Secure Component Specification

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1 Table of Contents

2 Preamble

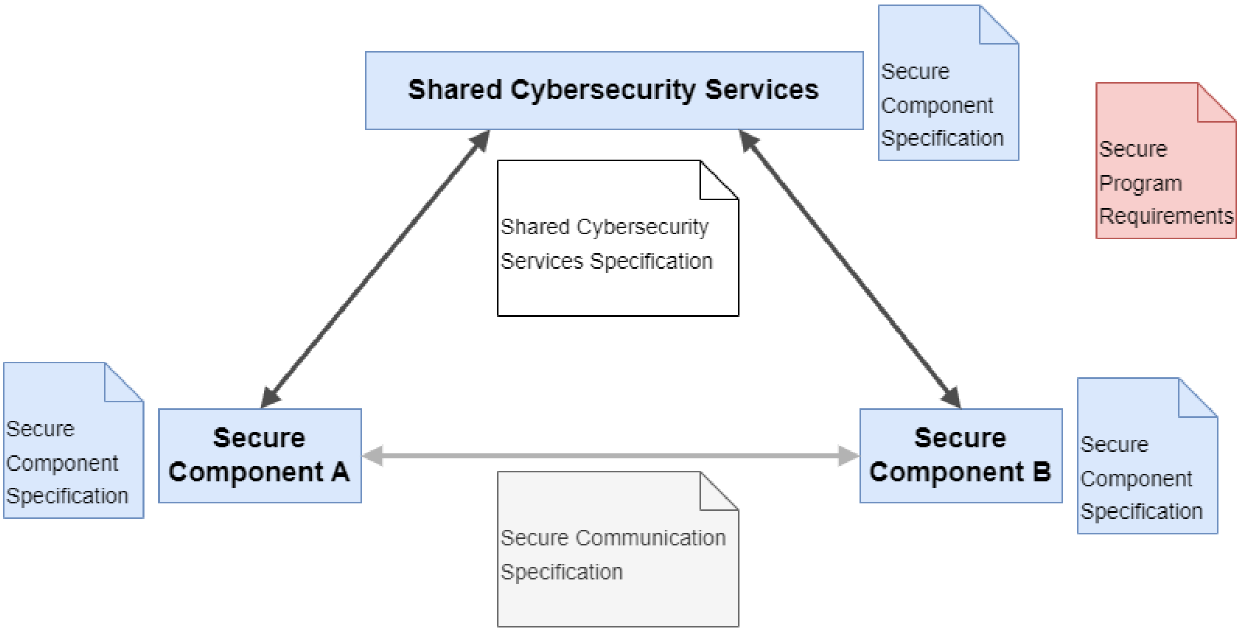
2.1 Scope, Purpose and Intended Audience

, **SP-SEC-Comp-2.1-1 -** This specification is a Cybersecurity Requirements Specification (CRS) according with [IEC 62443-3-2:2020], [CEN-CENELEC TS 50701:2023] and [IEC PT 63452]

, **SP-SEC-Comp-2.1-2 -** This CRS is intended to be a canditate for a certification scheme compatible to the EU CSA together with an evaluation method (as being defined in upcoming IEC 62443-6-2).

, **SP-SEC-Comp-2.1-3 -** The following figure shows the relationship of this specification to the key terms and other referenced specifications.

, **SP-SEC-Comp-2.1-4 -** Key terms and technical specs used in this document.



, **SP-SEC-Comp-2.1-5 -** In particular this CRS does not define:

· Detailed requirements for Secure Communication. These requirements can be found in the Secure Communication Specification [SP-SEC-CommSpec] .

· Requirements for the interfaces to the shared cybersecurity services. These requirements can be found in the Shared Cybersecurity Services Specification [SP-SEC-ServSpec]

· Security life-cycle requirements, including operational requirements. These requirements can be found in Shared Cybersecurity Services Interface Specification [SP-SEC-PrgmReq].

, **SP-SEC-Comp-2.1-6 -** The Secure Component specification has been specified to be used together with the Shared Cybersecurity Services Specification and the Secure Communication Specification.

, **SP-SEC-Comp-2.1-7 -** Secure Components (see definition Secure Component) connect to a communication network. The security functionality defined in this specification requires certain functions of network components. These requirements related to network devices are marked in this specification with the component type "Network Component" (see definiton Network Component).

, SP-SEC-Comp-2.1-8 - The attribute "Component Type" defines for which component type the requirement is applicable.

- Requirements with component type "Generic" is applicable to all components except network components. See definiton Secure Component.
- Requirements with component type "HMI" is only applicable for components with a Human Machine Interface (e.g. a component with a screen and interaction capabilities as keyboard, mouse, touch,...). See definition HMI Component.
- Requirements with component type "Wireless" is only applicable for components with a wireless communication interfaces (e.g. IEEE 802.11, GSM, 5G, FRMCS,...). See definition Wireless Component.
- Requirements with component type "Network" are applicable only for network components (see definition Network Component.

2.2 Document usage

, SP-SEC-Comp-2.2-1 - This specification includes all requirements required for protection against threats defined in the generic risk assessment (see SP-SEC-CompSpec Ch 4.2.7 - Threat and risk analysis result) and compliance to various standards (see [Document base]).

, SP-SEC-Comp-2.2-2 - The requirements in this specification are intended to lead to harmonised security of Secure Components in the market (level playing field). Deviations, if any, should be kept to a minimum and are only possible when documented by the following two requirements.

, SP-SEC-Comp-2.2-3 - If a requirement of this specification can't be implemented (yet), the component documentation shall include documentation of non-implemented requirements and justification for each non-implemented requirement (e.g. interface is not needed for operation, alternative mitigation, justified by impact / risk analysis). **[**Generic **]**

, SP-SEC-Comp-2.2-4 - If a requirement of this specification can't be implemented (yet), the component documentation shall include a description how to handle this case which has to be agreed with the asset owner (e.g. definition of a security related application condition). **[**Generic **]**

, SP-SEC-Comp-2.2-5 - This specification uses identifiers starting with "SP-SEC-Comp".

, SP-SEC-Comp-2.2-6 - References, taxonomy, key terms, and icon types used in this document are defined in [SP-SEC-Tax].

2.3 References

, SP-SEC-Comp-2.3-1 - This chapter contains all references of this document. For a complete list including external references see [SP-SEC-Tax] Chapter 3.

- [SP-SEC-Tax]

Europe's Rail System Pillar Cybersecurity Domain - Taxonomy and References, v1.0

- [Document base]

This CRS was developed based on:

- [IEC 62443-4-2:2019]
- [EULYNX/EU-Rail BL4 R3]
- ESCG Requirements
- [UNISIG SUBSET-146 v4.00]
- [UNISIG SUBSET-147 v4.00]
- [CEN-CENELEC TS 50701:2023] and
- [IEC PT 63452] (draft version Jan 2025)

- [SP-SEC-ThreatAna]

Europe's Rail SystemPillar Cybersecurity Domain - Intial Threat Analysis, v1.0

- [SP-SEC-ThreatCat]

Europe's Rail SystemPillar Cybersecurity Domain - Threat Catalog, v1.0

- [SP-SEC-DocTempl]

Europe's Rail SystemPillar Cybersecurity Domain - Product Documentation Template, v1.0

- [SP-SEC-CompSpec]

Europe's Rail System Pillar Cybersecurity Domain - Secure Component Specification, v1.0

- [SP-SEC-CommSpec]

Europe's Rail System Pillar Cybersecurity Domain - Secure Commmunication Specification, v1.0

- [SP-SEC-ServSpec]

Europe's Rail System Pillar Cybersecurity Domain - Shared Cybersecurity Services Interface Specification, v1.0

- [SP-SEC-PrgmReq]

Europe's Rail System Pillar Cybersecurity Domain - Secure Program Requirements, v1.0

- [RFC 4086]

Randomness Requirements for Security

- [IEC 62443-4-1:2018]

Secure product development lifecycle requirements

- [MinElements_SBOM]

The Minimum Elements for an SBOM

- [CIS benchmark]

Operating System and application specific benchmarks, regularly updated

List of available benchmarks, use latest and the most specific benchmark matching the operating system and/or application.

- [UNISIG SUBSET-146 v4.00]

ERTMS End-to-End security layer (TLS layer for ETCS and ATO communication), v4.0

- [UNISIG SUBSET-147 v4.00]

CCS Consist network communication layer, V4.0

- [UNISIG SUBSET-137 v4.00]

ETCS On-line Key Management, v4.0

- [CEN-CENELEC TS 50701:2023]

Railway applications - Cybersecurity

- [IEC PT 63452]

Railway applications - Cybersecurity - January 2025 draft

- [IEC 62443-3-2:2020]

Security risk assessment for system design

- [ISO/IEC 27001:2022]

Information security, cybersecurity and privacy protection - Information security management systems - Requirements

- [IEC 62443-2-1:2024]

Security program requirements for IACS asset owners

- [IEC 62443-2-4:2023]

Security program requirements for IACS service providers

- [IEEE 802.1Q-2018]

IEEE Standard for Local and Metropolitan Area Networks-Bridges and Bridged Networks

2.4 Acronyms and Abbreviations

ATO - Automatic Train Operation

CCS - Control Command and Signalling

CMP - Certificate Management Protocol

COTS - Commercial-off-the-shelf

CPU - Central Processing Unit

CRA - Cyber Resilience Act

CRL - Certificate Revocation List

CRS - Cybersecurity Requirement Specification

DNS - Domain Name System

DMZ - Demilitarized Zone

DoS - Denial of Service

EU - European Union

ETCS - European Train Control Sysem

FQDN - Fully Qualified Domain Name

GDPR - General Data Protection Regulation

HMI - Human Machine Interface

IAM - Identity and Access Management

IACS - Industrial Automation Control System

I/O - Input / Output

IT - Information Technology

IXL - Interlocking

LAN - Local Area Network

OB - Onboard

OT - Operational Technology

PKI - Public Key Infrastructure

RBC - Radio Block Centre

SBOM - Software Bill of Material

SC - Secure Component

SCS - Shared Cybersecurity Services

SNMP - Simple Network Management Protocol

SUC - System under Consideration

SSI - Standard Security Interfaces

TS - Trackside

VLAN - Virtual LAN

WLAN - Wireless LAN

2.5 Terms and Definitions

, SP-SEC-Comp-2.5-1 - Secure Component

An implementation, as part of an automation control system, either a host device, embedded device, network device or software application on a host device, which realizes subsystem functions, implements security capabilities and consisting of a physical encasing, computing capabilities and network communication, and interfacing to the Shared Cybersecurity Services.

Examples of CCS secure components are object controller, trackside cabinet, IXL rack, ATO-OB, OBU, ATO-TS, IXL/RBC combination, shared cybersecurity services, security proxy for legacy devices, …)

Examples of components which are not meeting the definition of a Secure Component are components with no network communication, e.g. directly connected sensors or displays.

, SP-SEC-Comp-2.5-2 - Shared Cybersecurity Services (SCS)

A collection of standard security interfaces (SSIs) of central security functions accessible for all Secure Components in the automation solution. The realization of the Shared Cybersecurity Services (SCS) implements the requirements of the Secure Component Specification as they are considered as Secure Components as well.

The interfaces from Secure Components to Shared Cybersecurity Service are identified by SSI-<service name>.

The Shared Cybersecurity Services implementations are identified by SCS-<service name>.

, SP-SEC-Comp-2.5-3 - Enterprise Cybersecurity Services

A collection of enterprise security interface (ESI) implementations of central security and IT communication functions in a back-office environment.

Examples are Security Incident and Event Management System (SIEM), Intrusion Detection System, PKI Certificate Authority, Corporate Directory, Asset Management, DNS. These services are typically accessible for the automation network via controlled communication paths (e.g. DMZ). The interfaces of the Shared Cybersecurity Services to the Enterprise Services are identified by ESI-<Service name>.

Note: Enterprise Shared Services are typically 3rd-party components not dedicated to the rail environment. Therefore the realization of the Enterprise Shared Services may use other security requirements than the Secure Component Specification. Recommended security specification are ISO 27033, ISO 27034, NIST 800-53, and/or IEC 62443-4-2.

Note: Enterprise Shared Services and Shared Cybersecurity Services are separated by the IT/OT border (e.g. by a DMZ).

, SP-SEC-Comp-2.5-4 - Network Component

A device that facilitates IP data flow between devices, or restricts the flow of data, but may not directly interact with a control process.

Examples of Network Components are network switches, LAN/WAN routers, firewalls, data diodes and VPN endpoints.

Excluded from this definition are media converters, transceivers and bridges with no routing, switching or filtering capabilities. Such devices are not affected by this specification.

, SP-SEC-Comp-2.5-5 - Wireless Component

A Secure Component or Network Component with a wireless communication interface.

Examples of Wireless Components are handheld devices, WLAN access points, WLAN/5G/FRMCS/... routers, modems and wireless object controllers.

Note: additional requirements apply to Wireless Components (as IEC 62443-4-2 NDR 1.6, NDR 1.6 RE1 and CR 2.2, CR 2.2 RE1)

, SP-SEC-Comp-2.5-6 - HMI Component

A Secure Component with a human machine interface.

Examples of HMI Components are PC Workstation, tablet device, smart phone, device with touch screen,...
Exemptions: embedded components without a screen, e.g. with push buttons and LEDs.

, SP-SEC-Comp-2.5-7 - Essential Function

Function or capability that is required to maintain health, safety, the environment (HSE) and availability for the equipment under control (definition from IEC 62443-4-2)

Note: Essential functions include, but are not limited to, the safety instrumented function (SIF), the control function and the ability of the operator to view and manipulate the equipment under control. The loss of essential functions is commonly termed loss of protection, loss of control and loss of view respectively. In some industries additional functions such as history may be considered essential.
In the context of the ERJU System Pillar all systems in scope provide functionality as defined in "Essential functions".

Note: IEC 63452 definition: All functions needed to operate the railway system, such as per example traffic control, speed control, traction/brake control,...

, SP-SEC-Comp-2.5-8 - Threat landscape

Threat landscape is used in this document as synonym for threat environment.

Threat environment (definition from CENELEC TS 50701, IEC PT 63452)
environment summary of information about threats, such as threat sources, threat vectors and trends, that have the potential to adversely impact a defined target (for example a company, facility or SuC)

2.6 Modification History

First release (V1.0) - February 2025

- reviewed by System Pillar domains, rail cybersecurity mirror groups, external organizations in three review rounds during 2024

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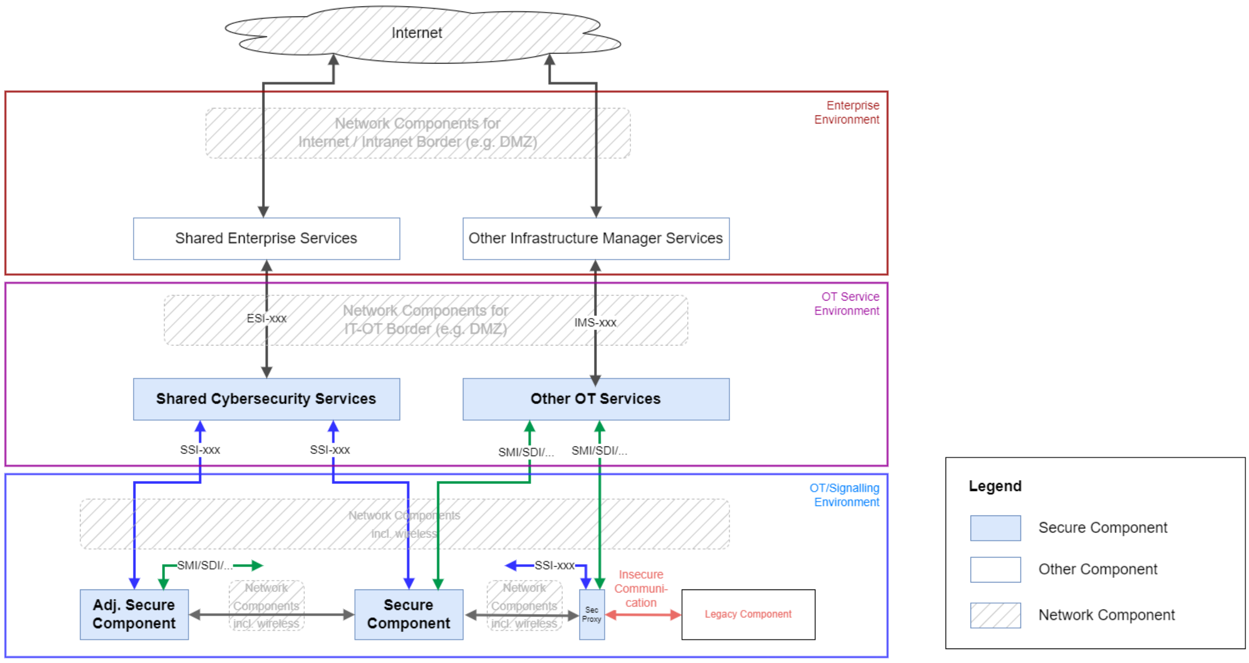
4 Component Description

This chapter contains the required information for a cybersecurity requirements specification (CRS) as defined in IEC 62443-3-2 ZCR-6-1, CENELEC TS 50701 chapter 7.2.10 and IEC 63452 ZR-06-01.

4.1 General SuC Description

, SP-SEC-Comp-4.1-1 - The System under Consideration (SuC) in the context of this specification is the Secure Component.

, SP-SEC-Comp-4.1-2 - The Secure Components are shown in blue color in the figure below.



4.1.1 SuC Scope and Boundary

, SP-SEC-Comp-4.1.1-1 - The Secure Component, as per definition SP-SEC-CompSpec Ch 3.5 - Secure Component , has a physical encasing which defines the SuC boundary, and has computing and network communication capabilities.

, SP-SEC-Comp-4.1.1-2 - The standard scope for Secure Components is the automation environment, also called operational technology environment (OT), which contains mainly embedded devices, some devices with an HMI, and network communication devices. In the figure above, the OT/signalling environment and OT service environment contain Secure Components.

, SP-SEC-Comp-4.1.1-3 - Enterprise environments, also called back-office environments, and cloud environments are outside the scope of Secure Components. These environments adhere to different security standards and specifications. However, if applications or services within the back office or cloud environment are part of the rail domain, the Shared Cybersecurity Services interfaces and parts of this specification may be applicable.

, SP-SEC-Comp-4.1.1-4 - Train components that do not reside in the signaling environment are outside the scope of Secure Components specification. Modern trains integrate hundreds of components from a numerous suppliers which vary from country to country. Therefore, special care should be used when applying this or parts of the specification (e.g. for CRA compliance) to other parts of the train than the signaling environment.

, **SP-SEC-Comp-4.1.1-5 -** For the rail automation / CCS scope, examples of secure components are object controller, trackside cabinet, IXL rack, ATO-OB, OBU, ATO-TS, IXL/RBC combination, shared cybersecurity services…

4.1.2 High-level Description

, **SP-SEC-Comp-4.1.2-1 -** A Secure Component implements one or more control functions of a rail system. The intended function is automatic control or manual control combined with operator view.

, **SP-SEC-Comp-4.1.2-2 -** Essential functions of a Secure Component are all control functions which maintain health, safety, the environment and availability for the equipment under control (see definition SP-SEC-Comp-3.5-7 - Essential Function Definition). Typical examples include safety-related functions that allow the operator to control, view, and manipulate the system under supervision.

4.1.3 Interfaces of the SuC

, **SP-SEC-Comp-4.1.3-1 -** A Secure Component has the following interfaces:

1. Interfaces to a adjacent Secure Components via protocols defined in SecCommSpec
2. Interfaces to Shared Cybersecurity Services, specified in [SP-SEC-ServSpec] - Shared Cybersecurity Services interface specification
3. Interfaces to OT Shared Services defined by SMI and SDI, specified in System Pillar & EULYNX publication of BL4 R2 (EU.Doc 76 and EU.Doc. 77) and SP-SEC-CommSpec Ch. 4 - Secure Communication for OPC UA
4. All other interfaces, for which SP-SEC-CommSpec Ch 6- Securing other communicating interfaces is applicable

4.1.4 Support for Essential Functions

, **SP-SEC-Comp-4.1.4-1 -** Secure Components interact with other Secure Components to support the essential functions. Examples for assets supporting an essential functions are:

- an interlocking interacts with object controllers to set a route for a train
- an RBC sending a movement authority to a train involving the Onboard unit (OBU) / European Vital Computer (EVC).

4.2 Component Security Context

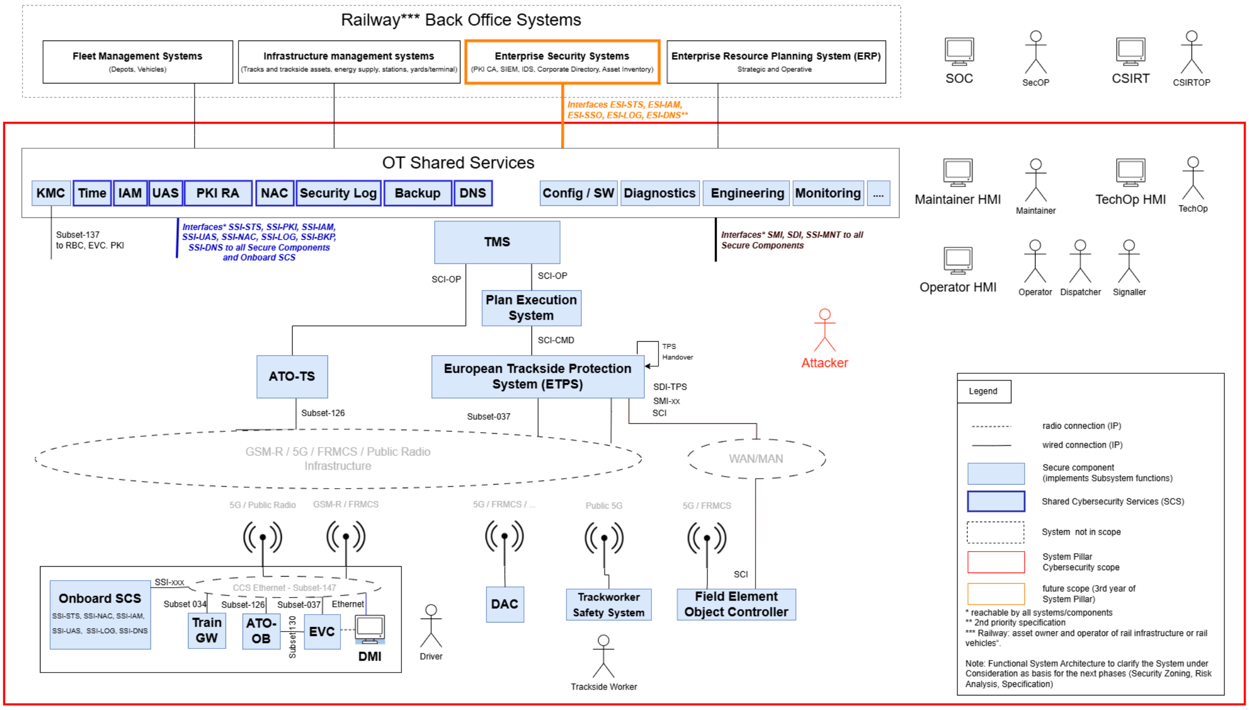
4.2.1 Generic Architecture

, **SP-SEC-Comp-4.2.1-1 -** The generic security architecture is defined in SP-SEC-Comp Ch 4.1 - General SuC Description

4.2.2 Mapping to Specific Architecture

, **SP-SEC-Comp-4.2.2-1 -** The generic security architecture can be mapped to a specific security architecture. The figure below shows the mapping to the System Pillar scope.

, **SP-SEC-Comp-4.2.2-2 -** Cybersecurity Architecture for an example rail automation system following the ERJU System Pillar Future Architecture approach based on definitions in [CLS:TS 50701:2023] and [IEC 62443-3-3:2013] .

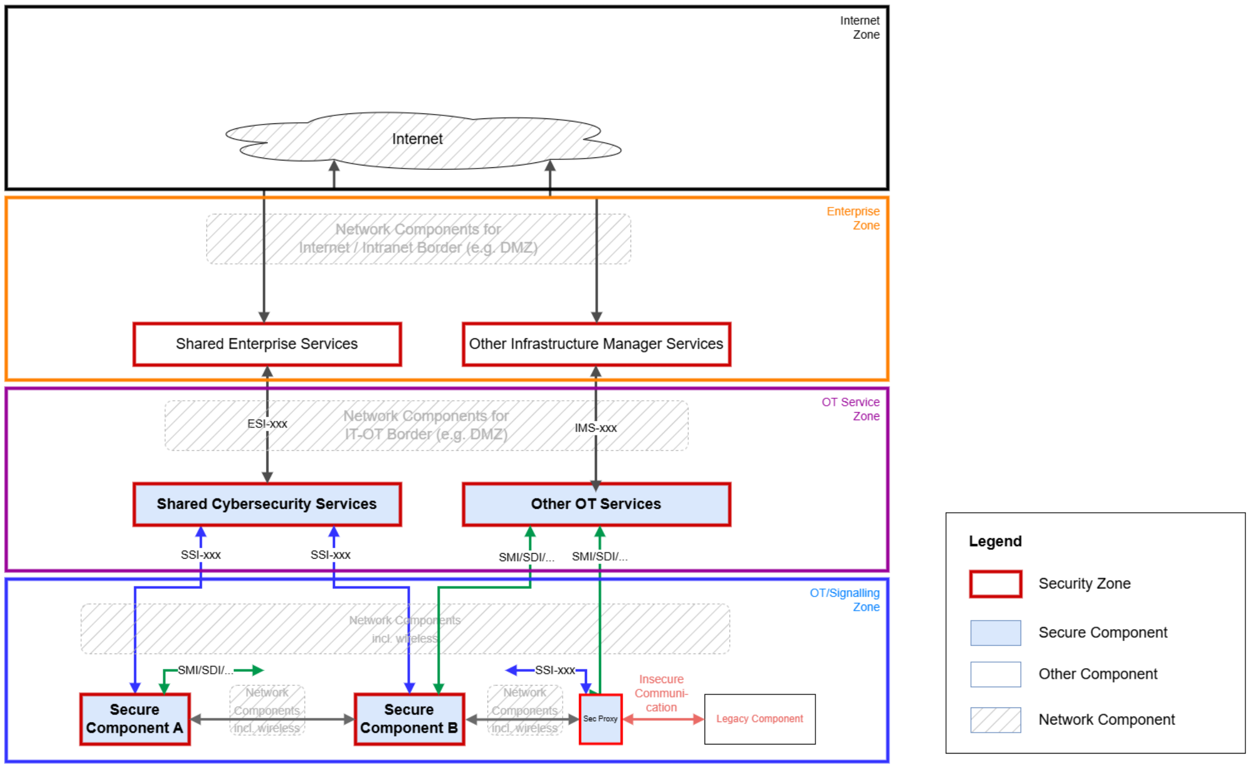


Note: the red rectangular defines the scope of the ERJU System Pillar. The architecture is based on the solution concept of the Traffic CS System Concept SPT2TRAFFIC-4459.

4.2.3 Zone and Conduits Drawing

, **SP-SEC-Comp-4.2.3-1 -** The generic zone and conduits drawing for this SuC is depicted in the figure below.

, **SP-SEC-Comp-4.2.3-2 -** Generic Security Zoning



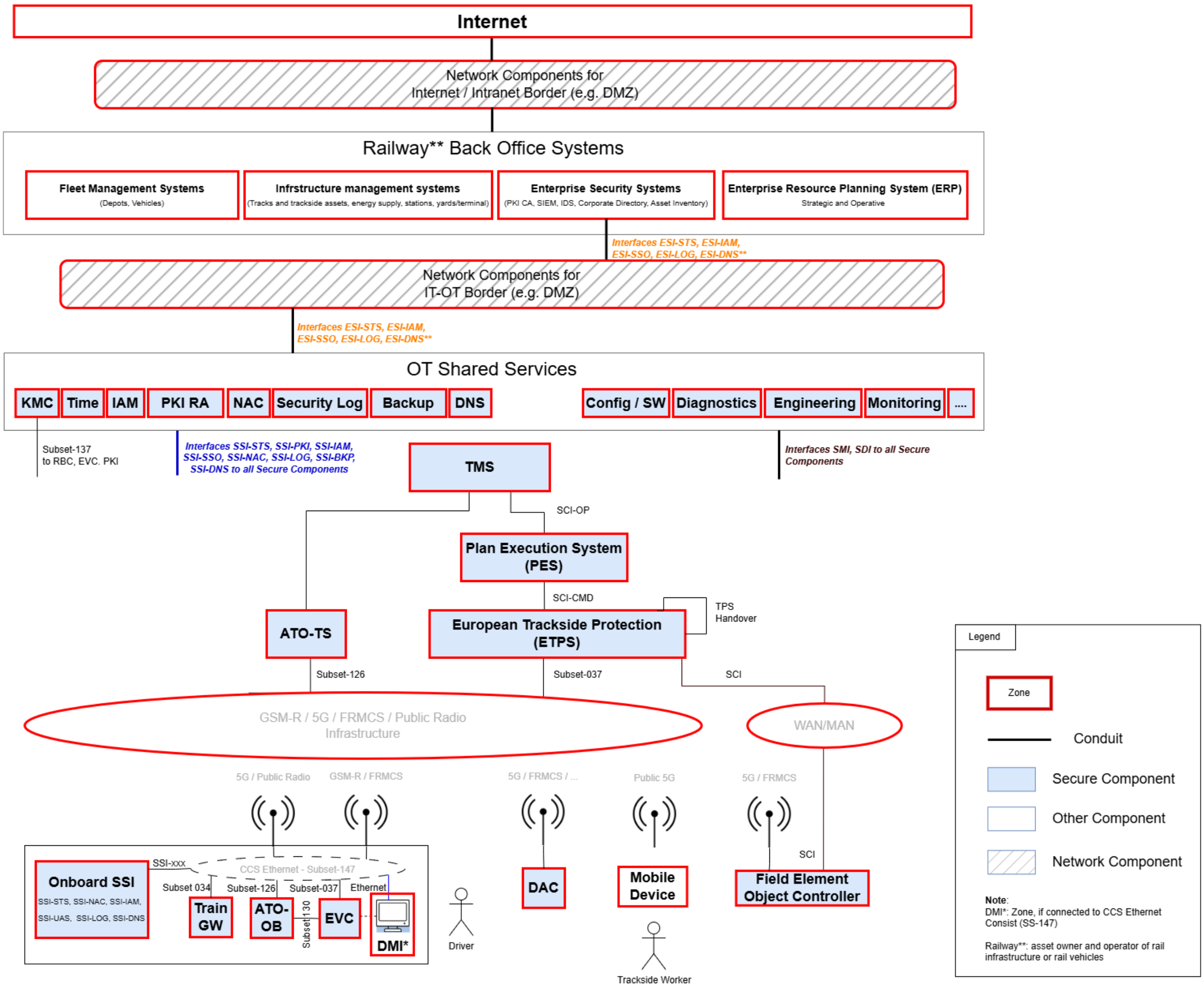
, **SP-SEC-Comp-4.2.3-3 -** The smallest security zone can be the Secure Component itself. The Secure Component is contained in a bigger zone, e.g. the OT/Signaling zone. The conduits are the interfaces to other components, the Shared Cybersecurity Services and other OT services. See also SP-SEC-Comp-4-1-3 - Interfaces of the SuC .

, **SP-SEC-Comp-4.2.3-4 -** A special security zone is the legacy component zone. In order to interface with Secure Components, a Security Proxy implementing this specification can be used. As this zone uses insecure communication (i.e. communication without authentication or integrity protection), additional physical security measures are typically required.

, **SP-SEC-Comp-4.2.3-5 -** Wireless devices are normally grouped in dedicated wireless security zones. In above drawing, the Secure Components have either wired and/or wireless interfaces and are in their own security zone.

, **SP-SEC-Comp-4.2.3-6 -** The generic zone and conduit drawing can be mapped to a specific zone and conduit drawing of a specific scope. The figure below shows the result of the mapping for a rail automation system.

, **SP-SEC-Comp-4.2.3-7 -** Example of a Security Zoning (rail automation system), where each component has its own zone. Zones could also include several components, especially when the components are co-located.



4.2.4 Zone and Conduits Characteristics

4.2.4.1 Zone Identification

, SP-SEC-Comp-4.2.4.1-1 - This zone description is for the security zone of the SuC (Secure Component), identified as Zone-SC.

4.2.4.2 Accountable Organisations

, SP-SEC-Comp-4.2.4.2-1 - The accountable organisation for the Zone-SC is the railway duty holder. For trackside and central installed Secure Components this can be the infrastructure manager, for Secure Components installed on rolling stock the vehicle owner.

4.2.4.3 Logical and Physical Boundary

, SP-SEC-Comp-4.2.4.3-1 - The physical boundary of the Zone-SC in context of this specification is the encasing of the Secure Component.

Note: Further physical boundaries may exists in the environment (rack, cabinet, room) or inside the Secure Component (composed devices, e.g. host with virtual machine).

, SP-SEC-Comp-4.2.4.3-2 - The logical boundary of the Zone-SC are the logical interfaces of the Secure Component to external communication partners.

4.2.4.4 Safety Designation

, SP-SEC-Comp-4.2.4.4-1 - Secure Components implementing safety-related functions for the rail system have a safety designation up to SIL4.

, SP-SEC-Comp-4.2.4.4-2 - Secure Components not implementing safety-related functions (e.g. components in the OT Service Zone), but interfacing with safety-related Secure Components typically have a Basic Integrity Safety Level or no Safety Level (in case non-interference can be demonstrated).

Note: safety-related standards describing safety levels are EN 50716 and EN 50126

4.2.4.5 Logical and Physical Access Points

, SP-SEC-Comp-4.2.4.5-1 - The SuC has various interfaces which are described in SP-SEC-Comp-4-1-3 - Interfaces of the SuC

, SP-SEC-Comp-4.2.4.5-2 - The table below describes the logical and physical access points for each conduit.

Conduit	Logical access point	Physical access point	Data flows	Connected zone
Interface to an adjacent Secure Component	Secure Component (e.g SCI endpoint)	Ethernet / Fibre port or radio (GSM-R, FRMCS, 5G)	mainly Safety-related communication, in some cases non-safety related communication	adjacent Secure Component zone
Interface to Shared Cybersecurity Services and OT Shared Security Services	Secure Component (SMI, SDI, SSI endpoints)	Ethernet / Fibre port or radio (GSM-R, FRMCS, 5G)	SMI messages, SDI messages, SSI messages	OT service zone
Additional Interfaces to other components/ services	Secure Component (other endpoint)	Ethernet / Fibre port or radio (GSM-R, FRMCS, 5G)	other communication specific	adjacent Secure Component, OT service zone

, SP-SEC-Comp-4.2.4.5-3 - Interfaces with no networking capabilities such as USB, serial, JTAG, Display Ports, removable SSD, NFC are not considered for zoning design.

4.2.4.6 Risk of Zone Assets

, SP-SEC-Comp-4.2.4.6-1 - The main risks for the asset in the Zone-SC (the Secure Component) is a compromise of the following protection objectives:

1. Integrity: can lead to loss of control, loss of safety, loss of essential functions
2. Availability: can lead to loss of control, loss of operation
3. Confidentiality: can lead to attacks on integrity and availability when confidential key material is extracted (impersonating attack)

Note: a detailed list of threats is described in [SP-SEC-ThreatCat].

4.2.5 Operating Environment Assumptions

, SP-SEC-Comp-4.2.5-1 - It is assumed that a Secure Component is installed in a housing with physical access restrictions. The assumed physical security protection requirements are stated in SP-SEC-PGRM-6.2 - Physical Access Control.

, SP-SEC-Comp-4.2.5-2 - It is assumed that a Secure Component has connectivity to the shared cybersecurity services as defined in [SP-SEC-ServSpec] .
Note: On-board Secure Components connectivity can be intermittent. Therefore, certain Shared Cybersecurity Services should have an on-board proxy functionality (see also SP-SEC-SERV Ch. 3.2 Service Overview)

, SP-SEC-Comp-4.2.5-3 - It is assumed that the Secure Component is operated, maintained and commissioned according to the [SP-SEC-PrgmReq] , e.g. implementing [IEC 62443-2-1:2024] / [ISO/IEC 27001:2022] , and [IEC 62443-2-4:2023] .

, SP-SEC-Comp-4.2.5-4 - The physical and logical environment of a specific Secure Component (in Zone-SC) is documented in chapter 5 of [SP-SEC-DocTempl] .

4.2.6 Threat Environment

, SP-SEC-Comp-4.2.6-1 - The following attacker types are considered from threat and risk analysis: state agency, criminal organization and internal attacker. This includes the cybersecurity threats from terrorists, hacktivists and script kiddies.

, SP-SEC-Comp-4.2.6-2 - The threats considered for this specification are described in the [SP-SEC-ThreatCat].

4.2.7 Threat and Risk Analysis Result

, **SP-SEC-Comp-4.2.7-1 -** The initial risk analysis is documented in [SP-SEC-ThreatAna]

5 List of Detailed Security Requirements

This chapter lists the security requirements for Secure Components. The chapter is structured by technical building blocks.

Special sections are available for security requirements for specific Secure Components: Secure Components with wireless network access, Secure Components with a Human-Machine Interface (HMI), and Network Components (switches, routers, firewalls, gateways,...)

5.1 General

, **SP-SEC-Comp-5.1-1 -** The Secure Component shall be developed according to [IEC 62443-4-1:2018] (maturity level 3 at minimum).
Note: from table 1 - maturity levels of IEC 62443-4-1: maturity level 3 is achieved when a level 2 process has been practiced at least for one product (with required evidence). [Generic]

, **SP-SEC-Comp-5.1-2 -** The Secure Component shall use for implementation of security functionality proven or mature security libraries and security hardware.
Note: proven/mature security libraries are widely and internationally used programming libraries. An example of a such security library is openSSL and operating system functions for obtaining random numbers. Using proven/mature security libraries limits implementation errors and risks of side-channel attacks, as well as purging of key material.
Proven/mature security hardware refers to widely recognized and internationally used hardware components specifically designed for security purposes. Examples of standard security hardware include cryptographic modules certified under FIPS 140-2, tamper-resistant secure elements, and hardware security modules (HSMs),Trusted Platform Module (TPM) chips and CPUs with Trusted Execution Environments (TEE). [Generic]

5.2 Device Hardware

5.2.1 Real Time Clock

, **SP-SEC-Comp-5.2.1-1 -** The Secure Component shall provide an internal real-time clock.

Note: this does not require a battery-buffered clock. However, a battery- or supercapacitor-buffered clock simplifies and speeds up the time synchronization during start up (e.g. after a power cycle) and enhances the entropy for seeding the random-number generator of the operating system. [Generic]

, **SP-SEC-Comp-5.2.1-2 -** In the absence of battery-buffered clock, or exhaustion of battery capacity, the Secure Component shall maintain monotonic date and time for its real-time clock upon reboot.
Note 1: This could be achieved by periodic storage of current time during execution and reload of last known date upon reboot.
Note 2: Verification of certificate and certificate revocation list and logging of security-related events do not require a high level of accuracy, as usually +/- 1 second is acceptable. With NTP/NTS the achieved time synchronization can be improved. [Generic]

5.2.2 Random Number Generation

, **SP-SEC-Comp-5.2.2-1 -** A Secure Component should follow the guidance for initializing random numbers with sufficient entropy by following the recommendations in [RFC 4086].

5.2.3 Hardware Trust Anchor

, SP-SEC-Comp-5.2.3-1 - The Secure Component shall protect the integrity and confidentiality of critical and long-life private and symmetric keys via a commonly accepted cryptographic mechanism originating from hardware. **[**Generic **]**

, SP-SEC-Comp-5.2.3-2 - The Secure Component shall protect the integrity of roots of trust (root certificates) via a commonly accepted cryptographic mechanism originating from hardware.
Note: examples of commonly accepted cryptographic mechanism originating from hardware are trusted execution environment (TEE), trusted platform module (TPM 2.0 or higher), hardware security module (HSM). **[**Generic **]**

5.2.4 Hardware-related Firmware Update

, SP-SEC-Comp-5.2.4-1 - The Secure Component shall support the update of the firmware of security-related hardware mechanisms.

Note: Examples of firmware of secure hardware mechanism include secure boot functions, firmware of trusted environments, UEFI. **[** Generic **]**

5.2.5 Secure Boot

, SP-SEC-Comp-5.2.5-1 - The Secure Component shall use the Secure Boot functions defined by the used chipset manufacturer. **[**Generic **]**

, SP-SEC-Comp-5.2.5-2 - The Secure Component shall use the certificate chain up to the Manufacturer Root CA Certificate (MRCAC) (refer to SP-SEC-ServSpec Ch 5.2.1 - Manufacturer Certificates) to verify the authenticity of the firmware, boot-loader and operating system.
Note: If the Secure Component uses a COTS hardware provided by a 3rd party, the existing credentials (e.g. Microsoft keys in UEFI) can be used as the Manufacturer Root CA Certificate (MRCAC) to verify the authenticity of the firmware, boot-loader and operating system. Additional risks created needs to be analysed and documented.
Note: If the Secure Component is an embedded systems, the first stage of Secure Boot uses different credentials (e.g. write-once keys or hashes) defined by the used chipset manufacturer and not the MRCAC. **[**Generic **]**

, SP-SEC-Comp-5.2.5-3 - If a secure boot verification fails, the Secure Component shall provide a visible or audible indication.
Note: the visual or audible indication of an integrity check failure is necessary, as the Secure Component cannot securely log errors before successful start-up of the operating system. Examples could be a LED indication or audible notification. For COTS devices as PCs, laptops and servers, refer to manufacturer handbook for indications of a integrity failure during secure boot **[**Generic **]**

, SP-SEC-Comp-5.2.5-4 - If an integrity check of a secure boot stage fails during secure boot, the Secure Component shall terminate the boot process. **[**Generic **]**

, SP-SEC-Comp-5.2.5-5 - The Secure Component shall continue with the next boot stage only if the integrity and authenticity checks are successful. **[**Generic **]**

, SP-SEC-Comp-5.2.5-6 - The Secure Component shall verify all secure boot stages from start of the hardware to the operating system / root file system.
Note: Examples of secure boot stages are chipsets, BIOS/UEFI, boot loader, operating system and other static code/applications on the file system. **[**Generic **]**

5.2.6 Electronic Tamper Detection

, **SP-SEC-Comp-5.2.6-1 -** When powered the Secure Component shall provide a tamper detection mechanism which detects the opening of the physical encasing. **[**Generic **]**

, **SP-SEC-Comp-5.2.6-2 -** If tampering is detected, the Secure Component shall provide notification of the detection to the SSI-LOG service.
Note: If a Secure Component does not implement these functions, then the environment where the Secure Component is installed needs to provide these functions (e.g. tamper-protected cabinet). See also chapter 3.5 how to document and export not implemented requirements (e.g. as security application condition as access-controlled environment with tamper detection and alarm function e.g. room). **[**Generic **]**

5.2.7 Physical Security Seal

, **SP-SEC-Comp-5.2.7-1 -** The supplier shall provide a security seal on the Secure Component. **[**Gene ric **]**

, **SP-SEC-Comp-5.2.7-2 -** The security seal shall contain a number unique to the supplier. **[**Generic **]**

, **SP-SEC-Comp-5.2.7-3 -** The supplier shall place the security seal on the enclosure edges which breaks the seal, if the enclosure is opened.
Note: seals should not be placed on edges which are opened for operation (e.g laptop screen vs. laptop housing, access panel for regular maintenance vs. internal interfaces) **[**Generic **]**

, **SP-SEC-Comp-5.2.7-4 -** The seals shall be designed to break in case of standard attacks using heat or solvents. **[**Generic **]**

5.2.8 Physical Identification

, **SP-SEC-Comp-5.2.8-1 -** The Secure Component shall bear a type, batch or serial number on its enclosure. **[**Generic **]**

5.2.9 Physical Diagnostic Interfaces

, **SP-SEC-Comp-5.2.9-1 -** If physical diagnostic and test interfaces are accessible without opening the protected enclosure, the Secure Component shall disable physical factory diagnostic and test interfaces during manufacturing or commissioning. **[**Generic **]**

5.2.10 Crypto Agility

, **SP-SEC-Comp-5.2.10-1 -** The Secure Component should be designed with crypto agility in mind. It is envisioned, that during the lifetime of a Secure Component, additional ciphers are added to a future version of these specifications (e.g. to support post quantum cryptography). This requires to update firmware of the component, update of issued certificates (e.g. MDC, ODC,..), use of new ciphers or a combination of ciphers for protecting communication and ensuring integrity of files (e.g. configuration files, CMP messages) and additional certificate profiles. The hardware specification (especially for CPU and memory specs) should envision these upcoming changes.

5.3 Device Software

5.3.1 Process Runtime Integrity Check

, **SP-SEC-Comp-5.3.1-1 -** The Secure Component shall only start a software process if it passes the runtime integrity check.
Note: This protects against execution of unauthorised software. Typical solutions are a process allowlist or anomaly detection. An allowlist typically contains the hashes of the authorised executable binaries. [Generic]

, **SP-SEC-Comp-5.3.1-2 -** At startup, the Secure Component shall check the integrity and authenticity of runtime integrity check.
Note: if the process runtime-integrity check is realised using an process allowlist, this could be part of the firmware and therefore is part of the secure boot process. If the allowlist is outside of the secure boot process (e.g. on a configuration partition), a possible solution is the signing of the allowlist with the certificate of the software manufacturer. [Generic]

5.3.2 Persistent Data Integrity

, **SP-SEC-Comp-5.3.2-1 -** The Secure Component shall verify the integrity and authenticity of configuration data using the installed roots of trust before it is used.
Note: configuration data is cryptographically signed. Verification of integrity and authenticity is done by verifying the signature. [Generic]

, **SP-SEC-Comp-5.3.2-2 -** For retrieval of log data, the Secure Component shall protect the integrity of log data by restricting authorised users to read-only access.
Note: For writing to log, applications/software processes typically use a logging API to append data to the log. The log is generally protected by the operating system, e.g. applications/software processes have no direct access to the log (see also hardening requirements). External users (human or technical users) have read-only access. [Generic]

, **SP-SEC-Comp-5.3.2-3 -** If a Secure Component is implementing a Juridical Recording function, then it shall protect the integrity of juridical recording data at rest.
Note: If personal identifiable information or financial data is recorded, as of GDPR also confidentiality needs to be considered [Generic]

5.3.3 Persistent Data Confidentiality

, **SP-SEC-Comp-5.3.3-1 -** If read access authorisation to persistent data is required, the Secure Component shall encrypt this data.
Note: this applies at least for all confidential data at rest. It could be realized using file system encryption which encrypts all persistent data. [Generic]

5.3.4 Input Validation

, **SP-SEC-Comp-5.3.4-1 -** The Secure Component shall validate the syntax, length and content of any input data.
Note: specific care should be taken for input data received via external interfaces and from other sources (e.g. file systems). Examples for content checks are type checks and value range checks.
The input checks are typically realized on the application layer which processes the input.
A rule formulating input checks is to accept all data conforming to an interface spec and reject non-conforming data. [Generic]

5.3.5 Deterministic Output

, **SP-SEC-Comp-5.3.5-1 -** If the Secure Component has physical I/O controlling an automation process, the Secure Component shall provide the capability to set all physical outputs to a predetermined state if normal operation cannot be maintained.
Note: The predetermined state is normally the safe state of the component and normally invoked in fault situations and realized by the safety system.8 **[**Generic **]**

5.3.6 Hardening

, **SP-SEC-Comp-5.3.6-1 -** The Secure Component shall implement the hardening measures according to the relevant **[CIS benchmark]**, achieving compliance to at least Level 1 or in accordance with a comparable benchmark and compliance level. **[**Generic **]**

5.3.7 Time Synchronisation

, **SP-SEC-Comp-5.3.7-1 -** The Secure Component shall synchronize the component time using **SSI-STS** secure time synchronization interface (refer to SP-SEC-ServSpec Ch 4 - STS: Secure Time Synchronisation). **[**Generic **]**

, **SP-SEC-Comp-5.3.7-2 -** The Secure Component shall update its internal real-time clock with the synchronized time received via interface SSI-STS (refer to SP-SEC-ServSpec Ch 4 - STS: Secure Time Synchronisation). **[**Generic **]**

5.4 Network Capabilities

5.4.1 VLAN Support

, **SP-SEC-Comp-5.4.1-1 -** The Secure Component shall support **[IEEE 802.1Q-2018]** tagged VLAN and multiple gateways (at least one per IP network used).
Note: this allows logical network segmentation for zone and conduits. **[**Generic **]**

, **SP-SEC-Comp-5.4.1-2 -** The Secure Component shall be capable to bind each communicating process to configured interface(s) corresponding to a specific VLAN. **[**Generic **]**

, **SP-SEC-Comp-5.4.1-3 -** The Secure Component shall be capable to separate at least maintenance (e.g. SMI), diagnostic (e.g. SDI), security (e.g. SSI) and operational data (e.g. SCI) to specific VLANs.
Note: There could be additional VLANS for example for further segmentation of SCI (different SIL level, different SSI-XXX), on-board specific VLANs. This further segmentation can be configured via the component configuration. **[**Generic **]**

5.4.2 Host-based Firewall

, **SP-SEC-Comp-5.4.2-1 -** The Secure Component shall provide the capability of a host-based firewall (e.g. packet filter using IP addresses, destination and source port, protocol and connection state (TCP) as filter parameter). **[**Generic **]**

, **SP-SEC-Comp-5.4.2-2 -** The host-based firewall shall deny by default all inbound and outbound connections except for the designed network communications of the Secure Component. **[**Generic **]**

, **SP-SEC-Comp-5.4.2-3 -** The Secure Component's host-based firewall filter shall be capable of filtering incoming and outgoing network traffic. **[**Generic **]**

, SP-SEC-Comp-5.4.2-4 - If the Secure Component supports packet forwarding, the Secure Component's host-based firewall filter shall be capable of filtering forwarded network traffic. **[**Generic **]**

5.4.3 Network Access Control

, SP-SEC-Comp-5.4.3-1 - The Secure Component shall support to authenticate to the network using the SSI-NAC interface (refer to SP-SEC-ServSpec Ch 7 - NAC: Network Access Control). **[**Generic **]**

, SP-SEC-Comp-5.4.3-2 - The Secure Component shall support separate re-authentication per physical network interface using NAC. **[**Generic **]**

, SP-SEC-Comp-5.4.3-3 - The Secure Component shall use the Operator Device Certificate (ODC) as specified in SP-SEC-ServSpec Ch 13.1.2-1 - Operator Device Certificate for authentication towards the Network Authentication Server. **[**Generic **]**

, SP-SEC-Comp-5.4.3-4 - If no Operator Device Certificate (ODC) is available, the Secure component shall use the Manufacturer Device Certificate (MDC) as specified in SP-SEC-ServSpec Ch 13.1.1-1 - Manufacturer Device Certificate for authentication towards the Network Authentication Server.
Note: to ensure that the Network Authentication Server uses the Manufacturer Device Certificate (MDC) only in the cases where it is necessary (e.g. when a new device is plugged into the network which does not have an Operator Root CA Certificate), the Network Authentication Server will authenticate itself by picking the certificate based on the EAP identity sent by the supplicant.
[Generic **]**

, SP-SEC-Comp-5.4.3-5 - If the Secure Component has no Operator Root CA Certificate (ORCAC) available, the Secure Component shall use the EAP identity "manufacturer".
Note: in this case, the Secure Component uses the MRCAC (initial commissioning phase) **[**Generic **]**

, SP-SEC-Comp-5.4.3-6 - If the Secure Component has an Operator Root CA Certificate (ORCAC) available, the Secure Component shall use the EAP identity "operator". **[**Generic **]**

5.4.4 Denial of Service Resilience

, SP-SEC-Comp-5.4.4-1 - The Secure Component shall limit use of system resources by security functions to protect against resource exhaustion.
Note: This can be tested by monitoring system resources as CPU utilization, volatile memory, persistence memory and network utilization during normal and stress situations over an extended period of time. The test should show that resource utilization stays in the specified limits. **[**Generic **]**

, SP-SEC-Comp-5.4.4-2 - After a Denial of Service (DoS) event (e.g. saturation / high load of the network interface), the Secure Component shall operate normally.
Note: recommended test time for network saturation is at least one minute, recommended time to check for normal operation after network saturation is 30 seconds.
This supports maintaining essential functions in a degraded mode as the result of a DoS event, together with SP-SEC-Comp-5.4.4-3 and SP-SEC-Comp-5.4.4-1 **[**Generic **]**

, SP-SEC-Comp-5.4.4-3 - The Secure Component shall provide the capability to only allow a configurable maximum number of concurrent sessions per interface for any given user (human, or technical user). **[**Generic **]**

5.4.5 Minimisation of Data

, **SP-SEC-Comp-5.4.5-1 -** The Secure Component shall process only data, personal or other, that are adequate, relevant and limited to what is necessary in relation to the intended purpose of the Secure Component (‘data minimisation’). **[**Generic **]**

5.5 Identification, Authentication & Authorisation

5.5.1 Identification, Authentication and Authorisation of Standard Communication Interfaces

, **SP-SEC-Comp-5.5.1-1 -** If the Secure Component uses the standard communication protocols defined in [SP-SEC-CommSpec], the Secure Component shall implement the requirements from the [SP-SEC-CommSpec]. **[**Generic **]**

, **SP-SEC-Comp-5.5.1-2 -** The Secure Component shall implement the interfaces defined in [SP-SEC-ServSpec].

Note: This ensures the identification, authentication, integrity, and confidentiality requirements, as well as the first step of authorisation for network based communication for interfaces defined in Shared Cybersecurity Services Specification. For all other communication interfaces, the requirements are listed in chapter 7 of [SP-SEC-CommSpec] **[**Generic **]**

5.5.2 Public Key Certificates

, **SP-SEC-Comp-5.5.2-1 -** The Secure Component shall implement the interface SP-SEC-ServSpec Ch 5 - Public Key Infrastructure to request certificates. **[**Generic **]**

, **SP-SEC-Comp-5.5.2-2 -** The Secure Component shall generate a new individual key pair for every requested certificate. **[**Generic **]**

, **SP-SEC-Comp-5.5.2-3 -** The Secure Component shall generate keys on the Secure Component itself. **[**Generic **]**

, **SP-SEC-Comp-5.5.2-4 -** The Secure Component shall implement the interfaces SP-SEC-ServSpec Ch 5 - PKI: Public Key Infrastructure to renew a certificate. **[**Generic **]**

, **SP-SEC-Comp-5.5.2-5 -** The Secure Component shall automatically request the renewal of its certificates a configurable number of days in advance to the certificate's expiration date.

Note: after rekeying a certificate, it is recommended to not revoke the old certificate to keep CRLs manageable. **[**Generic **]**

, **SP-SEC-Comp-5.5.2-6 -** If the certificate update contains a renewed certificate which is used in current communication, the Secure Component shall re-establish the communication using the renewed certificate.

[Generic **]**

, **SP-SEC-Comp-5.5.2-7 -** If the renewed certificate(s) corresponds to a two-channel safety-related connection (e.g. SCI), the Secure Component shall re-establish communications only one active channel at a time.

Note: If in a two-channel safety communication, one channel is not active (e.g. in maintenance, not connected), a diagnostic event should be generated and the re-establishment should happen when the other channel becomes active again. **[**Generic **]**

, **SP-SEC-Comp-5.5.2-8 -** The Secure Component shall be able to trust a list of certificate authorities.

Note: a PKI hierarchy can have multiple trusted certificate authorities (manufacturer and several operators). [Generic]

, **SP-SEC-Comp-5.5.2-9 -** The Secure Component shall update its CRLs via the SSI-PKI interface. [Generic]

, **SP-SEC-Comp-5.5.2-10 -** The Secure Component shall update its CRLs as defined in RFC 5280 chapter 6.3.3 or by using externally configured CRL distribution points.
Note: a diagnostic method is also available to trigger a CRL update when required. See SP-SEC-Serv-12.2-1 [Generic]

, **SP-SEC-Comp-5.5.2-11 -** If the Secure Component cannot fetch a new CRL after the time defined by the nextUpdate field, the Secure Component shall keep using the latest locally cached CRL. [Generic]

, **SP-SEC-Comp-5.5.2-12 -** If an CRL update contains certificate which is used in current communications, the Secure Component shall terminate the communications using the revoked certificate. [Generic]

, **SP-SEC-Comp-5.5.2-13 -** The Secure Component shall support certificates defined in SP-SEC-ServSpec Ch 13.1 - Certificate Profiles . [Generic]

5.5.3 PKI Certificate Validation

, **SP-SEC-Comp-5.5.3-1 -** The Secure Component shall check if the certificate signature is valid. [Generic]

, **SP-SEC-Comp-5.5.3-2 -** The Secure Component shall validate the certificate's trust chain up to a trusted certificate authority. [Generic]

, **SP-SEC-Comp-5.5.3-3 -** The Secure Component shall check if the certificate is not revoked using CRLs. [Generic]

, **SP-SEC-Comp-5.5.3-4 -** If the lifetime of the certificate is not valid when checking the notBefore and notAfter certificate fields against the current time and date, the Secure Component shall reject the certificate or issue an diagnostic alarm depending on its configuration. [Generic]

, **SP-SEC-Comp-5.5.3-5 -** The Secure Component shall check if the communication partner has control of the private key corresponding to the presented certificate.
Note: Control of the private key by communication partner is normally implemented in challenge-response mechanisms. Examples of implementation is TLS, and for both communication parties: TLS mutual authentication. [Generic]

, **SP-SEC-Comp-5.5.3-6 -** The Secure Component shall map the authenticated identity of a certificate to a user (human or technical user) [Generic]

, **SP-SEC-Comp-5.5.3-7 -** The Secure Component shall validate and enforce the extended key usage according to the definition in SP-SEC-ServSpec Ch 5.2-3 - Object Identifiers (OIDs) [Generic]

, **SP-SEC-Comp-5.5.3-8 -** If the Secure Component cannot validate certificates because of a missing secure time source (e.g. during initial commissioning), the Secure Component shall use a fallback time source.
Note: The fallback time can for example be calculated using the following (possibly non-secure) time sources: NTP, last shutdown time, real-time clock of the device. [Generic]

5.5.4 PKI Commissioning Procedure

, SP-SEC-Comp-5.5.4-1 - The Secure Component shall be equipped with a Manufacturer Device Certificate (MDC) which includes the unique serial number of the Secure Component as described in SP-SEC-ServSpec Ch 13.1.1-1 - Manufacturer Device Certificate (MDC) profile . **[**Generic **]**

, SP-SEC-Comp-5.5.4-2 - The corresponding private key of the MDC shall be generated on the device upon either production or commissioning. **[**Generic **]**

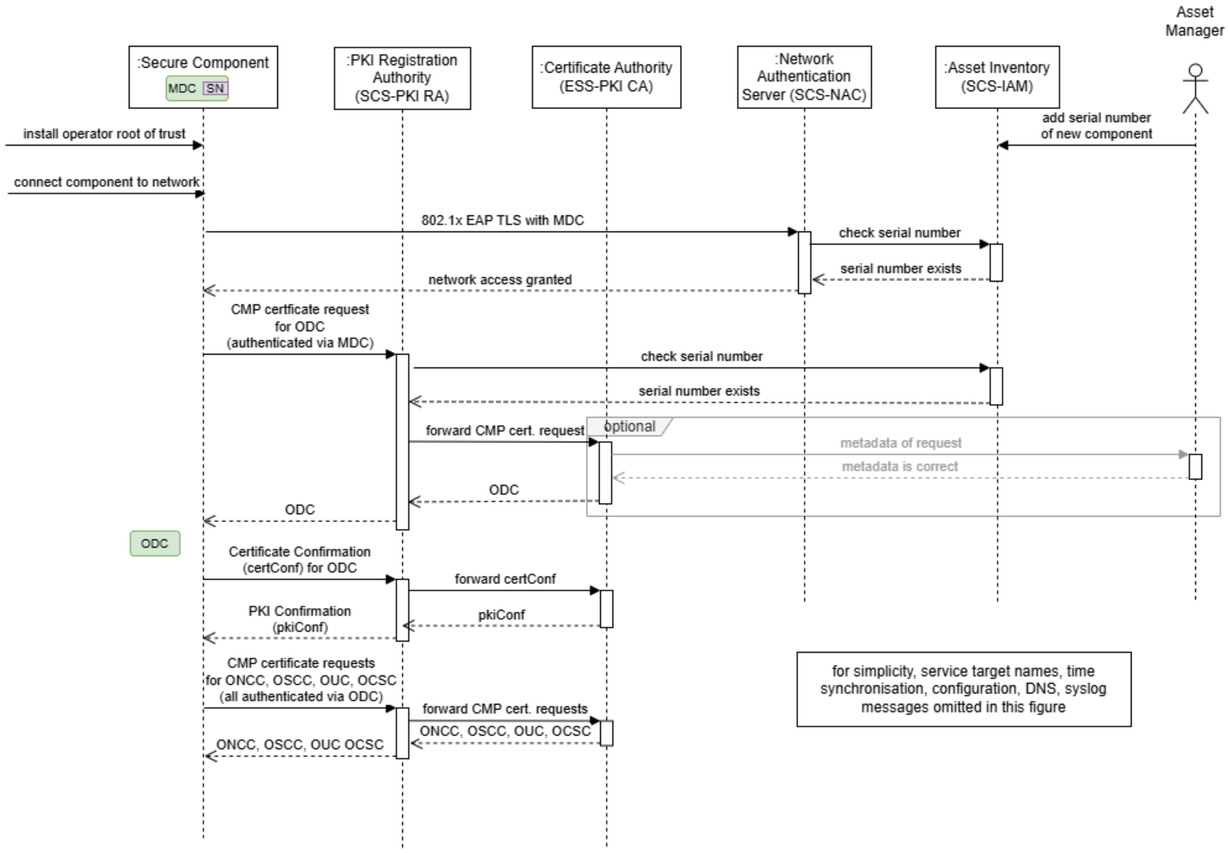
, SP-SEC-Comp-5.5.4-3 - The certificate chain of the MDC required to validate the certificate shall be installed on the device upon production or commissioning (see also SP-SEC-CompSpec Ch 5.5.5.-1). **[**Generic **]**

, SP-SEC-Comp-5.5.4-4 - The Secure Component shall have the capability to install and remove Operator Root CA Certificates (ORCACs) that are defined in a configuration file signed by the Manufacturer Trust Anchor Signer Certificate (MTASC) or Operator Trust Anchor Signer Certificate (OTASC) during the commissioning phase or earlier. **[**Generic **]**

, SP-SEC-Comp-5.5.4-5 - The Secure Component shall request the Operator Device Certificate (ODC) via the SSI-PKI interface using the Manufacturer Device Certificate (MDC) for message protection. **[**Generic **]**

, SP-SEC-Comp-5.5.4-6 - The Secure Component shall request all other operator certificates (ONCC, OSCC, OUC, OCSC, see SP-SEC-ServSpec Ch 5.1.3 - Use Case: Updating Operator Certificates) via the SSI-PKI interface using the Operator Device Certificate (ODC) for message protection. **[**Generic **]**

, SP-SEC-Comp-5.5.4-7 - Overview of commissioning steps:



, **SP-SEC-Comp-5.5.4-8 -** Note: for validation and testing purposes there might be additional certificate types used.

, **SP-SEC-Comp-5.5.4-9 -** Note: the step of checking additional metadata before issuing certificates is optional. The operator may define metadata to be checked.

, **SP-SEC-Comp-5.5.4-10 -** Note: usage of different networks for commissioning is optional and not depicted in the drawing.

5.5.5 Root Certificate Installation

, **SP-SEC-Comp-5.5.5-1 -** The Secure Component shall have the capability to install trusted certificates in the trust store via the mechanism described in Chapter SP-SEC-CompSpec Ch 5.6.1 - Software Update. **[**Generic **]**

, **SP-SEC-Comp-5.5.5-2 -**

The Secure Component shall have the capability to install certificate chains in the certificate store via the mechanism described in Chapter SP-SEC-CompSpec Ch 5.6.1 - Software Update. **[**Generic **]**

5.6 Software Update, Backup and Restore

5.6.1 Software Update

, **SP-SEC-Comp-5.6.1-1 -** The Secure Component shall support the update of software and configuration via the interface [I-STD-MAINTENANCE - SMI] .
Note 1: when updating non-safety related software, typically also the process allowlist has to be updated.
Note 2: this supports together with the backup and restore functionality (chapter 5.6.3) the recovery and reconstitution to a known secure state after a disruption or failure. **[**Generic **]**

, **SP-SEC-Comp-5.6.1-2 -** The Secure Component shall ensure that the safety functionality is not influenced by the security functionality.
Note: this ensures that security updates can be installed without affecting safety certifications. This can be achieved i.e. by demonstrating non-interference between safety and security functionality. Technical measures to ensure non-interference are logical separation and protection of computer resources.
[Generic **]**

, **SP-SEC-Comp-5.6.1-3 -** The Secure Component shall verify the signature of the update packages using the corresponding installed roots of trust before installation. **[**Generic **]**

, **SP-SEC-Comp-5.6.1-4 -** The Secure Component shall reject update packages without a valid signature. **[**Generic **]**

5.6.2 Update Package

Note: This chapter is for the SMI update package (used for reference from SMI specification)

, **SP-SEC-Comp-5.6.2-1 -** The update package shall be signed using the corresponding update signing key.
Note: the corresponding update signing key for firmware update is the MUSC and for configuration update is the MCSC or OCSC. **[**Generic **]**

, **SP-SEC-Comp-5.6.2-2 -** The update package shall use SHA-512 hash algorithm for the integrity protection. **[**Generic **]**

, **SP-SEC-Comp-5.6.2-3 -** The update package shall use X.509v3 certificates including extended key usage code signing for
the update package signature. **[**Generic **]**

5.6.3 Backup and Restore

, **SP-SEC-Comp-5.6.3-1 -** If operational data is not part of the configuration data from [I-STD-MAINTENANCE - SMI] interface, the Secure Component shall backup operational data which is relevant for its operational availability via SSI-BKP SP-SEC-Serv - Ch. 11 - BKP: Backup and Restore
Note 1: Backups are intended for operational data that is relevant for operational availability (e.g. changes in databases), but is not part of the configuration (e.g. obtained via I-STD-MAINTENANCE (SMI)). Most rail automation devices receive all data required for operational data via I-STD-MAINTENANCE and do not need the interface SSI-BKP
Note 2: Backups are triggered remotely via SSI-BKP, additionally the Secure Component has also the option to trigger a backup creation locally , e.g. based on time or change events. **[**Generic **]**

, **SP-SEC-Comp-5.6.3-2 -** If the Secure Component backups operational data , the Secure

Component shall be capable of restoring operational data via SSI-BKP SP-SEC-ServSpec Ch 11 - BKP: Backup and Restore [Generic]

, SP-SEC-Comp-5.6.3-3 - If the Secure Component backups operational data, the Secure Component shall be capable of verifying the authenticity and integrity of backup data received via SSI-BKP SP-SEC-ServSpec Ch 11 - BKP: Backup and Restore [Generic]

5.7 Logging and Diagnostics

Security Logging contains the continuous stream of logging events from operating systems and applications from a Secure Component. In contrast, Security Diagnostic contains the current state of the Secure Component, based on a diagnostics model.

5.7.1 Security Logging

, SP-SEC-Comp-5.7.1-1 - The Secure Component shall log at least the following events:
a) access control;
b) request errors;
c) control system events;
d) backup and restore event;
e) configuration changes; and
f) audit log events (incl. administrative actions, input validation errors)
g) threats (attacks and probes)
h) resource events (system resources reaching a threshold)
i) availability (shutdown, failures, crashes).

Note: more detail of log events is described in chapter SP-SEC-ServSpec Ch 9.1 - Log Message Format [Generic]

, SP-SEC-Comp-5.7.1-2 - The Secure Component shall send the logging events via SSI-LOG SP-SEC-ServSpec Ch 9 - LOG: Security Logging .

Note: this ensures encryption of the log messages and ensures that no information is provided that can be exploited by adversaries to attack the system. [Generic]

, SP-SEC-Comp-5.7.1-3 - The Secure Component shall provide the capability to send logging data to multiple configurable log collector destinations. [Generic]

, SP-SEC-Comp-5.7.1-4 - The Secure Component shall send log messages complying to the log message format defined in SP-SEC-ServSpec Ch 9.1 - Log Message Format

Note: This ensures that the log messages contain the following data:
a) timestamp (synchronized);
b) source (originating device, software process or human user account);
c) category;
d) type;
e) event ID; and
f) event result [Generic]

, SP-SEC-Comp-5.7.1-5 - The Secure Component shall be able to store untransferred log data for eight hours or longer, up to the maximum available or reserved capacity.
Note: These untransferred logs are accessible using the maintenance method described in SP-SEC-Serv Ch 12.3 - Log Maintenance .

The untransferred logs are assumed to be accessible until a restart / reboot. [Generic]

, **SP-SEC-Comp-5.7.1-6 -** The Secure Component implementing a Log Server (e.g. a Log Relay) shall store log data on a non-volatile memory for a configurable duration.
Note: typical log retention duration depend on the log destination retention capabilities (e.g. SIEM features) and network connectivity. In mobile environments (e.g a train), a log server / relay in the mobile environment with longer retention duration may be required. [Generic]

, **SP-SEC-Comp-5.7.1-7 -** If the storage capacity is exceeded, the Secure Component shall overwrite the oldest log entry first. [Generic]

, **SP-SEC-Comp-5.7.1-8 -** If the storage capacity has reached a defined threshold, the Secure Component shall indicate this on its diagnostic interface and send it via SSI-LOG. [Generic]

, **SP-SEC-Comp-5.7.1-9 -** If the Secure Component starts overwriting not transferred log data, it shall generate a log that overwriting has started. [Generic]

, **SP-SEC-Comp-5.7.1-10 -** If the Secure Component cannot send log messages due to connection loss, caching of log messages can be used before sending the cached messages to the configured relay after the connection is reestablished.

5.7.2 Security Maintenance and Diagnostics

, **SP-SEC-Comp-5.7.2-1 -** The Secure Component supports the verification of the intended operation of security functions by the diagnostic values and maintenance methods in this chapter.

Security Function	Verification	Verification time
Process Allowlisting	maintenance call Security:TestProcessAllowListing()	during normal operation
Security Logging	implicit tested via Security:TestProcessAllowListing() which produces a log message	during normal operation
Integrity checks	maintenance call Security:IntegrityCheckStatus()	during normal operation
Certificates Management	maintenance call Security:GetInstalledCerts(), Security:GetInstalledCRLs() and Security:RenewCert()	during normal operation
Hardware trust anchor	only positive test case: maintenance call Security:GetInstalledCerts(), Security:GetInstalledRoots()	during normal operation
Host-based firewall	maintenance call Security:TestHostFirewall()	during normal operation
Backup & Restore	calls to Backup & Restore interface (SSI-BKP)	during normal operation
Secure boot	only positive test case: Secure Component has successfully booted and reacts on maintenance calls (e.g. Security:SecurityStatus()	during normal operation

Security Function	Verification	Verification time
Network Access control	only positive test case: Secure Component has successfully connected to the network and reacts on maintenance calls (e.g. Security:SecurityStatus()	during normal operation
Identification and Authentication	any call to the maintenance interface involves user identification and authentication, testable using different users with different permissions	during normal operation
User Authorization	any call to the maintenance interface involves user authorization, testable using different users with different permissions	during normal operation
Random number generation	verification of using OS standard implementation for random number generation, check randomness for seeds after boot-up (esp. for components without a battery-buffered clock), check of entropy of random number generation	during product development
Electronic tamper detection	check detection when opening the encasing	during product development
Input validation	Fuzz testing	during product development
Deterministic output	Trigger a safe-state, document output settings	during product development
Hardware trust anchor	code review of section storing private keys	during product development
Secure Boot	Tamper firmware and reboot	during product development
Denial-of-service resilience	Create high network load	during product development and system / integration test
Hardware-related firmware update	Update hardware-related firmware	during product development and system / integration test
Network Access Control	negative test case: remove asset in SSI-IAM, trigger a reboot	during product development and system / integration test

6 Manufacturing, Configuration, Documentation

6.1 Secure Component Manufacturing

, **SP-SEC-Comp-6.1-1 -** Before commissioning the Secure Component shall retrieve and store its Manufacturer Device Certificate (MDC) and the corresponding Manufacturer Root CA Certificate (MRCAC).

Note: the Manufacturer Device Certificate (MDC) plays a role in the commissioning identification/authentication/security bootstrapping process, and software/firmware updates. **[**Generic **]**

6.2 Secure Component Configuration

, **SP-SEC-Comp-6.2-1 -** The Secure Component shall support the SMI interface for updating the security configuration. **[**Generic **]**

, **SP-SEC-Comp-6.2-2 -** The Secure Component shall provide following configuration items:

- own network configuration IP addresses (IPv4 or IPv6 or FQDN, hostname, subnet mask, gateway address)
- IP addresses / FQDN to all shared cybersecurity services instances (LOG, IAM, PKI, BKP, TIME), support for at least four instances per service for high availability
- maximum access token lifetime
- binding of communication processes to VLANs / interfaces
- days before expiration date to start certificate renewal
- time invalid certificate handling (reject or only issue warning)
- enable automatic session lock
- time period of inactivity of a human user session
- action after time period of inactivity by human user (lock session or terminate session)

[Generic **]**

, **SP-SEC-Comp-6.2-3 -** The Secure Component shall have a factory configuration that is secure by default.

Note: a secure by default configuration is a configuration that has all configurable security functions enabled. **[**Generic **]**

, **SP-SEC-Comp-6.2-4 -** If the Secure Component supports local password-based authentication, the Secure Component shall provide following configuration items:

- password rules (minimum length, variety of character types)
- number of generations before reusing a password
- minimum and maximum password lifetime
- number of consecutive invalid access attempts
- time period to deny access when the limit of consecutive invalid login attempts has been reached
- number of days before password expiration to prompt the human user to change their password

Note 1: The Secure Component implementing the SSI-UAS service should support password-based authentication and the password configuration items.
Note 2: Secure Components using user authentication via the SSI-UAS interface do not need to support password-based authentication or password configuration items.
Note 3: Common security practices recommend to only change passwords when there is an indication of comprise. Therefore, the

maximum password lifetime should be set to infinite (e.g. a long time in the future). [Generic]

6.3 Component Documentation

, **SP-SEC-Comp-6.3-1 -** The Secure Component shall include the information set out in the [SP-SEC-DocTempl] - Product Documentation Template in a document accompanying the product.
Note: the product documentation should be available in electronic form in a open file format (defined by an openly published specification as PDF-A, Office Open XML, Drawing Interchange Format, Scalable Vector Graphics (SVG)) [Generic]

, **SP-SEC-Comp-6.3-2 -** The Secure Component documentation shall be written in an official language of the EU member states in a clear, understandable, intelligible and legible manner. [Generic]

, **SP-SEC-Comp-6.3-3 -** The manufacturer shall update continuously the Secure Component technical documentation, where appropriate, for at least during the support period. [Generic]

7 Requirements for specific component types

7.1 COTS Network Components

7.1.1 Network Component Requirements

, **SP-SEC-Comp-7.1.1-1 -** This section contains the requirements mandatory for COTS network components (switches, routers, gateways, firewalls,...).

Note. Since these products are COTS products, it is not expected that they meet all requirements of Secure Components (chapter 5).

, **SP-SEC-Comp-7.1.1-2 -** The Network Component shall support IEEE 802.1x EAP TLS network authentication **[**Network **]**

, **SP-SEC-Comp-7.1.1-3 -** The Network Component shall support the RFC 2865 RADIUS protocol for network authentication. **[**Network **]**

, **SP-SEC-Comp-7.1.1-4 -** The Network Component shall support IEEE 802.1q VLAN tagging. **[**Network **]**

, **SP-SEC-Comp-7.1.1-5 -** The Network Component shall support IEEE 802.1q priority code points, also referred as IEEE 801.1p. **[**Network **]**

, **SP-SEC-Comp-7.1.1-6 -** The Network Component shall support ingress policing to enforce bandwidth limitations. This can be fulflilled using Per-Stream Filtering and Policing (PSFP) as of IEEE 802.1Qci. **[**Network **]**

, **SP-SEC-Comp-7.1.1-7 -** The Network Component shall support sending logs and alarms via syslog (RFC 5424), preferable using Syslog over TLS (RFC 5425). **[**Network **]**

, **SP-SEC-Comp-7.1.1-8 -** The Network Component shall support SNMPv3 (RFC 3410). **[**Network **]**

, **SP-SEC-Comp-7.1.1-9 -** The Network Component should support detailed flow information forwarding to analysis system (e.g. RFC 3954 NetFlow, RFC 3176 SFlow) **[**Network **]**

, **SP-SEC-Comp-7.1.1-10 -** The Network Component shall support configuring a separate physical management port. **[**Network **]**

, **SP-SEC-Comp-7.1.1-11 -** The Network Component shall support authentication on all enabled management network interfaces. **[**Network **]**

, **SP-SEC-Comp-7.1.1-12 -** The Network Component shall support integrity and encryption protection for the protocols used for the enabled management network interfaces. **[**Network **]**

, **SP-SEC-Comp-7.1.1-13 -** The Network Component shall support 802.1X on trunk ports **[**Network **]**

7.1.2 Access from Untrusted Networks

, SP-SEC-Comp-7.1.2-1 - If the Network Component supports device access from untrusted networks (e.g. part of a remote access solution), the Network Component shall monitor and control all methods of access. **[**Network **]**

, SP-SEC-Comp-7.1.2-2 - If the Network Component supports device access from untrusted networks (e.g. part of a remote access solution), the Network Component shall be capable of deny access requests via untrusted networks unless explicitly approved by an assigned role. **[**Network **]**

7.1.3 Network-based Firewall

, SP-SEC-Comp-7.1.3-1 - The Network Component implementing a firewall shall be capable of deny-all and allow-on-exception filter configuration (allowlist configuration). **[**Network **]**

, SP-SEC-Comp-7.1.3-2 - The Network Component implementing a firewall shall be capable of packet filtering according to source and destination port, source and destination addresses and direction of flow. **[**Network **]**

, SP-SEC-Comp-7.1.3-3 - The Network Component implementing a firewall shall be capable of enabling an island mode.

Note: island mode is defined as blocking or disabling interfaces to another network zone (e.g. from signalling network to back-office or enterprise network) **[**Network **]**

, SP-SEC-Comp-7.1.3-4 - The Network Component implementing a firewall shall automatically block connections (fail close) during a failure of the network filter mechanisms. **[**Network **]**

7.1.4 Wireless Access Management

, SP-SEC-Comp-7.1.4-1 - If a Network Component supports wireless access management (e.g. WLAN access point), the Network Component shall provide the capability to uniquely identify and authenticate all users (humans, software processes or devices) engaged in wireless communication with a control system.

Note: this can be achieved using IEEE 802.1x EAP TLS. **[**Wireless **]**

7.2 Components with HMIs

, SP-SEC-Comp-7.2-1 - If the Secure Component provides a human-machine interface, the Secure Component shall support human user authentication using the central authentication service via SSI-UAS. **[**HMI **]**

, SP-SEC-Comp-7.2-2 - If the Secure Component provides a human-machine interface, the Secure Component shall enforce the permissions received from the IAM service via SSI-IAM for the corresponding communication session. **[**HMI **]**

, SP-SEC-Comp-7.2-3 - If central security-related components with a human-machine interface (e.g. IAM, software update system) allow high-risk operations, the central security-related Component shall be capable to enforce the dual control principle.

Note. Examples for high-risk operations are: assign admin role, update security configuration or software. **[**HMI **]**

, SP-SEC-Comp-7.2-4 - If the Secure Component provides a human-machine interfaces, the Secure Component shall lock or terminate sessions after a time period of inactivity depending on configuration. **[** HMI **]**

, SP-SEC-Comp-7.2-5 - If the Secure Component provides a human-machine interfaces, the Secure Component shall enable the human user to lock or terminate sessions manually. **[**HMI **]**

, SP-SEC-Comp-7.2-6 - If the Secure Component provides a human-machine interfaces, the Secure Component shall unlock the locked human-user sessions only after re-authentication of the human user.

Note: See also SP-SEC-Comp-7.2-7 for supervisor override in case of HMI controlling essential services. **[**HMI **]**

, SP-SEC-Comp-7.2-7 - If the Secure Component implements a human-machine interface which is needed to control an essential service, the Secure Component shall support a supervisor manual override for a configurable time or sequence of events. **[**HMI **]**

, SP-SEC-Comp-7.2-8 - If the Secure Component implements a human-machine interface with interactive log-in, the log-in screen shall be configurable to provide information about user log-in histories and recently failed log-in attempts according to IEC 62443-2-1 User 1.13. **[**HMI **]**

, SP-SEC-Comp-7.2-9 - If the Secure Component implements a human-machine interface with interactive log-in, the log-in screen shall display log-in failure information only after successful login.

Note: this prevents to display useful information to attackers (see also IEC 62443-2-1 USER-1.14) **[**HMI **]**

, SP-SEC-Comp-7.2-10 - If the Secure Component provides a human-machine interface, the human-machine interface shall be designed considering human-factors.

Note: this ensures that security functions can be operated easily and without faults by human users. The recommended standard for human-factors is **[EN ISO 14915]** **[**[Component Type] **]**

7.3 Components using Password-based Authentication

, SP-SEC-Comp-7.3-1 - This section is for Secure Components that use local password-based authentication and local user management for their interfaces. e.g. it does not integrate into an user authentication service (SCS-UAS) password-based authentication.

, SP-SEC-Comp-7.3-2 - If the Secure Component supports local password-based authentication and local user management, then Secure Component shall enforce configurable password strength (minimum length, variety of character types). **[**Generic **]**

, SP-SEC-Comp-7.3-3 - If the Secure Component supports local password-based authentication and local user management, then the Secure Component shall provide the capability to protect against any given human user account from reusing a password for a configurable number of generations. **[**Generic **]**

, SP-SEC-Comp-7.3-4 - If the Secure Component supports local password-based authentication and local user management, then the Secure Component shall provide the capability to enforce password minimum and maximum lifetime restrictions for all human users. **[**Generic **]**

, SP-SEC-Comp-7.3-5 - If the Secure Component supports local password-based authentication and local user management, then the Secure Component shall provide the capability to prompt the human user to change their password upon a configurable time prior expiration. **[**Generic **]**

, SP-SEC-Comp-7.3-6 - If the Secure Component supports local password-based authentication and local user management, then the Secure Component shall limit the number of consecutive invalid access attempts by any user (human or technical user). **[**Generic **]**

, SP-SEC-Comp-7.3-7 - If the Secure Component supports local password-based authentication and local user management, then the Secure Component shall deny access for a specific period of time when the limit of consecutive invalid attempts is reached. **[**Generic **]**

, SP-SEC-Comp-7.3-8 - If the Secure Component supports local password-based authentication and local user management and user accounts can be locked (e.g. due consecutive invalid access attempts), then the Secure Component shall be capable to unlock a locked account by an administrator
[Generic **]**

, SP-SEC-Comp-7.3-9 - If the Secure Component supports local password-based authentication and local user management, then the Secure Component shall obscure feedback of authentication information.
Note: In case of invalid username/password combination, the feedback is invalid username/password combination, not give hints that could help an attacker as "invalid user" or "invalid password", "password length insufficient". **[**Generic **]**

7.4 Components using Symmetric Key-based Authentication

, SP-SEC-Comp-7.4-1 - If symmetric key-based authentication is used, the Secure Component shall establish the mutual trust using the symmetric key. **[**Generic **]**

, SP-SEC-Comp-7.4-2 - If symmetric key-based authentication is used due to interoperability requirements by TSI, the Secure Component shall protect the symmetric key-based authentication by another security layer conformant to chapter 4 of the Secure Communication Specification (SP-SEC-Comm Ch 3 - End-to-End Security Layer (TLS) .)
Note 1: the use of symmetric key-based authentication requires the distribution of the symmetric keys ensuring confidentiality. This can be done using PKI / asymmetric cryptography or a out-of-band transmission ensuring confidentiality.
Note 2: Symmetric key authentication does not conform to internationally recognized and proved security practices. The only reason to implement it, may be the TSI. In this case, the appropriate security will be provided by adding a second security layer which uses industry-wide accepted security mechanism. This is, for example, done with the ETCS communication with Subset-146 for symmetric cipher of Subset-137-2) **[**Generic **]**

8 Residual risk

The following general risks remain after applying the three System Pillar Cybersecurity technical requirements specifications ([SP-SEC-CompSpec], [SP-SEC-CompSpec], and [SP-SEC-ServSpec])

8.1 Vulnerabilities in Secure Components or Network Components

, SP-SEC-Comp-8.1-1 - Secure Components and Network Components are complex products composed of various hardware (chipsets, CPU,...) and software (Open Source SW components, 3rd party SW components,...). Vulnerabilities are found and mostly documented in vulnerability databases. In recent years, these database documented thousands of new vulnerabilities.

, SP-SEC-Comp-8.1-2 - The risk caused by vulnerabilities in Secure Components and Network Components are reduced by the Defense-in-depth design of the System Pillar technical specifications. However, as time passes, more vulnerabilities are detected and can lead to an exploitable vulnerability.

, SP-SEC-Comp-8.1-3 - Mitigation: Vulnerability Management (as defined in IEC 62443-4-1 DM1-DM6) and installation of security updates (see SP-SEC-PrgmReq Ch 8.1-21 - Updating Secure Components)

8.2 Compromise of Privileged accounts

, SP-SEC-Comp-8.2-1 - Secure Components and Network Components can be compromised by attackers when privileged accounts, especially from the implementations of SCS-IAM, SCS-UAS, SCS-BKP and software update and configuration systems, have been compromised.

, SP-SEC-Comp-8.2-2 - Attackers can use these accounts to add themselves as legitimate users, even with elevated privileges, and access components which implement access control. Attackers can also install previous configurations or firmware with exploitable vulnerabilities (downgrade attack) or when the software signing keys are also compromised, install malware-infected software or configurations disabling security features.

, SP-SEC-Comp-8.2-3 - Compromise of privileged accounts can be caused by social attacks (e.g. phising, black mailing, quid pro quo, water-holing,...).

, SP-SEC-Comp-8.2-4 - Mitigation: Training of security operators against account compromise and awareness of social attack threats (see SP-SEC-Prgm Ch 5.10 - Personell awareness training)

8.3 Supply Chain Attacks

, SP-SEC-Comp-8.3-1 - Secure Component and Network Components can be compromised by introducing vulnerabilities in the supply chain. This can lead to undetected and undocumented exploitable vulnerabilities.

, SP-SEC-Comp-8.3-2 - Several cases of supply chain attacks of hardware chipsets, open source software and 3rd party software has been recorded over the last years.

, SP-SEC-Comp-8.3-3 - Supply chain attacks are hard to be detected and hard to be mitigated. They can only be detected by change reviews (suitable mainly for open source software) or by anomaly detection during operation.

, SP-SEC-Comp-8.3-4 - Mitigation: Review of relevant open source components (this can be practicable only be done on an international level, spanning industry sectors and national boundaries). This is due to the required effort and benefit structure (high effort not feasible for an individual company, once detected the benefit is across industry sectors and national boundaries). Therefore, a funding to conduct change analysis on relevant open source components in necessary at least at a European level.

, SP-SEC-Comp-8.3-5 - Mitigation: Anomaly detection systems (e.g. in NIDS) should be employed in environments of installed Secure Components to detect unexpected behaviour and communication attempts.

8.4 Security-related Application Conditions

, SP-SEC-Comp-8.4-1 - No additional application conditions have been identified beyond the requirements specified in the SP Cybersecurity requirements documents.