

# Reaching for the Sky with Certified and Safe Solutions for the Aerospace Market

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



TTTech Aerospace provides high-performance, safety-critical network and processing solutions for aviation and space applications. TTTech Aerospace's products have surpassed 1 billion flight hours in the highest safety-critical applications like fly-by-wire, power systems, avionics, engine controls and environmental control systems and covered distances of more than two million kilometers in deep space.

## Advancing customer applications with integrated avionics network solutions in aerospace

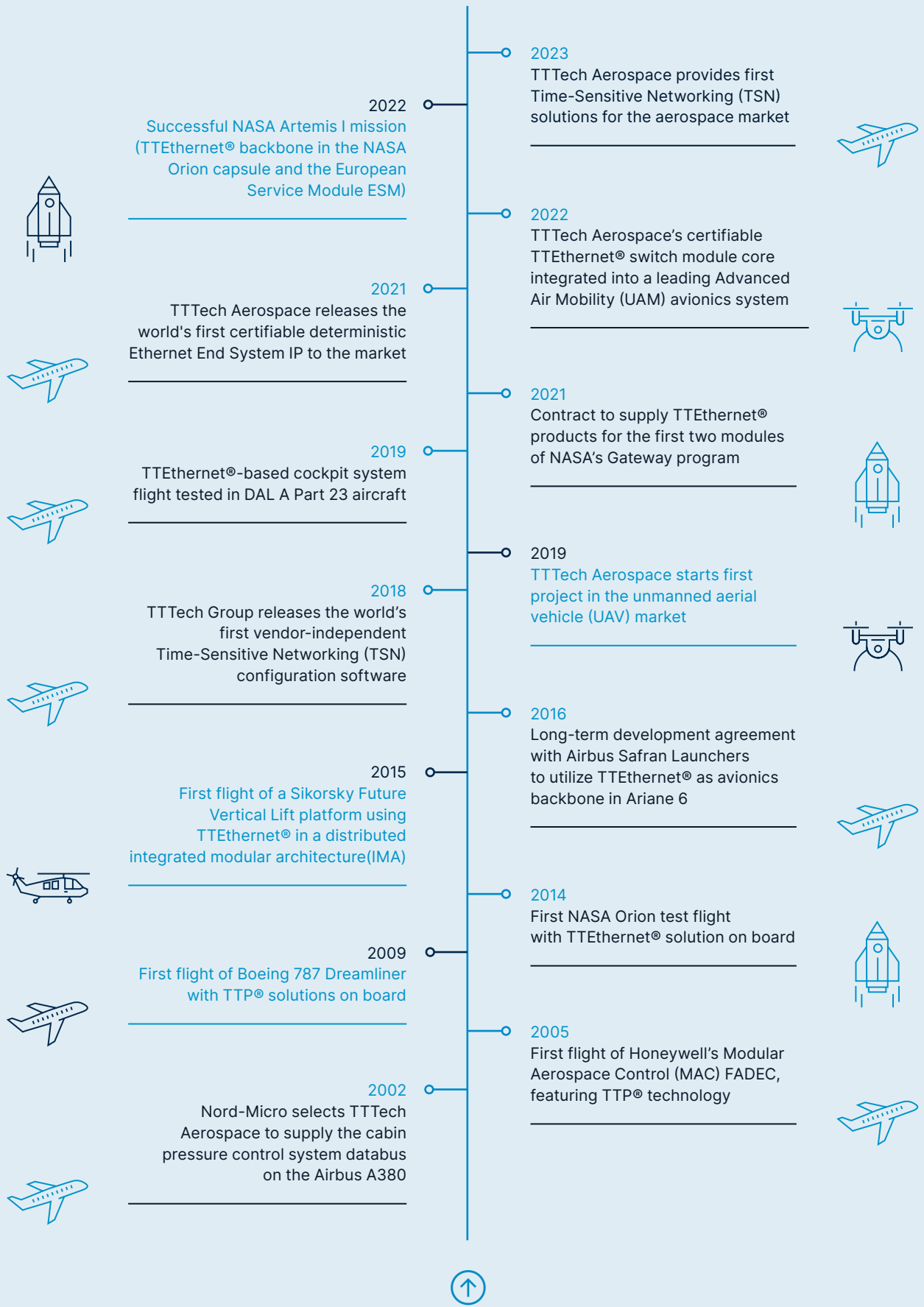
TTTech Aerospace's systems solutions act as the 'nervous system' and the 'brain' of an aircraft, ensuring dependability and security by complying to open standards and applying the necessary certification rigor required by the aerospace industry. Worldwide industry market leaders like Airbus, Boeing, Bombardier, Embraer, Lockheed Martin, and their systems suppliers use TTTech Aerospace's solutions in their programs.

Deterministic Ethernet solutions are an ideal fit to meet current and future industry requirements. TTTech Aerospace provides proven, open, and mature digital backbone solutions that enable customers in the aviation industry to manage the complex development of safety-critical systems. With our certifiable building blocks, customers are able to reduce time-to-market, development cost, and risk, while increasing performance and dependability. In addition, our solutions are offering a high ratio of speed and performance for the reduction of size, weight, and power (SWaP), allowing to lower total lifecycle costs.

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. TTTech Group's Deterministic Ethernet solutions are already being applied successfully in other industries and have been implemented in some of the world's leading space exploration endeavors.



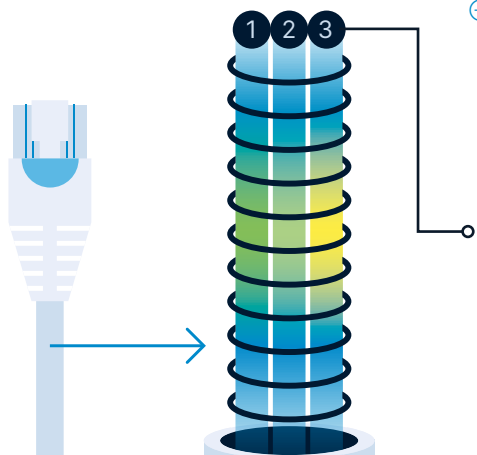
# TTTech Aerospace: A proven innovator in safety-critical digital backbones



# Modular, certifiable, and mature solutions based on open standards

TTTech Aerospace supports customers in reducing SWaP and increasing bandwidth by providing versatile, deterministic embedded network and platform solutions that support customers along the whole product lifecycle. Our product portfolio complies with open industry standards and covers a wide range of technologies to ensure customers can find the best fit for their programs:

- ③ **Time-Triggered Ethernet:** Deterministic real-time communication over Ethernet, designed for safe and highly available real-time applications, cyber-physical systems, and unified networking.
- ② **Time-Sensitive Networking (TSN):** a set of IEEE 802 Ethernet sub-standards enabling fully deterministic real-time communication over Ethernet.
- ① **Time-triggered communication protocol (TTP®):** reduces the complexity of distributed fault-tolerant architectures and supports efficient system reconfiguration, upgrades, and growth.



#### Guarantee of service

- ① SAE AS6802 Time-Triggered Ethernet
- ② ARINC 664 part 7

#### Quality of service

- ③ IEEE 802.3 Ethernet

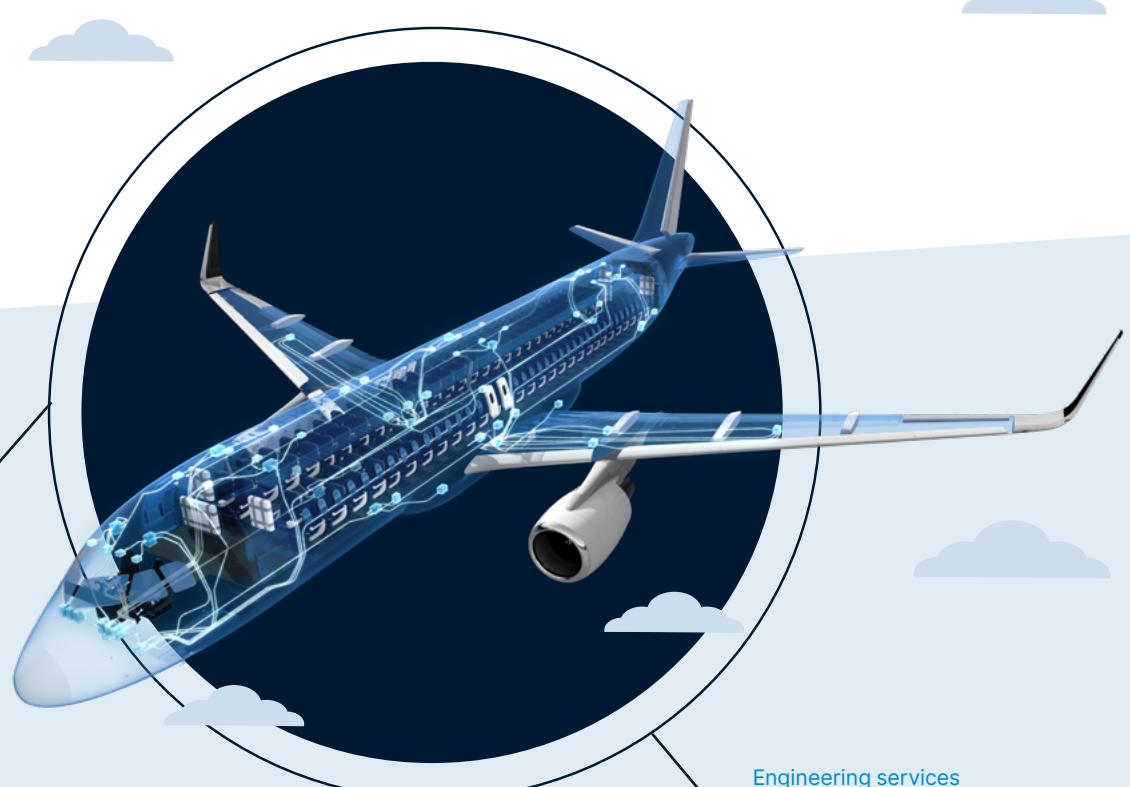
## Mixed-criticality networks with TTEthernet® and TSN

TTTech Aerospace's Deterministic Ethernet products are ideally suited for high-availability, safety-critical systems and allows the combination of **previously federated** systems into **a single unified architecture**, with different traffic classes and priorities.

- ③ Create an enhanced safety-critical system for Modular Open Systems Approach (MOSA) systems by enabling three open protocols on the same wire:
  - Time-Triggered Ethernet SAE AS6802
  - ARINC 664 part 7
  - IEEE 802.3
- ③ Leverage the flexibility of emerging technologies like Time Sensitive Networking (TSN) into aerospace applications

TTTech Aerospace follows a cross-industry, modular COTS approach:

- ➔ Modular approach covering complex electronics allows a fast time-to-market, low-cost and risk deployment certification of required form-factors
- ➔ Certifiable TTEthernet® solutions allow different services on one mixed-criticality network (standard Ethernet IEEE 802.3, rate-constrained Ethernet ARINC 664 part 7, and Time-Triggered Ethernet SAE AS6802)
- ➔ Modular certifiable system building blocks fulfill industry standards (such as ARP4754A, ARP4761, DO-160, DO-254, DO-178C, DO-330, DO-326A) at highest safety levels
- ➔ TTTech Aerospace's products are compliant to open standards and designed for a wide range of applications in the aviation industry
- ➔ Software available for multiple operating systems and processor platforms
- ➔ Development and production processes in accordance with ISO9001 and AS9100



Products

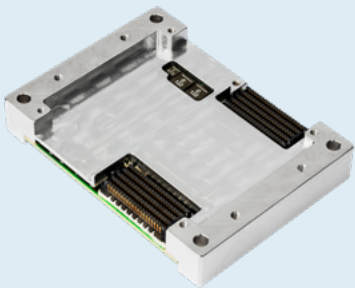
- Hardware products
- IP cores products
- Software and middleware products
- Configuration tools
- Verification tools
- Certification data packages

Complete lifecycle solutions

- Solution definition
- Design
- Development and integration
- Verification and validation
- Certification
- Production transition and series production
- Maintenance, repair, and overhaul (MRO)

Engineering services

- Network architecture development
- Program management
- Certification management
- Product assurance
- Reliability, safety, and security support
- Integration and test support



## TTE Switch Module A664 Pro

TTTech Aerospace's TTEthernet® reliable integrated network solutions are comprised of switches, end systems, and box-level equipment, as well as tooling, development equipment, and integration support. They reduce system complexity and system lifecycle costs thanks to mixed-criticality architectures, allowing three traffic classes (best-effort Ethernet acc. to IEEE 802.3, rate-constrained traffic acc. to ARINC 664 part 7 and Time-Triggered Ethernet acc. to SAE AS6802) to use the same network/physical medium.

The TTE Switch Module A664 Pro brings the full power of Deterministic Ethernet communication technology to aerospace-certifiable hardware. The switch module enables a wide range of certifiable networks: from standard Ethernet networks, ARINC A664 part 7 networks to fully-configurable TTEthernet® networks - with speeds up to 1 Gbit/s.

The switch module uniquely supports three standard traffic classes in parallel on one physical media enhanced by additional features for seamless integration of Ethernet network interface cards. Its very small form factor makes it fit at the core of all avionics switches.

## Overview TTE Switch Module A664 Pro

### Switch fabric and processor supporting three configurable traffic classes

- Best-effort traffic (IEEE 802.3)
- Rate-constrained traffic (ARINC 664 part 7)
- Time-triggered traffic (SAE AS6802)

### Switching capability

- 8 × 10/100 Mbit/s Ethernet ports
- 6 × 10/100/1,000 Mbit/s Ethernet ports (e.g., for backbone links)
- 1 × 10/100/1,000 Mbit/s Ethernet mirroring port

### Qualification package

- Performed for DO-160G

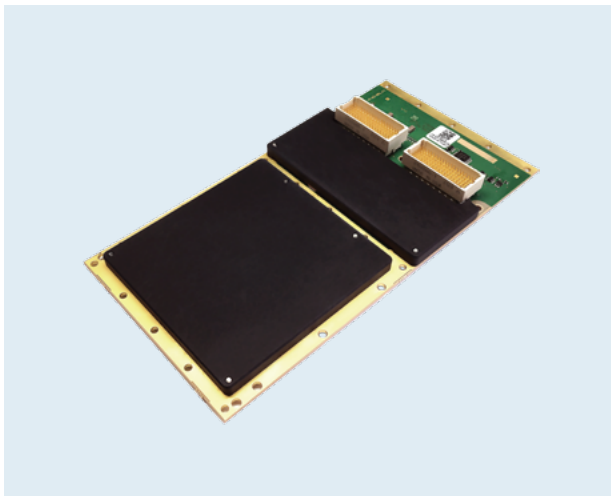
### Certification package

- DAL A:
  - DO-254
  - DO-178C

# Certifiable Deterministic Ethernet products

With a TTEnd System it is possible to turn any node on a network into a Deterministic Ethernet node. TTEch Aerospace's end system network interface cards and IP products allow users to exchange safety-critical data at up to gigabit traffic speeds.

## TTEnd System A664 Pro (XMC)



### Overview TTEnd System A664 Pro (XMC)

- Two redundant channels supporting 10/100/1,000 Mbit/s line rates

#### Configurable traffic classes and protocol services:

- Time-triggered traffic (SAE AS6802)
- Rate-constrained traffic (ARINC 664 part 7)
- Standard Ethernet (IEEE 802.3)

#### Parametrization:

- 256 output VLs, 2,048 input VLs
- 1,024 output ports, 4,096 input ports
- 2 memory partitions

#### Other features:

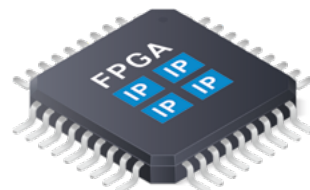
- Flexible, configurable periods ( $\mu$ s granularity)
- Profiled IP/UDP, sampled and queued COM port network interfaces, handled in hardware
- Diagnosis and status registers
- Embedded CPU for Built-in Tests (BITs)

Certification evidence available



## TTEnd System A664 Pro (PMC)

- Three redundant channels supporting 10/100 Mbit/s line rates via a PCI host interface
- Fully compliant with standard Ethernet (IEEE 802.3), rate-constrained (ARINC 664 part 7) and Time-Triggered Ethernet traffic (SAE AS6802)
- Certification evidence available



## TTEnd System A664 Core IP

- RTCA DO-254 DAL A certifiable end system core IP for use in flight programs
- Fully compliant with standard Ethernet (IEEE 802.3), rate-constrained (ARINC 664 part 7) and Time-Triggered traffic (SAE AS6802)
- Support of 10/100/1,000 Mbit/s on both network and host interface
- Certification evidence available

Find out more:

[ttech.com/aerospace/products](http://ttech.com/aerospace/products) ➤



Advancing safe technologies,  
improving human lives

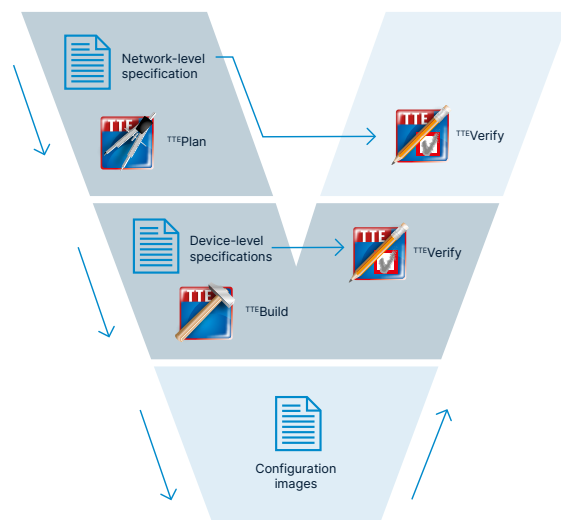
# Tooling and development systems

## Reduce complexity with TTEthernet® and TSN tools

TTTech Aerospace's 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® and TSN-based networks. TTTech Aerospace's highly efficient embedded software components comply with DO-178B/C Level A 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.



## Flexible set of tools for configuring TTEthernet® and TSN networks and systems for:

- Modeling of network and topology
- Modeling of real-time communication requirements

## Network design, schedule generation, and checking capabilities for:

- Verifying real-time communication requirements

## Network timing analysis and verification for:

- Creating device configurations for switches and end systems
- Verifying device configurations of switches and end systems

## Support for manual and automated design processes:

- Based on open XML database formats for flexible integration into third-party tool chains
- Specialized editors for each design step

TTTech Aerospace's Development Systems serve as an all-in-one platform for scaling Deterministic Ethernet architectures in a lab setting. With the full development environment for hard real-time and non-real time Ethernet communication on the same network provided by TTTech Aerospace, the user can test different quality-of-service traffic classes. Standard Ethernet traffic seamlessly integrates with fully deterministic synchronous hard real-time Ethernet traffic on the same physical media.

TTTech Aerospace also offers dedicated on-site training customized to customers' use cases and platform needs.

## The TTEDevelopment System A664 (Linux) includes:

- 2x 24-port TTEthernet® switches
- 4x 3-channel TTEthernet® end systems
- TTEDriver + API for PCIe-based end system controller
- 1x TTETools bundle
- 4x High-performance PCs + digital input/output monitoring module (12 I/O signals)
- 1x COTS switch for data loading
- 1x LCD monitor + USB keyboard + USB mouse



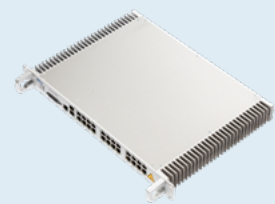




Also  
available:



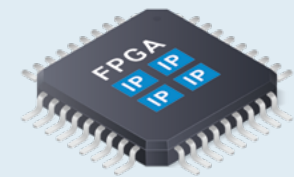
TTEDevelopment System  
A664 for VxWorks® 653



TTESwitch A664 Lab



TTEEnd System A664 Lab



TTEEnd System A664 IP Kit  
for Zynq™ UltraScale+™

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

# Time-Sensitive Networking (TSN) products

## IEEE Time-Sensitive Networking (TSN) for next-generation Ethernet networking in airworthy and safety-critical integrated systems

As a leader in real-time networking, TTTech Group is a pioneer in the development of the IEEE 802.1 TSN standard.

The TTTech Group's TSN product line is fielded in millions of automotive products today. TTTech Group has also brought the first vendor independent TSN configuration tool to market.

Backed by deep experience in TSN technology in the industrial and automotive markets, TTTech Aerospace is now bringing the potential of TSN into the aerospace realm with a certifiable, 802.1DP compliant product offering.

### Key advantages

- ➔ Leveraging of mature aerospace grade form factors and components to meet MOSA and HOST requirements
- ➔ Deep expertise in real-time Ethernet device architecture and implementation for critical system integration and DO-254 / DO-178 DAL A applications
- ➔ Cross-industry IEEE TSN background and footprint (automotive, aerospace, industrial) with millions of fielded devices
- ➔ Incorporation of 802.1DP aerospace profile requirements
- ➔ Network configuration tools

## Our TSN capabilities

### Non flight-critical applications

TSN IP currently available (TRL 9) in > 11 million vehicles worldwide

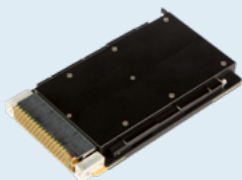
- Fielded in automotive and industrial markets
- 8 Gbit/s max throughput
- Suitable for use outside flight-critical applications
- Development hardware and IP available for purchase

Combine fielded experience with certifiable pedigree

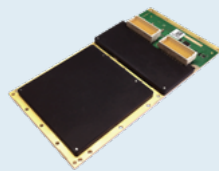
### Safety-critical applications

TTTech Aerospace builds on previous TSN products to bring a DAL A version to market

- Incorporates 802.1DP extensions
- Support for MOSA-conformant interfaces
- Leverages current flight grade hardware for quick time-to-market and risk reduction
- TSN end-point support
- Path to state-of-the-art bandwidth speeds (10 Gbit/s+)



TSN Switch (3U VPX) Pro



TSN End System (XMC) Pro

### TSN features planned for TTTech Aerospace's new 802.1DP aligned TSN product line

- 802.1AS-2020 Timing and Synchronization
- 802.1ASdm Timing and Sync for Time-Sensitive Applications – Hot Standby
- 802.1Qav Credit Based Shaper
- 802.1Qbv Scheduled Traffic
- 802.1Qci Per-Stream Filtering and Policing
- 802.1CB Frame Replication and Elimination

Time Aware Shaper  
 Fault-Tolerant Clock Sync  
 Memory Partitions for Flexible Frame Buffer

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

# TTP® products

## Time-Triggered Protocol (SAE AS6003) – a core technology for robust modular controls

The Time-Triggered Protocol (TTP) is an open (SAE AS6003) standard and deterministic databus, which enables reliable distributed computing and networking for safety-critical systems at lower lifecycle costs.

As a core technology for the design of open and modular control systems and embedded platforms, TTP supports efficient system reconfiguration, upgrades, and growth.

TTP supports different topologies. At 4 Mbit/s or 20 Mbit/s, it offers substantially increased bandwidth compared to ARINC 429, MIL-1553 and CAN. TTP integrates distributed platform services which simplify the design of advanced integrated systems hosting time- and safety-critical applications.

By 2025, TTTech Aerospace's TTP® communication controllers will have accumulated more than 3 billion flight hours in over 20 of the most advanced and "more electric" aircraft types.

## Key advantages

Mature technology, proven in aerospace programs for 25 years

- Over 1 billion flight hours in DAL A applications today, used in over 20 aircraft types

Designed for deterministic real-time flight, engine, environmental and other critical DAL A controls

- DO-254 and DO-178B Level A
- Proven RS-485 physical layer up to DO-160F Level 5
- TTP 4 Mbit/s and 20 Mbit/s
- Bus and star topology
- Low protocol overhead

Reduced system and integration complexity

Simplified upgrades and late system modifications – minimized system integration verification and validation



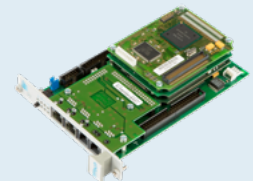
## Product line



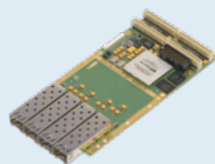
TTPController



TTPDevelopment Cluster



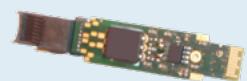
TTPPowerlink



TTPSimulate XMC/PCle



TTPMonitoring Node



TTPPhysical Layer

Find out more:

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



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

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Munich (DE)      Bucharest (RO)  
Ingolstadt (DE)      Novi Sad (RS)  
Brixen (IT)      Belgrade (RS)  
Madrid (ES)      Osijek (HR)  
Barcelona (ES)      Banja Luka (BA)  
Tampere (FI)      Izmir (TR)

## Asia

Nagoya (JP)  
Seongnam (KR)

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## Austria

TTTech Computertechnik AG  
Schoenbrunner Strasse 7  
1040 Vienna, Austria

Phone: +43 1 585 34 34-0  
E-Mail: [office@tttech.com](mailto:office@tttech.com)

## United States

TTTech North America Inc.  
300 Brickstone Square  
S. 1003Andover  
MA 01810, USA

Phone: +1 978 933 7979  
E-Mail: [usa@tttech.com](mailto:usa@tttech.com)

## Japan

TTTech Japan Corporation  
2 Chome-14-19 Meiekiminami  
Nakamura Ward, Nagoya  
Aichi 450-0003, Japan

Phone: +81 52 485 5898  
E-Mail: [office@tttech.jp](mailto:office@tttech.jp)

