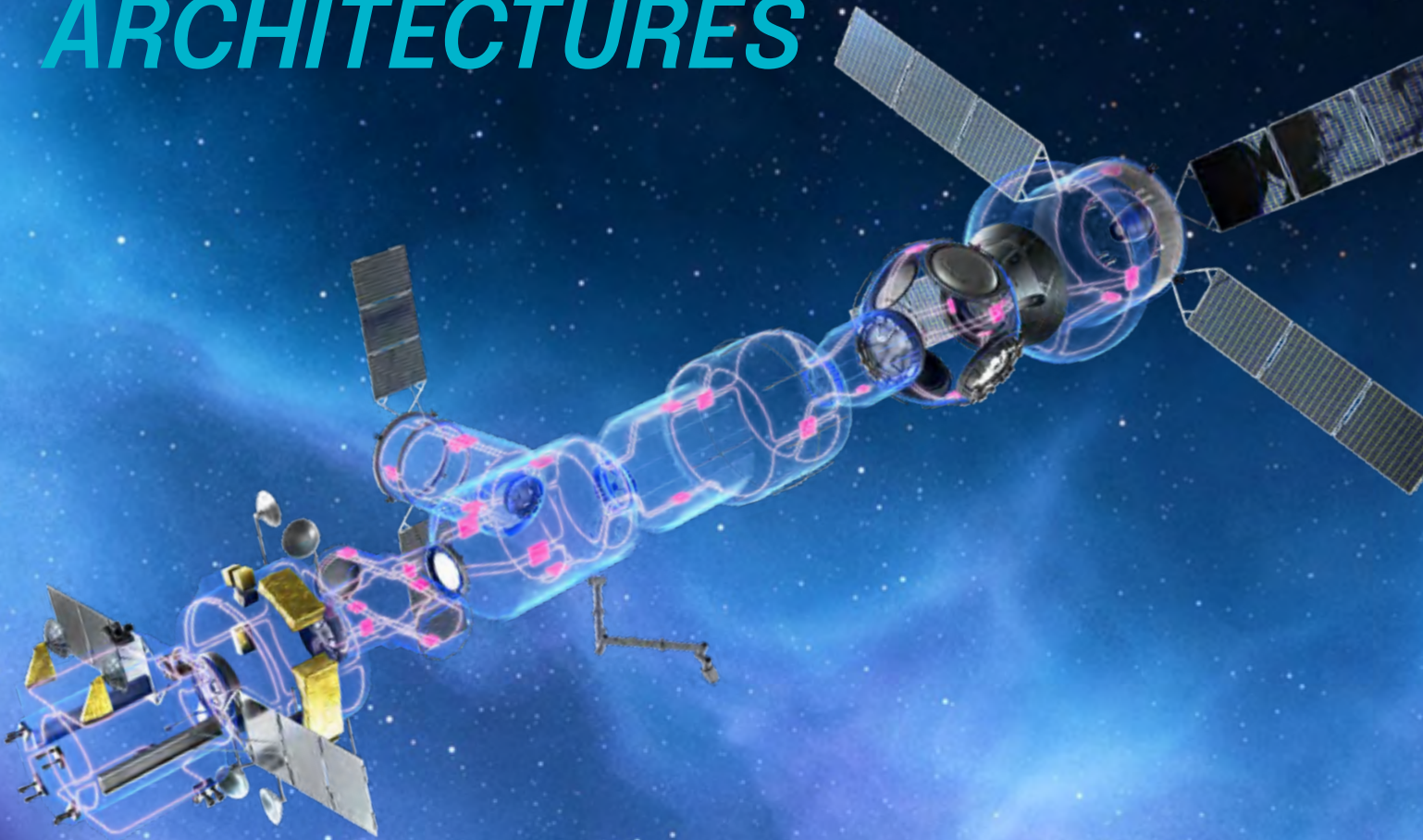


TTTECH—

EXPLORING NEW WAYS TO SIMPLIFY SPACECRAFT SOFTWARE AND SYSTEM ARCHITECTURES



ADVANCED INTEGRATED SYSTEMS AND DETERMINISTIC NETWORKS FOR DIVERSE SPACE APPLICATIONS



TTTECH Aerospace provides deterministic embedded network and platform solutions for safety- or mission-critical applications in aviation, space, defense and adjacent industries. For the space sector in particular, it offers reliable radiation-hardened components and integrated modules for Ethernet networking applications designed for the use in extreme environmental conditions found in space or during launch.

TTTECH's avionic backbone network systems act as the "central nervous system" of various spacecraft, most notably NASA Orion and its European Service Module (ESM), the Lunar Gateway built by NASA and its international partners, as well as launch vehicles on several continents including the European Ariane 6. For complex space programs interoperability is a key requirement fulfilled by TTTECH's solutions.

+25

YEARS

LEVERAGING
DECADES OF
TECHNOLOGY
LEADERSHIP.

TTTECH Aerospace is part of the TTTECH Group, a globally oriented group of hightech companies with around 1,200 employees in 11 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.

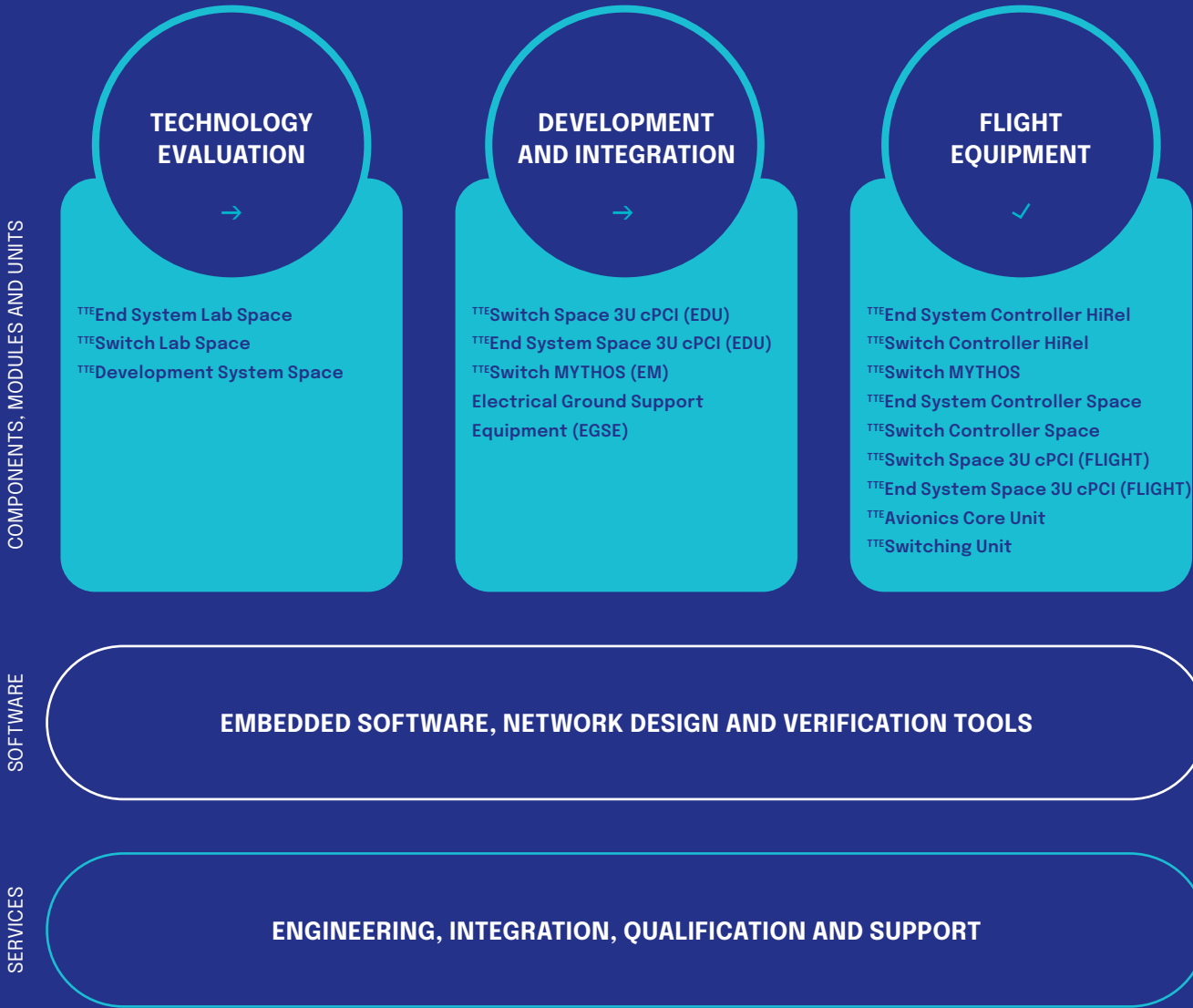


BENEFITS

BENEFITS OF DETERMINISTIC ETHERNET

- Modular and scalable system architectures enable cost savings
- A single network for command and control as well as payload data simplifies spacecraft avionics
- Up to 1 Gbit/s bandwidth per link (soon 10 Gbit/s) supports applications demanding high-speed and large amounts of data
- The network transparently manages redundancy across paths and devices for highest dependability
- Guaranteed transmission latencies and predictable jitter for hard real-time functionality
- Precise clock synchronization via the network and time distribution to any subscriber saving the need for a dedicated software solution
- Fault tolerance and fault containment to increase both safety and availability
- Interoperability with standard Ethernet provides flexibility and also simplifies development, testing and integration

CUSTOMER PROGRAM LIFECYCLE



TT Ethernet® DEVELOPMENT AND LAB PRODUCTS

TTETHERNET® DEVELOPMENT PRODUCTS



TTDevelopment System Space



TTESwitch Lab Space



TTEnd System Lab Space

Find out more → tttech.com/aerospace/products

EVALUATION, DEVELOPMENT AND TESTING – FOCUS ON TTETHERNET

TT Ethernet development products are used to develop and evaluate network architectures and configurations intended for space applications.

The TT Ethernet testing products are used to test the developed avionic equipment before integrating it into the TT Ethernet network, thereby making the integration simpler and significantly reducing effort.

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

The TTDevelopment 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 TT Ethernet examples, accelerating the development process.

The TTEnd 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 TT Ethernet application development program.

The TTSwitch 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 TTEnd System Controller and TTSwitch 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
- TTSwitches with up to 25 ports for complex networks
- TTEnd 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

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

KEY BENEFITS

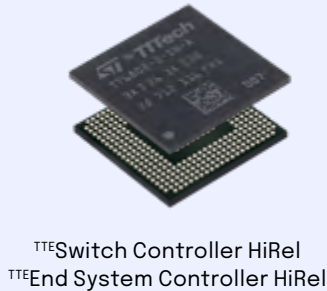
- Ideal for technology evaluation, advanced development and testing applications
- Precisely optimized to efficiently support space applications from the laboratory to the flight phases
- Scalable and modular solution for building, testing and integration of TT Ethernet networks with any level of complexity



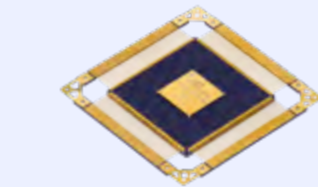
HIREL & SPACE COMPONENTS



RADIATION-HARDENED COMPONENTS SUPPORTING VARIOUS ETHERNET TRAFFIC CLASSES



TTESwitch Controller HiRel
TTEEnd System Controller HiRel



TTESwitch Controller Space
TTEEnd System Controller Space

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ETHERNET COMPONENTS PRODUCT LINE

TTEControllers are part of the TT6802-device family that includes TTESwitch Controllers and TTEEnd System Controllers. Both are the basic building blocks for data networks, integrating synchronized and non-synchronized functions in Ethernet-based distributed systems.

Our application-specific integrated circuits 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 TTECONTROLLER PRODUCTS ARE AVAILABLE:

- TTEEnd System Controller Space
- TTESwitch Controller Space
- TTEEnd System Controller HiRel
- TTESwitch Controller HiRel

All HiRel products are qualified per a tailored automotive AEC-Q100 process including burn-in, while all Space products are offered with QML-V qualification.

KEY CHARACTERISTICS

- Up to three (TTEEnd System) or 22 (TTESwitch) Ethernet ports with 100/1000 Mbit/s
- Supports three Ethernet 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 TTEEnd 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
- Packaging: PBGA400 (HiRel, MOQ applies) or hermetic CQFP-352 (Space)

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 SPACE EQUIPMENT PRODUCT LINE

EQUIP

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 space-crafts. 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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TTETHERNET® LAB-GRADE EQUIPMENT



TTESwitch Space 3U cPCI (EDU)

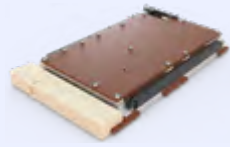


TTEEnd System Space 3U cPCI (EDU)

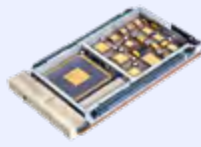


TTESwitching Unit (EDU)/TTAvionics Core Unit (EDU)

TTETHERNET® FLIGHT-GRADE EQUIPMENT



TTESwitch Space 3U cPCI (FLIGHT)



TTEEnd System Space 3U cPCI (FLIGHT)



TTESwitching Unit (FLIGHT)/TTAvionics Core Unit (FLIGHT)

KEY ELEMENTS

TTESWITCH SPACE 3U cPCI

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

TTEEND SYSTEM SPACE 3U cPCI

- 3 x 1000BASE-T/100BASE-TX Ethernet ports
- PCI or SpaceWire host interface

TTESWITCHING UNIT

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

TTEAVIONICS CORE UNIT

- 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

TTTECH SOFTWARE TOOLS FOR DEVELOPMENT AND TESTING

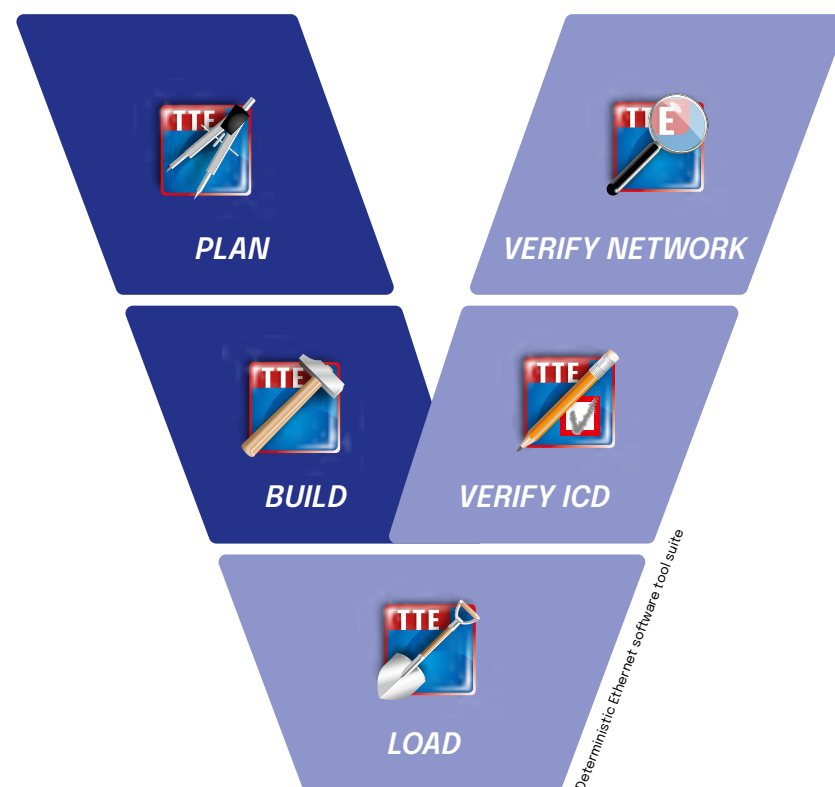
TTTECH's PC-based software tools offer a powerful development environment for building and configuring fault-tolerant real-time systems based on Deterministic Ethernet. They enable seamless design, configuration, re-configuration, data loading, and validation of data networks during all phases of the product lifecycle.

VERIFICATION AND FORMAL QUALIFICATION

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

EMBEDDED SOFTWARE

TTTECH's efficient embedded software components are developed according to DO-178C Level A or ECSS standards. They can be seamlessly integrated with different hardware and software platforms including time- and space-partitioned operating systems. The latest innovation is an embedded software module which can take over functionalities of an End System interface card.

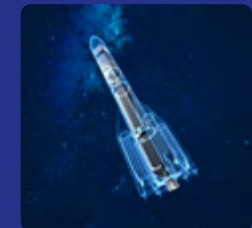


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REFERENCES AND CASE STUDIES

ARIANE 6

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



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NASA



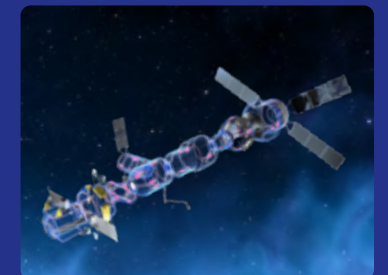
© NASA

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

ORION

LUNAR

TTTEthernet 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.



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GATEWAY



NORTH AMERICA

Boston (US-MA)
Houston (US-TX)

EUROPE

HQ Vienna (AT)
Munich (DE)
Brixen (IT)
Tampere (FI)

Brno (CZ)
Bucharest (RO)
Novi Sad (RS)
Osijek (HR)
Banja Luka (BA)

ASIA

Nagoya (JP)

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