TTTech

Návrh distribuovaných riadiacich systémov reálneho času s využitím deterministickej komunikácie na báze TTEthernet-u

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September 7th, 2023

TTTech Group
Key facts

Founded in 1998, headquartered in Vienna, Austria, with 21 offices in 15 countries worldwide

Products in 1173 production programs

Connected companies:
TTTech Auto, TTTech Industrial, TTControl, RT-RK

2,300
Employees/ subcontractors

60
Nations represented in our workforce

390
R&D/ENG/ADMIN

30
TTTech Industrial

500
RT-RK

120
TTControl

1,160
TTTech Auto

250
TTTech Aerospace

OUR VISION

Advancing safe technologies, improving human lives

What do they have in common?

Reliable networks and safety controls from TTTech

From fail-silent to fail-operational

Fail-silent

IEC 61508

EN/ISO 13849

ISO 26262

DO 178C/254

Fail-operational

Safety by design according to highest safety standards in multiple industries

01

Journey to the Moon and Mars

TTTech

TTTech Aerospace key facts

Proven, mature solutions help customers develop platforms that increase **safety**, **fault-tolerance** and **availability**

TTTech Aerospace **provides deterministic embedded network and platform** solutions for aerospace and space applications

250 employees across Europe, Asia & the USA (100 in TTTech Aerospace, 150 associated in TTTech Group)

Highly Reliable Networks for Aerospace Applications

Boeing 787

NASA Orion

ESA Ariane 6

- TTTech is the leading supplier of dependable networking solutions based on time-triggered technology and modular safety platforms
- TTTech is the innovator of Deterministic Ethernet and the driving force behind the SAE Time-Triggered Ethernet standard and IEEE, ECCS standards
- The solutions and best-in-class products improve the safety and reliability of networked computer systems and are used in various industries such as automotive, aerospace, off-highway, energy, railway and manufacturing

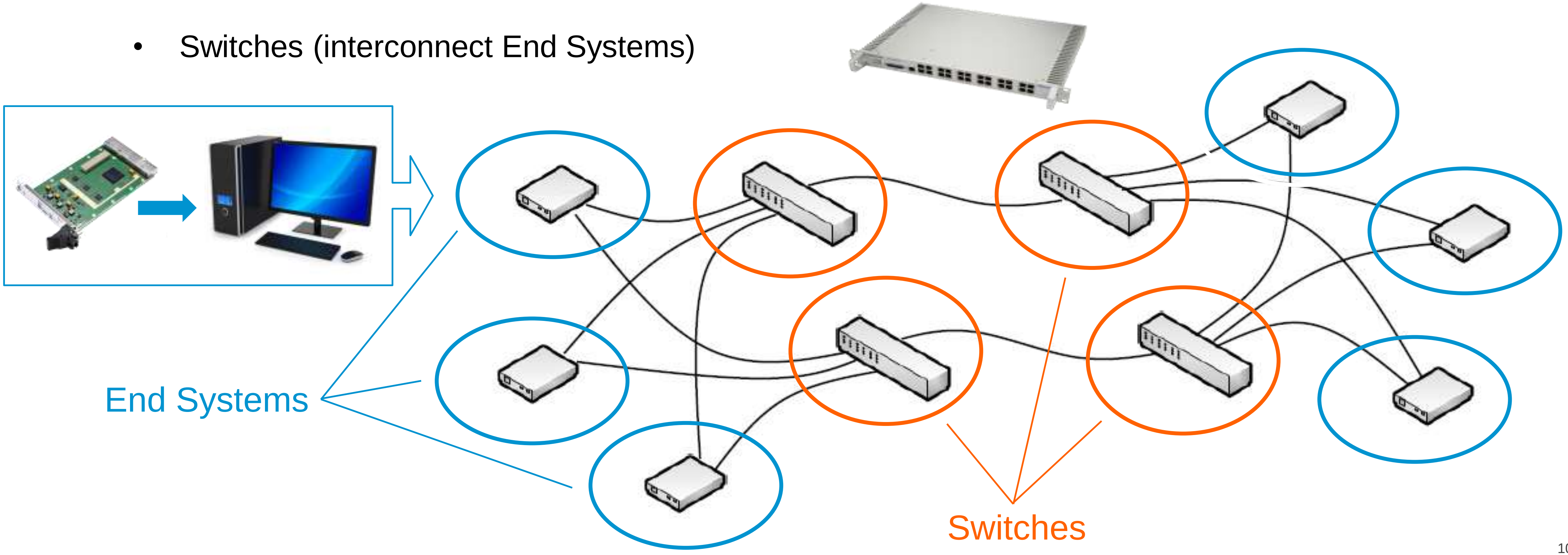
Why TTEthernet?

TTEthernet is optimized for deterministic, fault tolerant, safety critical applications

- Provides fault tolerant network timing to all applications
- Provides synchronous and asynchronous deterministic ethernet traffic classes in a switched based high speed data network
- Provides 802.3 Ethernet support (“Best Effort Ethernet”) using residual network bandwidth after critical traffic is serviced
- All traffic classes run on same physical wires, saving mass, power, and cost
- Provides Redundancy Management for Ethernet Networks in different topologies

Time-Triggered Ethernet

- Switched communication network based on industry-standard Ethernet
- Two device types
  - End Systems (exchange data over the network)
  - Switches (interconnect End Systems)



Time-Triggered vs Event-Triggered

Transportation Example

01

Cars and Taxis are event-triggered:
They go whenever they are needed

Advantage of the event-triggered approach:
very flexible

02

Trains area time-triggered:
They go according to a fixed schedule

Advantage of the time-triggered approach:
very predictable

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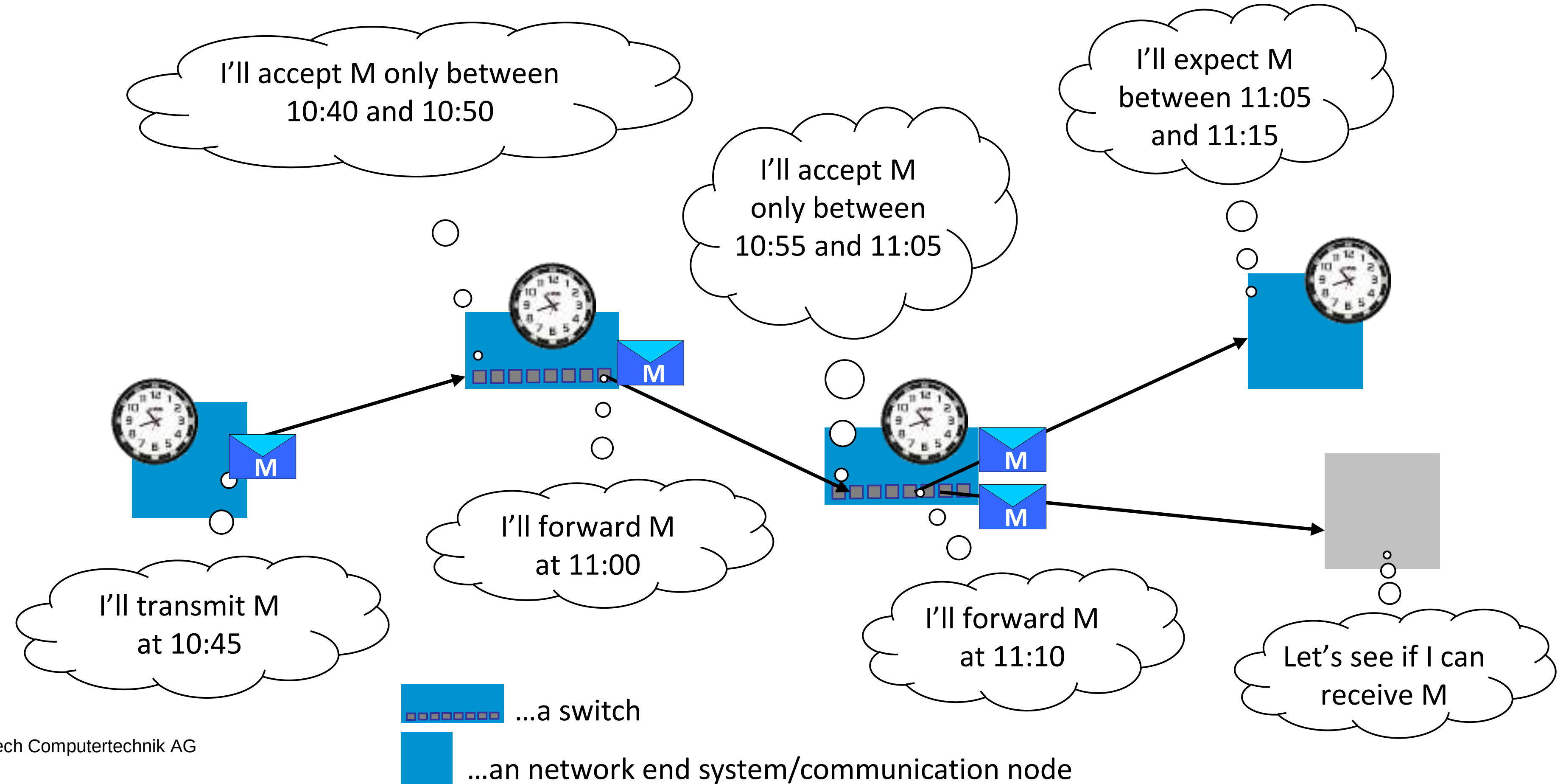
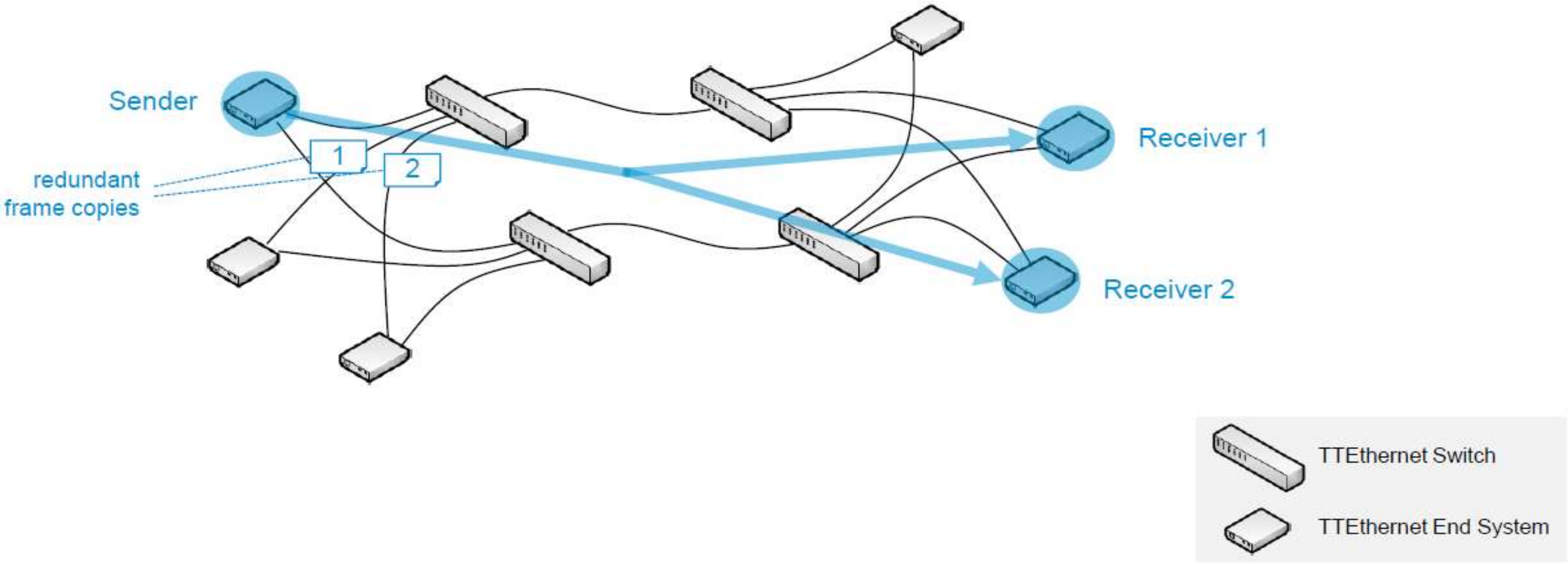
Time-triggered communication & timing checks in a network with forwarding: global schedules & delays apply



Redundancy

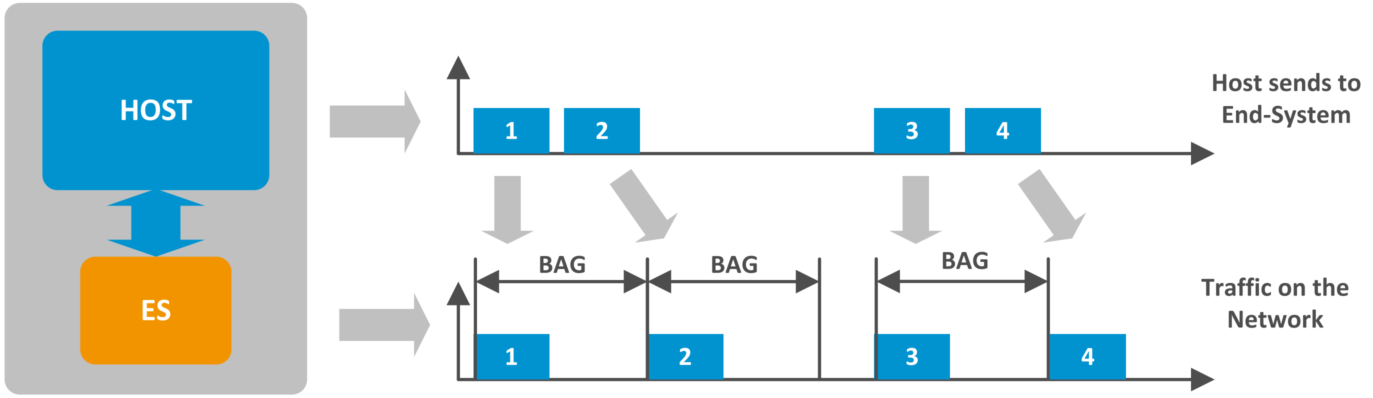
The **redundancy**, i.e. the number of channels in the network, is defined using a redundancy level, which can be defined individually for each virtual link in the network. With a redundancy level > 1 *multiple copies* of a frame will be transmitted on *independent routes*.



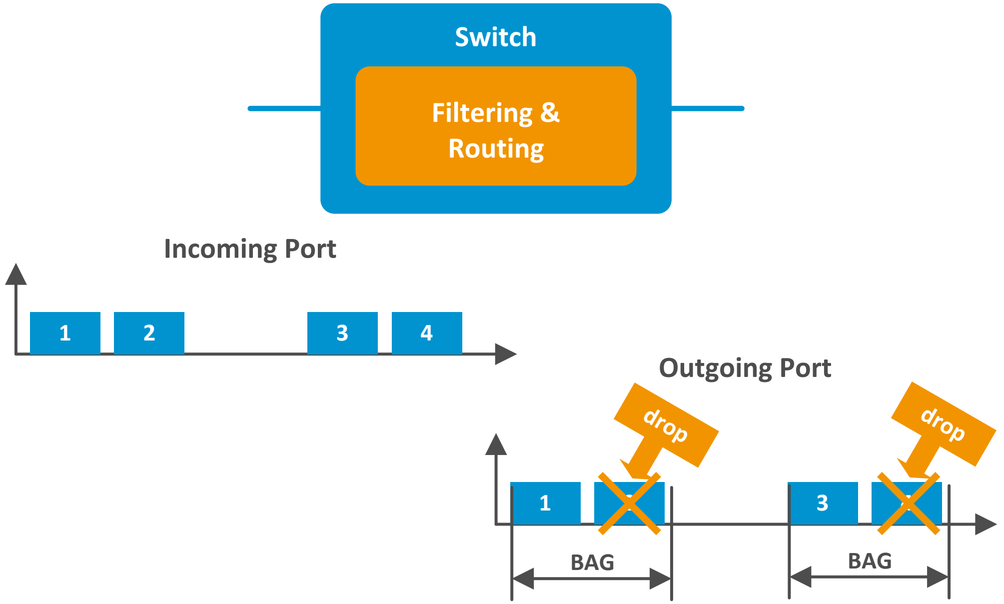
Reliability – Traffic Shaping and Policing

Traffic using virtual links defined by:

- Maximum frame size
- RC: Minimum time between two frames - Bandwidth Allocation Gap (BAG)
- TT: Exact time windows for sending/receiving frames
- Switches = fault containment Region



Traffic Shaping in the End System

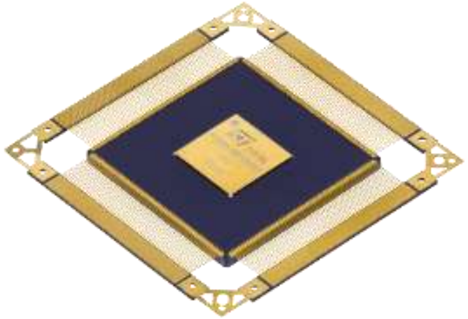


Traffic Policing in the Switch

What Does It Need To Take-Off into Space?

Radiation-Hardened by Design Components

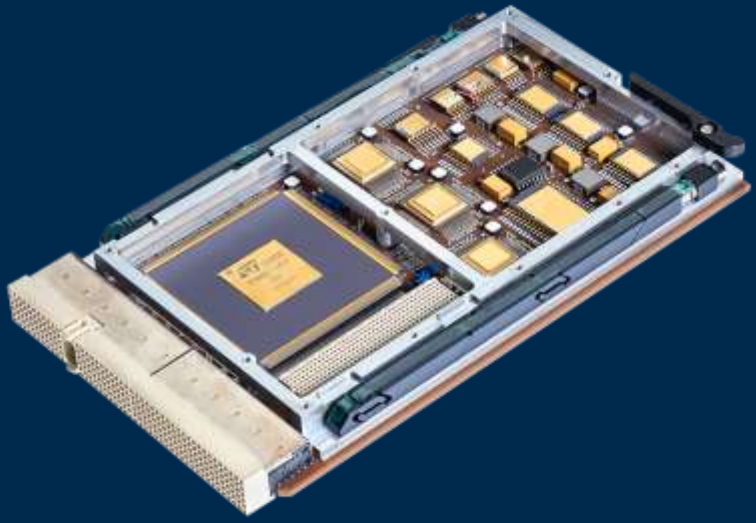
- Up to 15 years on Lunar orbit
- Solar flares
- Extreme temperature range, vacuum



life.augmented

Size, Weight and Power optimized HW

- Modular TTEthernet® network and computing platform



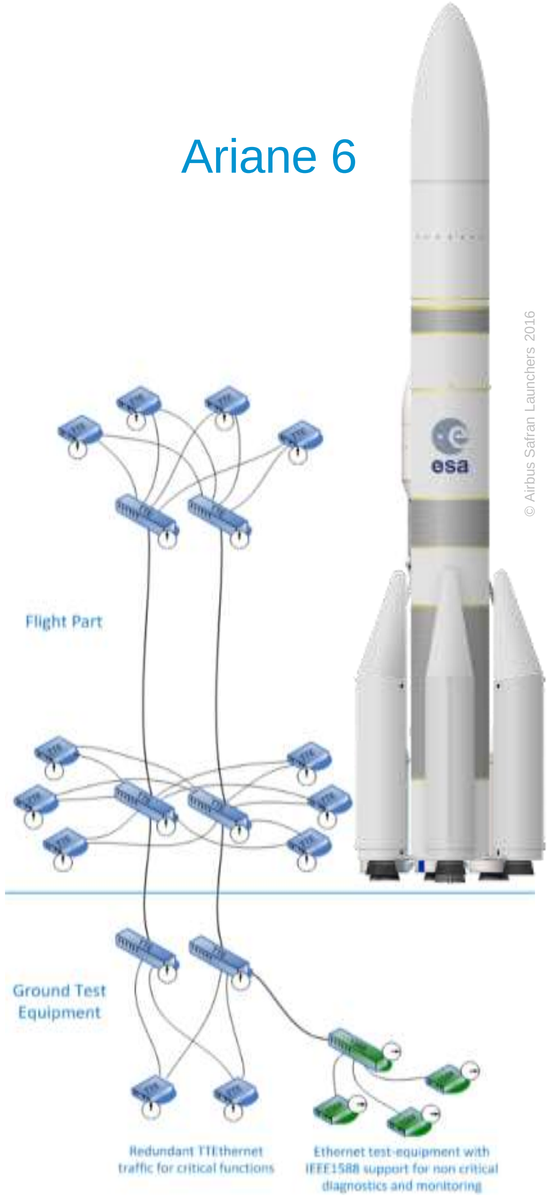
ARIANE 6

ESA FLPP-3 Project

- Maximize use of **network bandwidth and computing resources for critical embedded functions**
- Scalability **10/100 Mbit/s**

Complexity reduction
(long-term cost saving)

Ariane 6



Single network

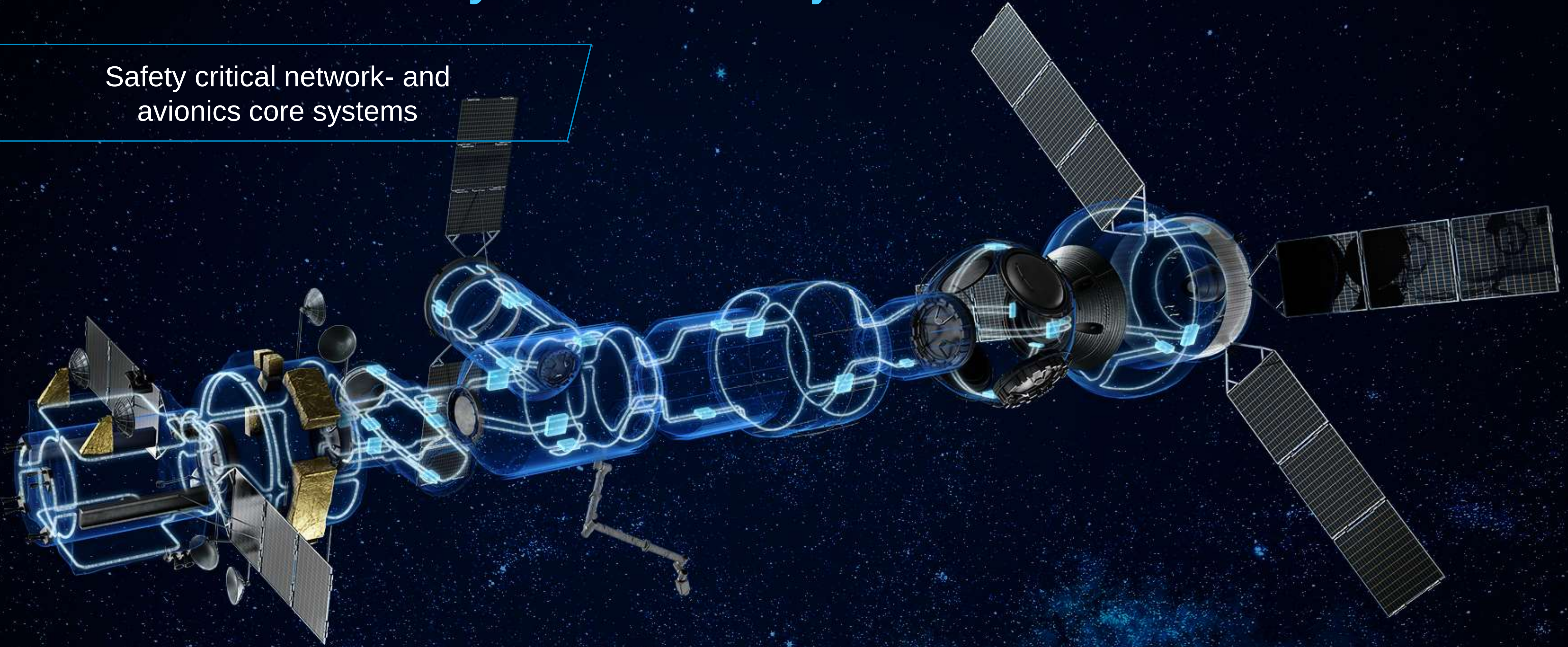
- Scalable platforms
- Inherent fault-tolerance (no complex software solution needed)
- One single network configuration can cover various launcher configurations/states

Full determinism:
defined latency and minimal jitter

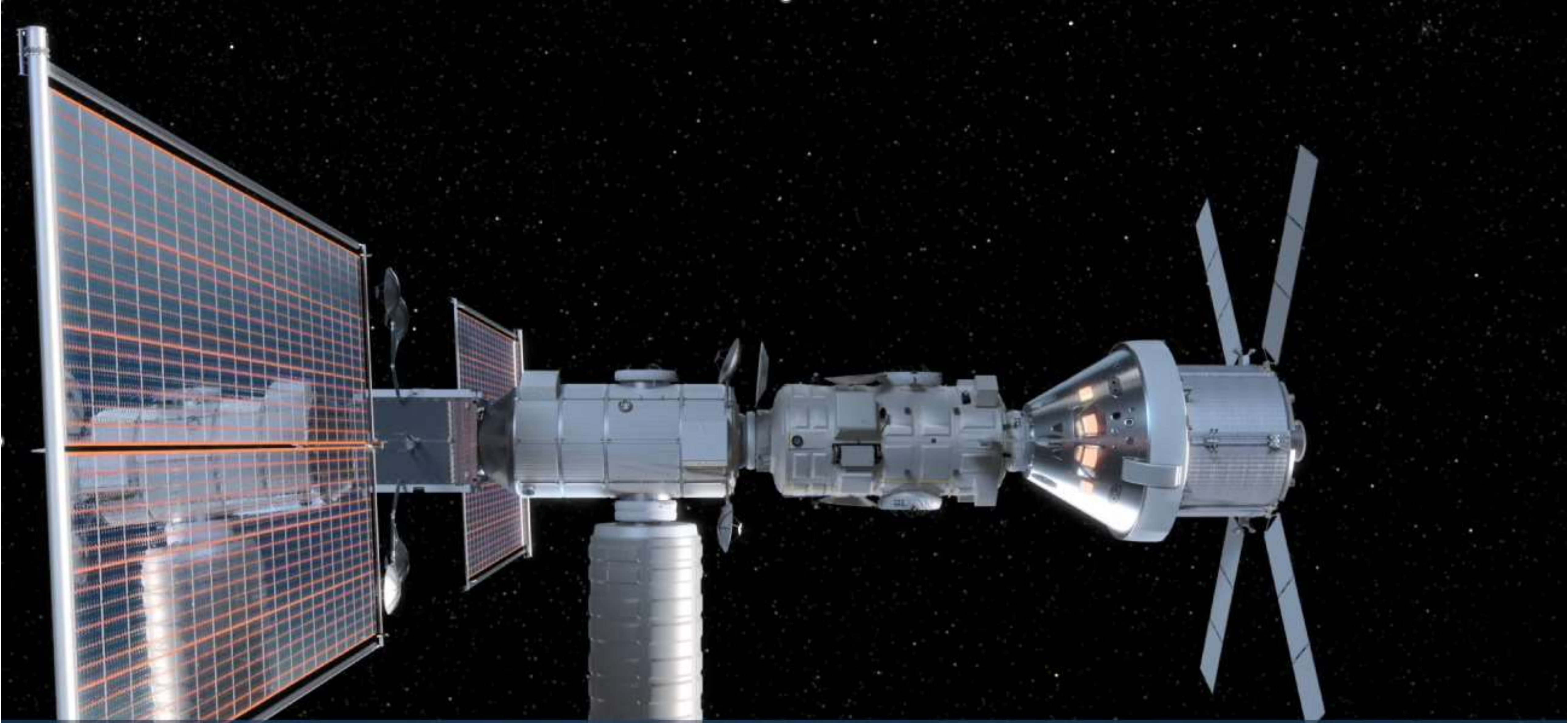
- Separation of boosters and stages tolerated by the protocol
- Potential synchronization to absolute time (GPS)
- Seamless ground segment connection via standard Ethernet

NASA/ESA Gateway/Artemis Project

Safety critical network- and avionics core systems



Bring the next generation of astronauts to the Moon to stay and to explore



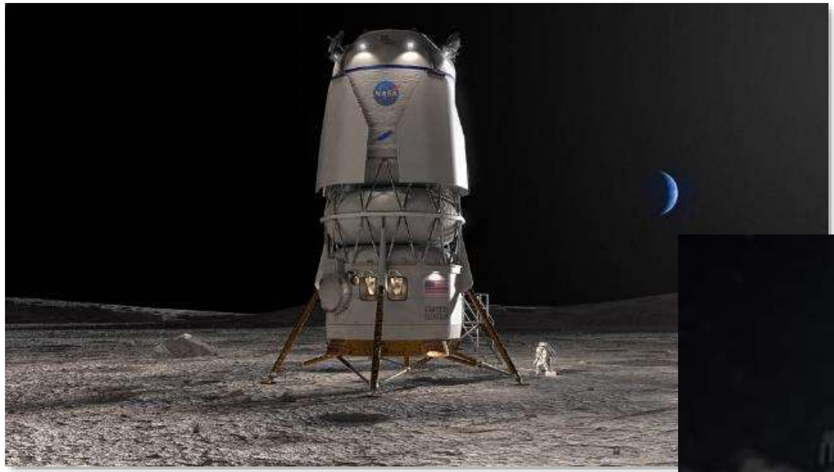
Advantages of TTEthernet®

Reduces Mass, Power, and Software Complexity in Safety Critical Systems

Next Steps of Lunar Exploration

Support for Lunar Landers, Lunar Terrain Vehicles and Lunar Infrastructure

- Building on the Gateway experience and modular network architecture



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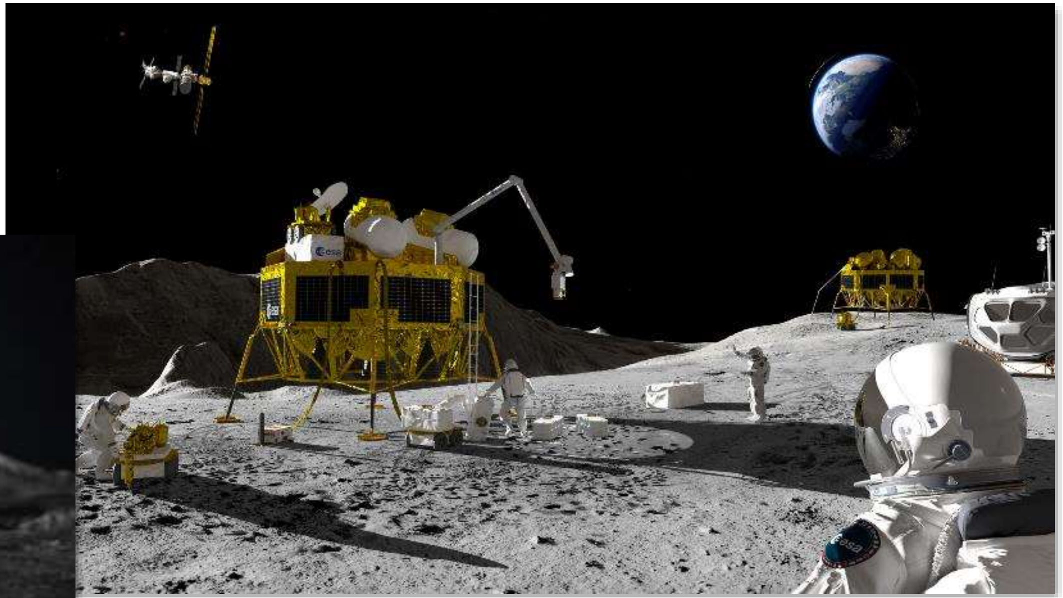

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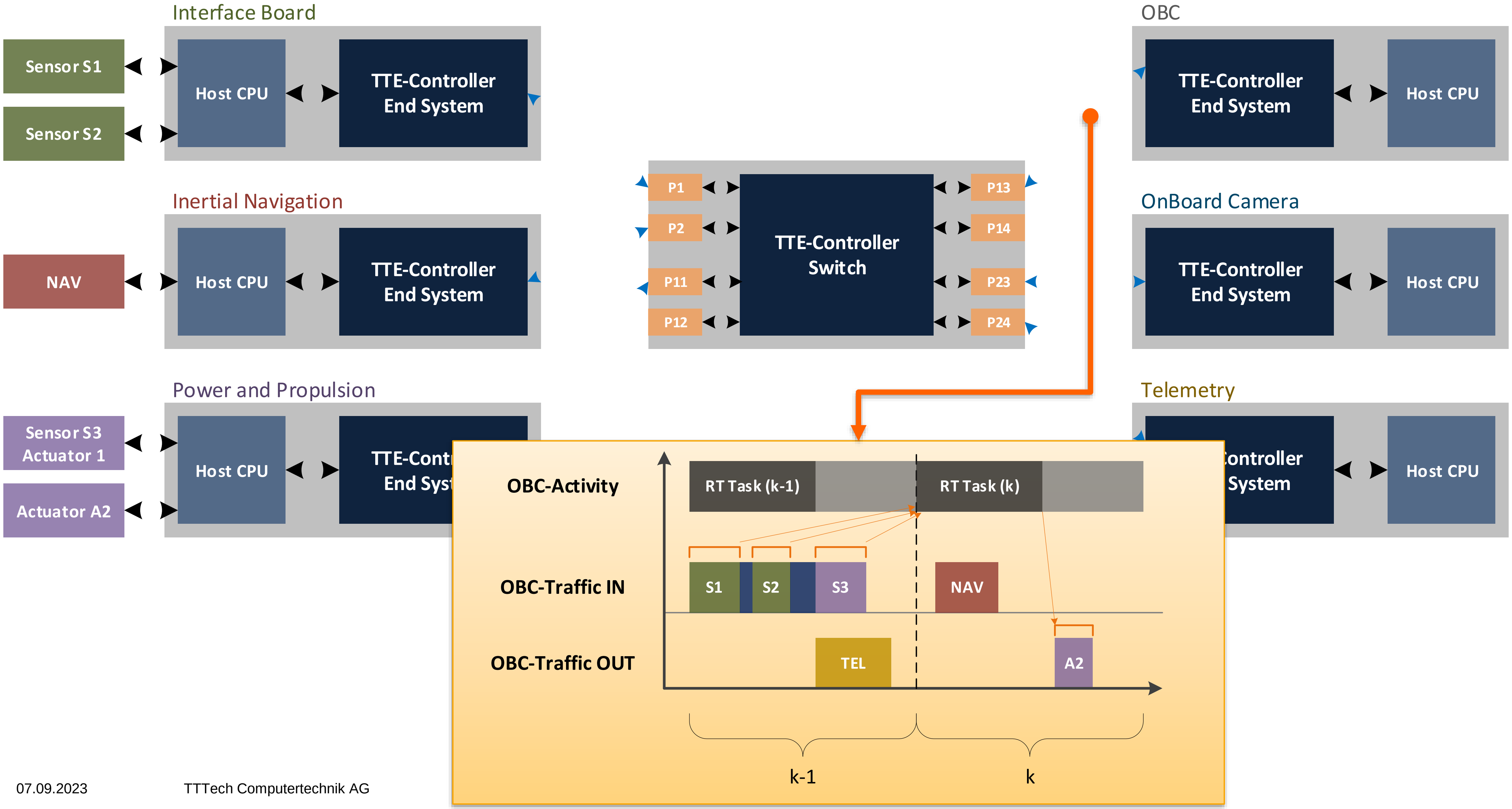
02

Model-Based Design and Rapid Prototyping Using Matlab/Simulink

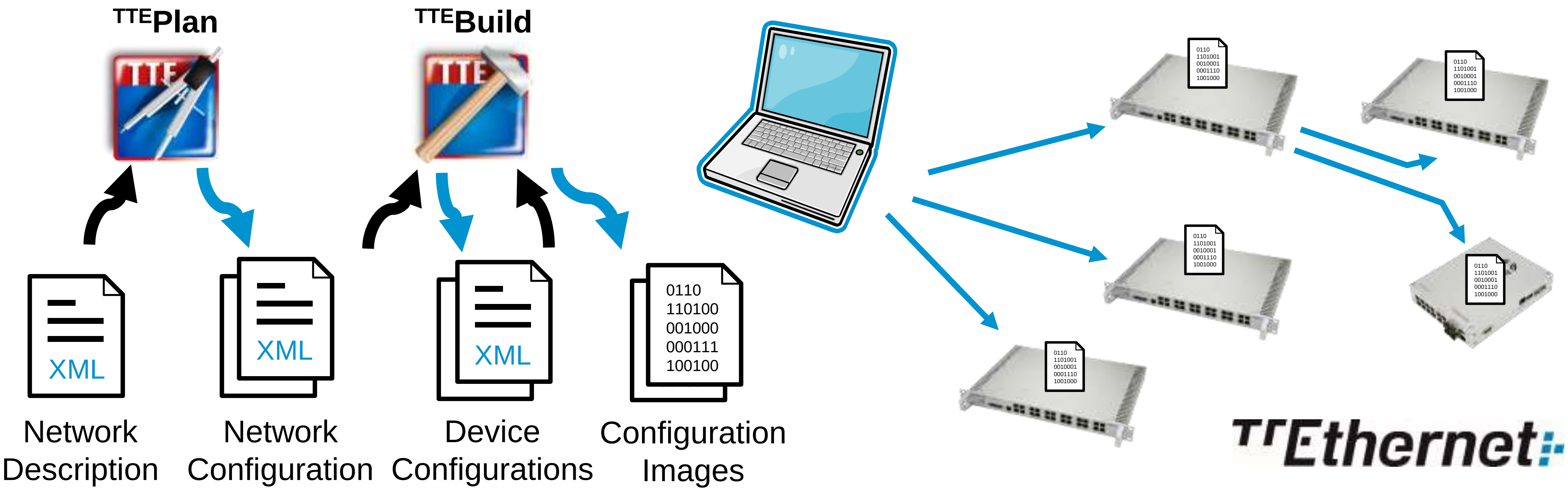
Distributed Real-Time Applications



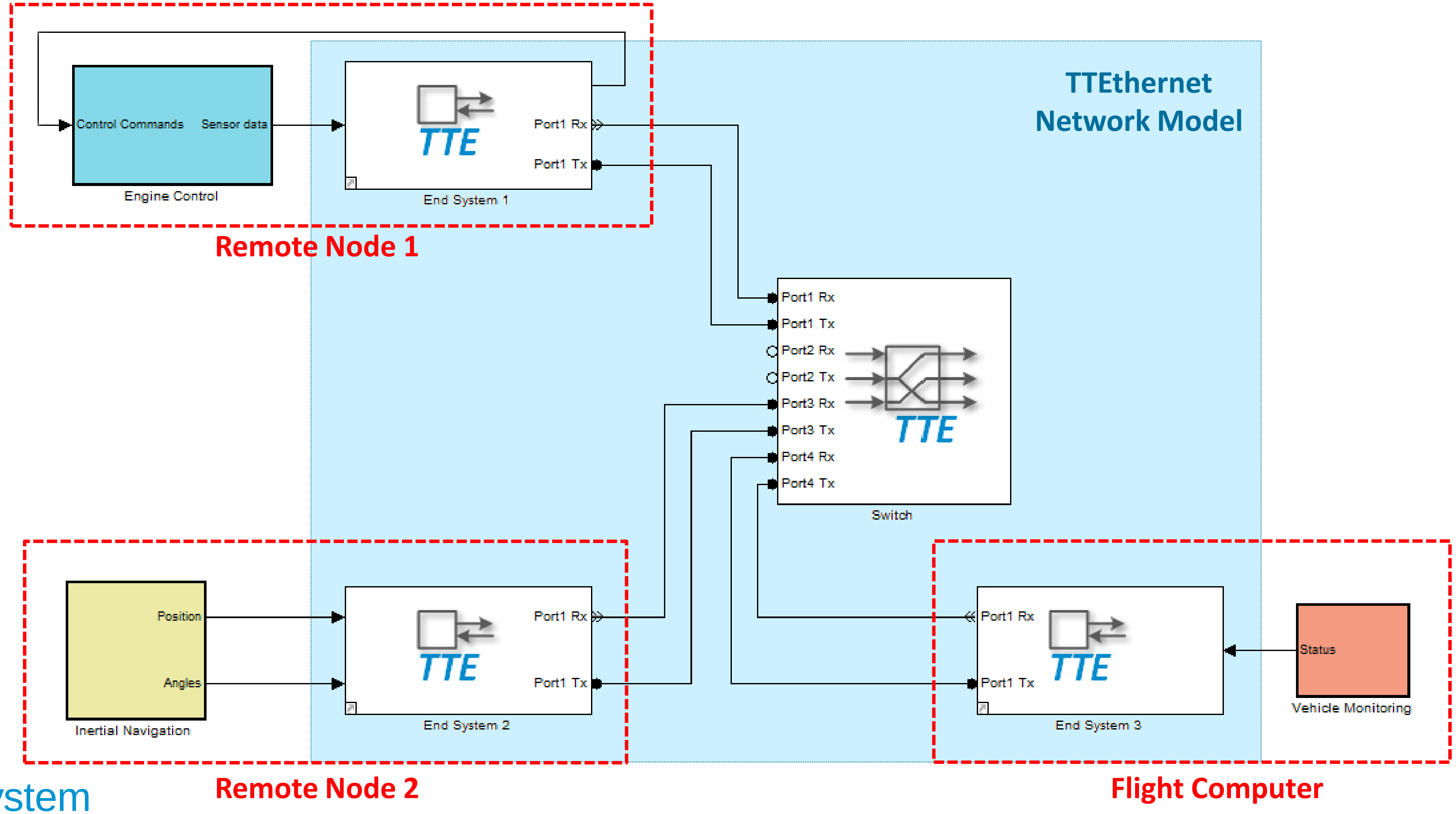
TTEthernet Network Configuration - ^{TTE}Tools

^{TTE}Tools

- Creating and loading device configurations in a multi-step process
- Using XML files with network description and device configuration
- Gengerates binary files to be loaded into TTE-devices (Switches, End Systems)



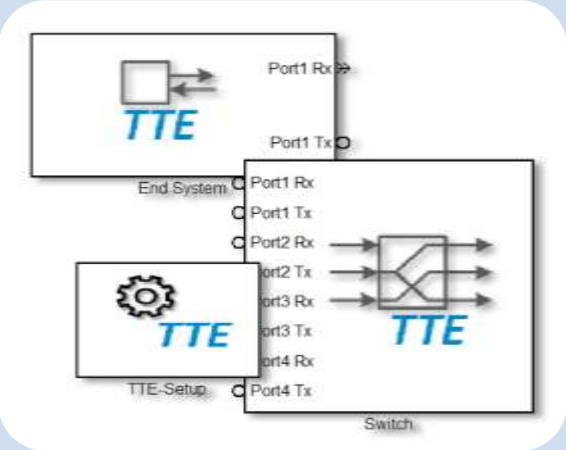
Modeling of Complex Distributed Real-Time Systems

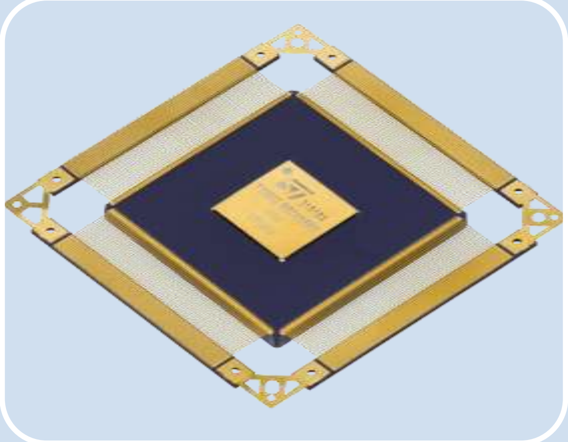


Distributed System

- Consists of spatial distributed continuous (actuators, sensors) and discrete system (flight controllers, data processing units, CPUs) exchanging data over TTE network
- Simulation of communication channels (e.g. transmission delays and jitters) and different clock domains (e.g. drift and offset of individual system clocks) and their impact on the performance of the overall system

TTE-Toolbox Components





TTE-Lib

Simulink Library with building blocks for modeling and simulation of TTE networks

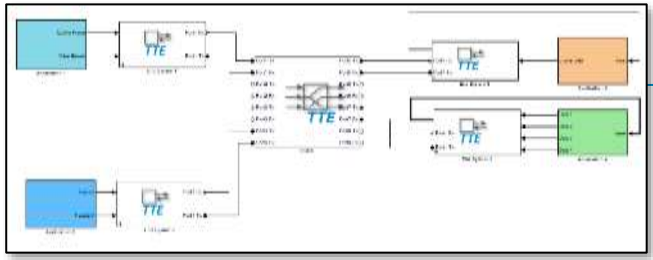
TTE-Tools Integration

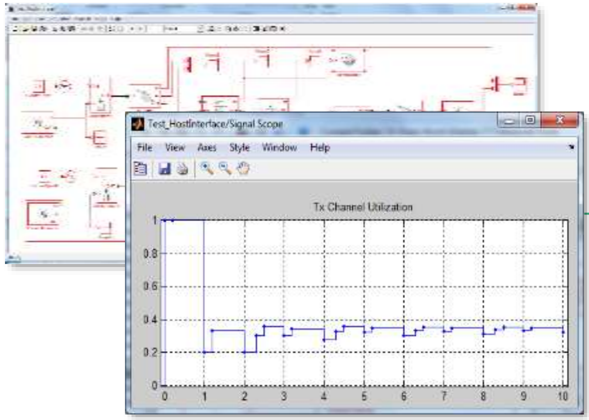
Generation of scheduling parameters for simulated TTE network automatically using TTE-Tools

Code Generation

Automatic code generation for applications running on Host-CPU and synchronised with TTE network

Workflow by Using TTEthernet Toolset





Modeling

Application and network models

Configuration

Network and components (Switch, ES)

- Time synchronization
- Virtual Links editor

Simulation

Scheduling triggers generated by TTE-Tools

Code Generation

Support for Host CPU targets including TTC Space (125MHz Leon2 CPU)

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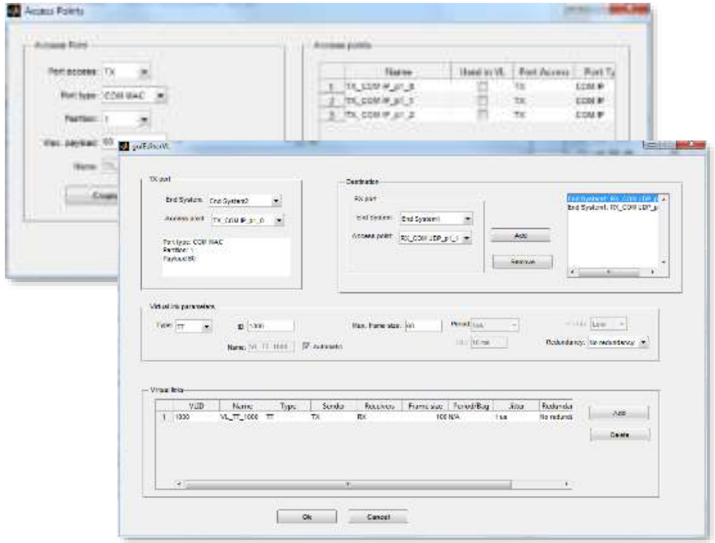
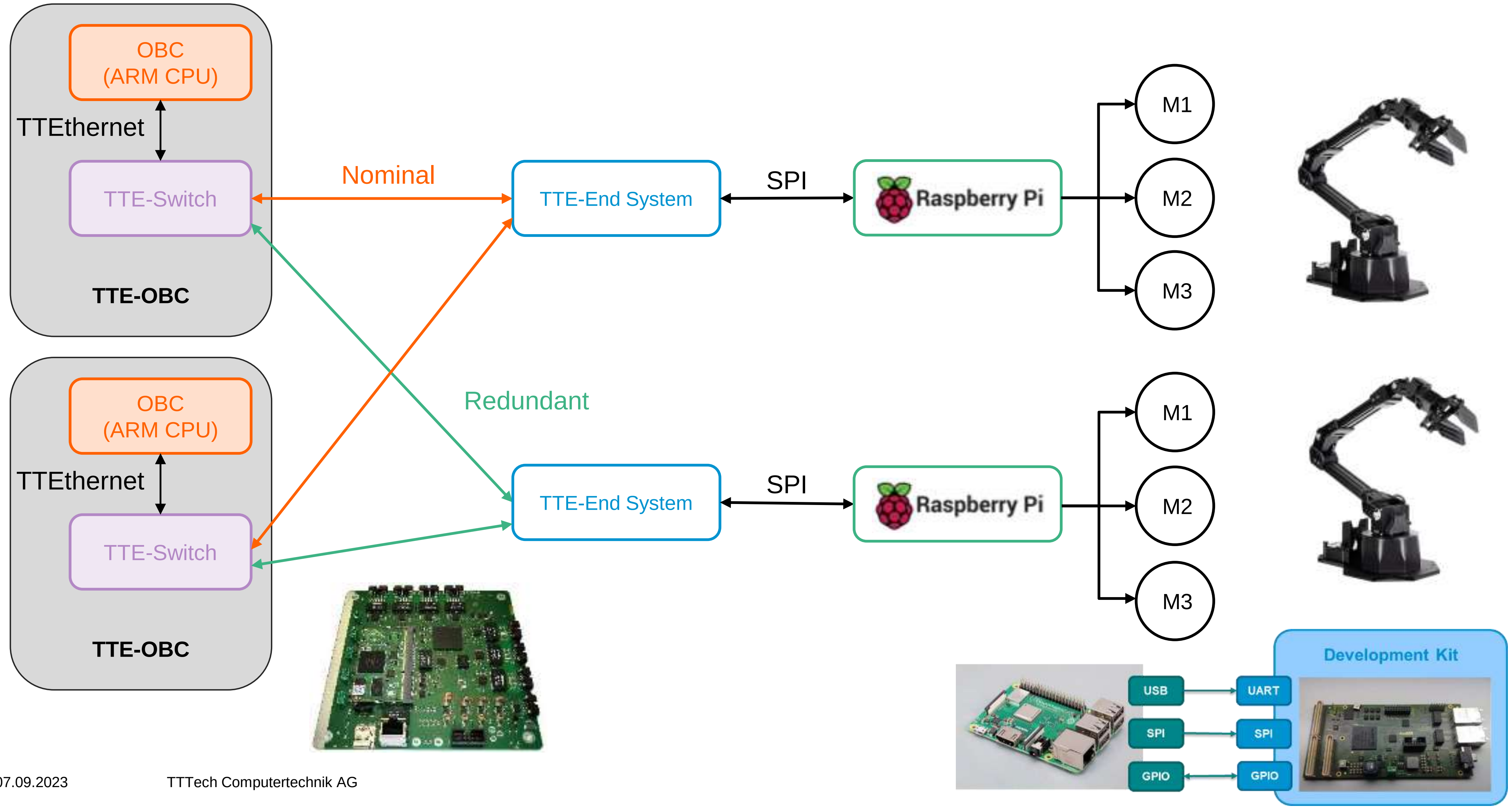


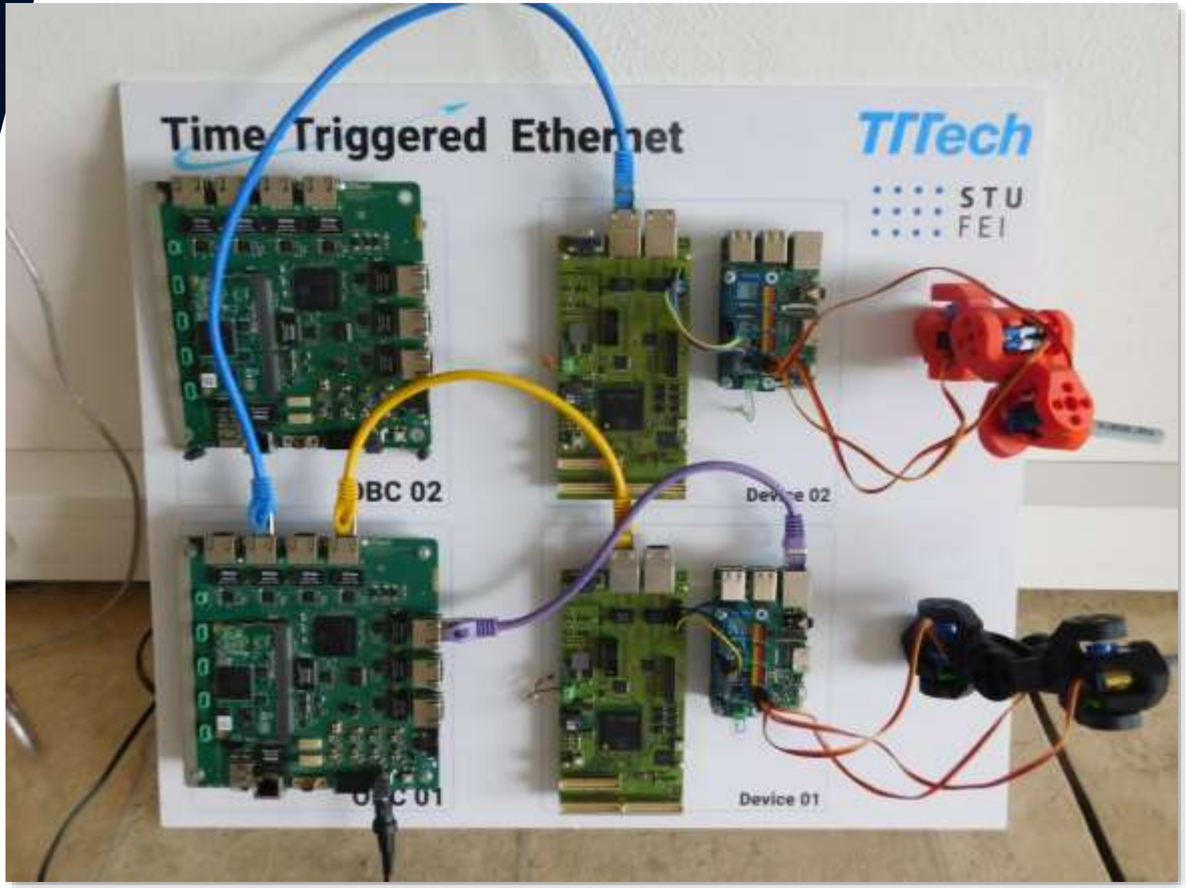
Cooperation with FEI STUBA (Master Thesis)

Space Robotics Demo - Synchronous Robot Controll Using TTEthernet



Space Robot Demo using TTEthernet and Matlab/Simulink

- Development of the TTEthernet test setup
- Demonstration of synchronized robotic arms using TTEthernet
  - Synchronization required to perform coordinated manipulation
- Implementation of control applications and network configuration using Matlab/Simulink



Summary

Model-Based Design and Prototyping

- Translates network topology and communication configs from Simulink models into TTEthernet configuration
- Generates and compiles real-time applications using TTE data network
- Significantly simplifies and speeds-up design of complex distributed real-time applications