



# Exploring New Ways to Simplify Spacecraft Software and System Architectures

# Advanced integrated systems and deterministic networks for aerospace and space applications



TTTech Aerospace provides deterministic embedded network and platform solutions for aerospace applications. For the space sector, it offers reliable radiation-hardened components and integrated modules for Deterministic Ethernet networking applications designed for the use in extreme environmental conditions found in space exploration and human-rated space flight missions.

TTTech Aerospace's avionic backbone network systems act as the "central nervous system" of e.g. NASA's Orion spacecraft, the European Service Module by ESA (ESM) and the Ariane 6 launch vehicle. NASA and its international space agency partners have named TTEthernet®, the deterministic networking technology developed by TTTech, as "International Avionics Systems Interoperability Standards (IASIS)" for programs like the Gateway and future deep space missions.

## Leveraging 25 years of technology leadership

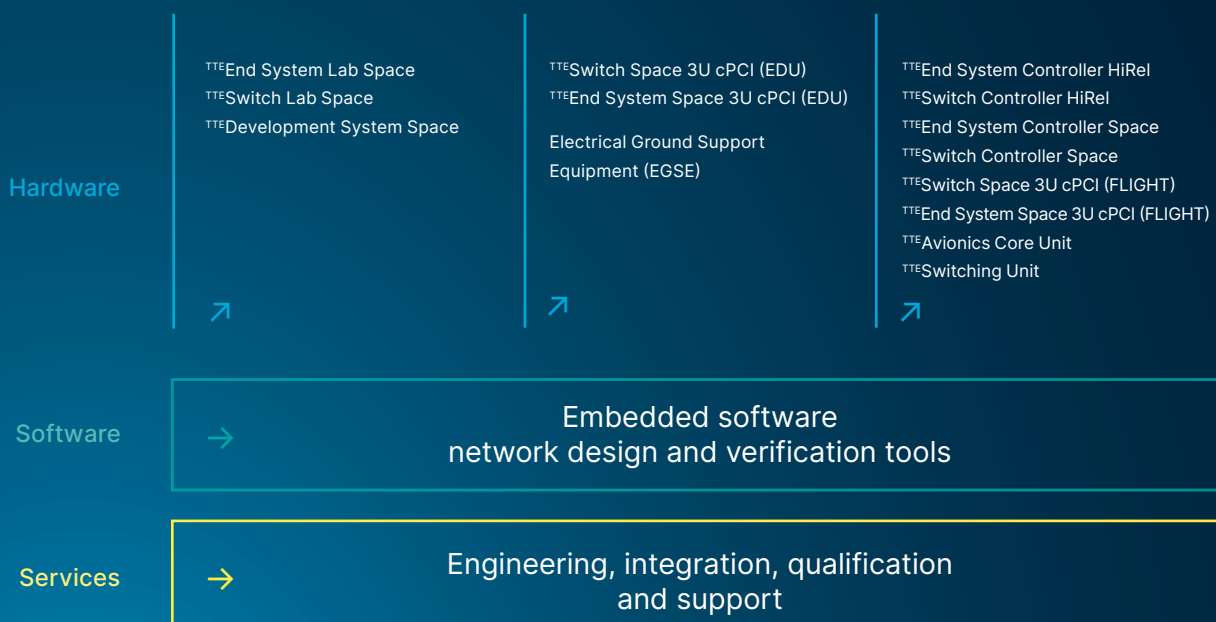


TTTech Aerospace is part of the TTTech Group, a globally oriented group of high-tech companies with around 2,300 employees in 15 countries, headquartered in Vienna, Austria. The solutions of the TTTech Group are applied in markets like mobile machinery, aerospace, smart manufacturing and automation and are trusted by many renowned market leaders, based on 25 years of technology leadership.

## Benefits of TTEthernet® for space applications:

- ➔ Modular and scalable system architectures enable cost savings
- ➔ Use of a single network for command and control as well as payload data simplifies spacecraft avionics
- ➔ Up to 1 Gbit/s bandwidth supports applications demanding high-speed and large amounts of data
- ➔ Time synchronization implemented in hardware saves costs for dedicated software and network integration
- ➔ Precise time distribution via the network (to any subscriber) enables building of safety-critical systems
- ➔ Deterministic data transfers characterized by predictable jitter and guaranteed transmission latency to realize real-time functions
- ➔ Fault tolerance and fault containment in hardware to increase safety and keep the system operational at all times
- ➔ Interoperability with standard Ethernet provides more flexibility in applications

## Customer program lifecycle



# TTEthernet<sup>®</sup>

## Development and lab products

### TTEthernet<sup>®</sup> development Products



TTE Development System Space



TTE Switch Lab Space



TTE End System Lab Space

Find out more:  
[tttech.com/aerospace/products](https://tttech.com/aerospace/products) ↗

# TTEthernet® development and testing

## Product line

TTEthernet® development products are used to develop and evaluate network architectures and configurations intended for space applications. The TTEthernet® testing products are used to test the developed avionic equipment before integrating it into the TTEthernet® network, thereby making the integration simpler and significantly reducing effort.



All TTEthernet® development and testing products use the radiation-hardened TTEController as a core component. This chip is also used in TTTech Aerospace's flight product series, ensuring an easy and fast migration from laboratory to flight hardware for the customer.

The TTEDevelopment System Space provides a complete development environment for hard real-time and non-real-time Ethernet communication on the same network using different quality of service traffic classes. It is a completely pre-configured and ready-to-run system that includes demo applications and TTEthernet® examples, accelerating the development process.

The TTEEnd System Lab Space (PCIe & PMC) cards have been developed to support laboratory testing applications with Time-Triggered or Best-Effort Ethernet. The cards feature up to 1 Gbit/s speed, support three traffic classes and are at the core of any TTEthernet® application development program.

The TTESwitch Lab Space provides 25 high-speed Ethernet switching ports and advanced deterministic traffic policing. It leverages 4,096 available virtual links and the integrated LEON2 CPU for remote management functions simplifies the device configuration and operation.

## Key characteristics

- Deterministic Ethernet development platform for space applications
- Based on the TTEEnd System Controller and TTESwitch Controller for efficient migration from laboratory to flight
- Integrates open standards for maximum flexibility:
  - Standard Ethernet traffic (IEEE 802.3)
  - Rate-constrained traffic\*
  - Time-triggered traffic (SAE AS6802)
- High speeds up to 1 Gbit/s
- Latency and jitter in µs range enable high-level real time applications
- TTESwitches with up to 25 ports for complex networks
- TTEEnd Systems with up to three ports enabling triplex avionic architectures
- Industry standard form factors like 3U cPCI, PMC for easy integration with other equipment
- Software support for common operating systems enabling quick development success

## Key benefits

- Ideal for technology evaluation, advanced development and testing applications
- Precisely optimized to efficiently support space applications from the laboratory to the flight phases
- Scalable and modular solution for building, testing and integration of TTEthernet® networks with any level of complexity

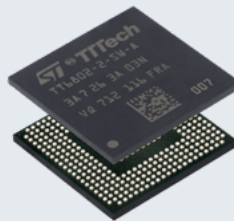


Advancing safe technologies,  
improving human lives

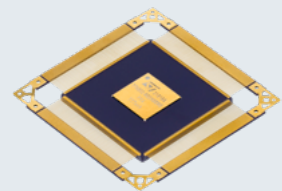
\* This component supports asynchronous Deterministic Ethernet traffic similar to and 100% compliant to the aeronautics standard ARINC 664 part 7.

# TTEthernet: Space components

## TTEthernet® radiation-hardened components



TTEthernet® Switch Controller HiRel  
TTEthernet® End System Controller HiRel



TTEthernet® Switch Controller Space  
TTEthernet® End System Controller Space

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# TTEthernet® space components

## Product line

TT<sup>E</sup>Controllers are part of the TT6802-device family that includes TT<sup>E</sup>Switch Controllers and TT<sup>E</sup>End System Controllers. Both are the basic building blocks for data networks, integrating synchronized and non-synchronized functions in Ethernet-based distributed systems.



TT<sup>E</sup>Controllers are available as both industrial- and space-graded products, offering optimal price-reliability-ratios for various applications.

The TT<sup>E</sup>End System Controller Space and the TT<sup>E</sup>Switch Controller Space are integrated communication controllers that support standard Ethernet, rate-constrained traffic\*, and time-triggered traffic according to the SAE AS6802 Time-Triggered Ethernet Standard for high flexibility in communication. These components are based on a radiation-hardened design that provides the necessary radiation tolerance for use in harsh space environments.

Four TT<sup>E</sup>Controller products are available:

- TT<sup>E</sup>End System Controller Space
- TT<sup>E</sup>Switch Controller Space
- TT<sup>E</sup>End System Controller HiRel
- TT<sup>E</sup>Switch Controller HiRel

All HiRel products are qualified under tailored automotive AEC-Q100 grade 2 standards and underwent burn-in, while all Space products are delivered with QML-V qualification which guarantees a very high product quality level, long-lifetime and high reliability for the benefit of our customers.

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## Key characteristics

- Up to three (TT<sup>E</sup>End System) or 22 (TT<sup>E</sup>Switch) Ethernet ports with 100/1000 Mbit/s
- Supports three TTEthernet® traffic classes:
  - Standard Ethernet traffic (IEEE 802.3)
  - Rate-constrained traffic\*
  - Time-triggered traffic (SAE AS6802)
- Three different host interfaces (SPI/Quad-SPI, PCI and SpaceWire) to connect TT<sup>E</sup>End System to different CPUs or FPGAs
- Integrated LEON2 CPU operating at 125 Mhz
- 1 MByte of internal memory
- Junction temperature range -40 °C to +125 °C
- Radiation tolerance for total dose up to 300 krad
- Latch-up immunity up to 60 MeV/cm2/mg
- Packaged in CQFP-352 or PBGA400

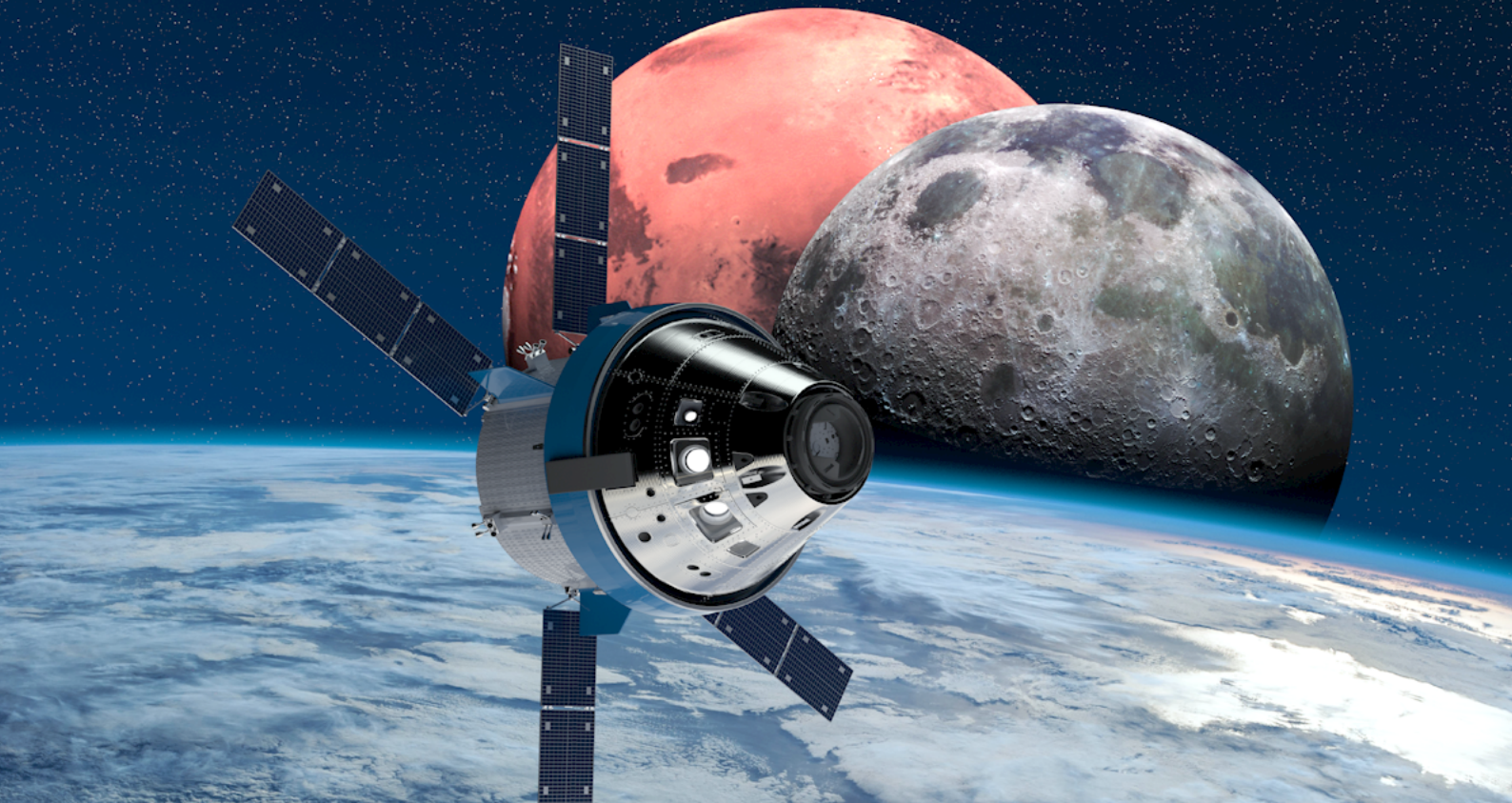
## Key benefits

- Enables robust and ultra-reliable Ethernet networks in space
- High design flexibility thanks to available interfaces, integrated CPU, on-chip memory and configurable functional modules
- Same rad-hard die implemented in plastic or ceramic package for any type of space application and environment – from launchers to human space flight, from low earth orbit (LEO) to Mars.



\* This component supports asynchronous Deterministic Ethernet traffic similar to and 100% compliant to the aeronautics standard ARINC 664 part 7.

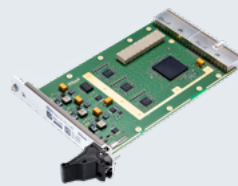
# TTEthernet® Space equipment



## TTEthernet® lab-grade equipment



TTEthernet® Switch Space  
3U cPCI (EDU)

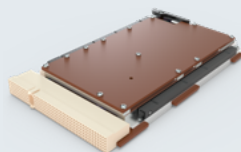


TTEthernet® End System Space  
3U cPCI (EDU)

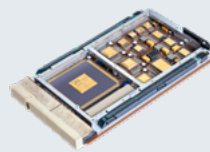


TTEthernet® Switching Unit (EDU)/  
Avionics Core Unit (EDU)

## TTEthernet® flight-grade equipment



TTEthernet® Switch Space  
3U cPCI (FLIGHT)



TTEthernet® End System Space  
3U cPCI (FLIGHT)



TTEthernet® Switching Unit  
(FLIGHT)/  
Avionics Core Unit  
(FLIGHT)

Find out more:  
[tttech.com/aerospace/products](http://tttech.com/aerospace/products) ↗



# TTEthernet® space equipment

## Product line

The TTEthernet® space equipment product line includes ready to use building blocks needed to realize spacecraft avionic data networks. Offered in three functional equivalent model variants (EDU, PROTO and FLIGHT), TTEthernet® space products are optimized for mass, power and functionality to fit the needs of modern, scalable, high-speed avionics designed for the highest levels of safety-criticality.



The TTEthernet® space equipment product line offers the functionality needed to implement any data network used on modern spacecrafts. TTEthernet® allows the implementation of highly reliable systems sharing safety-critical data (e.g. flight control) and non-critical payload (e.g. video streams) on the same Ethernet backbone. This allows a significant reduction in overall network cost and weight. Time and space partitioning of the traffic across the network enables the implementation of fault tolerance and fail-silent behavior on protocol level.

TTEthernet® space equipment allows easy integration into spacecraft data network and flight applications, either as single-function building blocks (TTEEnd System or TTESwitch) or integrated with additional modules (e.g. power module, onboard computer) in an avionic hosting unit, thanks to certifiable embedded software supporting industry real-time operating systems and hypervisors (e.g. VxWorks, PikeOS, RTEMS) and also NASA's cFS/cFE.

TTEthernet® Space Equipment is available in different quality levels to support the entire development flow during spacecraft design and integration:

- EDU (engineering model for development and functional verification)
- PROTO (populated with proto-parts)
- FLIGHT (qualified model for flight use in deep space)

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## Key elements

Compliant to the International Avionics System Interoperability Standards (IASIS)

### TTESwitch Space 3U cPCI

- 6 × 1000BASE-T and 6 × 100BASE-TX Ethernet ports

### TTEEnd System Space 3U cPCI

- 3 × 1000BASE-T/100BASE-TX Ethernet ports
- PCI, SPI/Quad-SPI or SpaceWire host interface

### TTESwitching Unit (pre-release)

- Two, three or four TTESwitch Space 3U cPCI integrated in a hosting unit (depending on the application)

### TTEAvionics Core Unit (pre-release)

- Processor Board
- TTEEnd System Space 3U cPCI
- Two TTESwitch Space 3U cPCI
- Hardware/software integration in a hosting unit



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# Software tools / embedded software

## Ease-of-use and full integration

### TTTech Aerospace software tools for development and testing

TTTech Aerospace software tools offer a powerful development and production environment for building fault-tolerant real-time systems. They enable seamless design, configuration, data loading, verification and validation of TTEthernet®-based networks.

### Configuration and verification

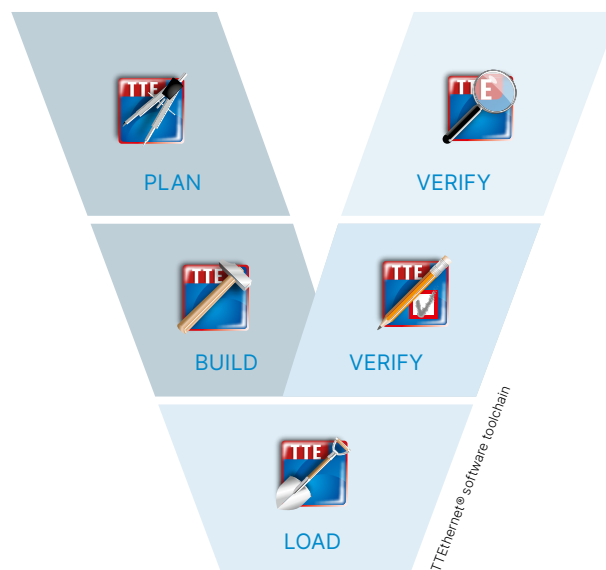
TTTech Aerospace's easy-to-use verification tools for the aerospace market support one of our core technologies, TTEthernet®. RTCA DO-330 qualifiable verification tools verify the configurations of TTEthernet® networks.

### Embedded software

TTTech Aerospace's highly efficient embedded software components comply to either DO-178B/C Level A or ESA's ECSS standards. They can be seamlessly integrated with different hardware and software platforms like standard- or space- and time-partitioned operating system architectures.

### Engineering, integration, qualification and support

Our engineering involvement in large production programs ranges from standard product support, requirement capturing, trade studies, platform architecture design, development of communication components and integration to validation and certification support.

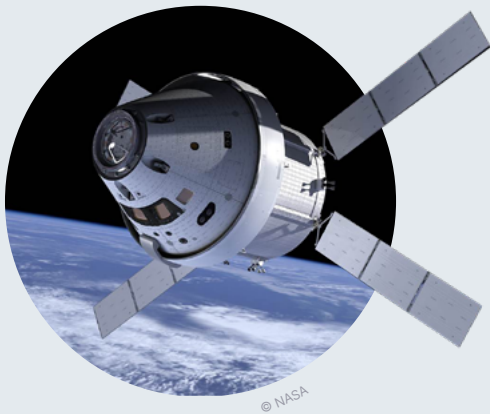
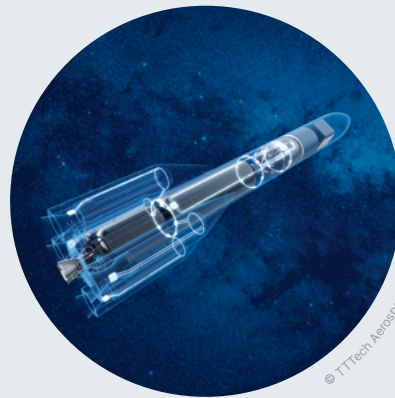


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# References and case studies

## Ariane 6

ArianeGroup has chosen TTEthernet® as single avionics network for the Ariane 6 launch vehicle. TTTech Aerospace's TTESwitch Controller HiRel and TTEEnd System Controller HiRel are the key components to achieve fully deterministic high-speed connectivity.

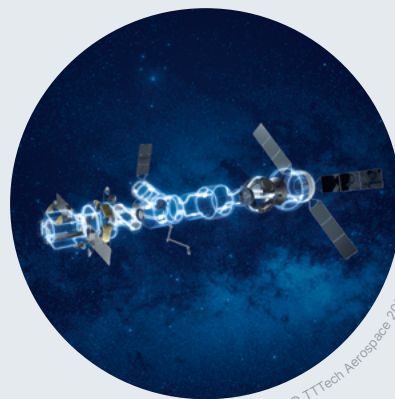


## NASA Orion

NASA's Orion spacecraft deploys TTEthernet® to facilitate the design of complex integrated control systems for a variety of distributed avionics applications.

## Gateway

TTEthernet® has been selected as the Gateway's avionics backbone network and will enable ultra reliable high-speed data communication between the different Gateway modules. Built-in dual fault tolerance is one of the key features to achieve a significantly higher safety level and a fail-operational system.





## North America

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Houston (US-TX)  
Milpitas (US-CA)

## Europe

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Munich (DE)      Bucharest (RO)  
Ingolstadt (DE)      Novi Sad (RS)  
Brixen (IT)      Belgrade (RS)  
Madrid (ES)      Osijek (HR)  
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## Asia

Nagoya (JP)  
Seongnam (KR)

Exploring new  
ways to simplify  
spacecraft  
software  
and system  
architectures

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