A Fast Path to High-Performance, Safety-Critical Embedded Solutions

Accelerate the development and certification of safety-critical applications in domains such as avionics and industrial applications with solutions based on SYSGO PikeOS and Intel Atom® x6000E processors. The joint solution stack built by SYSGO and Intel provides technologies and certification support to bring products to market more quickly at lower cost, with the ability to scale across the full range of Intel platforms.

SYSGO
EMBEDDING INNOVATIONS

Mitigating the time and expense to enable and certify safety-critical applications presents key challenges in embedded solution development for avionics and industrial control systems. These solutions must gracefully handle the unexpected — whether from operator error, hardware failure, environmental change or other factors — while remaining in a predictable state to avoid harming humans or equipment. Moreover, they must demonstrate that readiness with certification according to international standards such as DO-178C for avionics or IEC 61508 for industrial applications.

These challenges have traditionally been complicated by the proprietary nature of the equipment and systems in the embedded ecosystem. A lack of interoperation among components from different providers has interfered with streamlining efforts to consolidate hardware for reduced weight and power. In addition, as these solutions become more complex to handle more data at lower cost, safety certification becomes more difficult, expensive and burdensome. Real-time safety-critical systems must enhance cybersecurity and embrace new technologies such as 5G, advanced computer vision and AI/machine learning to remain competitive.

Within that context of innovation, openness and interoperability, solutions need deterministic, scalable performance in a range of platforms to accommodate throughput and latency requirements within embedded space and power constraints. They also require multipurpose operating environments for the coexistence of mixed-criticality applications as well as real-time and non-real-time workloads.

Intel and SYSGO offer a joint solution to deliver on all those needs, with a stack based on Intel® processors and the SYSGO PikeOS hard real-time operating system (RTOS) with built-in hypervisor functionality, as illustrated in Figure 1. The solution also includes a deep repository of processor artifacts that can accelerate the path to certification for developers of avionics and industrial systems.
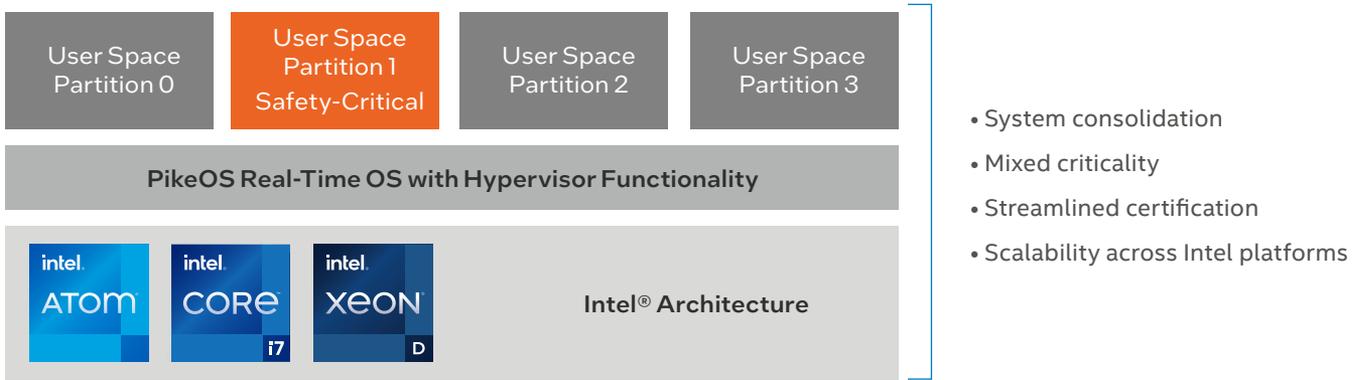
intel.
ATOM™

Figure 1. SYSGO and Intel joint solution for mixed-criticality embedded development.

Hard Real-Time OS with Built-In Hypervisor: SYSGO PikeOS

Designed for the highest levels of safety and security criticality, PikeOS is a hard RTOS based on a fast, efficient separation kernel that provides hypervisor functionality in a single product, as illustrated in Figure 2. PikeOS enables solutions where a large number of guest OSs must coexist on the same platforms, executing in isolation from each other. For example, these could include POSIX, Linux, Android, ARINC, AUTOSAR and ELinOS (SYSGO's embedded Linux product).

Virtualization in the solution stack can isolate workloads in space, meaning that OSs can exist side-by-side without interaction or access between them. It can also isolate workloads in time, providing for prioritized workload scheduling, which is a primary requirement for mixed-criticality systems. The PikeOS certification approach is modular and hardware-independent, providing flexibility and efficiency for bringing solutions to market. A range of

certifiable components are offered on top of PikeOS that help reduce the time to certification for safety-critical customer systems, including the following:

- **Certifiable File System (CFS)** is an optional fail-safe file system that provides additional functionality compared to PikeOS's built-in file system, while remaining simpler than those of standard Linux.

- **Certifiable IP Stack (CIP)** is a UDP/IP networking stack compatible with most standard RFC specifications, certified to DO-178B DAL C but certifiable according to higher levels.

- **Certifiable Math Library (CML)** is a double-precision mathematical library that provides mathematical proof of each function's precision to be used as certification evidence.

The PikeOS 5.1.3 separation kernel supports security certifications including Common Criteria EAL 5+ and provides a certification kit for Security Common Criteria (IEC 15408). It
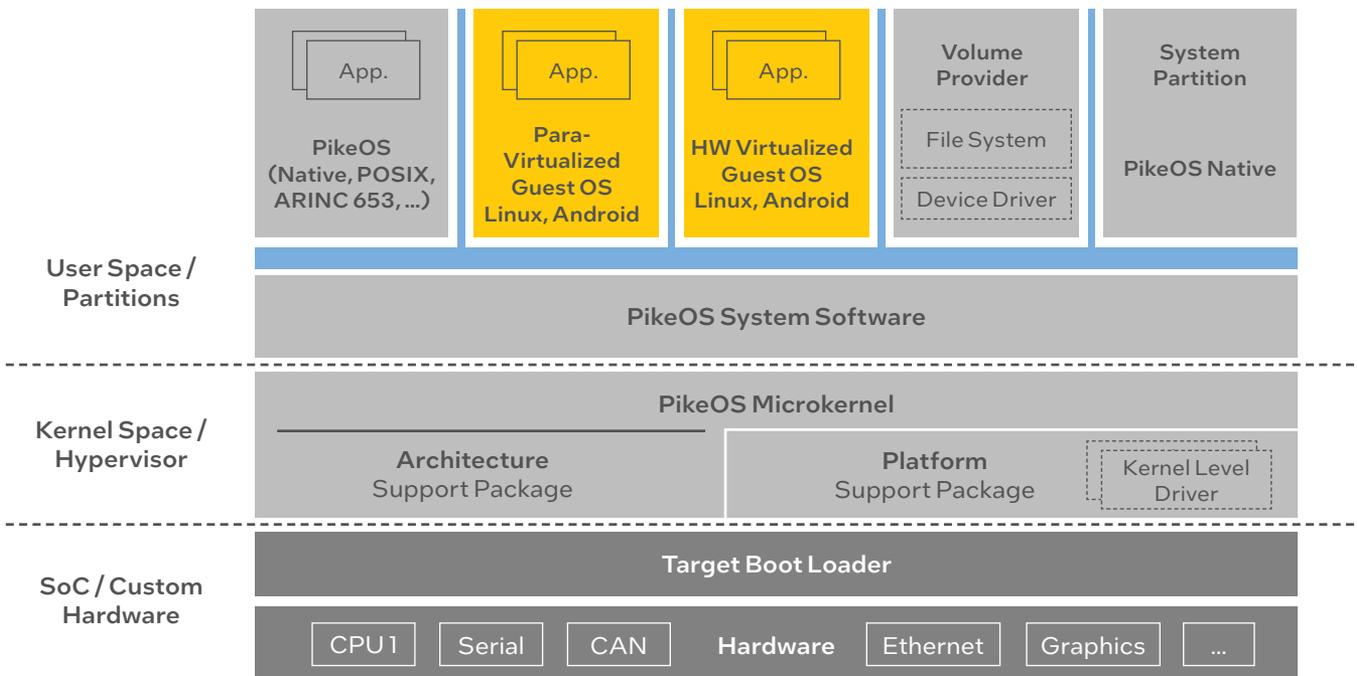

Figure 2. SYSGO PikeOS software stack.

supports diverse security standards, including DO-356A/ED-203A, IEC 62443 and compliance to Airbus SAR, SAL 3 and 4. The technology does not have export restrictions, and it offers long-term support for solutions in deployment.

Workload Consolidation at the Edge: Intel Atom® x6000E Processors

Intel Atom x6000E processors, shown in Figure 3, deliver energy-efficient performance and advanced hardware capabilities within the space, power and other design constraints of embedded systems and edge implementations. Operating in a small footprint, the platform provides results equivalent to legacy single-purpose systems with the cost, flexibility and scalability advantages of open, multicore hardware. In addition to high per-core performance, it incorporates a range of built-in accelerators and integrated Intel® Ethernet. Delivered in a compact, power-efficient system-on-chip (SoC) package, this platform provides high throughput with low power consumption for critical workloads.
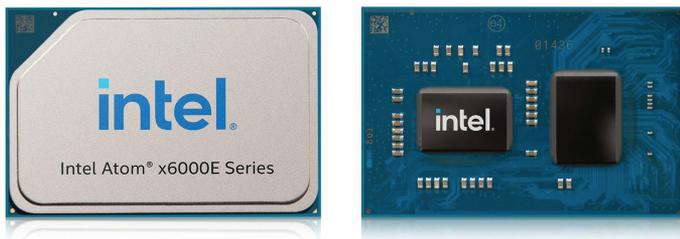

Figure 3. Intel Atom® x6000E Series processor.

The platform provides compelling performance advantages, as summarized in Figure 4, including higher performance than its predecessor by a factor of 1.7x for single-threaded workloads and 1.5x for multi-threaded ones. The 2x graphics performance improvement can dramatically improve end-user experience for data visualizations and other graphics-intensive workloads. Decoupling of the software and hardware aspects of the SYSGO and Intel solution enables hardware to be upgraded successively, with minimal disruption, to readily gain performance and capability benefits from future processor generations.

The performance advantages of Intel Atom x6000E processors exist alongside a compelling set of hardware features that enable new capabilities for safety-critical software. In particular, software programmability provided with the SYSGO and Intel joint solution enables solution providers to take advantage of the following:

• **Safety islands** built into the silicon of the Intel Atom® x6427FE and x6200FE processors offer integrated, functional intellectual property that works with the CPU

for error-checking, fault reporting and diagnostic testing to simplify meeting requirements including IEC 61508 and ISO 13849.[2]

• **Time Coordinated Computing (TCC) and Time-Sensitive Networking (TSN)** support real-time computing for worst-case runtime operations, with ultra-reliable low-latency communication.[2]

• **Out-of-band and in-band management** enables monitoring and management of devices, including the ability to restart, power down or power up from sleep states, even if the OS is unresponsive.

Intel Atom x6000E processors also deliver advanced hardware-based security measures. Intel® Platform Trust Technology (Intel® PTT) provides built-in Trusted Platform Module (TPM) 2.0 functionality, helping reduce bill of materials costs and conserve on board area. Hardware-accelerated cryptography based on Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI), Intel® SHA Extensions and Intel® Secure Key enables pervasive encryption while reducing or eliminating the associated performance impacts. Intel® Boot Guard helps protect against platform tampering using a hardware root of trust.

Accelerated Path to Production for Safety-Critical Applications

SYSGO and Intel provide a fast start to the development of safety-critical applications, with robust collections of software and hardware artifacts to aid in certification. Solution providers can begin by building features and capabilities, then add in considerations to certify later in the process. Intellectual property for safety and security built into Intel hardware and SYSGO system software abstract away process complexity for solution providers. Certification kits are available for safety-critical applications across industries, including avionics (DO-178C), industrial (IEC 61508), transportation (EN 50128) and automotive (ISO 26262).

Benefits for the Industrial Market

Functional safety requirements for systems such as industrial robots continue to become more demanding, even as the systems that underlie them become more complex. To aid in compliance, the SYSGO and Intel joint solution offers a SIL 2-certifiable software and hardware platform in collaboration with selected server board vendors. Certification artifacts from all three parties in aggregate can dramatically reduce the time to market for industrial robotics systems with real-time dynamic safety systems. In addition, the PikeOS 5.1.3 separation kernel attained the Common Criteria EAL 5+ assurance level in 2022, a critical step in certifying solutions for Industry 4.0 and the industrial internet of things (IIoT).

UP TO **1.7X** **Single-Thread Performance**[1]	UP TO **1.5X** **Multi-Thread Performance**[1]	UP TO **2X** **Graphics Performance**[1]
Improvement vs prior gen	Improvement vs prior gen	Improvement vs prior gen

Figure 3. Generation-over-generation performance improvements in Intel Atom® x6000E processors.

Scale Hardware Platforms Across Use Cases

Intel® processors for embedded applications provide deterministic performance at any scale, with software interoperability among systems with widely varying capacity, space and power footprints. Coupled with SYSGO system software ingredients, these platforms help accelerate time to certification for safety-critical systems.

- **Intel Atom® processors** offer low-power, high-performance compute and graphics, engineered specifically for small-form-factor designs and applications.

- **11th Gen Intel® Core™ i7 U-Series processors** enable systems to balance CPU and GPU performance with requirements such as power consumption and price.

- **Intel® Xeon® D processor** deliver high throughout and low latency for demanding embedded applications, with large memory space and I/O capacity.

Benefits for the Avionics Market

Intel and SYSGO have long experience in safety certification of mission critical devices in avionics and other markets. PikeOS is certifiable on X86 architecture up to DO 178C DAL C, optimized for high performance on multicore Intel processors and embraces AC/AMC 20-193 (formerly CAST-32A) design principles for timing behaviors, hardware contention and other idiosyncrasies that are not present with single-core systems. The stack is well suited to the growing shift toward implementing safety functions, information services and comfort features with integrated modular avionics modules (IMAs) rather than the traditional use of line-replaceable units (LRUs).

SYSGO's ARINC 664 data network software stack is designed to connect any kind of avionics end-system to an AFDX-compliant data network. PikeOS provides an ARINC 653-compliant partitioning model that enables multiple runtime environments and APIs to run in isolation from each other. These might include POSIX, Ada, Java or even a fully virtualized Linux OS running inside a partition in an IMA-compliant way, giving avionics developers outstanding deployment flexibility as they bring solutions to market.

Simplified Certification for Aerospace: Intel® Airworthiness Evidence Package

The Intel® Airworthiness Evidence Package (Intel® AEP) streamlines and accelerates the DO-254 certification path up to DAL A for avionics applications. Manufacturers and system integrators can obtain evidence needed for certification in the Intel® AEP as well as additional evidence in the form of answered questions and other information. Notable categories of such content include failure modes, effects and diagnostic analysis (FMEDA), dependent failure analysis (DFA), single event effects analysis and shared resource management. The Intel® AEP is a foundation on which complete end-to-end certifiable systems with Intel® architecture inside can be built.

Conclusion

Both SYSGO and Intel have long-standing expertise in the application of international certification standards. Individually and in collaboration with each other, the companies are deeply involved in global standards bodies, to help guide the embedded ecosystem in the development of systems to protect life and property. This sphere of expertise helps ensure that customers across industries have access to unparalleled advantage in bringing world-class safety-critical applications to market.

Learn More

Intel® IoT and Embedded Processors

Intel® Airworthiness Evidence Package

SYSGO PikeOS

Solution provided by:

intel. + SYSGO EMBEDDING INNOVATIONS