the highest levels of safety certification.

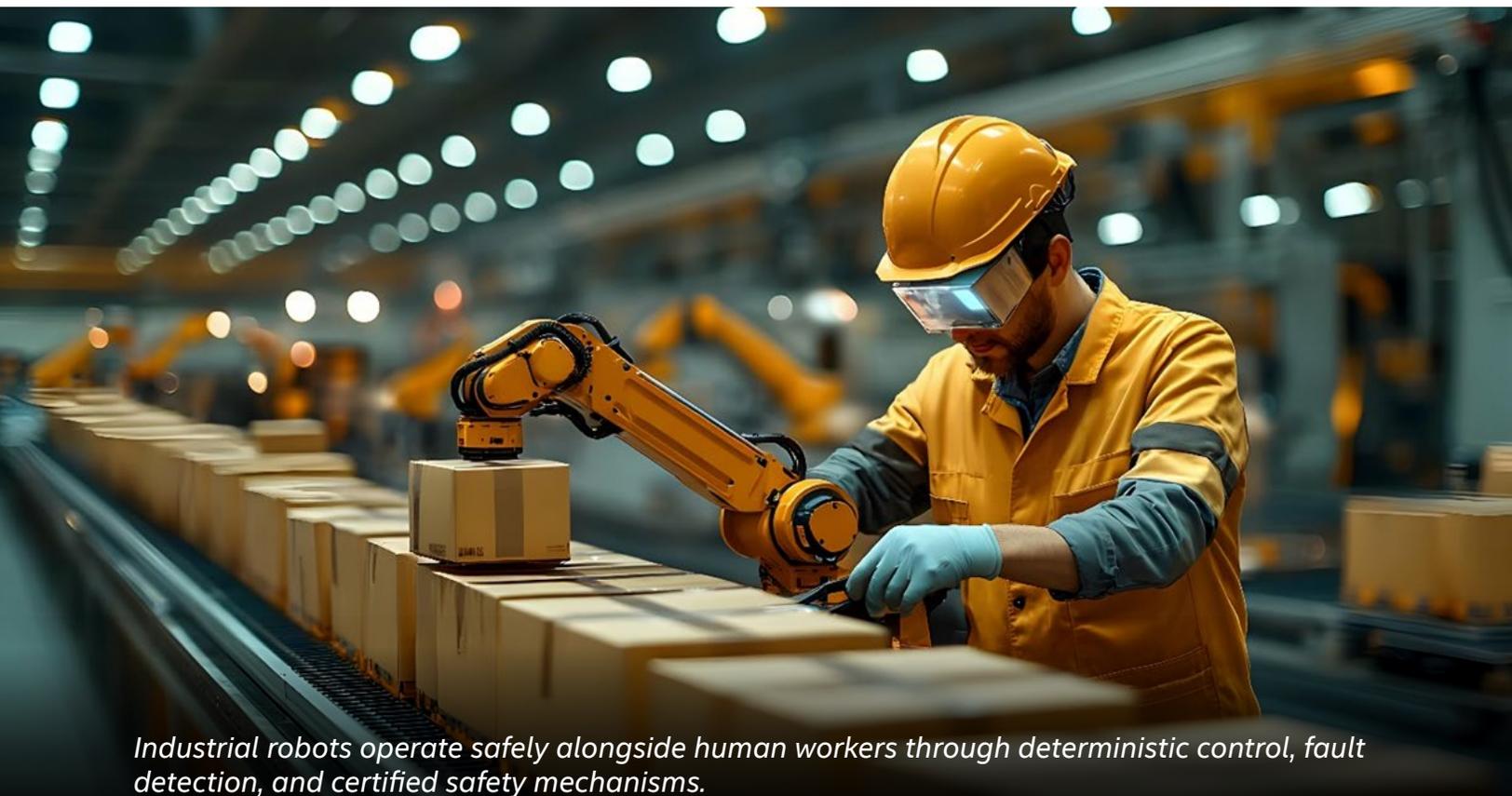
Emerging Applications

Humanoid robots and Urban Air Mobility introduce new safety challenges that increase the need for scalable, safety-ready compute platforms.

CONCLUSION

Functional Safety is a critical foundation for software-defined, intelligent systems — particularly as AI, autonomy, and system complexity accelerate. Intel technologies are used in safety-critical deployments across multiple industries, and together with a growing ecosystem of partners, provide a trusted foundation for building the solutions of today and tomorrow.

For detailed technical documentation, certification guidance, and reference architectures, don't hesitate to contact your Intel representative or access Intel resources under NDA.



Industrial robots operate safely alongside human workers through deterministic control, fault detection, and certified safety mechanisms.



Notices & Disclaimers

References to functional safety, safety-ready, or safety-capable designs do not imply certification or suitability for any specific safety integrity level. Certification to applicable safety standards (such as IEC 61508, ISO 13849, ISO 26262, or DO-178C) depends on system architecture, implementation, validation, and third-party assessment.

Intel technologies may require enabled hardware, software, or service activation.

No product or component can be absolutely secure.

Applicability of features and capabilities may vary by industry, use case, and regulatory jurisdiction.

Your costs and results may vary.

Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

Intel technologies are intended to support safety-related systems but do not, by themselves, provide or guarantee compliance with functional safety standards. System-level design, validation, and certification remain the responsibility of the system integrator or manufacturer.

Intel does not provide functional safety certification.

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