SYSGO
EMBEDDING INNOVATIONS

Space Avionics Systems

ready for Future Missions

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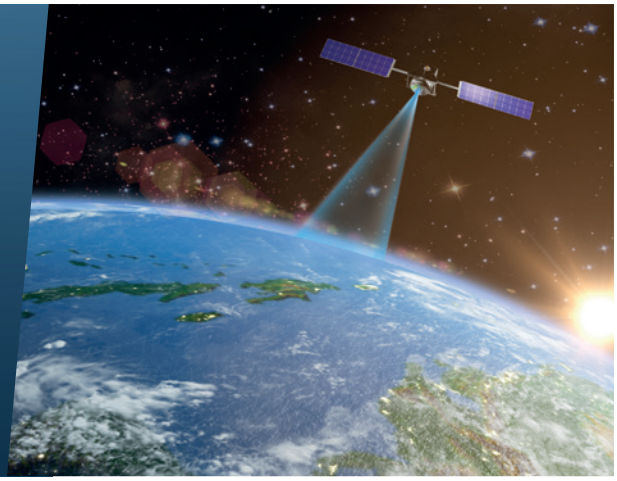


Europe's No 1 in Real-Time Operating Systems

SYSGO at a Glance

SYSGO is an independent entity from the THALES group and Europe's No 1 in safe & secure operating systems. Since 1991, SYSGO has expertise in embedded devices and is one of the pioneers in embedded Linux. The main markets are Aerospace & Defense, Railway, Automotive, and Industrial Automation, where we are active with professional services mainly in customer systems that are following various certification standards.

Our RTOS & Hypervisor PikeOS is well-known in the market as a reliable and certifiable operating system including virtualization and multi-core support.

Our solutions significantly reduce cost, space, weight, time-to-market for our customers. We guarantee a reliable, long-term supported operating system as basis for their innovative products.

SYSGO offers long-term support for devices that need to run more than 20 years. As an European company, our products have no export restrictions and are ITAR free.

→ **www.sysgo.com/about-us**

Space Specifics, Missions and Differences to Avionics

A spacecraft that has started usually stays a while in the orbit. In most cases you cannot easily access the hardware board and apply updates. Everything needs to be done remotely "over the air". Also, failure detection and recovery is hard without being able to directly inspect the computer board with debugging probes.

Once in space, health monitoring has to be done by the system itself. But space is a harsh place to operate, not only with regards to temperature, but also cosmic radiation may cause temporal or even permanent system damage. During the launch there is about 3G force applied with high shock and vibration impacts.

The mission of most satellites is related to handling a large amount of data. This can be monitoring earth for wildlife, weather, geology, and so forth. For all those cases the satellite communicates with one or more ground stations which requires a reliable communication layer as well as data buffering. Local storage in space has changed from block-based management to file structures. Likelihood of satellite damage through other obstacles in space is relatively high. Communication and observation from earth must be guaranteed, but is not always available – being in communication shadow of a planet, for example.

Avionics software projects are usually certified according to the DO-178C standard which is commonly accepted by major Avionics authorities such as FAA and the EASA. SYSGO is an expert in Avionics software appliances with many successful certification projects. The software running within spacecrafts follows other standards, such as ECSS-E-ST-40 and ECSS-Q-ST-80 from ESA.

Highest Space System Requirements – PikeOS: RTOS & Hypervisor

PikeOS is an operating system based on a microkernel with high real-time performance on multi-core hardware. It includes a hypervisor that provides partitions which can host different guest operating systems – from a simple yet highly critical control task, supporting ARINC or POSIX up to a full-fledged operating system like Linux.

Customers can start with a platform development using RTOS and later add hypervisor functionality. As a consequence, applications with mixed criticality can co-exist on the same platform. Complex systems, consisting of multiple devices in the past, can now be consolidated on a single hardware platform while assuring safe execution. This saves weight, energy consumption and reduces the bill of material. The PikeOS hypervisor runs on x86 as well as ARM, PowerPC or SPARC-LEON and can easily be adapted to other CPU architectures.

Space systems have to be lean, yet highly responsive. Issues of standardization, reusability and scalability become more and more important. Due to the ongoing integration of spaceborne, more specifically Space Avionics systems, SoCs, micro controller and processors nowadays are more efficient than ever and can fulfil more tasks in parallel. Thus, saving money by the reduction of energy consumption and weight by the depletion of hardware devices.

The PikeOS Separation Kernel Version 5.1.3 is currently the only Separation Kernel worldwide that holds a Common Criteria EAL 5+ certification for its separation performance.

→ **www.sysgo.com/pikeos**

Mixed Criticality to master Space System Requirements

Our technology provides solutions for task controlling, mission data processing, secure communication of subsystems and between the spacecraft and ground station with strong focus on failure Safety. We support mechanisms for Fault Detection, Fault Isolation and Recovery Techniques (FDIR). The Space industry benefits from our experience in integrated modular software development and certification in such fields as the Integrated Modular Avionics (IMA) concept and therefore SAVOIR FAIRE respectively Space Component Model (SCM) principles.

Our hypervisor isolates partitions ("containers") while maintaining real-time capability, allowing simultaneous execution of tasks with mixed criticality levels, from simple control tasks to an ARINC 653 application.

Reduced Complexity saves Weight, Energy, Space and Costs

PikeOS enables integration of a large number of electronic devices onto a single hardware platform. We support the highest DO-178C DAL A level on several hardware architectures (e.g. ARM, PPC, X86, SPARC LEON or RISC-V). We also reached the highest Category A software certification in Space according to ECSS and are ready for Independent Software Verification and Validation (ISVV) guidelines laid out by ESA.

PikeOS also supports both ARM cortex A family (MMU) and cortex R (MPU) family of cores. PikeOS can reduce the power consumption by issuing sleep instruction to the CPU or calculate each time how long it may enter sleep mode.

→ www.sysgo.com/pikeos-mpu

A big Step for a System – Software Maintenance in Space

Normally, space systems stay "always on" thus software updates and maintenance activities have to be performed in mission. During space flight, a standby sequence is applied to control and monitor applications to perform operations such as load, dump and check processor memories. The control application may also execute an update of one of the inactive application software images. The second sequence is called "monitor sequence" and is only used in the ground station.

Combination of Safety and Security

Different operations can be applied in space for both manned and unmanned missions. Communication between ground control or the satellites is required, therefore Security measures have to be taken. Among other tasks, PikeOS and its hypervisor can include partitions for system supervision, command and control operations as well as decoding beacons. It allows to use different software criticality levels based on the space ECSS standard.

Additionally, PikeOS can be the foundation of a secure gateway that builds a route of trust and allows secure software updates "over the air". Communication is assured by means of a Transport Layer Security (TLS) library. Cryptography and storage are supported by executable binaries and configuration files that are digitally signed and stored on a secure Certified File System (CFS). The gateway's network Intrusion Detection System (IDS) is located within a separate partition to monitor network traffic.

PikeOS can be mapped to DO-356A based on the Common Criteria classes with project-specific risk assessment and refutation analysis.

PikeOS for Space

PikeOS provides a modular system architecture allowing various applications to run simultaneously on a single hardware. A safe and efficient integration of electronics in Space systems is reached via virtualization technology.

The basis of PikeOS is a small, certifiable microkernel upon which a hypervisor provides separate partitions for resource and function needs. Thanks to strong separation of the partitions with different Security and / or Safety applications and varying criticality levels, real-time or non real-time can run in a mixed criticality environment.

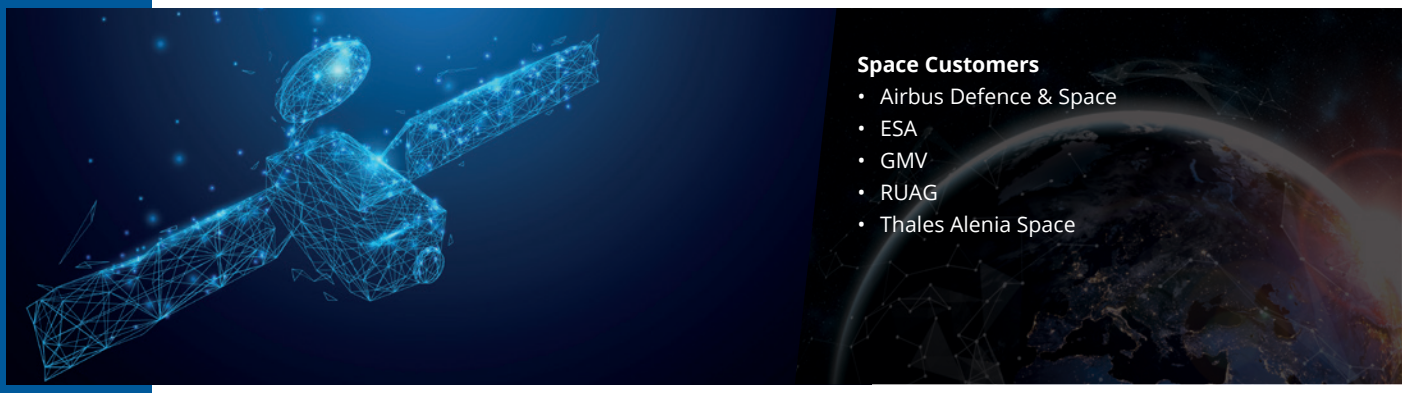
PikeOS was already applied in different space missions, like platform command and control computers with positioning and navigation applications, safe and secure virtualization for partitioning of spacecraft computing resources, on-board computers (mission payload) for military comm., flight management, ground control systems or the development of specific space processors for ESA.

Project Partner Voice

"ESA has a long track record [...] in implementing new technologies, and insuring safety and security requires to develop a new generation of solutions. We were very happy with the outcome of the IMA4Space project and with the contributions of the consortium members such as SYSGO."

Dr Martin Hiller
ESA Technical Officer

Move. Unite. Excite.
We are SYSGO



PikeOS protecting Earth

By the end of 2020, a revolution took place in space: The very first prototype of a new type of nano satellites was sending data, working fully operational and flying in a near-to-earth orbit. This satellite is called Argos Neo on a Generic Economical and Light Satellite (ANGELS) and belongs to the Kinéis satellite network.

25 satellites are now deployed to build the Kinéis constellation, improving the current system. These satellites will receive data from around the globe, increasing data transmission and two-way communication in very short time (10-15 minutes) between satellite passes, thus revolutionizing satellite telemetry.

Today, Argos is the only satellite-based system for location and data collection specifically designed to study and protect the earth's environment. By choosing PikeOS on Kinéis payload onboard computers, Thales Alenia Space continues its mutualization strategy by using a COTS RTOS for their current and future onboard platform and payload projects.

Read more about the success story:

→ www.sysgo.com/space

Hypervisor in Space

Development of certifiable systems and software for European Space Applications requires strict adherence to the ECSS standards. ECSS - the European Cooperation for Space Standardization - is a cooperation of the European Space Agency (ESA), national space agencies and the European Industry Association Eurospace with the aim of developing and maintaining coherent, commercially oriented and user-friendly standards for space applications. The main intention is to improve the performance and competitiveness of the European Space Industry on the world market.

One of the most important standards within the ECSS framework is ECSS-E-ST-40C, a software engineering standard for software being designed for space projects. It covers all aspects of space software engineering including requirements definition, design, production, verification and validation, transfer, operations and maintenance. ECSS-E-ST-40C is applicable to all the elements of a space system, including the space, the launch service and the ground segment.

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