

***REACHING FOR THE SKY
WITH CERTIFIED AND
SAFE SOLUTIONS FOR
THE AVIATION MARKETS***



ADVANCED INTEGRATED SYSTEMS AND DETERMINISTIC NETWORKS FOR AVIATION, DEFENSE, AND SPACE APPLICATIONS



TTTECH Aerospace provides high-performance, safety-critical networking and embedded computing platform solutions for aviation, defense and space applications. Its aviation products have surpassed billions of flight hours in the highest safety-critical applications like fly-by-wire, power distribution systems, federated engine control and environmental control systems.

ADVANCING CUSTOMER APPLICATIONS WITH INTEGRATED AVIONICS NETWORK SOLUTIONS

TTTECH's system solutions act as the 'nervous system' within aircraft, ensuring dependability and security by complying to open standards and applying the necessary certification rigor required by the aviation industry. Worldwide industry market leaders like Airbus, Boeing, Bombardier, Embraer, Lockheed Martin, and their system 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 and defense industries 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.



+25 YEARS OF TECHNOLOGICAL EXPERTISE

TTTECH Aerospace is part of the TTTECH Group, a globally oriented group of high-tech companies with more than 1100 employees in a dozen countries, headquartered in Vienna, Austria. The solutions of the TTTECH Group are mainly applied in mobile machinery, aerospace, smart manufacturing, and critical infrastructure. They are based on more than 25 years of technological expertise.

TTTECH AEROSPACE

A PROVEN INNOVATOR IN SAFETY-CRITICAL DIGITAL BACKBONES

2026		Successful NASA Artemis II mission (Orion with TTEthernet® backbone circles around the Moon)
2025		TTTECH Aerospace selected to provide 10 Gbps TSN digital backbone solutions for the US Army's HADES ISR aircraft
2023		TTTECH Aerospace provides first Time-Sensitive Networking (TSN) solutions for the aerospace market
2022		Successful NASA Artemis I mission (TTEthernet backbone in the NASA Orion capsule and the European Service Module ESM)
2022		TTTECH Aerospace's certifiable TTEthernet switch module core integrated into a leading Advanced Air Mobility (UAM) avionics system
2021		TTTECH Aerospace releases the world's first certifiable deterministic Ethernet End System chip IP
2019		TTEthernet-based cockpit system flight tested in DAL A Part 23 aircraft
2019		TTTECH Aerospace starts first project in the unmanned aerial vehicle (UAV) market
2018		TTTECH Group releases the world's first vendor-independent Time-Sensitive Networking (TSN) configuration tool
2016		Long-term development agreement with Airbus Safran Launchers to utilize TTEthernet as avionics backbone in Ariane 6
2015		First flight of Sikorsky's S-97 Raider with distributed integrated modular avionics (IMA) architecture based on TTEthernet
2014		First NASA Orion test flight with TTEthernet solution on board
2009		First flight of Boeing 787 Dreamliner with TTP® solutions on board
2005		First flight of Honeywell's F124 jet engine with TTP® technology in the Aermacchi M-346, and GE's F110 engine in the Lockheed-Martin F-16 jet
2002		Nord-Micro selects TTTECH Aerospace to supply the cabin pressure control system databus on the Airbus A380

MODULAR AND CERTIFIABLE SOLUTIONS BASED ON OPEN STANDARDS

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

ARINC 664 PART 7

Full-duplex Ethernet network for avionics backbones with performance guarantees (bandwidth reservation per virtual link).

TIME-TRIGGERED ETHERNET

Deterministic real-time communication over Ethernet, designed for safe and highly available real-time applications, cyber-physical systems, and unified networking.

TIME-SENSITIVE NETWORKING (TSN)

A set of IEEE 802 Ethernet sub-standards enabling fully deterministic real-time communication over Ethernet.

TIME-TRIGGERED COMMUNICATION PROTOCOL (TTP®)

Reduces the complexity of distributed fault-tolerant architectures and supports efficient system reconfiguration, upgrades, and growth.

MIXED-CRITICALITY NETWORKS WITH TTETHERNET® AND TSN

Our Deterministic Ethernet products are ideally suited for high-availability, safety-critical systems and allow the transition of previously federated systems into a single unified architecture, with different traffic classes and priorities:

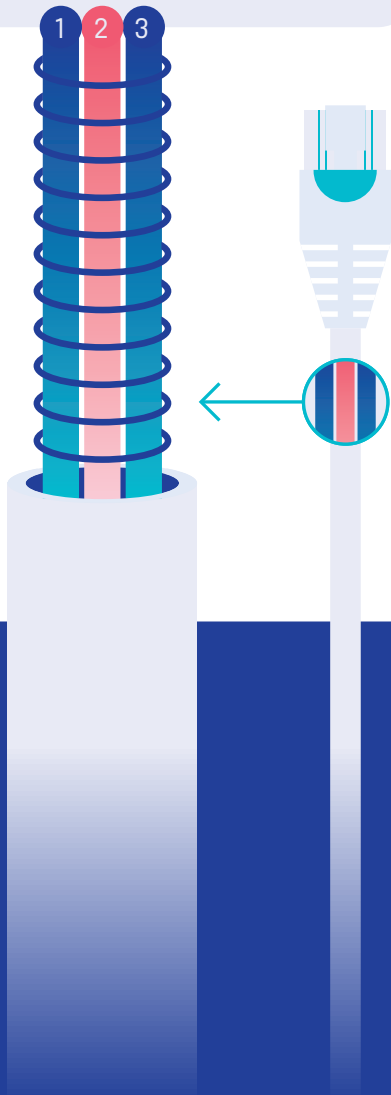
- Create an enhanced safety-critical system in line with the Modular Open Systems Approach (MOSA) by enabling three open protocols on the same physical network:
 - Time-Triggered Ethernet SAE AS6802
 - ARINC 664 part 7
 - IEEE 802.3
- Leverage the flexibility of Time Sensitive Networking (TSN) into aerospace applications

GUARANTEE OF SERVICE

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

QUALITY OF SERVICE

- 3 IEEE 802.3 Ethernet

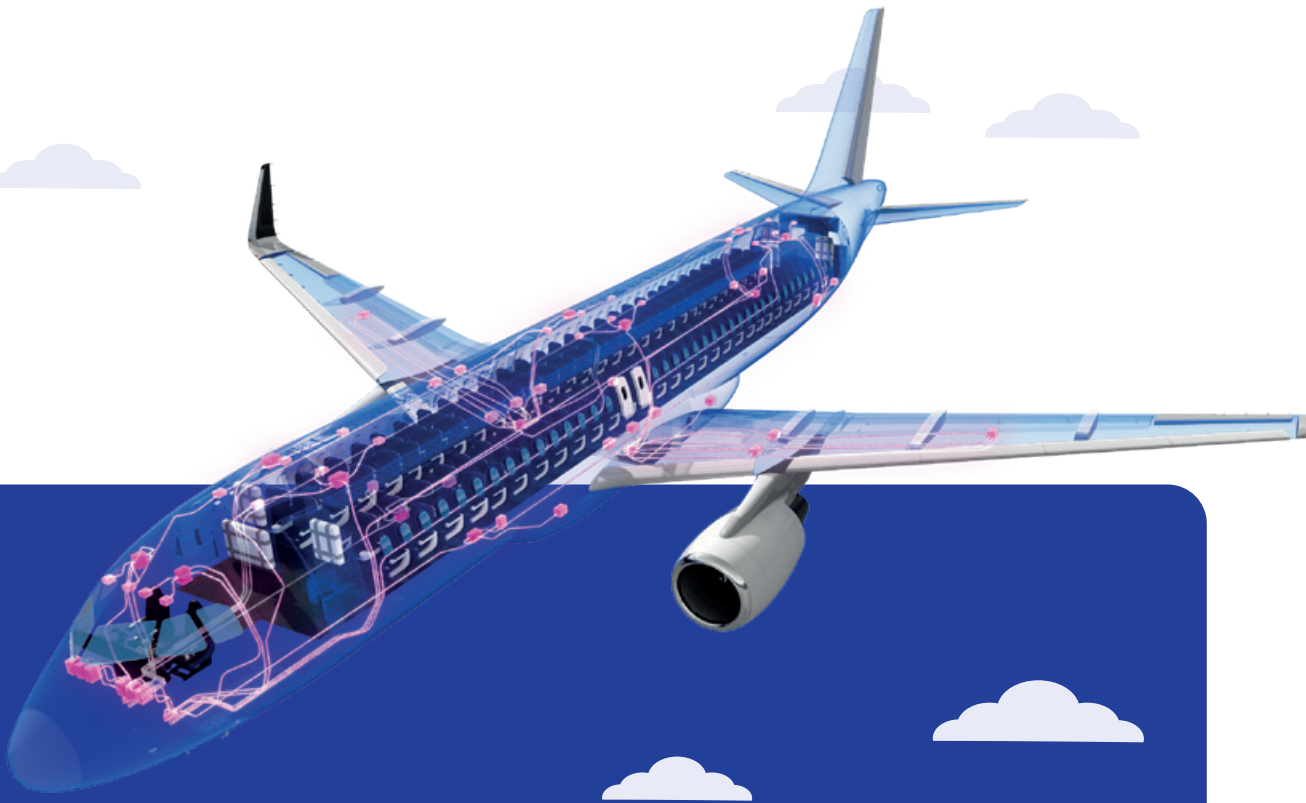


TTTECH AEROSPACE FOLLOWS A CROSS-INDUSTRY, MODULAR COTS APPROACH:

Modular approach for complex electronics allows a faster time-to-market at low risk

- 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)
- System building blocks fulfill industry standards (such as ARP4754A, ARP4761, DO-160, DO-254, DO-178C, DO-330, DO-326A) at highest functional 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

- Complete qualified units and modules
- Chip IP cores
- 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)

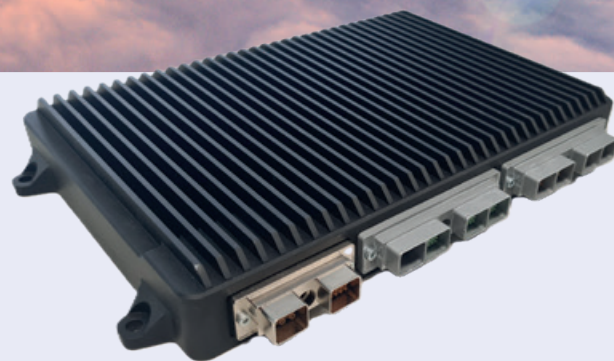
ENGINEERING SERVICES

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



CERTIFIABLE DETERMINISTIC ETHERNET PRODUCTS

^{TTE}End Systems turn any node on an aviation data network into a Deterministic Ethernet node. TTTECH Aerospace's end system network interface cards and IP products allow users to exchange safety-critical data at up to Gbit/s speed without the need for re-designing equipment.



^{TTE}SWITCHES A664 PRO

TTTECH Aerospace's reliable integrated network solutions are based on network switches, end systems, as well as tooling, development equipment, and integration support. They reduce system complexity and system lifecycle costs by enabling modular, mixed-criticality architectures, allowing three traffic classes to use the same Ethernet network/physical medium.

The certifiable ^{TTE}Switch Module A664 Pro is integrated into standalone switch units and line-replaceable switch modules in different form factors. This way it brings the full power of Deterministic Ethernet communication technology to aerospace-certifiable equipment. 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 and up to 25 ports.

OVERVIEW NETWORK SWITCHES BASED ON ^{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

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

QUALIFICATION PACKAGE

- Performed for DO-160G

CERTIFICATION PACKAGE

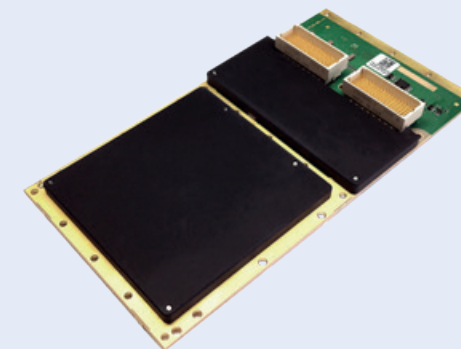
- DAL A:
 - DO-254
 - DO-178C



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^{TTE}END SYSTEM A664 PRO (XMC)



OVERVIEW ^{TTE}END 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:

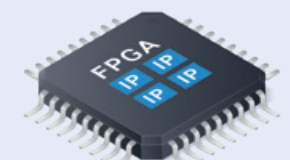
- Flexible, configurable periods (μs granularity)
- Profiled IP/UDP, sampled and queued COM port network interfaces, handled in hardware
- Diagnosis and status registers
- Embedded CPU for Built-in Tests (BITs)

CERTIFICATION EVIDENCE AVAILABLE



^{TTE}END 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



^{TTE}END 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

TOOLING AND DEVELOPMENT SYSTEMS

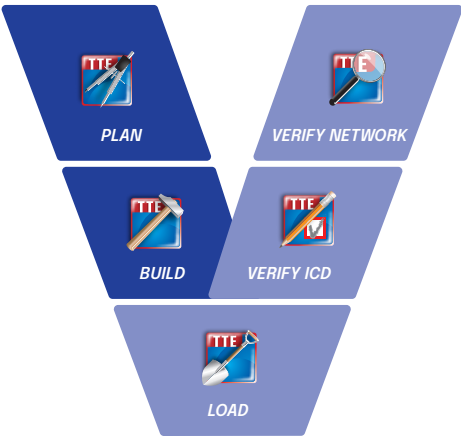
REDUCE COMPLEXITY WITH TTE AND TSN TOOLS

TTTECH Aerospace's software tools offer a powerful development and production environment for building and configuring fault-tolerant real-time systems. They enable seamless design, configuration, data loading, verification and validation of ARINC 664 part 7, TTEthernet and TSN based networks.

They interact with TTTECH Aerospace's embedded software components compliant with DO-178B/C Level A standards. These can be integrated with different hardware and software platforms including time- and space-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 TTEETHERNET® 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, users can test different quality-of-service traffic classes and architectures. Standard Ethernet traffic seamlessly integrates with fully deterministic synchronous hard real- time Ethernet traffic on the same physical media.

THE TTEDEVELOPMENT SYSTEM A664 (LINUX) INCLUDES:

- 2x 24-port TTEthernet lab 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 modules (12 I/O signals)
- 1x COTS switch for data loading
- 1x monitor (opt.) + USB keyboard and mouse



TTTECH AEROSPACE ALSO OFFERS DEDICATED ON-SITE TRAINING CUSTOMIZED TO PLATFORM NEEDS AND USE CASES.



ALSO AVAILABLE:



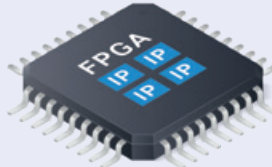
TTEDevelopment System A664 for VxWorks 653®



TTESwitch A664 Lab



TTTEnd System A664 Lab



TTTEnd System A664 IP Kit for Zynq™ UltraScale+™



Find out more → ttech.com/aerospace/products

TIME-SENSITIVE NETWORKING (TSN) PRODUCTS

THIS NEW FAMILY OF IEEE STANDARDS IS BEING INCREASINGLY USED IN AVIATION AND DEFENSE MATCHING OUR TSN CAPABILITIES AND PRODUCTS

As a leader in real-time networking, TTTECH was a pioneer in the development of the IEEE 802.1 TSN standard.

TTTECH Group's TSN products have been fielded in millions of cars and various manufacturing sites. TTTECH has also brought the first vendor-independent TSN configuration tool Slate 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.

NON FLIGHT-CRITICAL APPLICATIONS

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

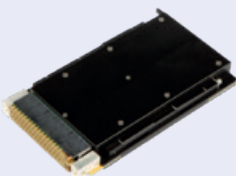
- Fielded in automotive and industrial markets
- 8 Gbit/s max throughput
- Suitable for use outside flight-critical applications
- Development hardware and IP available for purchase

Combine fielded experience with certifiable pedigree

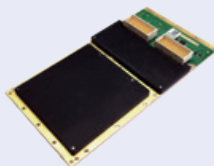
SAFETY-CRITICAL APPLICATIONS

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

TTTECH AEROSPACE'S 802.1DP ALIGNED TSN PRODUCT LINE FEATURES

- 802.1AS-2020 Timing and Synchronization
- Fault-Tolerant Clock Sync
- 802.1ASdm Timing and Sync for Time-Sensitive Applications
- 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
- Memory Partitions for Flexible Frame Buffer

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TTP® PRODUCTS

TIME-TRIGGERED PROTOCOL (SAE AS6003) – A CORE TECHNOLOGY FOR ROBUST MODULAR CONTROLS

The Time-Triggered Protocol (TTP) is an open 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 enables 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.

KEY ADVANTAGES

- Maturity: Several billion flight hours in DAL A applications today, used in over 20 aircraft types
- Stable supply chain: Key component in production in Austria for over twenty years
- Designed for determinism and fault-tolerance
- Reduces sub-system complexity
- Simplifies integration and testing/V&V, therefore also simpler upgrades and late system modifications



TTP Controller



TTP Simulate XMC/PCle



TTP Monitor

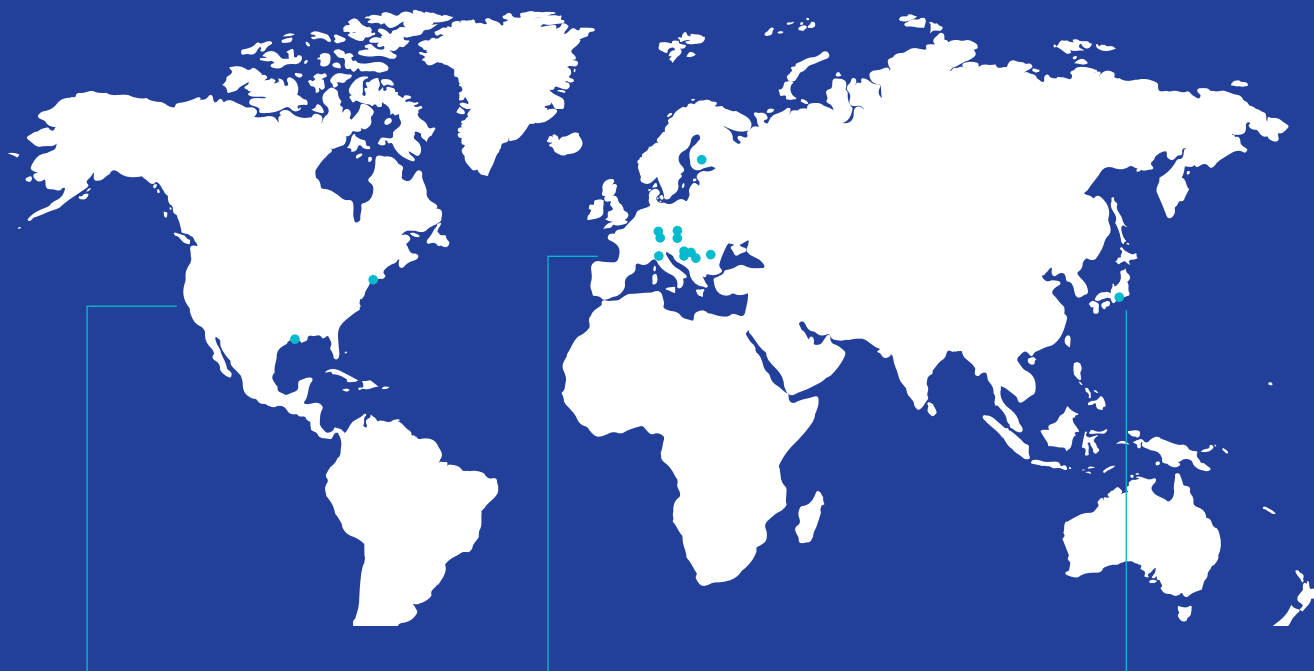
DESIGNED FOR REAL-TIME FLIGHT, ENGINE, ENVIRONMENTAL AND OTHER CONTROL SYSTEMS

- Full DO-254 and DO-178 Level A support
- Proven RS-485 physical layer up to DO-160F Level 5
 - 4 Mbit/s and 20 Mbit/s
 - Bus and star topologies

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EXPLORING NEW WAYS TO SIMPLIFY SPACECRAFT SOFTWARE AND SYSTEM ARCHITECTURES

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