Decoupling Control from Proprietary Hardware: Reducing PLC Footprint and Costs with Containerized SoftPLCs

Introduction

This solution brief demonstrates CODESYS Virtual Control SL and Virtual Safe Control SL running on an OnLogic Helix 521 (HX521) industrial PC, enhanced with Intel® Time Coordinated Computing (TCC) for improved real-time determinism. Multiple virtual PLC instances operate in Docker containers on a real-time Linux (Debian), with one instance executing IEC 61608 SIL3 certified safety logic directly on a standard Intel CPU, without dedicated safety hardware.

The demonstration shows that software-defined PLCs can achieve sub-millisecond cycle times while consolidating standard control, safety, and motion workloads on a single computing platform.
This approach decouples control logic from proprietary hardware, enabling deployment on standard industrial PCs, rugged computers, or edge servers.

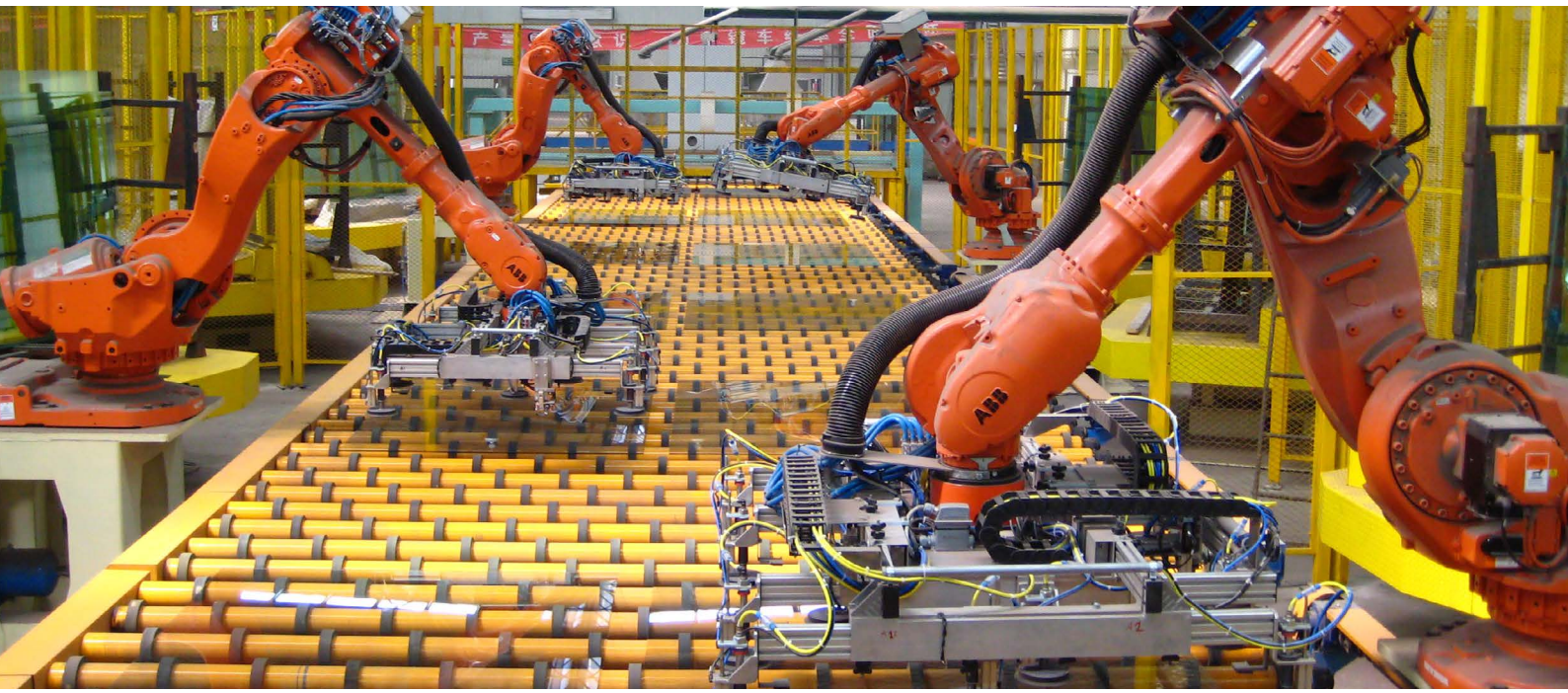


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The Challenge

Engineers deploying virtualized control systems face several technical hurdles:

1. **Real-time performance requirements:** Applications such as motion control and fieldbus communication demand cycle times 1 ms or below with minimal jitter. Standard operating systems and virtualization layers introduce latency that can disrupt deterministic execution.
2. **Safety integration:** Running SIL3 safety logic traditionally requires dedicated safety controllers, which is costly and also often introduces new tools making integration complicated. Consolidating safety functions onto general-purpose CPUs requires certified software to meet functional safety standards.
3. **Workload consolidation:** Combining multiple PLC instances, HMI, fieldbus masters, and safety logic on one device creates resource contention. Without proper CPU isolation, cache partitioning, and interrupt management, real-time tasks suffer unpredictable delays.
4. **Computational demands in safety logic:** Certain applications, such as safe robotics, require trigonometric calculations within the safety program itself. This adds computational load to time-critical safety tasks.





The Solution

The demonstrated architecture combines:

CODESYS Virtual Control SL: A containerized softPLC runtime that executes IEC 61131-3 programs. Each instance runs in a Docker container on a Linux RT host, enabling multiple independent controllers on one physical device. The container packages all dependencies (libraries, configurations, runtime versions) for reproducible deployment.

CODESYS Virtual Safe Control SL: A SIL3-certified safety runtime that executes safety logic on standard x86 CPUs. This eliminates the need for dedicated safety PLCs while supporting safety fieldbus protocols including PROFIsafe (over PROFINET) and FSoE (over EtherCAT).

Intel Edge Controls for Industrial (ECI): A reference software platform providing a deterministically optimized Linux kernel (PREEMPT_RT) plus industrial components.

ECI includes validated CODESYS packages and RT-tuning scripts that configure:

- CPU affinity (CODESYS tasks on isolated cores, system tasks on core 0)
- Cache Allocation Technology (CAT) for exclusive last-level cache access
- RT runtime limits to prevent throttling
- Interrupt affinity for fieldbus-related Ethernet traffic

Intel Time Coordinated Computing (TCC): A BIOS-level preset on supported Intel platforms (including Core Ultra Series 2) that reduces jitter by coordinating power states, memory timing, and cache behavior. TCC provides a deterministic baseline that ECI's software tuning builds upon.

Container platform: Docker on Debian Linux serves as the container runtime.

Use Cases

Robotic Cell with Integrated Safety

A robotic application runs on the OnLogic HX521 with:

- Virtual Control SL handling motion interpolation (SoftMotion) for "dumb" servo drives without integrated intelligence
- Virtual Safe Control SL executing SIL3 safety logic including safe speed monitoring and emergency stop functions
- Trigonometric calculations performed within the safety task for safe position and orientation monitoring

The drives communicate via EtherCAT with FSoE for safety I/O. Because the drives contain no application logic, they can be replaced or swapped without reprogramming—only the virtual controller requires updates.

Production Line Consolidation

An automotive body shop operating 2,000 PLCs faces (roughly estimated):

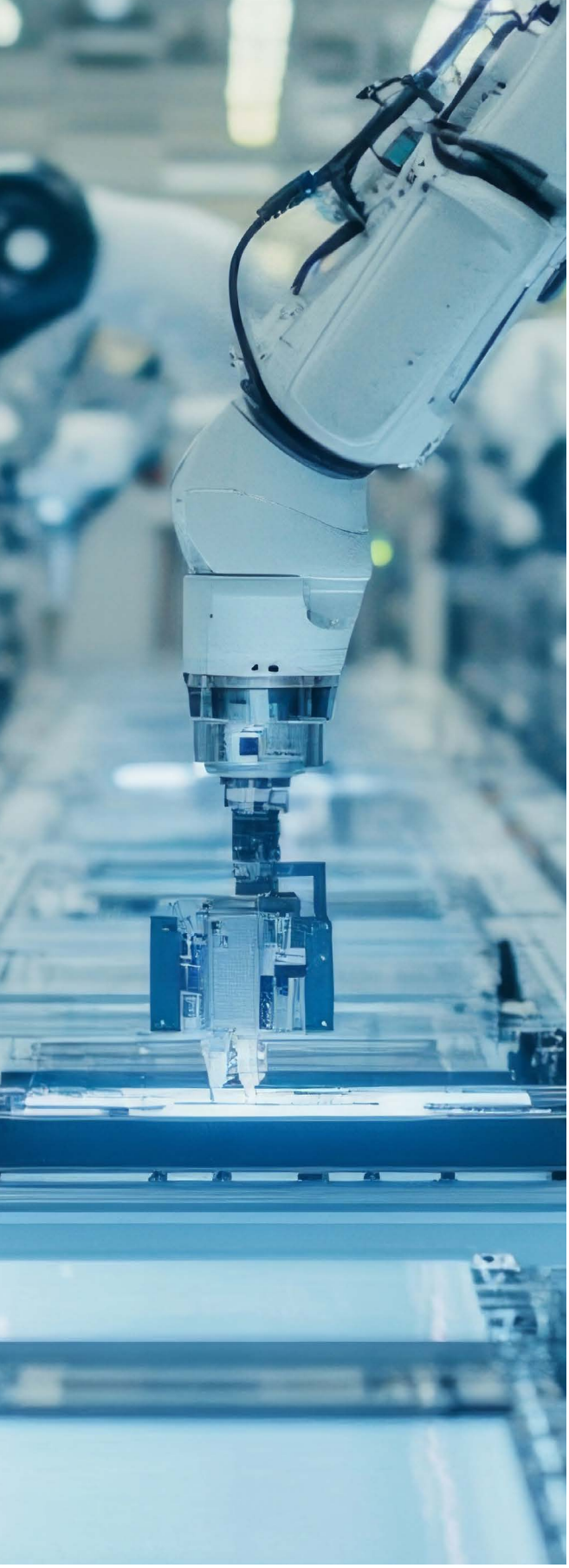
- 33 weeks annually for firmware updates
- 50 weeks annually for maintenance
- Over €10 million in PLC hardware investment

Consolidating these controllers onto virtualized instances on edge servers reduces hardware count, centralizes updates (deployable with standard IT tools), and improves security posture through container isolation and standardized patching.

Modular Machinery

Machine builders can deploy separate containers for distinct machine modules (e.g., infeed, processing, outfeed). Each module's control logic is versioned and maintained independently. Virtual commissioning using digital twins enables testing before physical deployment.





Why CODESYS

Hardware independence: CODESYS Virtual Control SL runs on any x86-64 Linux host meeting RT requirements—industrial PCs, edge servers, or hyperconverged infrastructure. There is no lock-in to proprietary PLC hardware.

Fieldbus flexibility: The runtime supports multiple industrial protocols including PROFINET (with PROFIsafe), EtherCAT (with FSoE), and OPC UA. Fieldbus masters run within the same container or in separate containers communicating via shared memory or network.

Certified safety: Virtual Safe Control SL is SIL3-certified by TÜV Süd for safety applications. It operates on standard CPUs using software-based redundancy and diagnostics, validated against IEC 61508 / IEC 62443 requirements.

Familiar engineering workflow: Both Safety and functional control logic are developed in the same CODESYS Development System V3.5. Safety function blocks, safe I/O mapping, and standard PLC logic coexist in one project. This simplifies coordination between safety and machine functions, reduces tool licensing overhead, and avoids error-prone data exchange between separate engineering environments.

Ecosystem: CODESYS provides a comprehensive software stack including SoftMotion for motion control, visualization (WebVisu), and connectivity libraries, reducing integration effort for complete automation solutions.

Why OnLogic

Platform portfolio: OnLogic offers industrial PCs, rugged fanless computers, and edge servers suited to different consolidation scenarios:

- IPCs and rugged systems for machine-level consolidation (one machine, multiple vPLC instances)
- Edge servers for plant-level consolidation (multiple machines or production lines)

Current Intel architectures: OnLogic prioritizes recent Intel platforms (Meteor Lake, Arrow Lake) that support TCC and benefit fully from ECI optimizations. Older platforms may lack TCC support or have limited CAT capabilities.

Scalable performance: The hardware is sized to consolidate multiple workloads onto a single device. From power-efficient processing to high-performance acceleration, OnLogic devices provide the specific computational power and headroom required for real-time tasks, motion control, and safety logic.

Industrial design: Fanless or fan-assisted cooling, wide temperature range, and vibration resistance enable deployment in factory environments without additional enclosures.

Key Capabilities

Capability	Specification
Control runtime	CODESYS Virtual Control SL (containerized)
Safety runtime	CODESYS Virtual Safe Control SL, SIL3 certified
Host OS	Debian Linux with PREEMPT_RT kernel
Container platform	Docker
RT tuning	Intel ECI (CPU isolation, CAT, IRQ affinity)
Platform optimization	Intel TCC (BIOS preset for determinism)
Supported fieldbuses	PROFINET/PROFIsafe, EtherCAT/FSoE, OPC UA
Engineering tool	CODESYS Development System V3.5 with Deploy Control SL
Target cycle time	<1 ms (control), ~1 ms (safety)



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Next Steps

Learn how CODESYS and OnLogic can help enterprises standardize edge deployments, improve operational resilience, and scale digital initiatives across distributed edge locations with a proven edge computing platform.

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