smartrail 4.0

Innovationstag ETCS Stellwerk

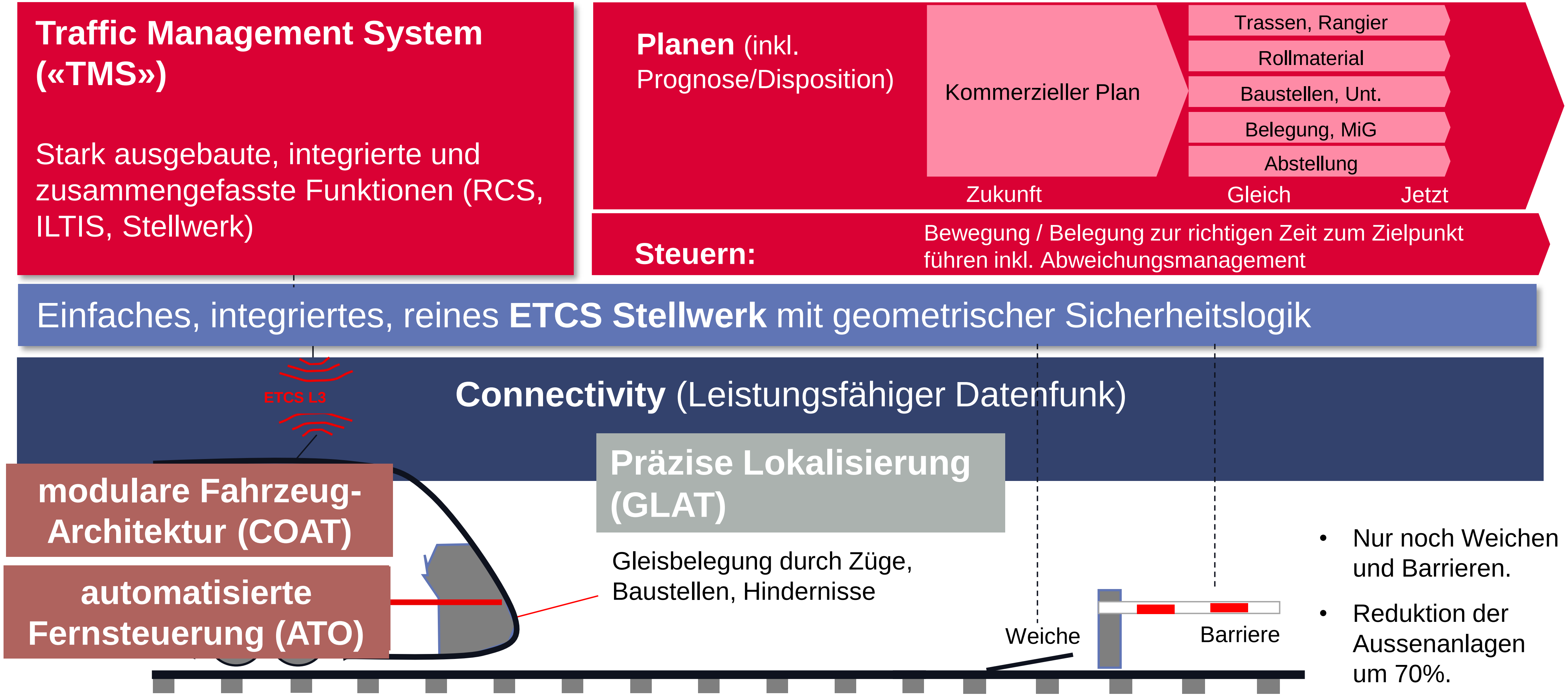
13. November 2018

smartrail4.0

smartrail 4.0 – Gesamtsystemarchitektur

13.11.2018 / Markus Kuhn

Der Weg zum Ziel



Traffic Management System («TMS»)

Stark ausgebaute, integrierte und zusammengefasste Funktionen (RCS, ILTIS, Stellwerk)

Planen (inkl. Prognose/Disposition)

Kommerzieller Plan

Trassen, Rangier

Rollmaterial

Baustellen, Unt.

Belegung, MiG

Abstellung

Steuern: Bewegung / Belegung zur richtigen Zeit zum Zielpunkt führen inkl. Abweichungsmanagement

Einfaches, integriertes, reines **ETCS Stellwerk** mit geometrischer Sicherheitslogik

Connectivity (Leistungsfähiger Datenfunk)

Präzise Lokalisierung (GLAT)

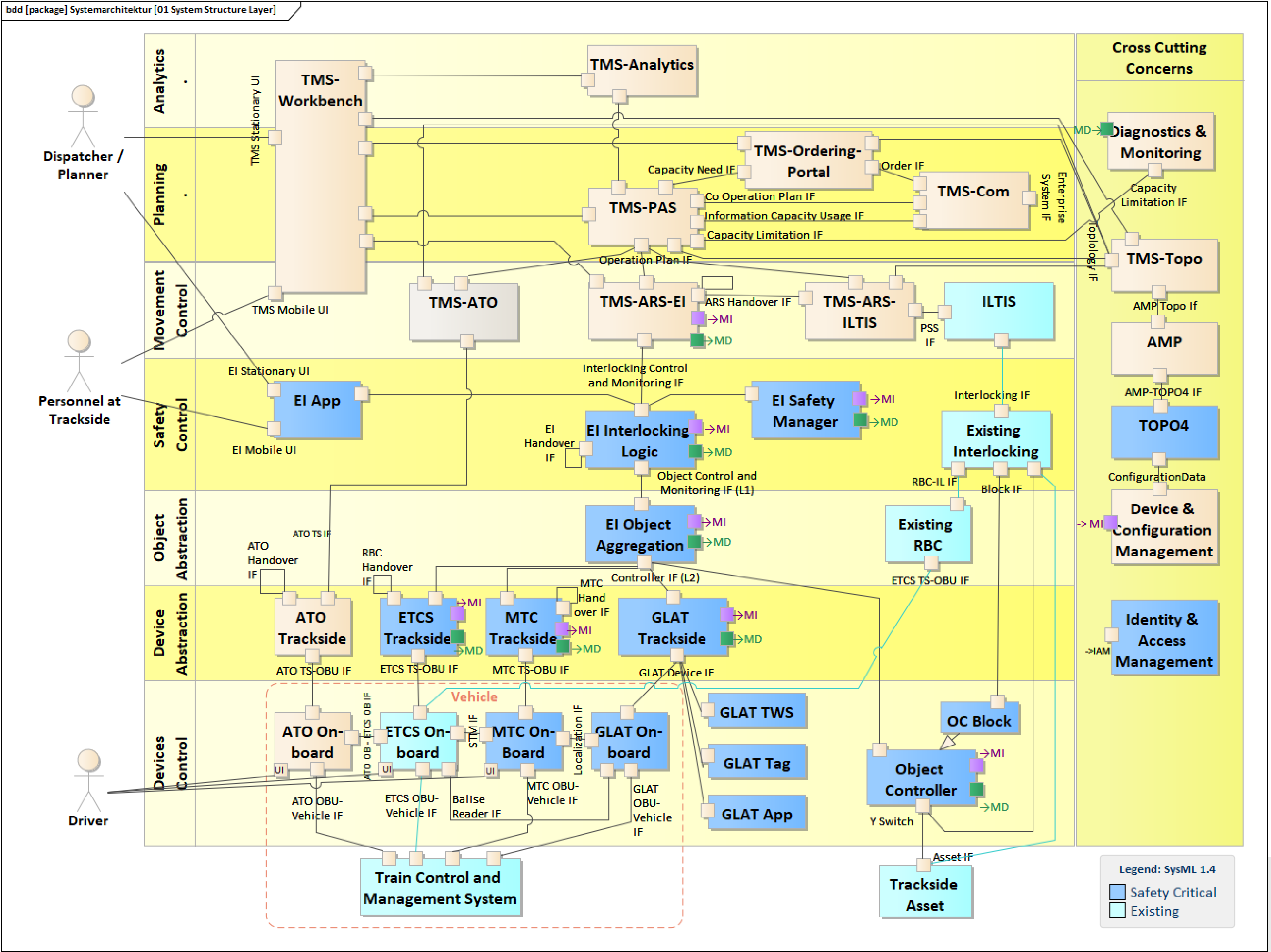
Gleisbelegung durch Züge, Baustellen, Hindernisse

modulare Fahrzeug-Architektur (COAT)

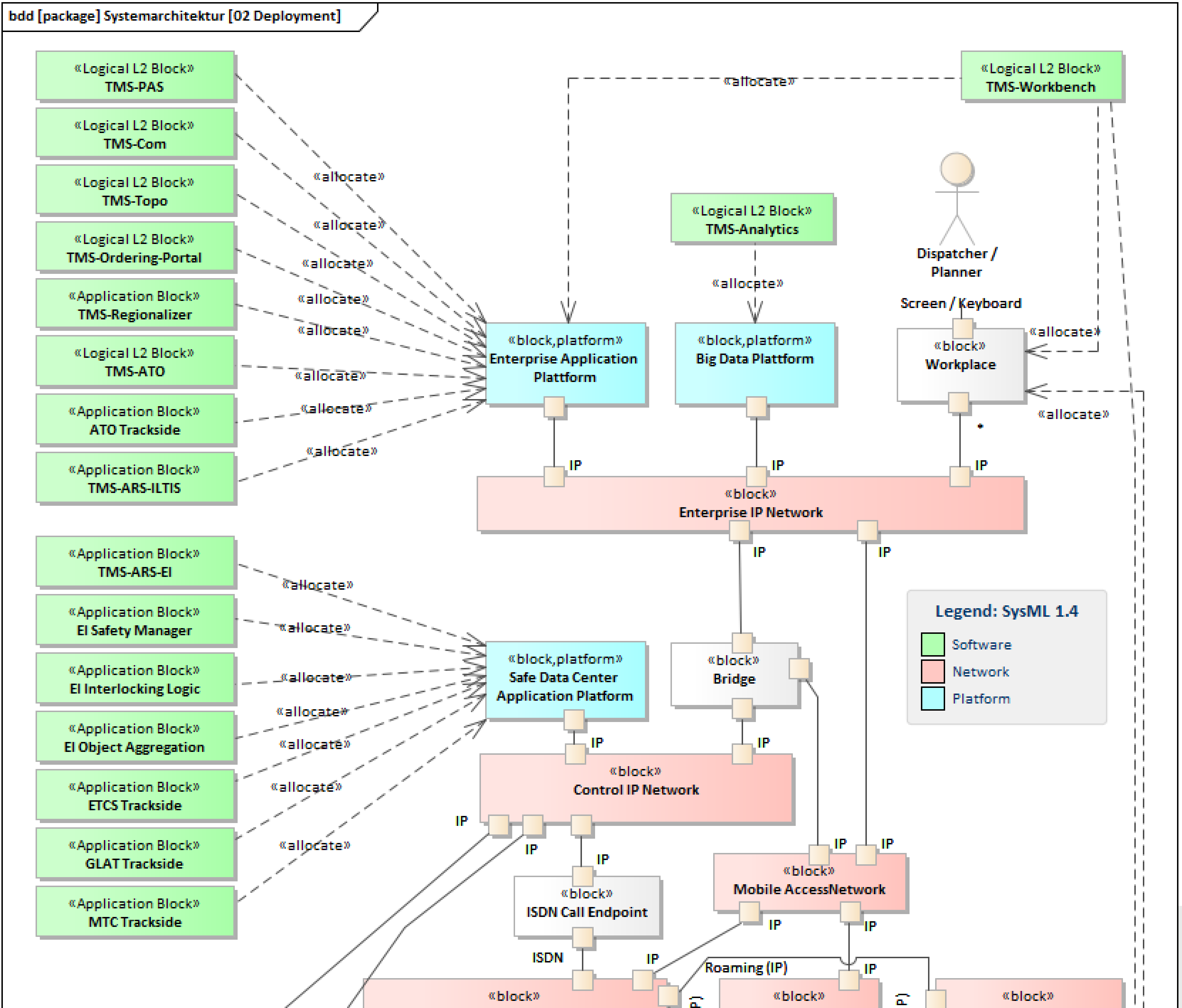
automatisierte Fernsteuerung (ATO)

- Nur noch Weichen und Barrieren.
- Reduktion der Aussenanlagen um 70%.

Functional Component View



Deployment View


bdd [package] Systemarchitektur [02 Deployment]
«Logical L2 Block» TMS-PAS
«Logical L2 Block» TMS-Com
«Logical L2 Block» TMS-Topo
«Logical L2 Block» TMS-Ordering-Portal
«Application Block» TMS-Regionalizer
«Logical L2 Block» TMS-ATO
«Application Block» ATO Trackside
«Application Block» TMS-ARS-ILTIS
«allocate»
«Logical L2 Block» TMS-Workbench
«Logical L2 Block» TMS-Analytics
Dispatcher / Planner
Screen / Keyboard
«block,platform» Enterprise Application Plattform
«block,platform» Big Data Plattform
«block» Workplace
IP
«block» Enterprise IP Network
«Application Block» TMS-ARS-EI
«Application Block» EI Safety Manager
«Application Block» EI Interlocking Logic
«Application Block» EI Object Aggregation
«Application Block» ETCS Trackside
«Application Block» GLAT Trackside
«Application Block» MTC Trackside
«block,platform» Safe Data Center Application Platform
«block» Bridge
«block» Control IP Network
«block» ISDN Call Endpoint
«block» Mobile AccessNetwork
ISDN
Roaming (IP)
«block»
Legend: SysML 1.4
Software
Network
Platform

Einige entwickeln sich schneller - Beispiele…

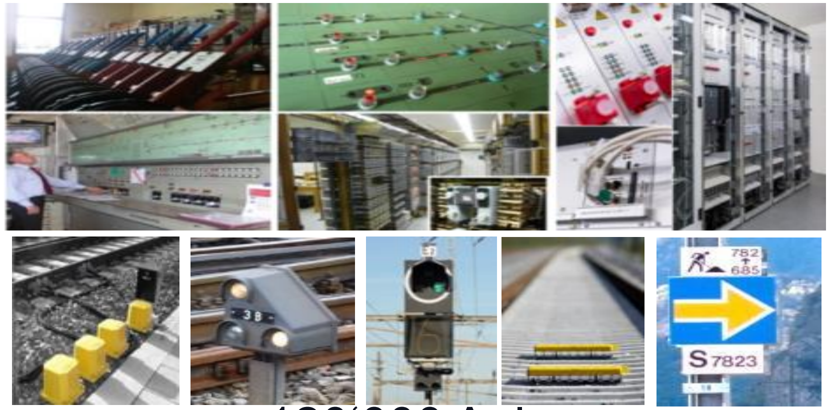
IMA

Modulare, austauschbare Avioniksysteme

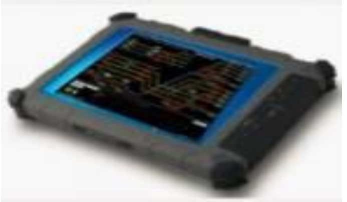
OPC UA

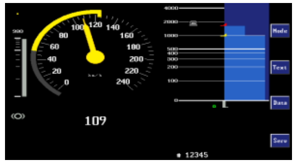
Die Sprache der Industrie 4.0

Wie entsteht der Quantensprung für den Bahnsektor?



120‘000 Anlagen

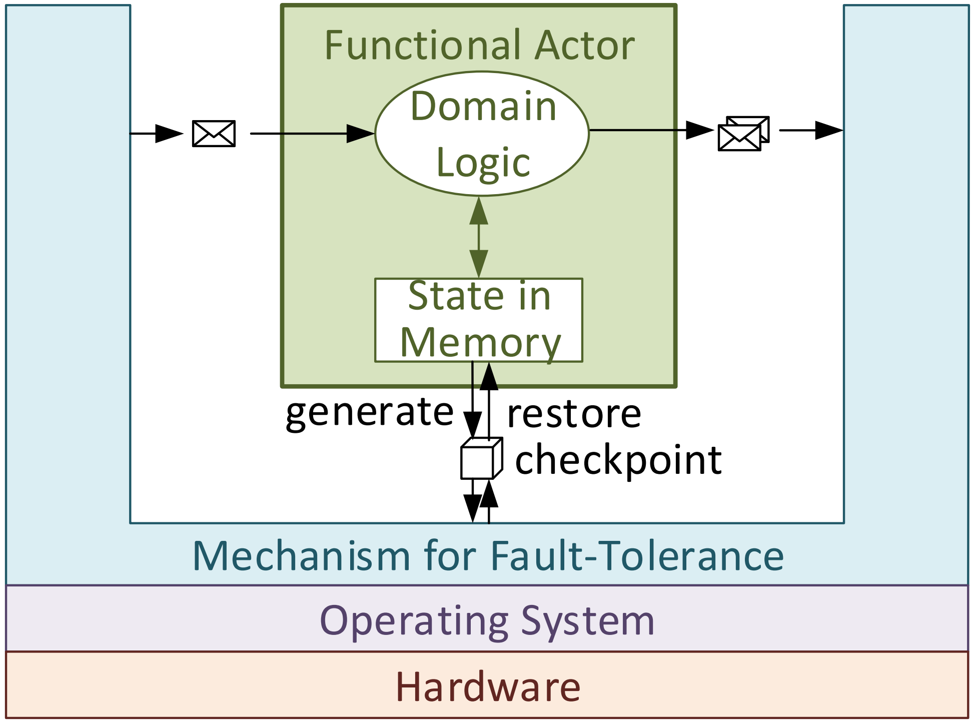


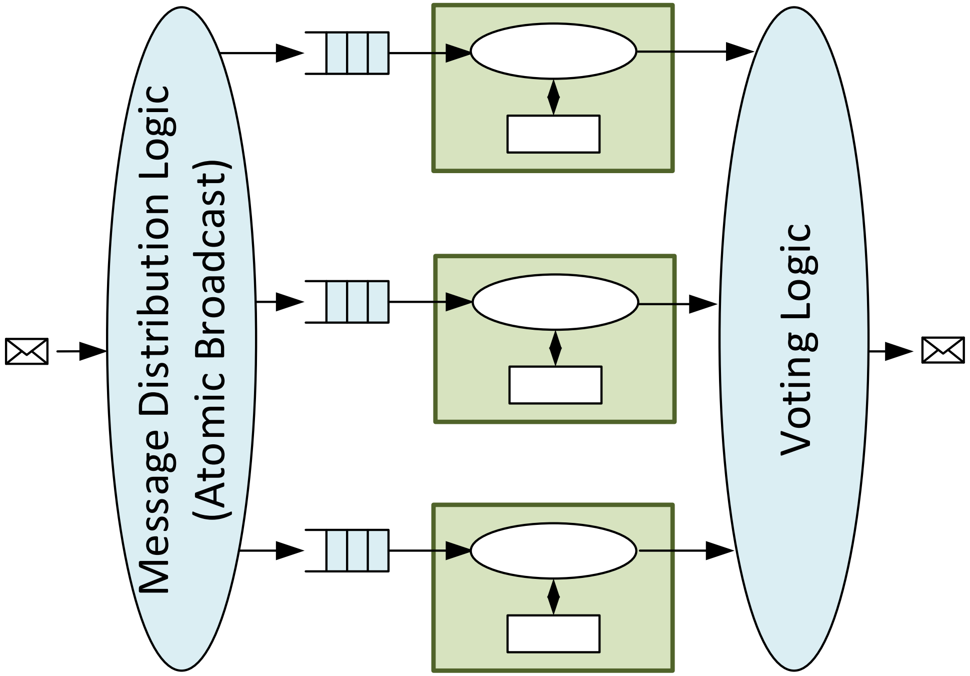


Einzelne Rechenzentren,
wenige Tausend mobile
Endgeräte und Fahrzeugausrüstungen

Portables «Application Model»

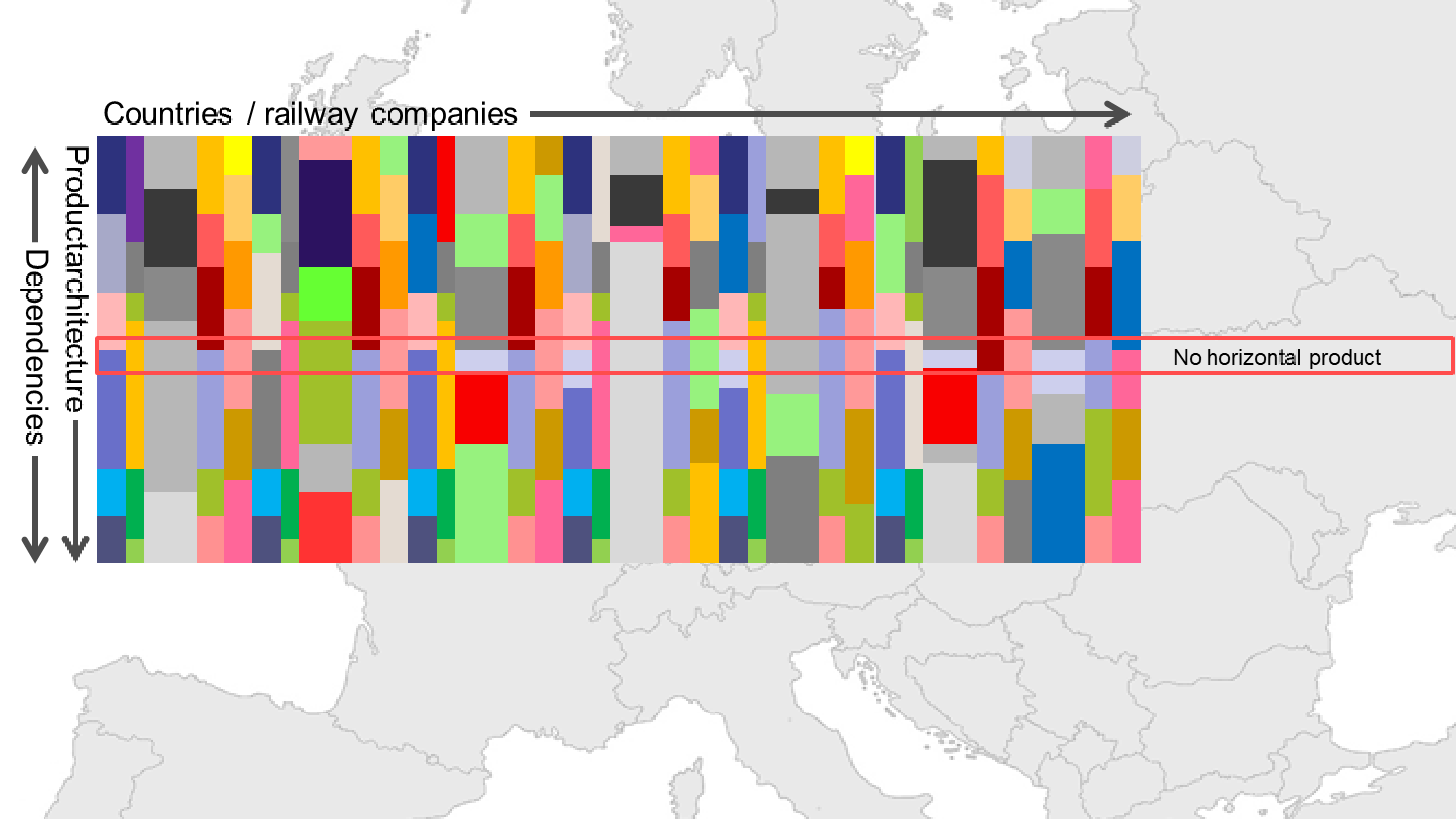
Ziel: Applikationen portabel zu unterschiedlichen «Safe Data Center Application Platform»





Deterministische Applikation:
Empfang von Meldung bei gegebenen State führt immer zum selben Folge-State und Sequenz von Out-Messages

Verwendung von standardisiertem Applikationsmodel, Meldungen und API.

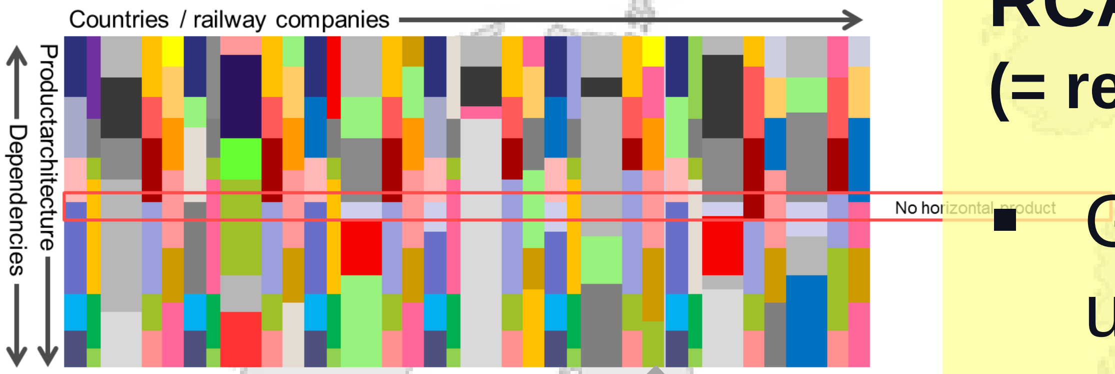


Countries / railway companies

Productarchitecture

Dependencies

No horizontal product

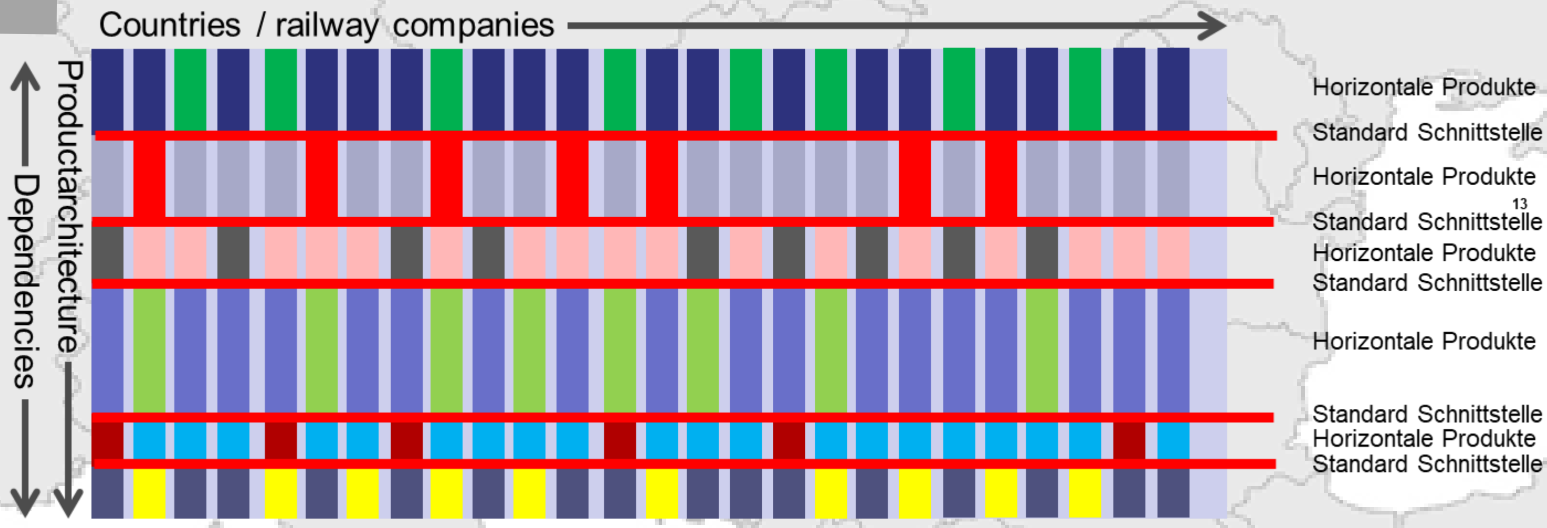


RCA
(= reference CCS architecture)

- Goal: shared interface specification for use in future projects / procurements.
- active members: DB, NR, ProRail, SBB, others to follow.
- first public «Alpha» release in feb. 19

smartrail 4.0 contrib

- Share our concepts & specifications (→ www.smartrail40.ch)
- Help drive the RCA process
- Want to apply RCA for smartrail 4.0



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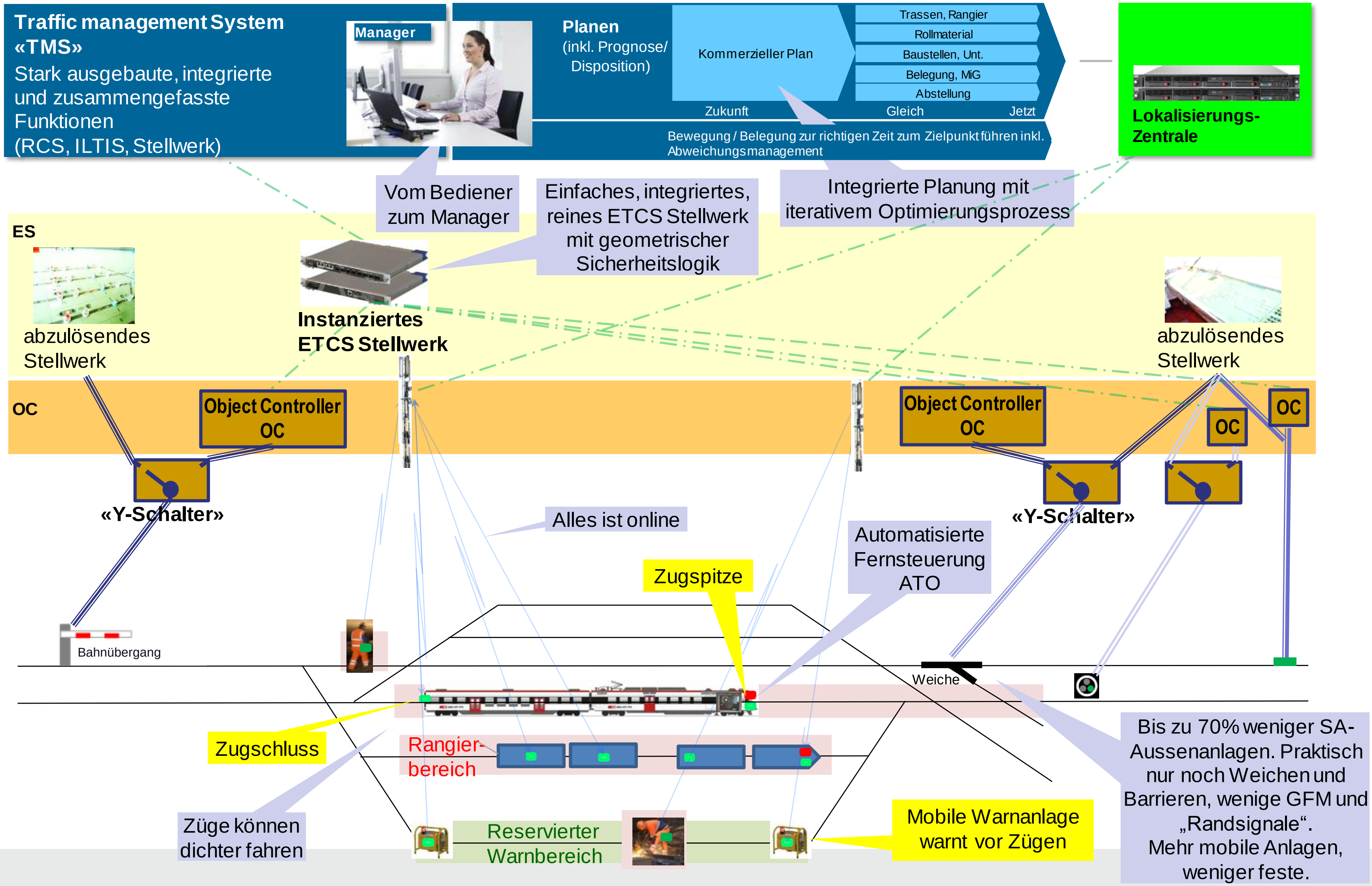
ES Innovationstag -
Teil Object Controller OC

13.11.2018 Martin Zehnder

Der OC in der Gesamtanwendung



Traffic management System «TMS»
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(RCS, ILTIS, Stellwerk)

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Bewegung / Belegung zur richtigen Zeit zum Zielpunkt führen inkl. Abweichungsmanagement

Vom Bediener zum Manager

Einfaches, integriertes, reines ETCS Stellwerk mit geometrischer Sicherheitslogik

Integrierte Planung mit iterativem Optimierungsprozess

Alles ist online

Automatisierte Fernsteuerung ATO

Bis zu 70% weniger SA-Aussenanlagen. Praktisch nur noch Weichen und Barrieren, wenige GFM und „Randsignale“. Mehr mobile Anlagen, weniger feste.

Mobile Warnanlage warnt vor Zügen

Züge können dichter fahren

🟩 : Lokalisierungsgerät

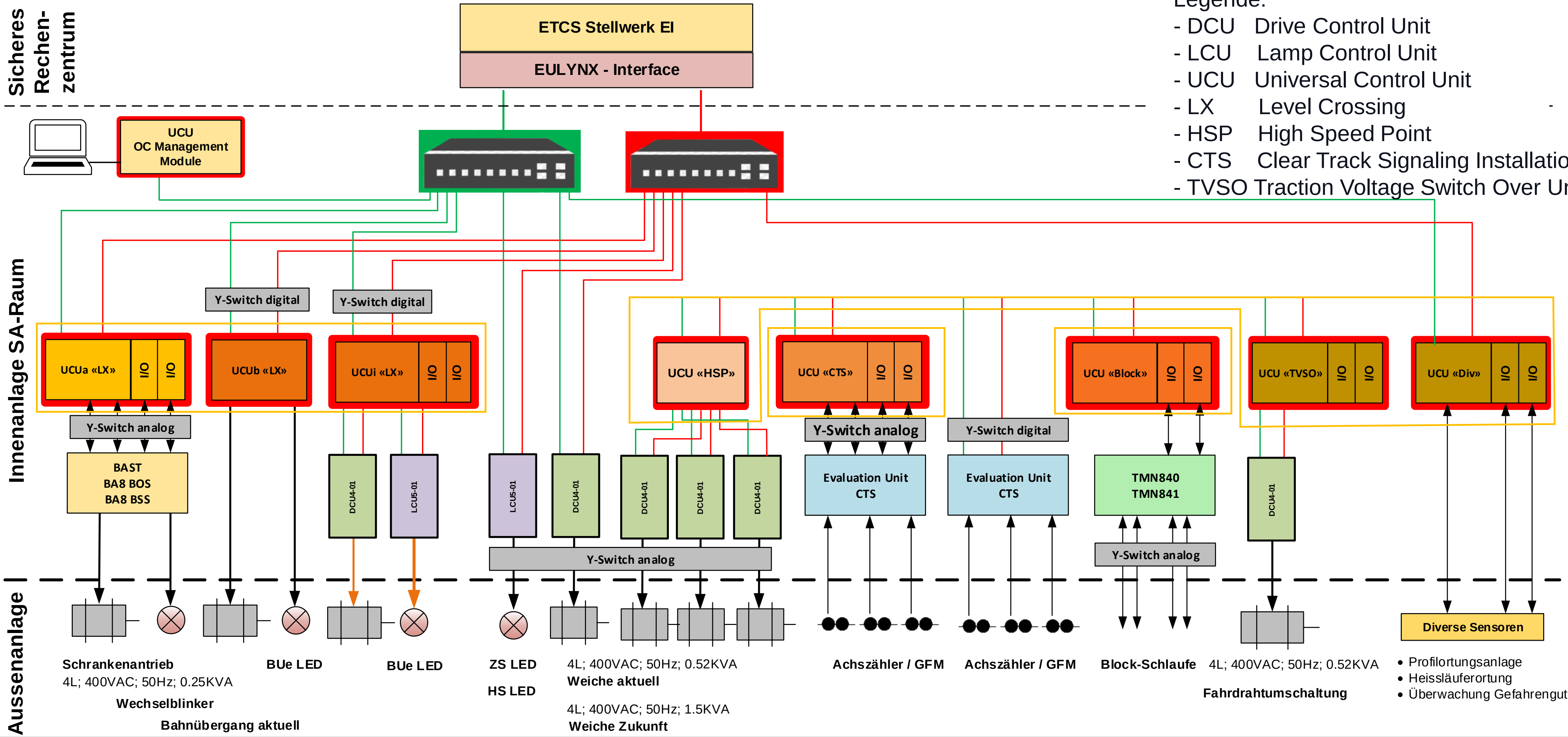
🟥 : ETCS CAB/Onboard Unit

▨ : Langfristiges Zielbild SR40

: Mobilfunk

OC Systemstruktur Übersicht, mögliche Beschaffungsgegenstände

Legende:
- DCU Drive Control Unit
- LCU Lamp Control Unit
- UCU Universal Control Unit
- LX Level Crossing
- HSP High Speed Point
- CTS Clear Track Signaling Installation
- TVSO Traction Voltage Switch Over Unit



Fragestellungen in den OC Workshops

- Mit welchen Technologien erfüllen Sie aktuell und in Zukunft die normierten Security Anforderungen?

- Werden Ihre Produkte aktuell oder künftig auf zertifizierten SIL4 Safety Plattformen entwickelt & zugelassen? Wenn ja: Welche?

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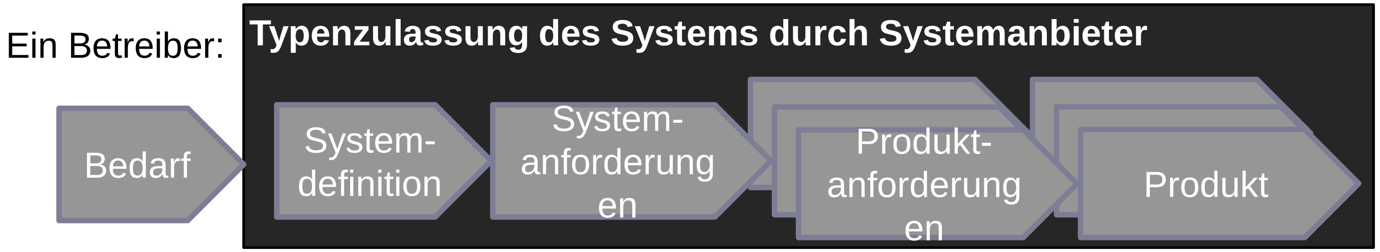
Zulassungskonzept (Auszug)

13.11.2018 / David Grabowski

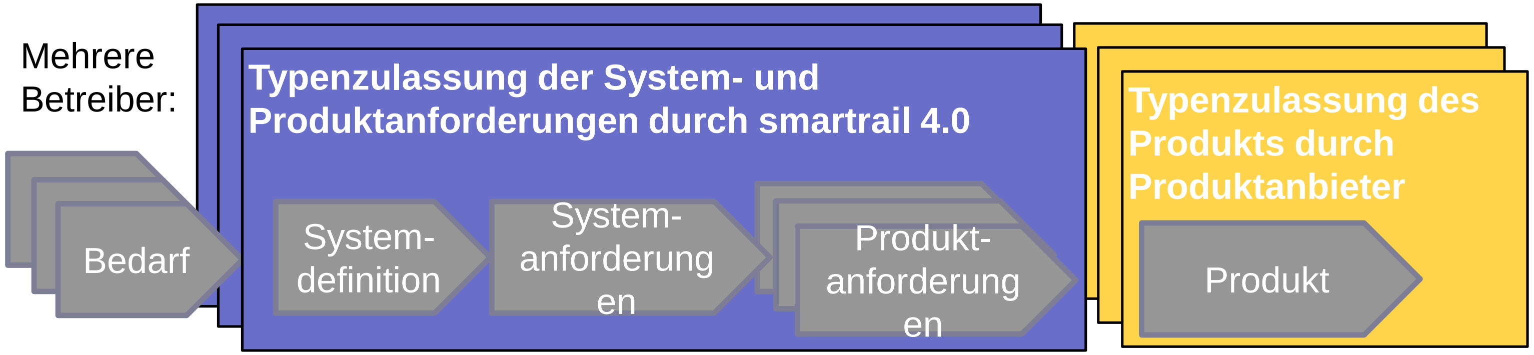
Zulassung von Anforderungen

Vom System zum Produkt

Klassisch (bisher):



Mit smartrail 4.0:

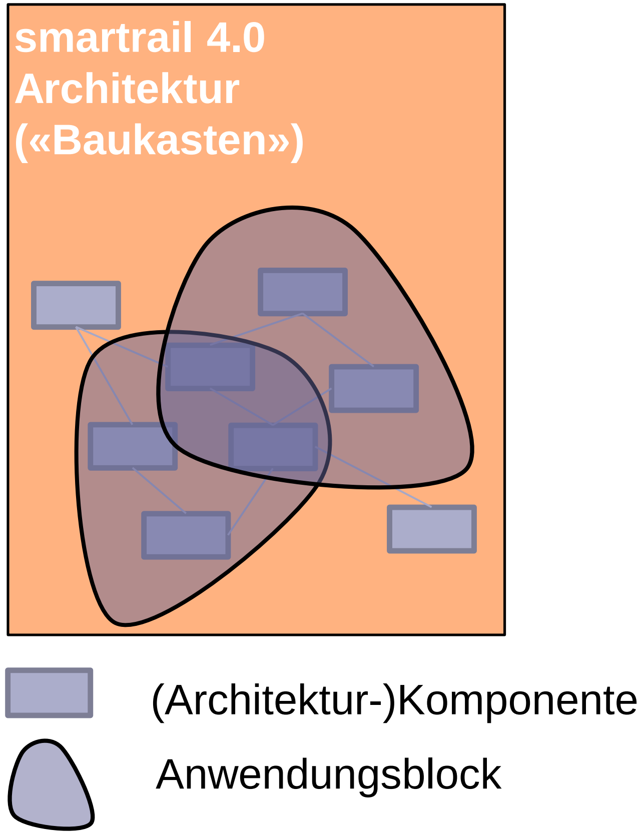


Mehrere Betreiber:
Typenzulassung der System- und Produktanforderungen durch smartrail 4.0
Bedarf
System-definition
System-anforderungen
Produkt-anforderungen
Typenzulassung des Produkts durch Produktanbieter
Produkt

Systembildung

Identifikation von Anwendungsblöcken

- Die Systeme in smartrail 4.0 heissen Anwendungsblöcke.
- Anwendungsblöcke sind (durchaus überlappende) Ausschnitte aus der smartrail 4.0 Architektur.
- Ein einzelner Anwendungsblock wird so gewählt, dass er möglichst invariant gegenüber den verschiedenen Anwendungszwecken von smartrail 4.0 ist.
- Eine smartrail 4.0-Anwendung wendet ausgewählte Anwendungsblöcke an.



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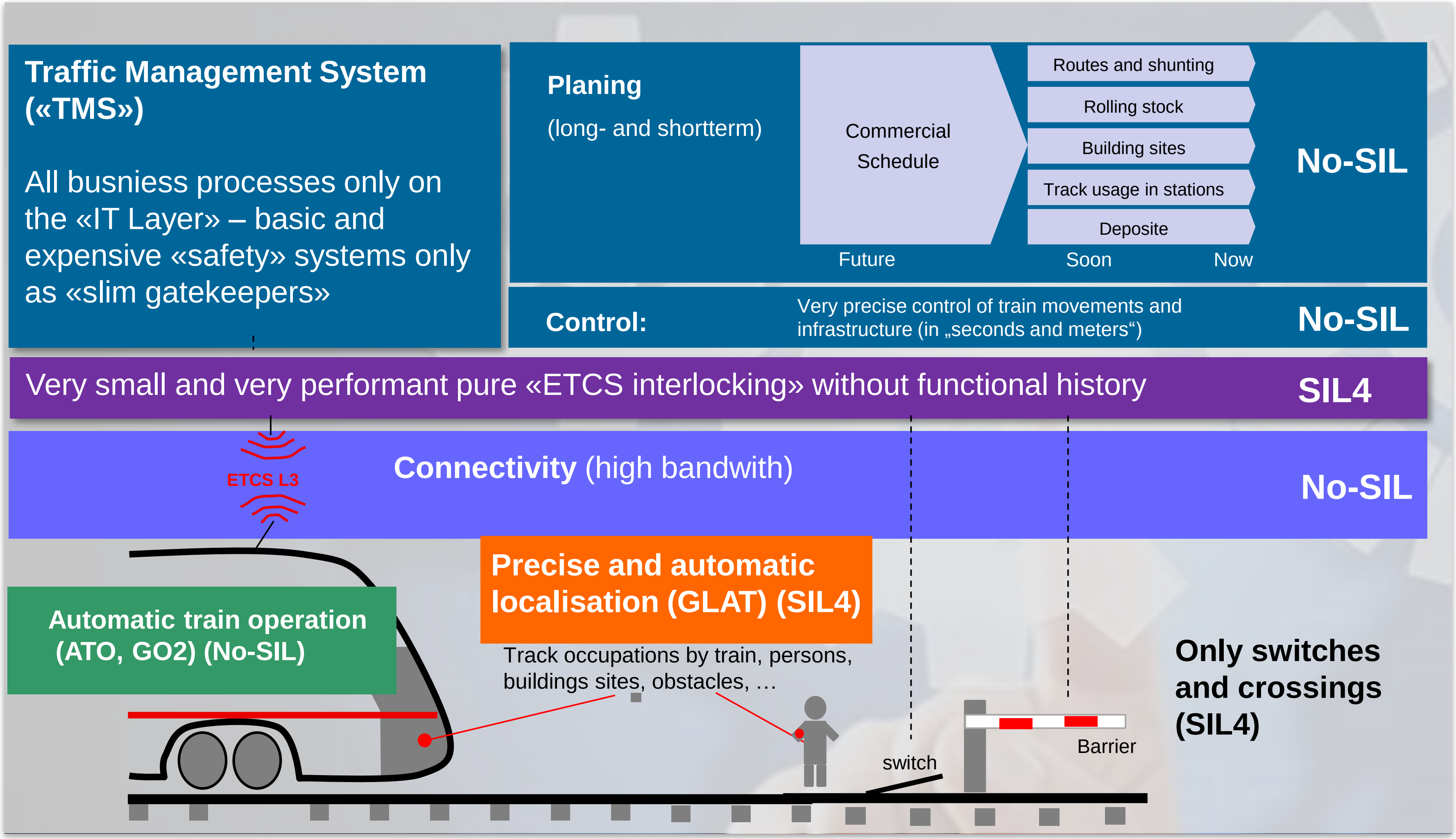
ETCS Interlocking: A centralized safety approch

13.11.2018 / David Grabowski

ETCS Interlocking: Reducing the safety critical part to a minimum



Traffic Management System («TMS»)

All busniess processes only on the «IT Layer» – basic and expensive «safety» systems only as «slim gatekeepers»

Planing

(long- and shortterm)

Commercial Schedule

Routes and shunting

Rolling stock

Building sites

Track usage in stations

Deposite

No-SIL

Control: Very precise control of train movements and infrastructure (in „seconds and meters“) **No-SIL**

Very small and very performant pure «ETCS interlocking» without functional history **SIL4**

Connectivity (high bandwith) **No-SIL**

Automatic train operation (ATO, GO2) (No-SIL)

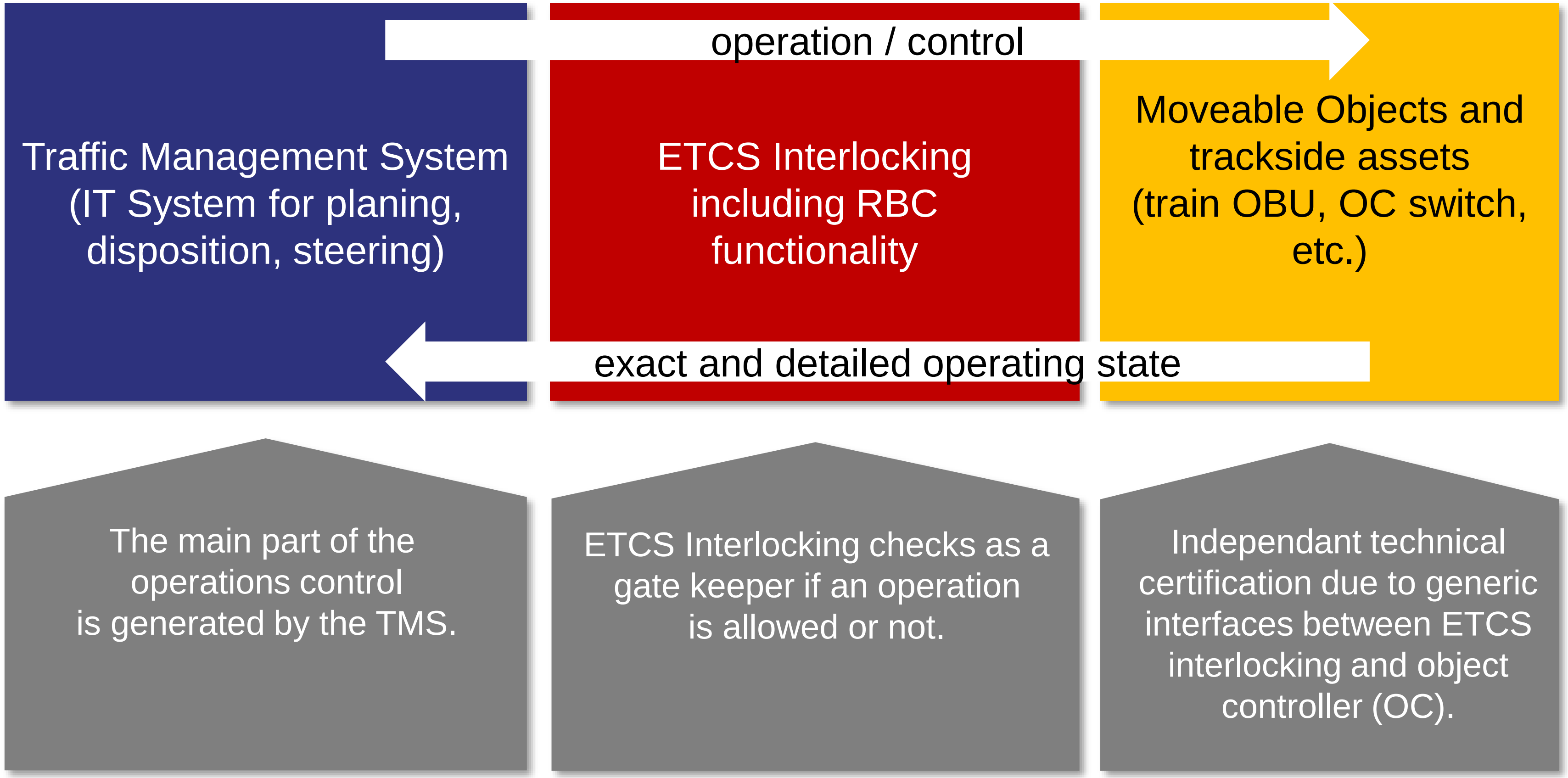
Precise and automatic localisation (GLAT) (SIL4)

Track occupations by train, persons, buildings sites, obstacles, …

Only switches and crossings (SIL4)

The ETCS Interlocking is „only“ a gate keeper

A safety structure with a minimum of SIL4 functionality.
(no special functions or operation functions with SIL4)



operation / control

Traffic Management System (IT System for planing, disposition, steering)

ETCS Interlocking including RBC functionality

Moveable Objects and trackside assets (train OBU, OC switch, etc.)

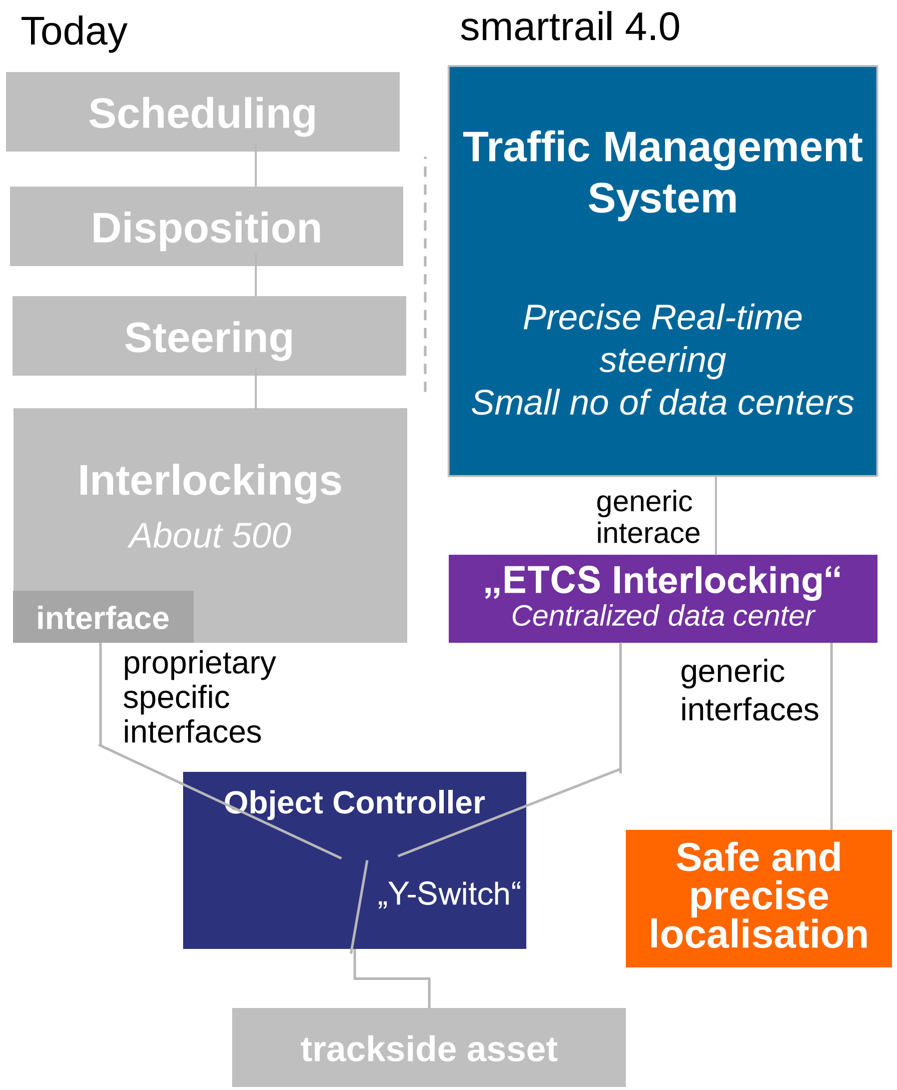
exact and detailed operating state

The main part of the operations control is generated by the TMS.

ETCS Interlocking checks as a gate keeper if an operation is allowed or not.

Independant technical certification due to generic interfaces between ETCS interlocking and object controller (OC).

The ETCS Interlocking



The Traffic Management System:

- Performs all non-safety critical functions
- Sends command requests

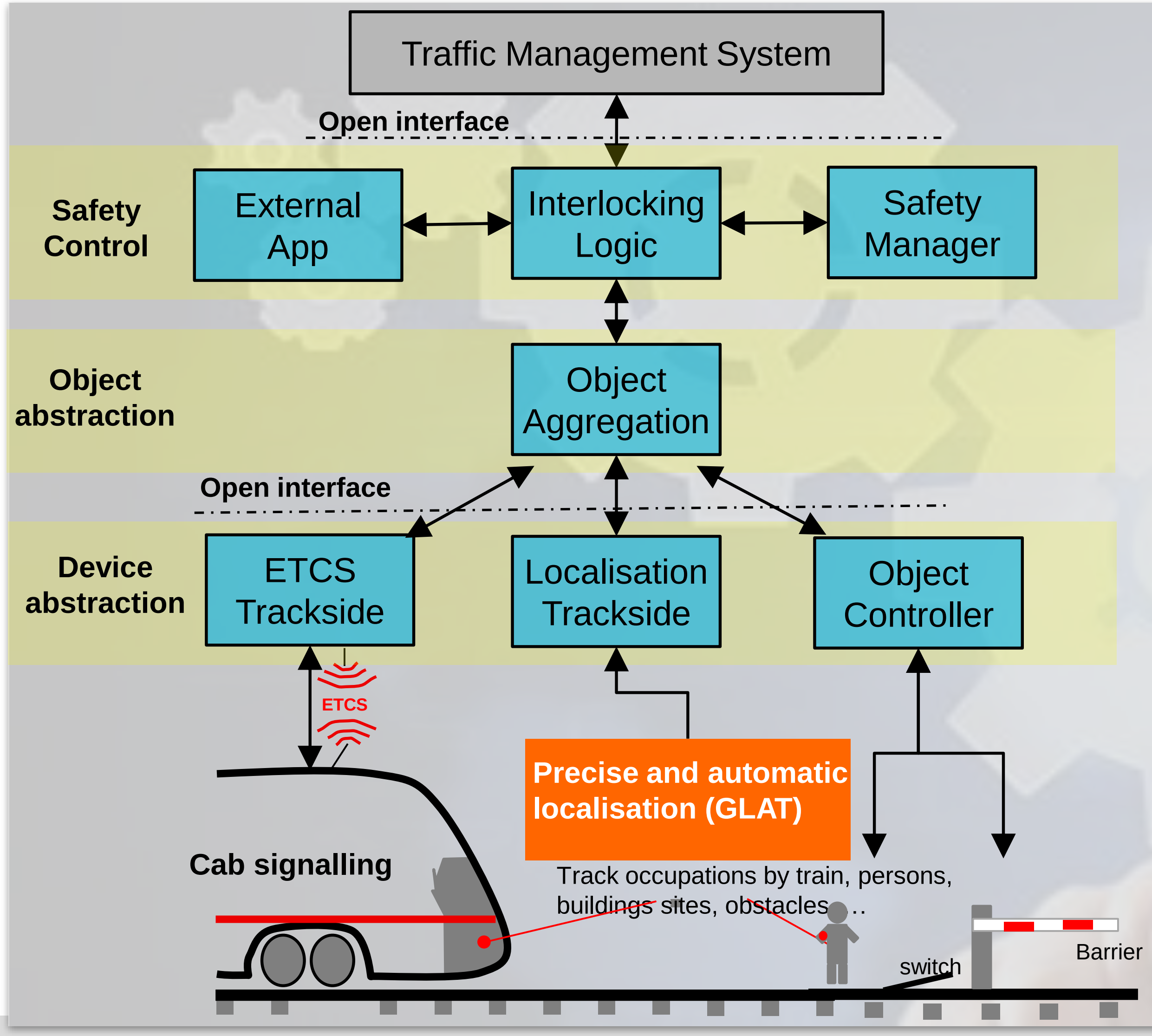
The ETCS Interlocking:

- Supports only cab signaling
- Includes the Radio Block Center
- Uses geometric safety logic
- Does the safety evaluation at runtime
- Has a minimum functionality
- Uses simple generic protocols

The Object Controller supports:

- Switching between “old” an “new”
- Simple migration of large segments

ETCS Interlocking architecture



External App: Stationary as well as mobile user interface

Interlocking Logic: decides if a request is granted or rejected depending on the resulting risk by applying the SRSS

Safety Manager: Continuously monitors the state of the system and triggers safety reactions if necessary.

Object Aggregation: Combines the information to one consolidated representation and dispatches information from «Interlocking logic»

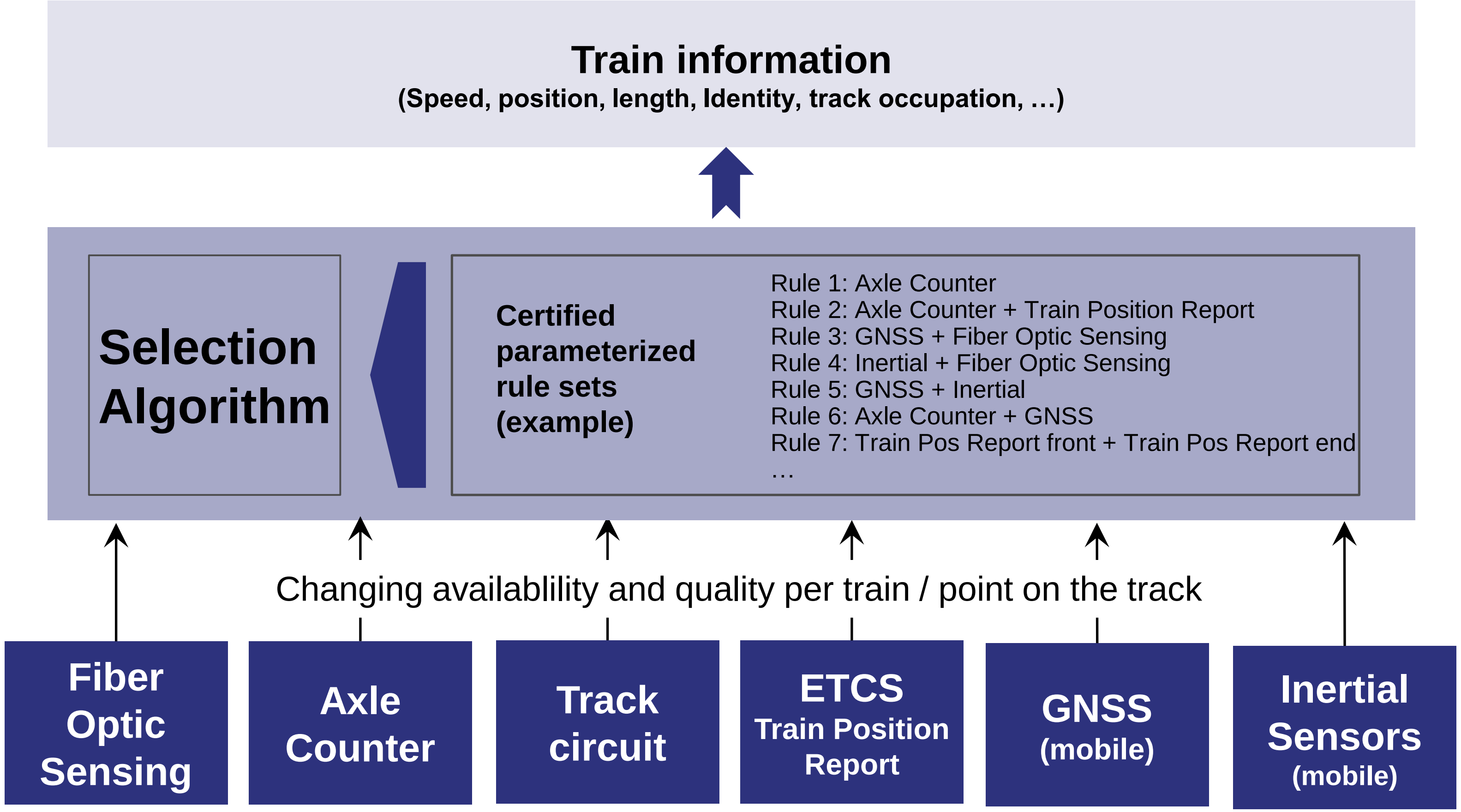
ETCS Trackside: Communicates with the registered ETCS capable vehicles

Localisation Trackside: manages the different kinds of GLAT devices and processes the received localization information

Object Controller: Monitors and controls Trackside Assets

Object Aggregation:

Rule based dynamic sensor fusion



Train information

(Speed, position, length, Identity, track occupation, …)

Selection Algorithm

Certified parameterized rule sets (example)

Rule 1: Axle Counter
Rule 2: Axle Counter + Train Position Report
Rule 3: GNSS + Fiber Optic Sensing
Rule 4: Inertial + Fiber Optic Sensing
Rule 5: GNSS + Inertial
Rule 6: Axle Counter + GNSS
Rule 7: Train Pos Report front + Train Pos Report end
…

Changing availablility and quality per train / point on the track

Fiber Optic Sensing

Axle Counter

Track circuit

ETCS Train Position Report

GNSS (mobile)

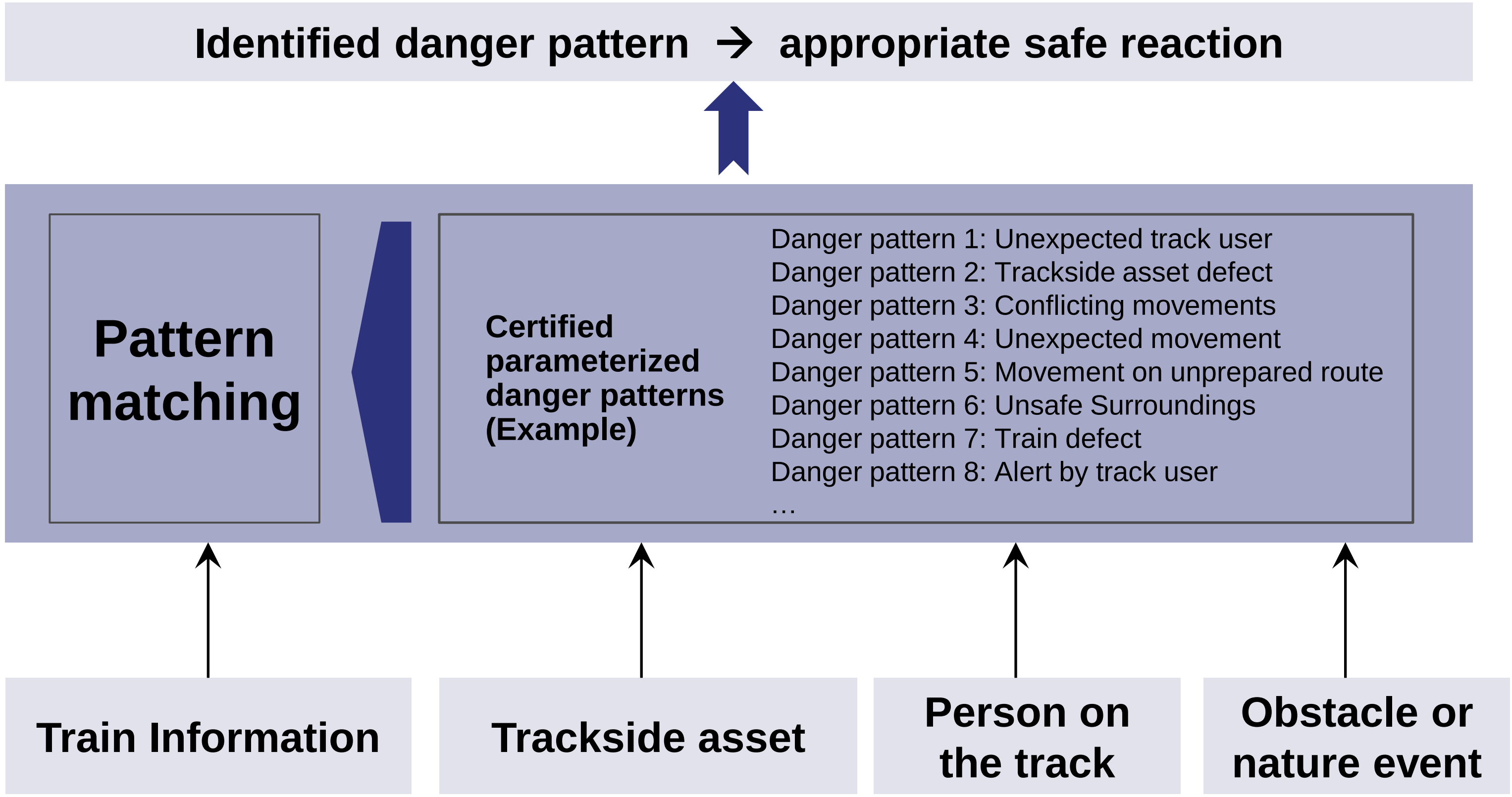
Inertial Sensors (mobile)

Trackside sensors

Rolling stock sensors

Safety Manager:

Rule based dynamic danger pattern matching



Identified danger pattern → appropriate safe reaction

Pattern matching

Certified parameterized danger patterns (Example)

Danger pattern 1: Unexpected track user
Danger pattern 2: Trackside asset defect
Danger pattern 3: Conflicting movements
Danger pattern 4: Unexpected movement
Danger pattern 5: Movement on unprepared route
Danger pattern 6: Unsafe Surroundings
Danger pattern 7: Train defect
Danger pattern 8: Alert by track user
…

Train Information

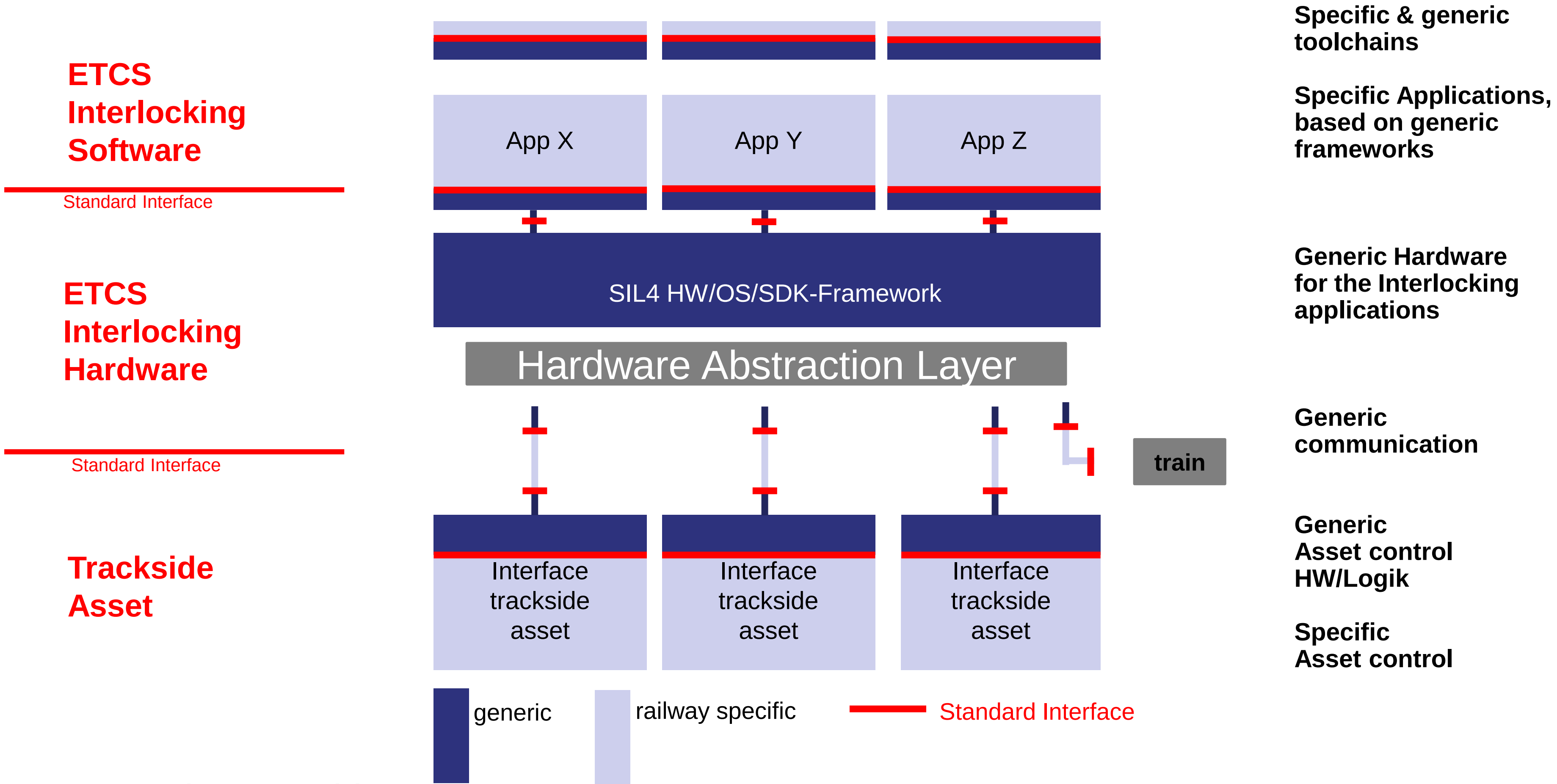
Trackside asset

Person on the track

Obstacle or nature event

HW – SW Architecture

Partitioning and standardization



ETCS Interlocking Software

Standard Interface

ETCS Interlocking Hardware

Standard Interface

Trackside Asset

App X

App Y

App Z

SIL4 HW/OS/SDK-Framework

Hardware Abstraction Layer

train

Interface trackside asset

Interface trackside asset

Interface trackside asset

Specific & generic toolchains

Specific Applications, based on generic frameworks

Generic Hardware for the Interlocking applications

Generic communication

Generic Asset control HW/Logik

Specific Asset control

generic

railway specific

Standard Interface

Separation of architecture layers

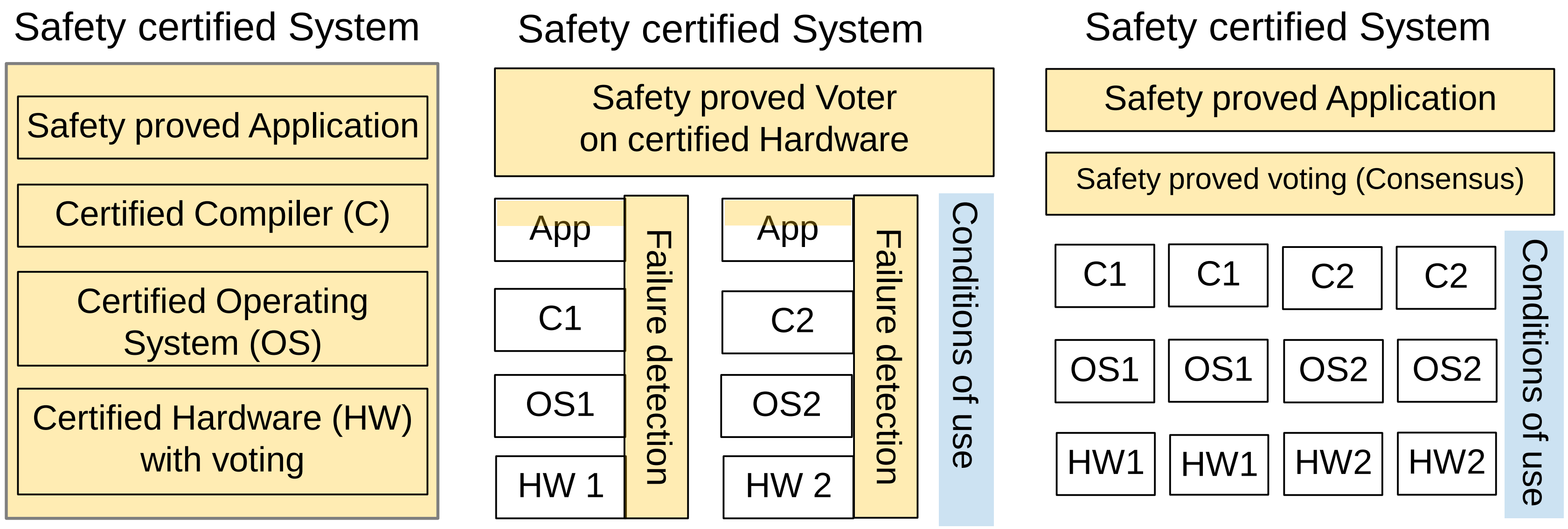
- Application and trackside asset independent of Hardware “in the middle”
- Usage of standard Interfaces

«Safe» Data Center

Data centers today:

- High availability (by redundancy) ✓
- High security (by firewall and access control) ✓
- Proven safety for certification (by voting) ✗

Several ways are possible, depending on the dissimilarity concept.
Here are three examples:



Using only safety proved/certified Hardware and Software

Using safety proved HW+SW and uncertified COTS Elements

Using safety proved SW and uncertified COTS Elements

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Inputreferate zu sicherem Rechencenter

- ESG – Matthias Spang, Andreas Kister
- Siemens Mobility GmbH – Sonja Steffens
- Thales Österreich – Wolfgang Wernhart

SBB
Innovation Day

RCDC:

The Railway Control Data Center

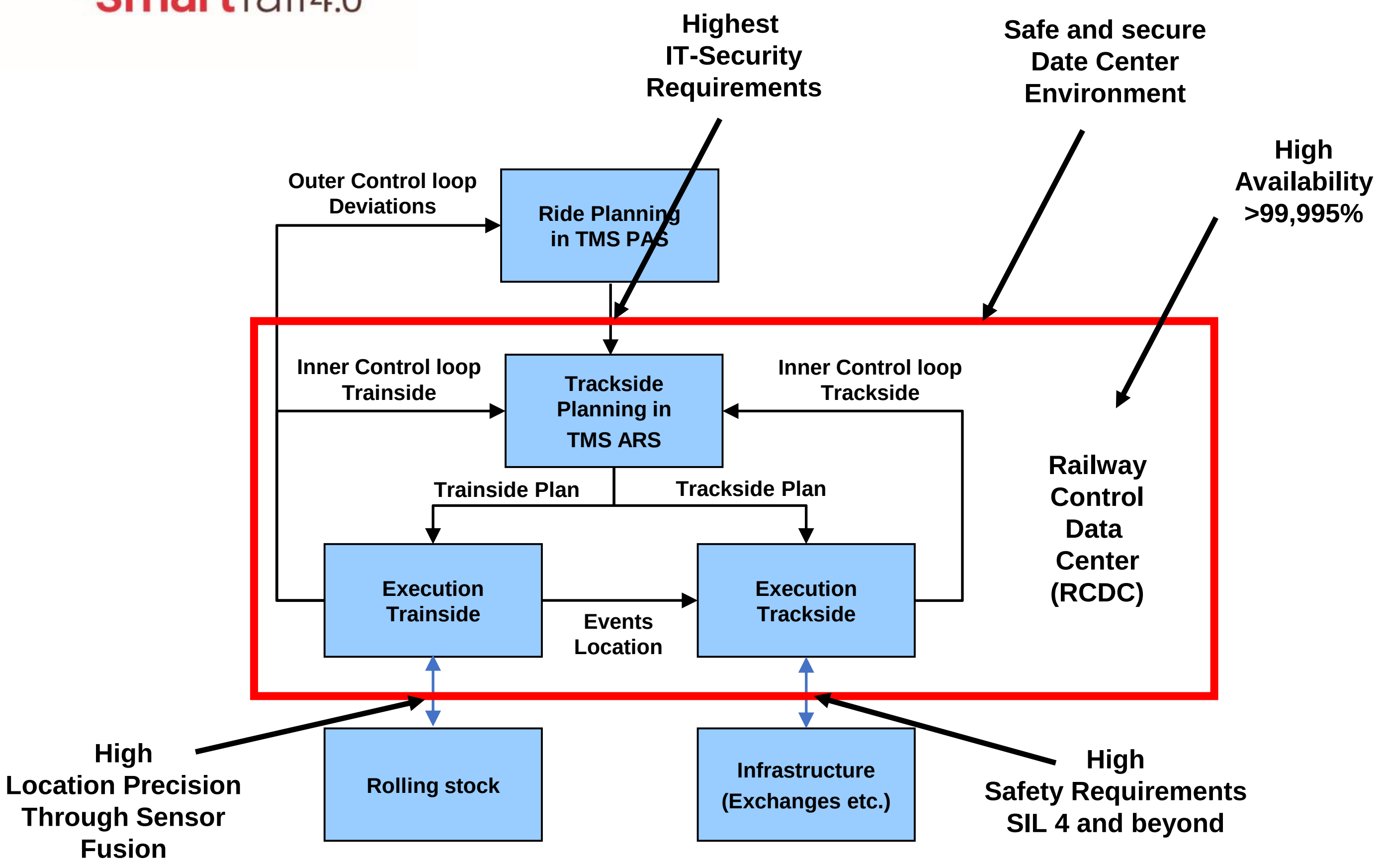
A core element of smartrail 4.0

Bern, 13.11.2018

Future Structure of Data Processing in smartrail 4.0

namely Infrastructure (simplified)

DEDICATED TO SOLUTIONS.



- The remote IT-components from all ETCS are bundled in a datacenter structure.
- Due to bundling effects the total quantity of HW is lowered.
- The data center will consist of several clusters with special capabilities like mass data processing and safety critical sections.
- All safety critical components (SIL4) are also bundled in cluster sections of the data center.
- The separation of SW and HW certification for such functionalities shall be achieved.

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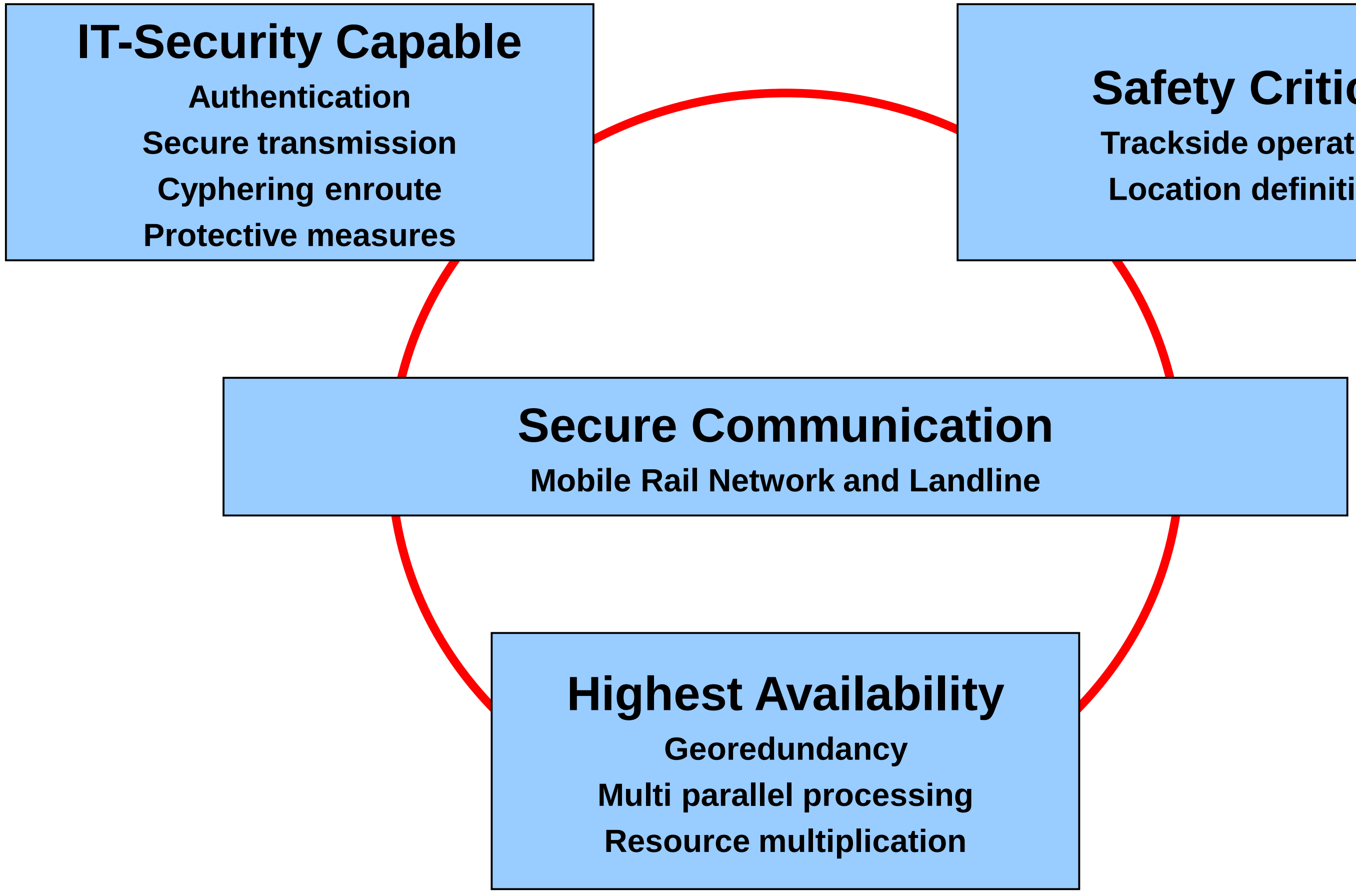
Non technical Requirements to the RCDC

The elements of the data center shall fulfill the following requirements:

- As far as possible COTS components shall be used to achieve multivendor environments to lower HW initial and replacement costs.
- Create a technical environment for a VHA-System providing an availability in excess of 99,995%.
- Any components, be it components such as disks or complete servers or controllers shall be replaceable without any interruption of operation.
- A hardware change shall not create the need for any SW change or recertification (SIL4) by using a high abstraction level for the SW creation process.
- All applications shall be virtualized on multiple clusters.
- Lifecycle costs shall be significantly lower than today.

Separation of functionalities in groups



IT-Security Capable

Authentication
Secure transmission
Cyphering enroute
Protective measures

Safety Critical

Trackside operation
Location definition

Secure Communication

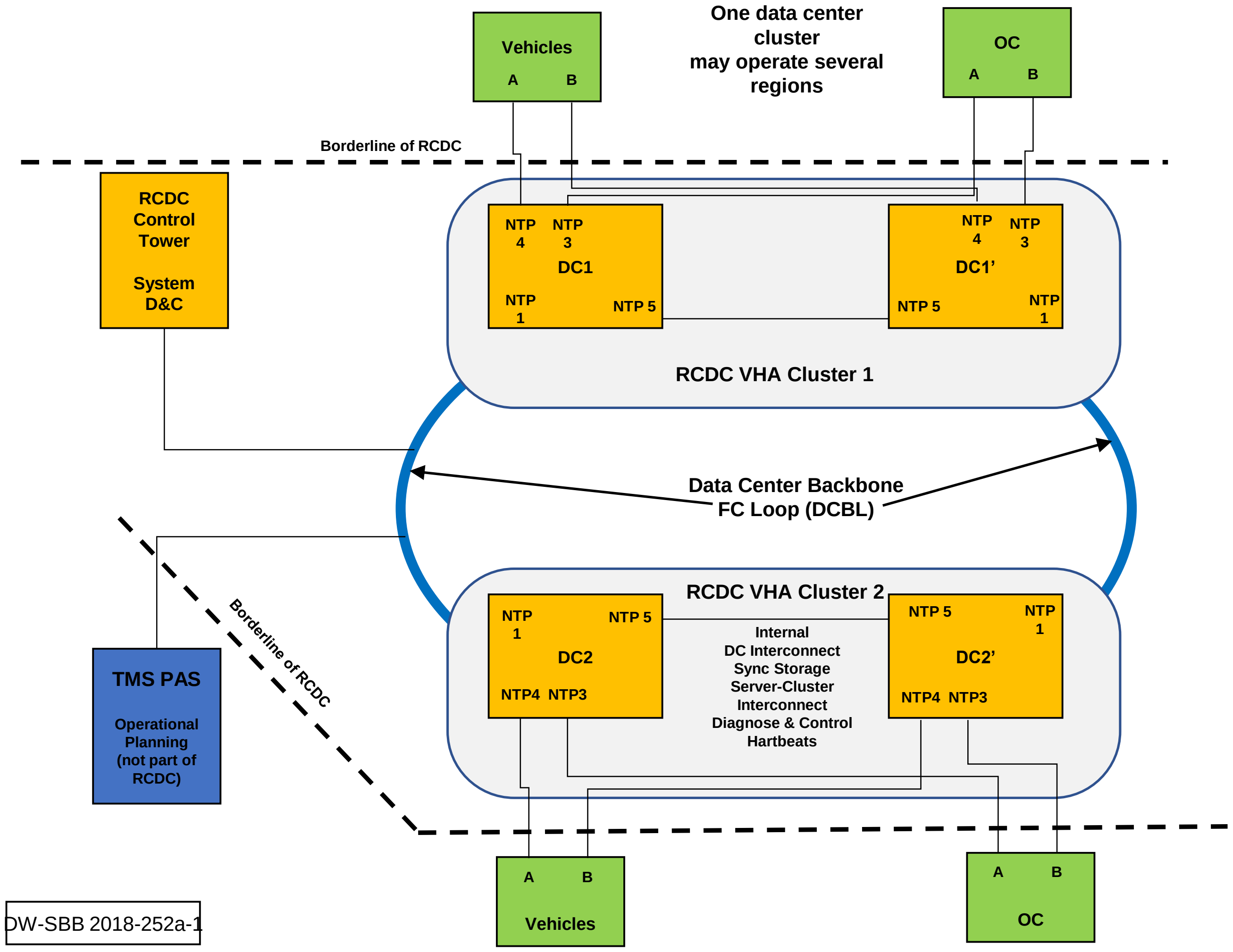
Mobile Rail Network and Landline

Highest Availability

Georedundancy
Multi parallel processing
Resource multiplication

- All functions are separated in respect to their safety and IT-security levels.
- All functions are based on VHA cluster systems with respective hard- and software.
- Safety critical functions are processed in specific cluster sections to comply with the requirements of SIL4 and “SIL4+”.

The structure of a suitable VHA- Cluster



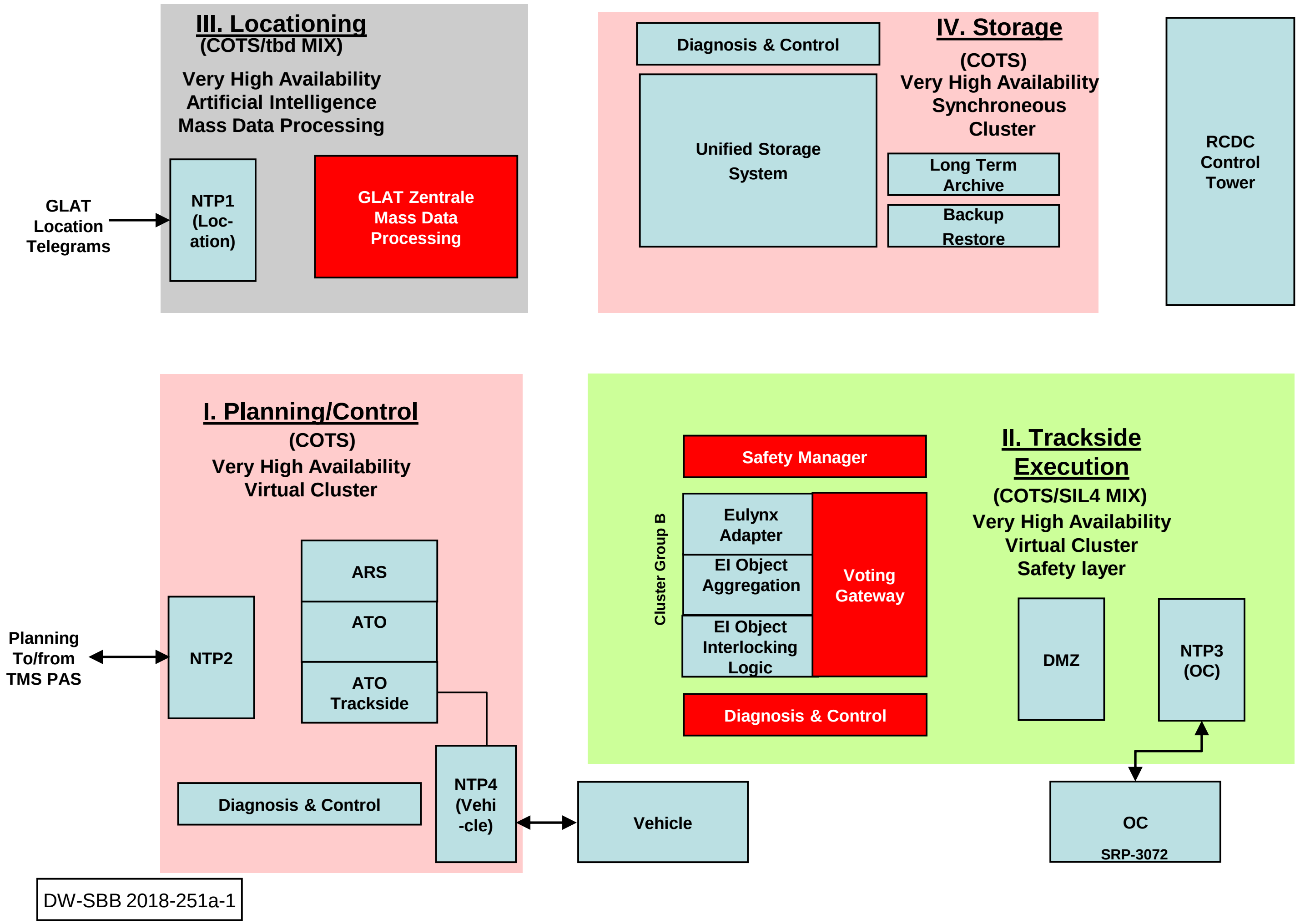
- Current assessment proposes the need for 4 Data Centers, combined to 2 georedundant clusters.

- A further separation into regions appear appropriate.

- Interconnectivity to the infrastructure is achieved also twofold with independent lines / connections.

The structure of a data center as part of a VHA Cluster

DEDICATED TO SOLUTIONS.



III. Locationing
(COTS/tbd MIX)
Very High Availability
Artificial Intelligence
Mass Data Processing

GLAT Location Telegrams

NTP1 (Loc-ation)

GLAT Zentrale Mass Data Processing

Diagnosis & Control

IV. Storage
(COTS)
Very High Availability
Synchroneous
Cluster

Unified Storage System

Long Term Archive

Backup Restore

RCDC Control Tower

I. Planning/Control
(COTS)
Very High Availability
Virtual Cluster

Planning To/from TMS PAS

NTP2

ARS

ATO

ATO Trackside

Diagnosis & Control

NTP4 (Vehi-cle)

Vehicle

Safety Manager

Cluster Group B

Eulynx Adapter

EI Object Aggregation

EI Object Interlocking Logic

Voting Gateway

Diagnosis & Control

II. Trackside Execution
(COTS/SIL4 MIX)
Very High Availability
Virtual Cluster
Safety layer

DMZ

NTP3 (OC)

OC
SRP-3072

DW-SBB 2018-251a-1

- Every data center consists of a safety critical section and a mass data section beside of the regular clusters.
- In-depth diagnosis, command and control are executed on several levels, being executed permanently.
- Operator interaction can be done by usage of the RCDC Control tower, overseeing the total network.

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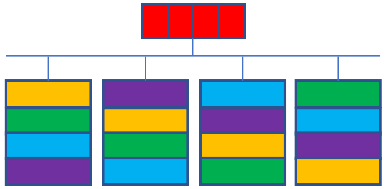
Solution Approaches to achieve SIL4 and beyond

DEDICATED TO SOLUTIONS.

We are used to embedded safety systems. But how to be safe on COTS servers?

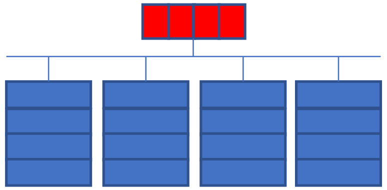
Hardware-centered approach

- Virtualized SIL4 application software
- Dissimilar COTS server types
- Servers and clusters diagnosed, voted and managed on SIL4 embedded hardware



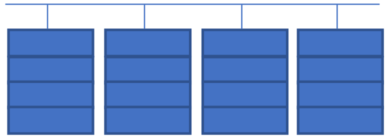
Mixed approach

- Virtualized coded SIL4 application software (inherently safe)
- COTS servers voted and managed on SIL4 embedded hardware



Software-centered approach

- Virtualized coded SIL4 application software
- Coded voting and system management software



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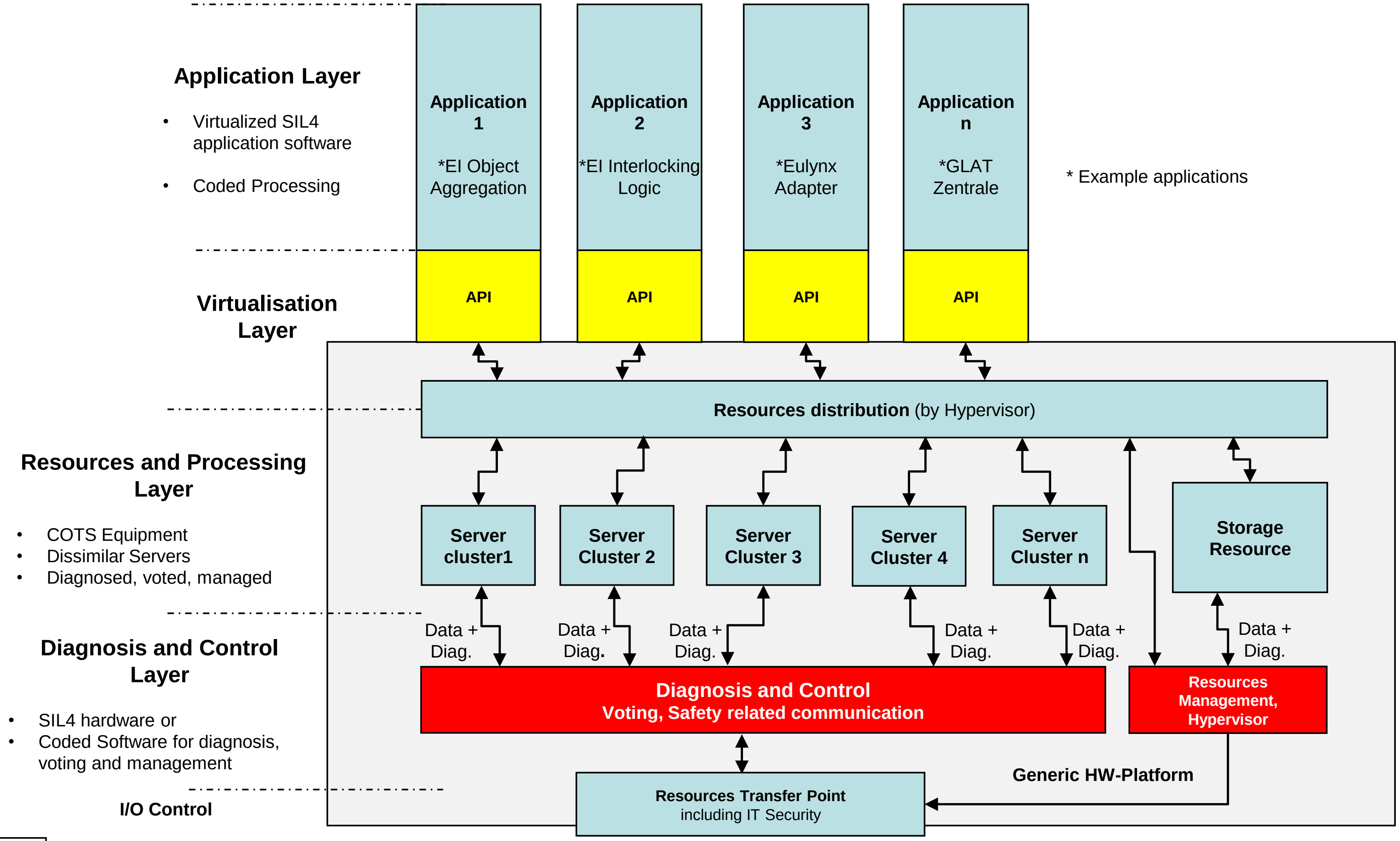


DW-SBB 2018-249a-1

SIEMENS
Ingenuity for life

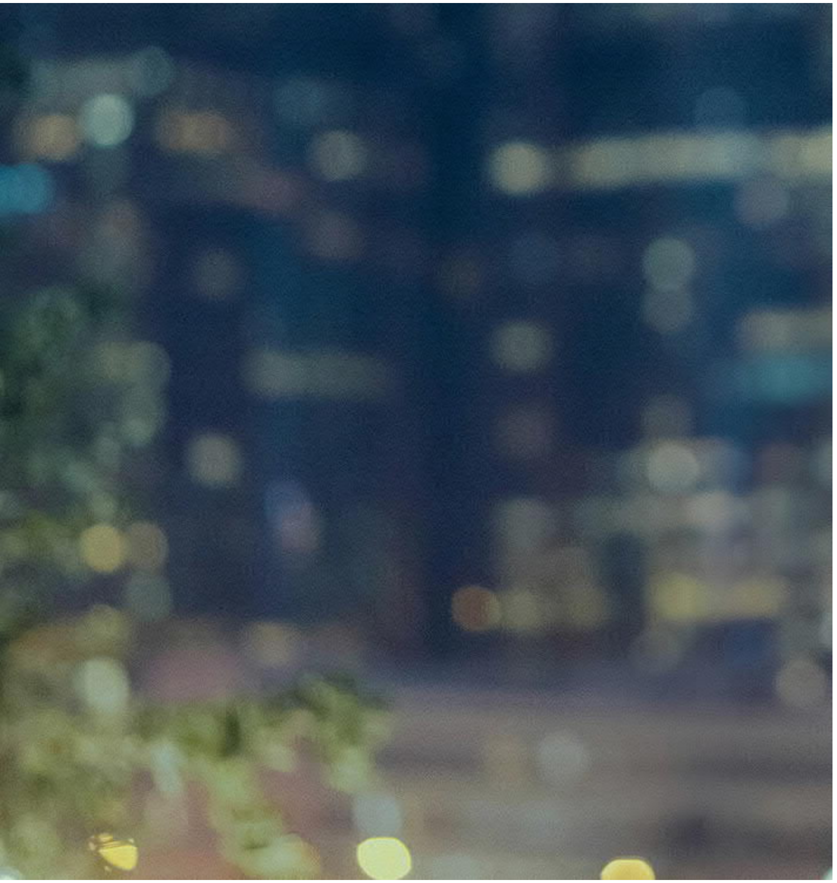
Safety @ COTS Multicore

Distributed Smart Safe System DS^3

November 2018 / Sonja Steffens Siemens Mobility GmbH

Table of content

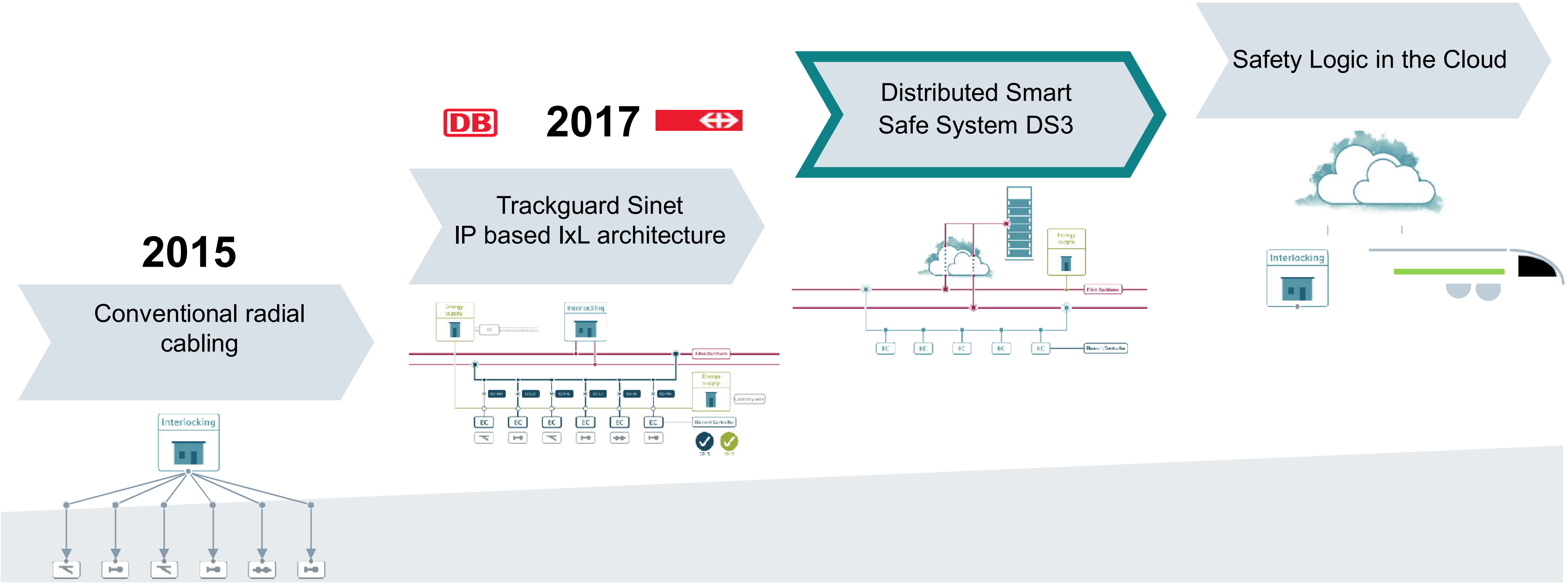
SIEMENS
Ingenuity for life



Next Generation of Automation
Intermediate Steps with Technological Change COTS Multicore

SIEMENS
Ingenuity for life

Distributed Wayside Architecture | **Next Generation of Automation**



2015

Conventional radial cabling

2017

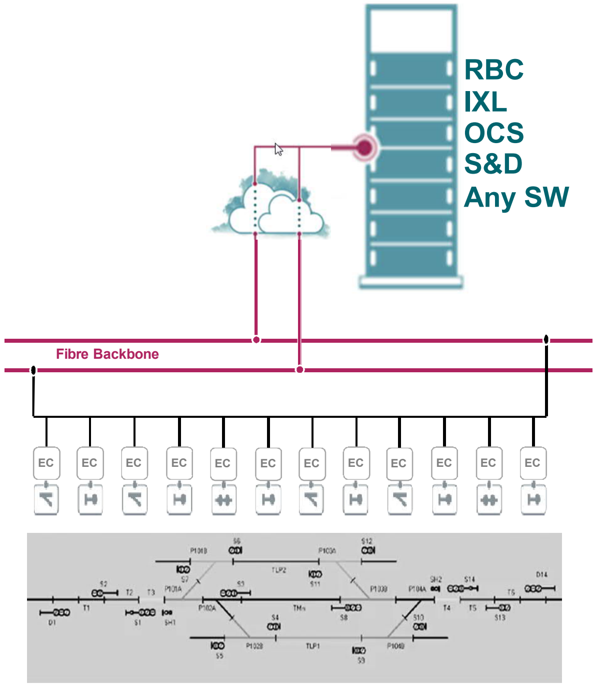
Trackguard Sinet
IP based IxL architecture

Distributed Smart
Safe System DS3

Safety Logic in the Cloud

Challenges to shape the Future of Digitalization

Safety @ COTS multicore



Basics	Communication	Enhancements	R&D Invest
! Safety & Availability	Flexible Communication	x Appl. on same COTS	Smooth Migration Legacy Appl.
! Real Time Behavior !	IT-Security	Mixed SIL on same COTS	
COTS multicore	High Perform.	Geographical Redundancy	
HW-Independency		Limitless Scalability	
		Big Data	

Rome wasn‘t built in a day ..
How we started 5 years ago

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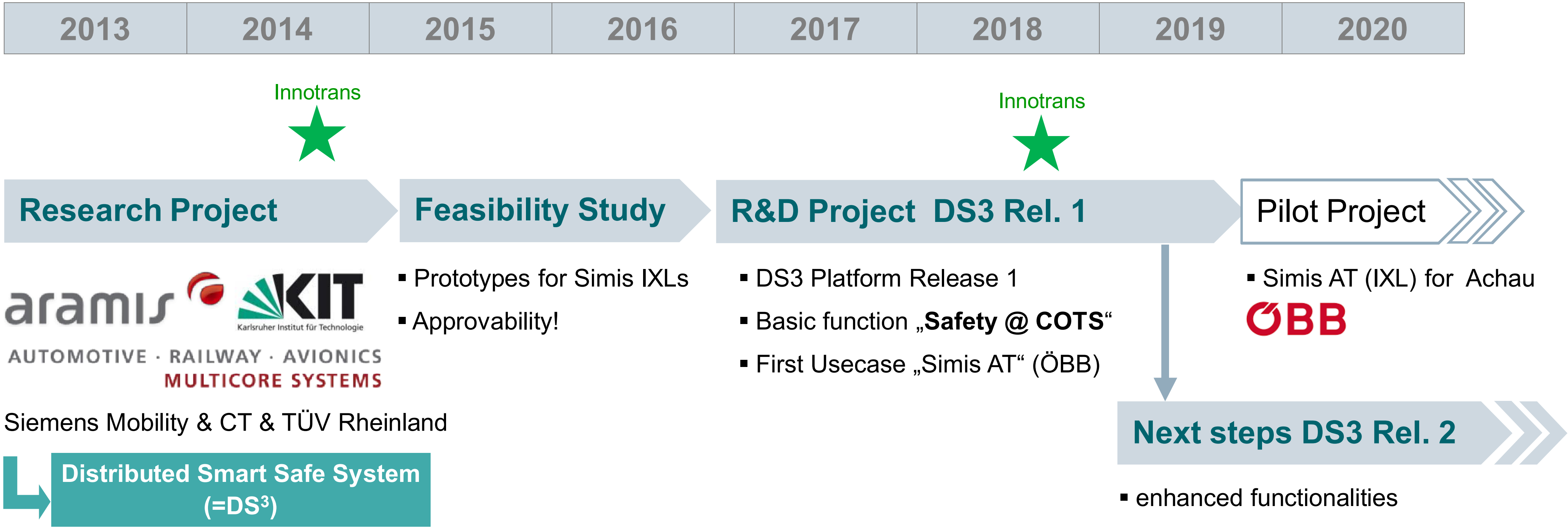
Ingenuity for life



2013	2014	2015	2016	2017	2018	2019	2020

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Research Project

aramis
KIT
Karlsruher Institut für Technologie
AUTOMOTIVE · RAILWAY · AVIONICS
MULTICORE SYSTEMS

Siemens Mobility & CT & TÜV Rheinland

Distributed Smart Safe System (=DS^3)

Feasibility Study

- Prototypes for Simis IXLs
- Approvability!

R&D Project DS3 Rel. 1

- DS3 Platform Release 1
- Basic function „**Safety @ COTS**“
- First Usecase „Simis AT“ (ÖBB)

Pilot Project

- Simis AT (IXL) for Achau

ÖBB

Next steps DS3 Rel. 2

- enhanced functionalities
- next portfolio elements

Basic Safety Principle

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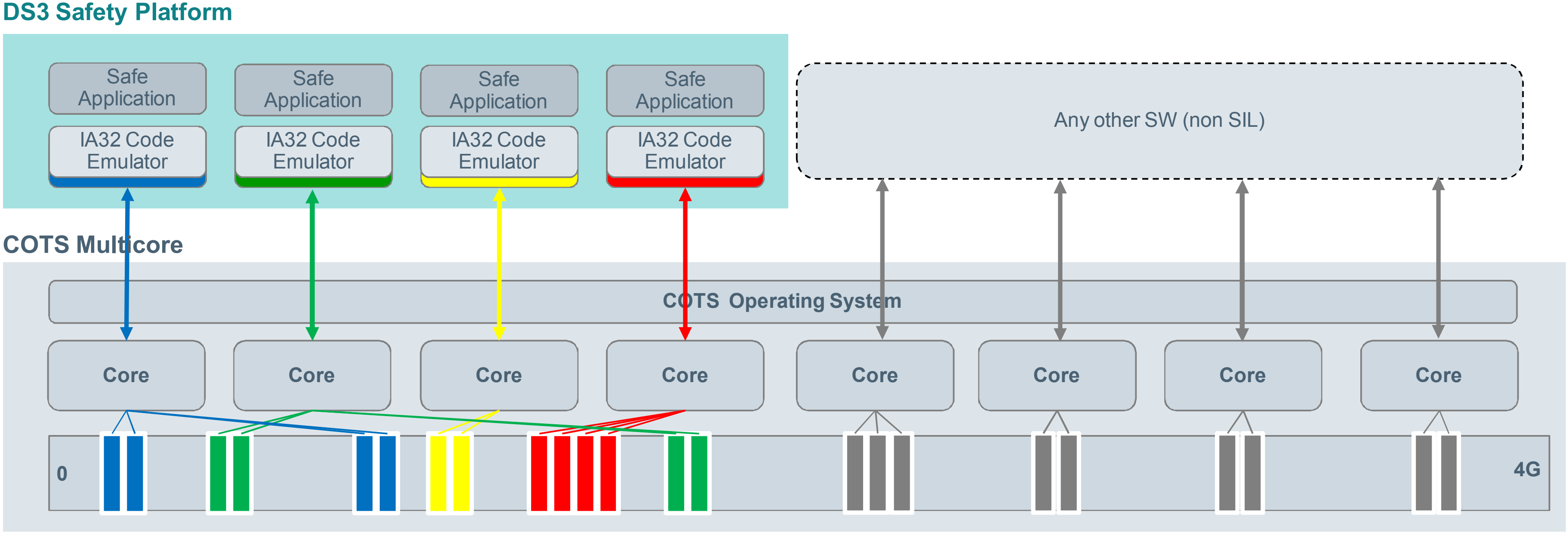

- Each safety application is running embedded in a code emulator in a own core. **-> HW independency**
- One safety application is running (unmodified) in several (>=2) diverse = colored code emulators **-> Redundancy**
- Emulator diversity (=color) by different „scattering“ for memory management (page handling) **-> Diversity**
- Core oriented encapsulation of running safe applications **-> mixed SIL possible**

& → for Safety !

Every failure leads to impact onto the memory -> manifestation by diverse memory management !

Two Variants of Safety Patterns

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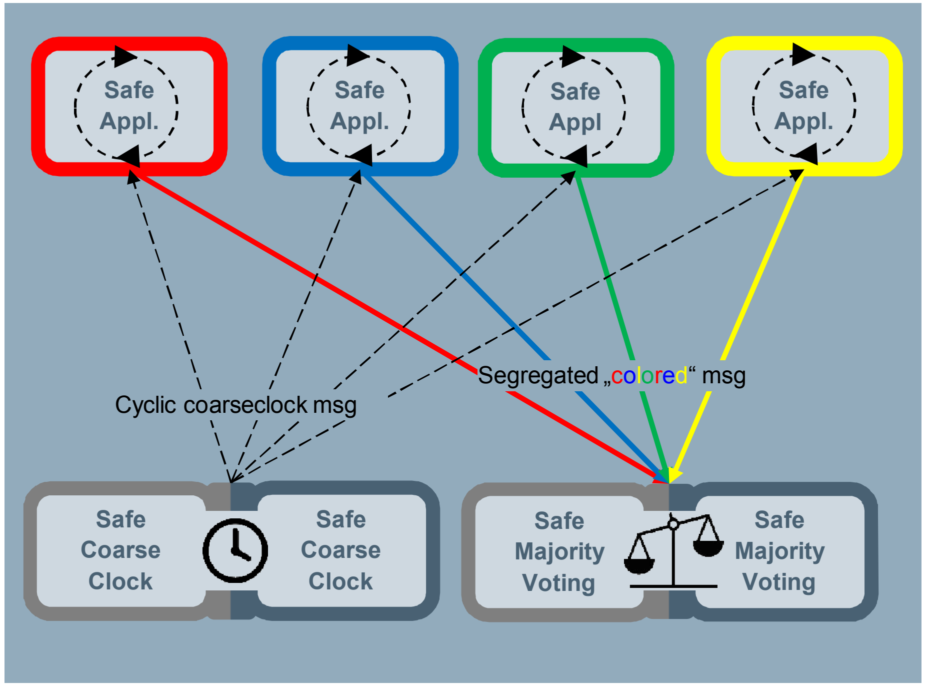

(1) Safe Application with high available memory

- Running unmodified synchronously in several colored code emulators
- Running as cyclic machine, triggered by a safe coarseclock.
- Each instance generates colored „segregated“ outputs with program + data flow digest (by code emulator)
- Segregated Outputs are compared by a safe majority voting.

Usecases:
IXL-Logic, RBC-Logic,..

(2) Safe Platform function with momentary memory

- Running unmodified in 2 colored code emulators with inter-channel-dependency for safety = „Twin Pattern“

Usecases:
Safe CoarseClock, Safe Voting, Protocol Gateways,..

Assessment Inspectation Certificate available:
„DS3 is a safety platform up to SIL4 which can be used on any kind of commercial-of-the-shelf components“

Safe Message Passing (SaMP)
EN50159 Safe Communication

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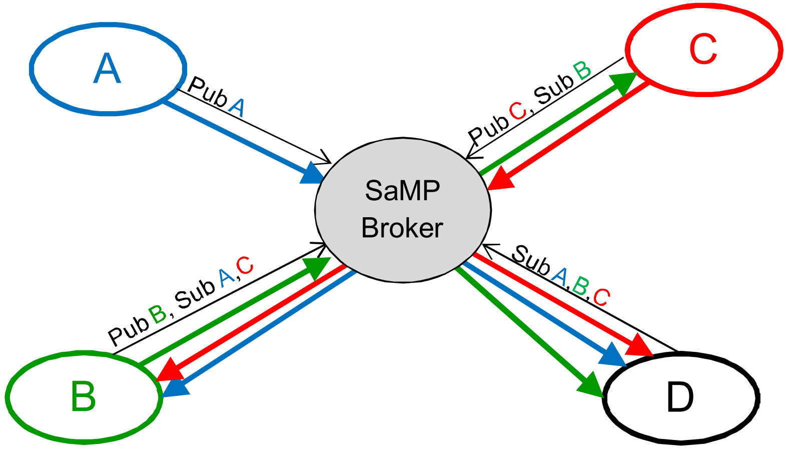

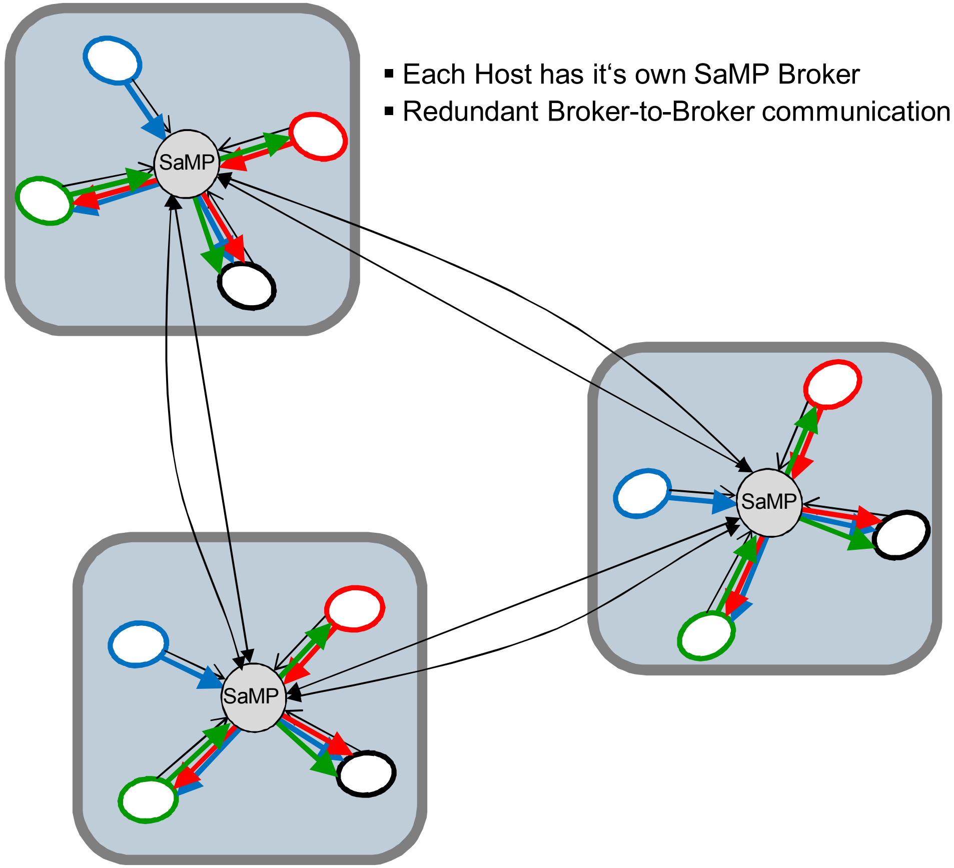

- Each Host has it's own SaMP Broker
- Redundant Broker-to-Broker communication

- **Highest flexibility** by publish-/subscribe principle (instead of „peer-to-peer“ like e.g. RaSTA)
- **Safety by communication** protocol XDM (authentication within Safetyheader)
  SaMP Broker without safety relevance

Flexible Solution for Communication

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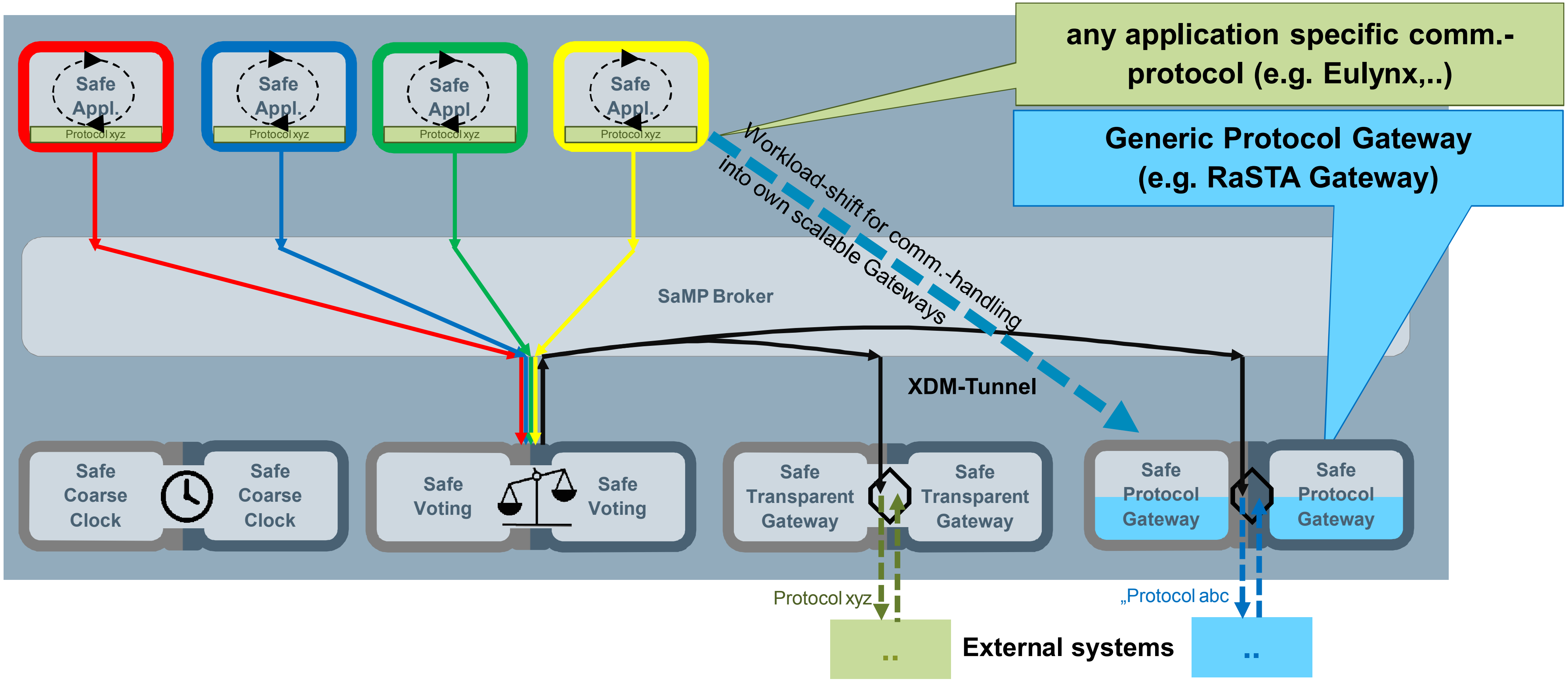

Maximal Flexibility in COTS multicore usage

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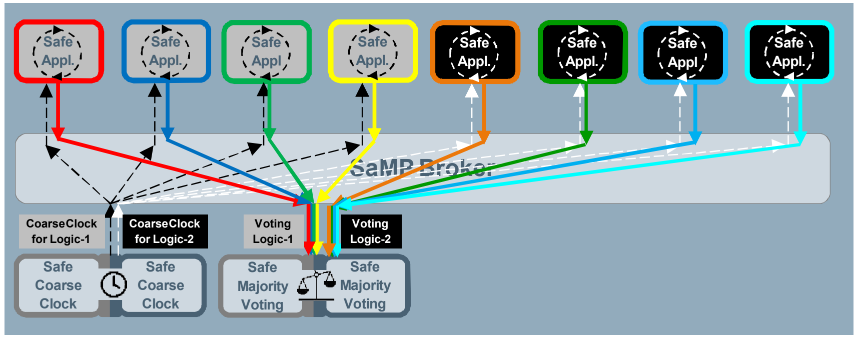
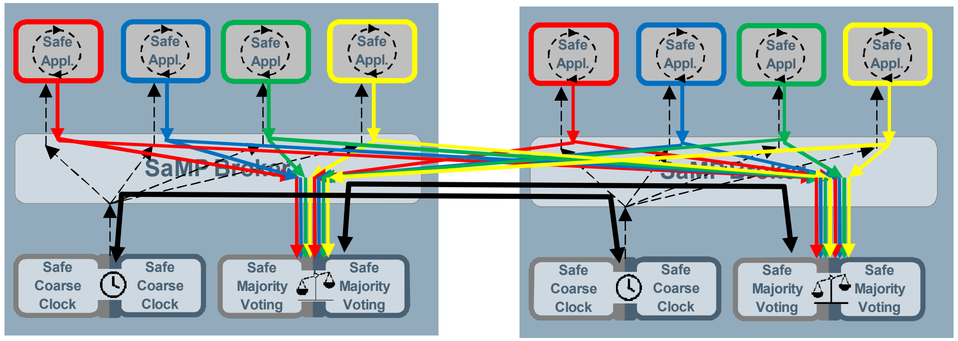
2 Applications running in each 4 redundant channels on 1 Host



- Application specific CoarseClock
- Application wise Voting

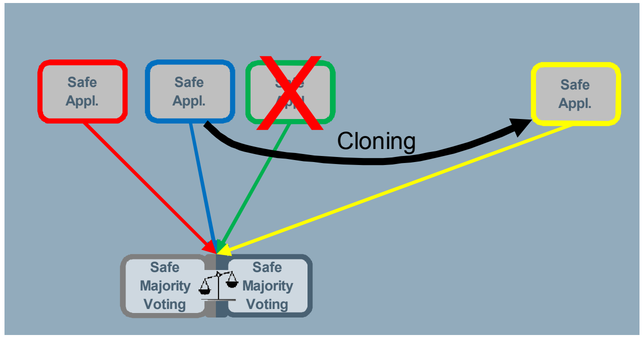
-> Integration of several Applications on same COTS

1 Application running in 8 redundant channels on 2 Hosts



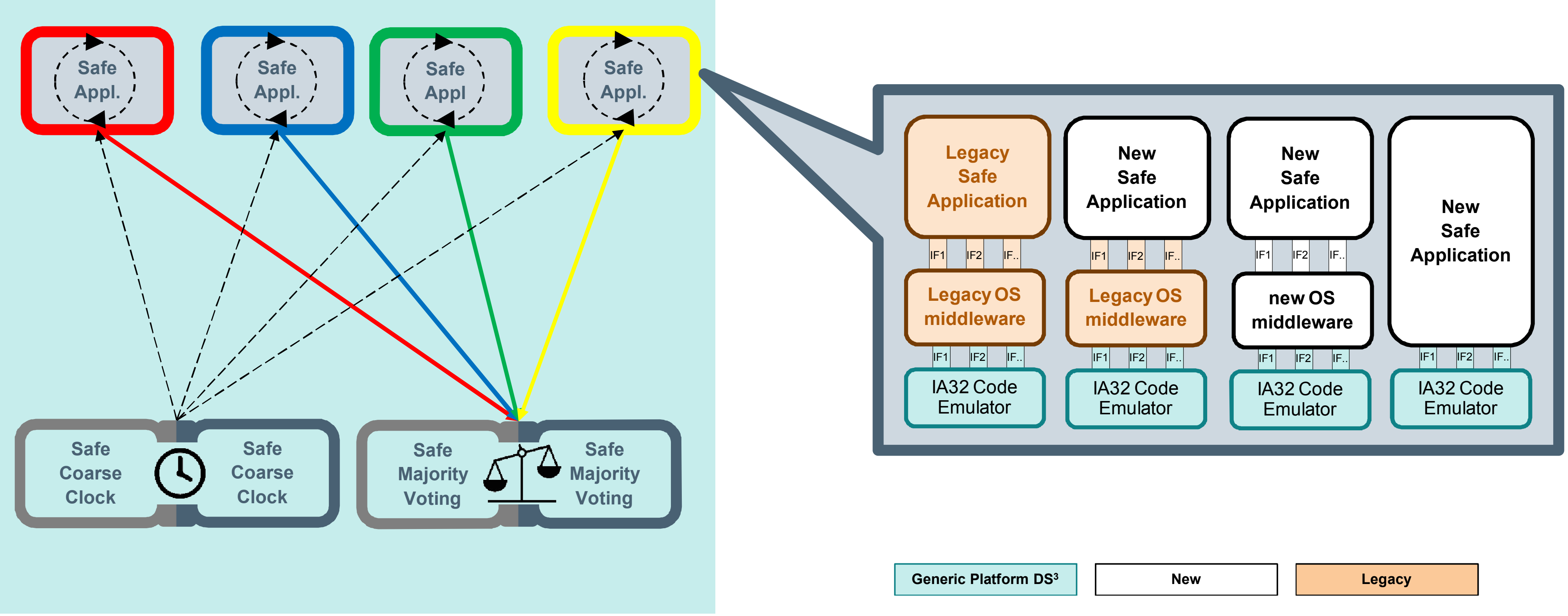
- Crossover Voting of all channels with Voter / Clock synchronization

Clone Concept



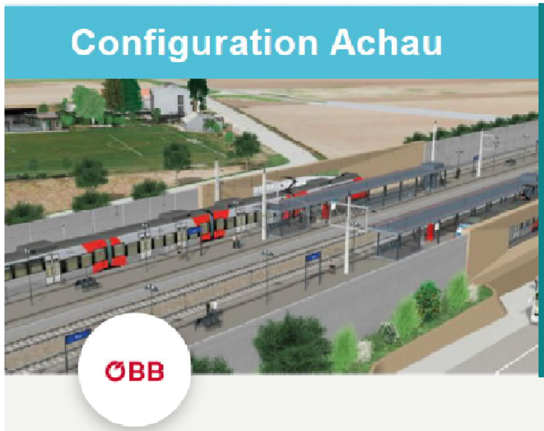
- „Clone Concept“ for highest availability and geographical redundancy

SW Layers within the Safe Application

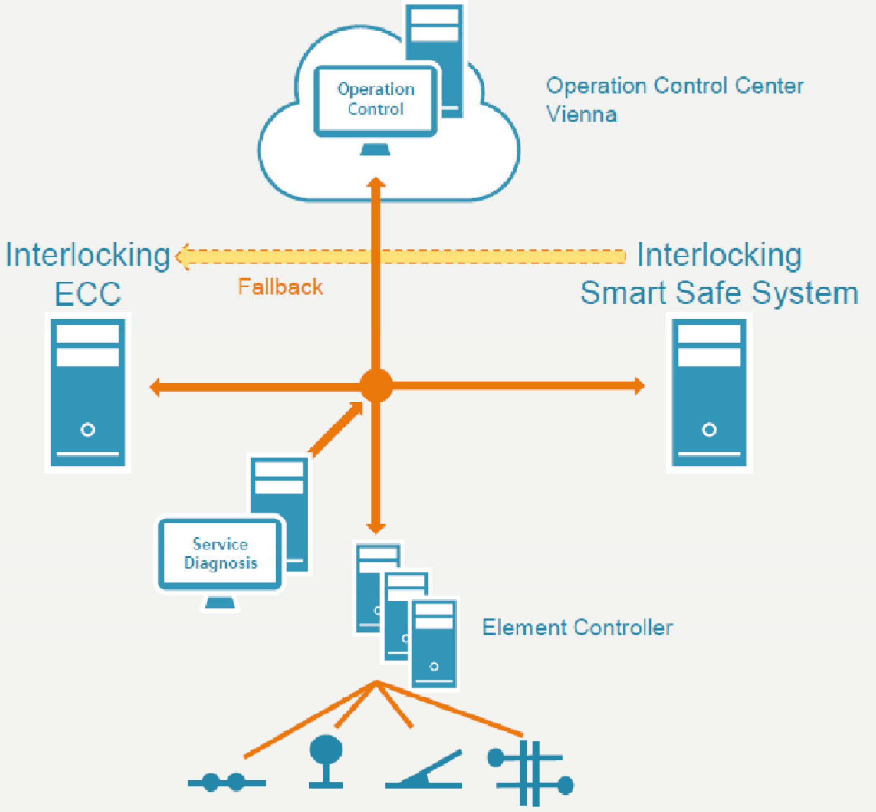


Configuration Pilot Project (IXL Achau, ÖBB)

Configuration Achau



Innotrans 2018



System Data:

12	Point Machines
16	Main Signals
04	Single Shunt Signals
01	Level Crossing
01	X25 Connection to BFZ (redundant)

- Start operational tests without safety responsibility: December 2018
- Operation with full safety responsibility: August 2019
- Fallback: existing electronic interlocking

**Visualization: ÖBB/Geoconsult*

Outlook into the Future: Stepwise Approach

First Step until 2019

<u>Minimal basic</u> Platform Functionality:

- Safety @ COTS Multicore
- Local Redundancy
- OS Middleware for Pilot Product „Simis AT“ (IXL for ÖBB)

IXL
Simis AT

Until 2021

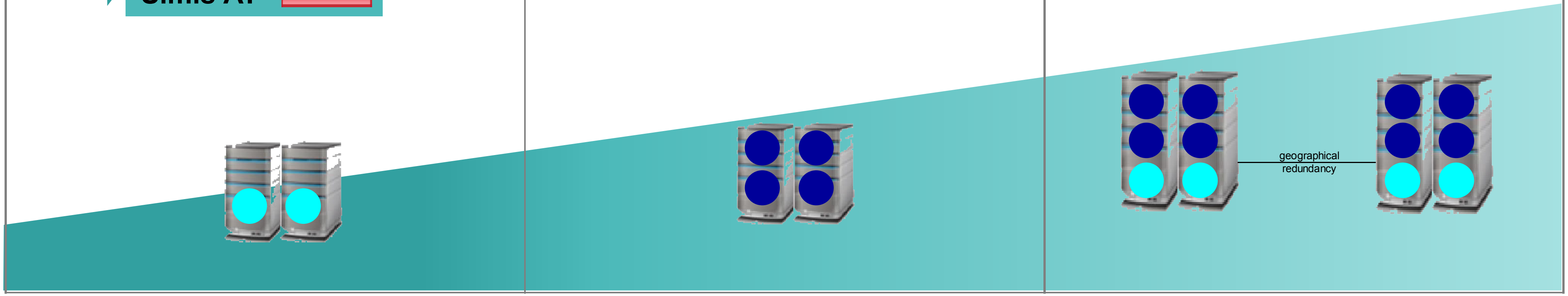
<u>Extended</u> Platform Functionality

- IT-security for DS3 external Network
- Protocol Gateways with Multiplexing Functionality (usecase „Communication Server“)
- OS Middleware for further Legacy Applications

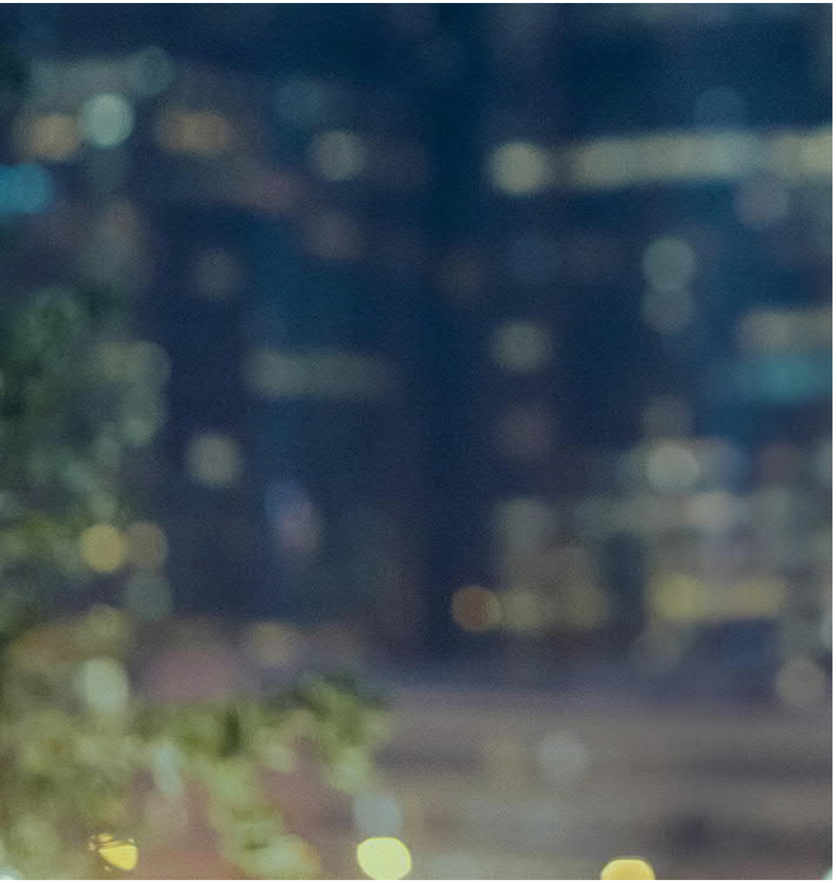
Later on

<u>Further enhancements:</u>

- Geographical Redundancy
- IT-Security within DS3 Area
- Remote registry for Installation and Software Maintenance
- New Applications @ DS3
- Safety @ mobile / tablet ?



Contact



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Main Line Signalling

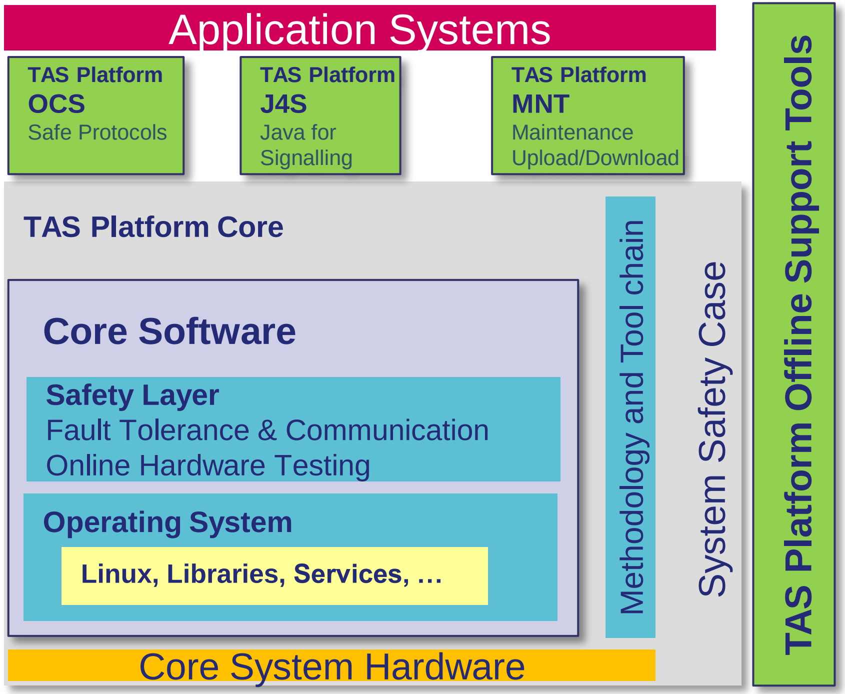
Execution Platform

W. WERNHART, NOV. 2018

www.thalesgroup.com

Overview of TAS Platform

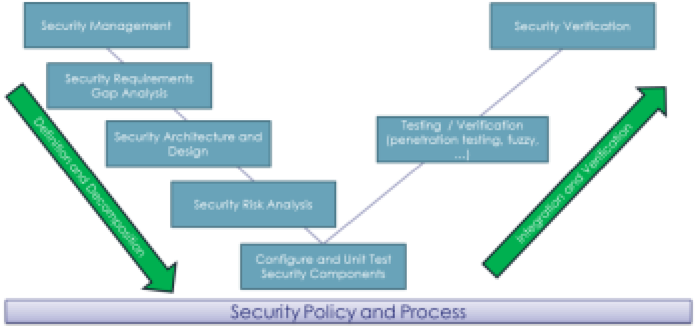
- Vital HW & SW Platform
- Common for Thales safety critical applications (GTS)
- Enables hardware independent applications
- Safety approval according to CENELEC 50129 SIL 4
- Based on COTS hardware / operating system
- Support for 25 years of application systems (with changing underlying hardware and software)
- Security functions supplied with COTS components (OS and libraries)


Application Systems
TAS Platform OCS Safe Protocols
TAS Platform J4S Java for Signalling
TAS Platform MNT Maintenance Upload/Download
TAS Platform Core
Core Software
Safety Layer
Fault Tolerance & Communication
Online Hardware Testing
Operating System
Linux, Libraries, Services, …
Methodology and Tool chain
System Safety Case
TAS Platform Offline Support Tools
Core System Hardware

THALES OPEN

Security enabled by TAS Platform

- Common Vulnerabilities and Exposures (CVE) Mgt.
- OS hardening done, customer guideline available
- Full traceability, reqs IEC 62443-4-2 to test cases
- Security Application Conditions for customer
- Security Management Report


Security Management
Security Requirements Gap Analysis
Security Architecture and Design
Security Risk Analysis
Configure and Unit Test Security Components
Testing / Verification (penetration testing, fuzzy, ...)
Security Verification
Definition and Decomposition
Integration and Verification
Security Policy and Process

in work…

- Fully compliant to IEC 62443
- Secure Boot, openSCAP, TPM support
- Participation in **CENELEC TC9X/WG26 „IT Security“**

„Security Case“ is referred in the „Safety Case“.
A statement about safety and security conformance is given by the safety assurance manager.

Extended Software Features of TAS Platform

Versatile Redundancy Architecture

- e.g. 1oo1, 2oo2, 2oo3, 2x2oo2

Mixed Criticality

- Non-SIL and SIL4 applications on one HW configuration
- Multi-Application-Support

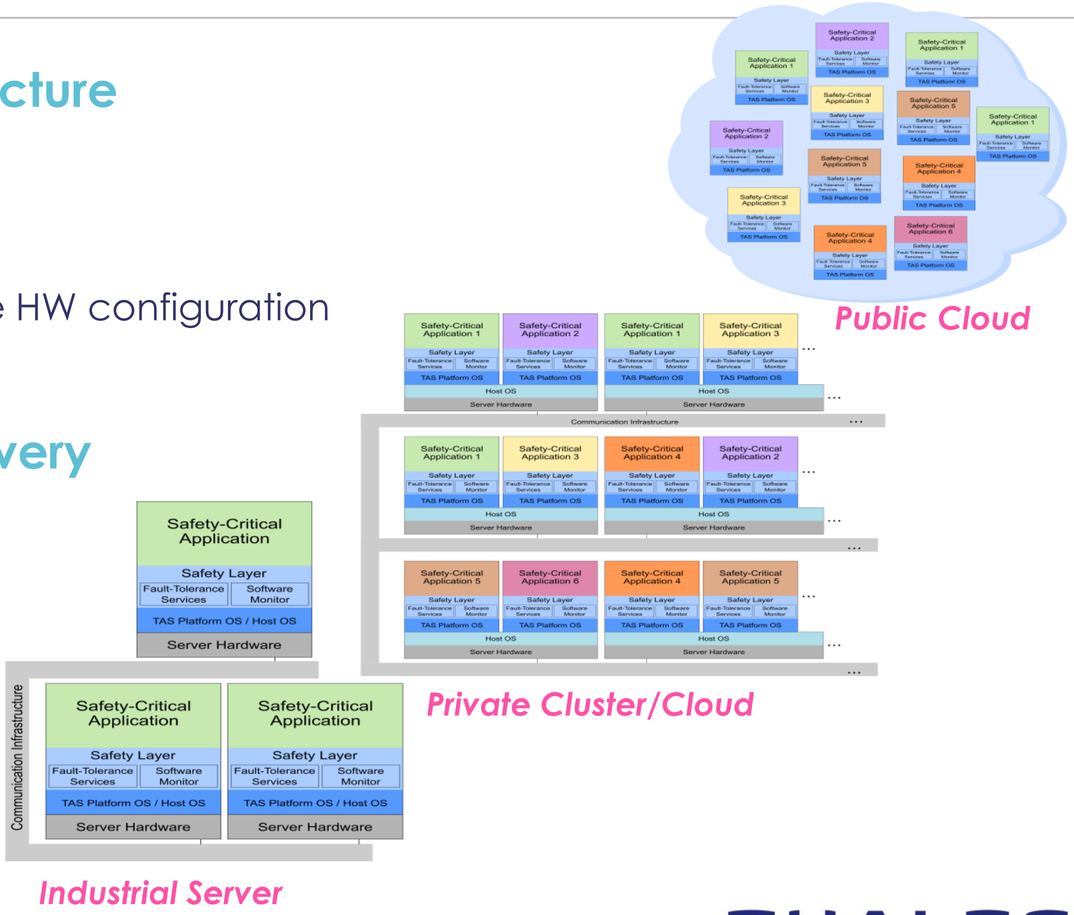
Transparent Application Recovery

Maintenance

- SW up/download
- Diagnosis (e.g. SNMP, …)

Toolchain Support

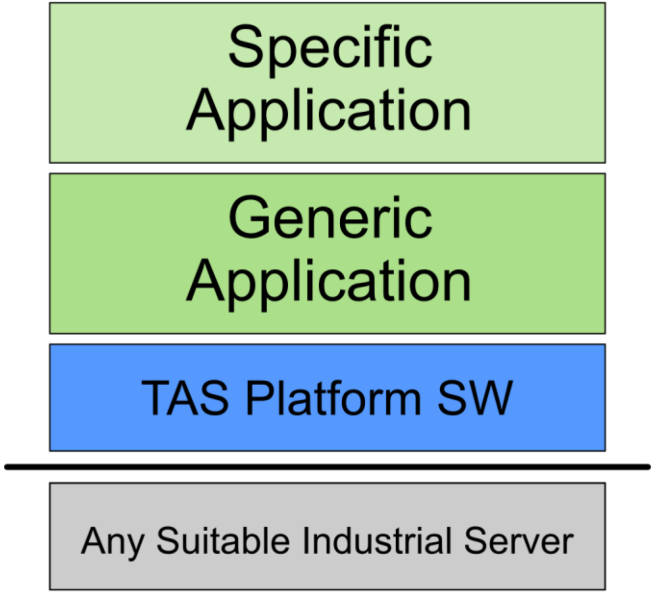
- validated compilers, build, image generation on Ubuntu environment


Safety-Critical Application
Safety Layer
Fault-Tolerance Services
Software Monitor
TAS Platform OS / Host OS
Server Hardware
Communication Infrastructure
Safety-Critical Application 1
Safety-Critical Application 2
Safety-Critical Application 3
Safety-Critical Application 4
Safety-Critical Application 5
Safety-Critical Application 6
TAS Platform OS
Host OS
…
Public Cloud
Private Cluster/Cloud
Industrial Server

Hardware Independent Certification with TAS-Plf

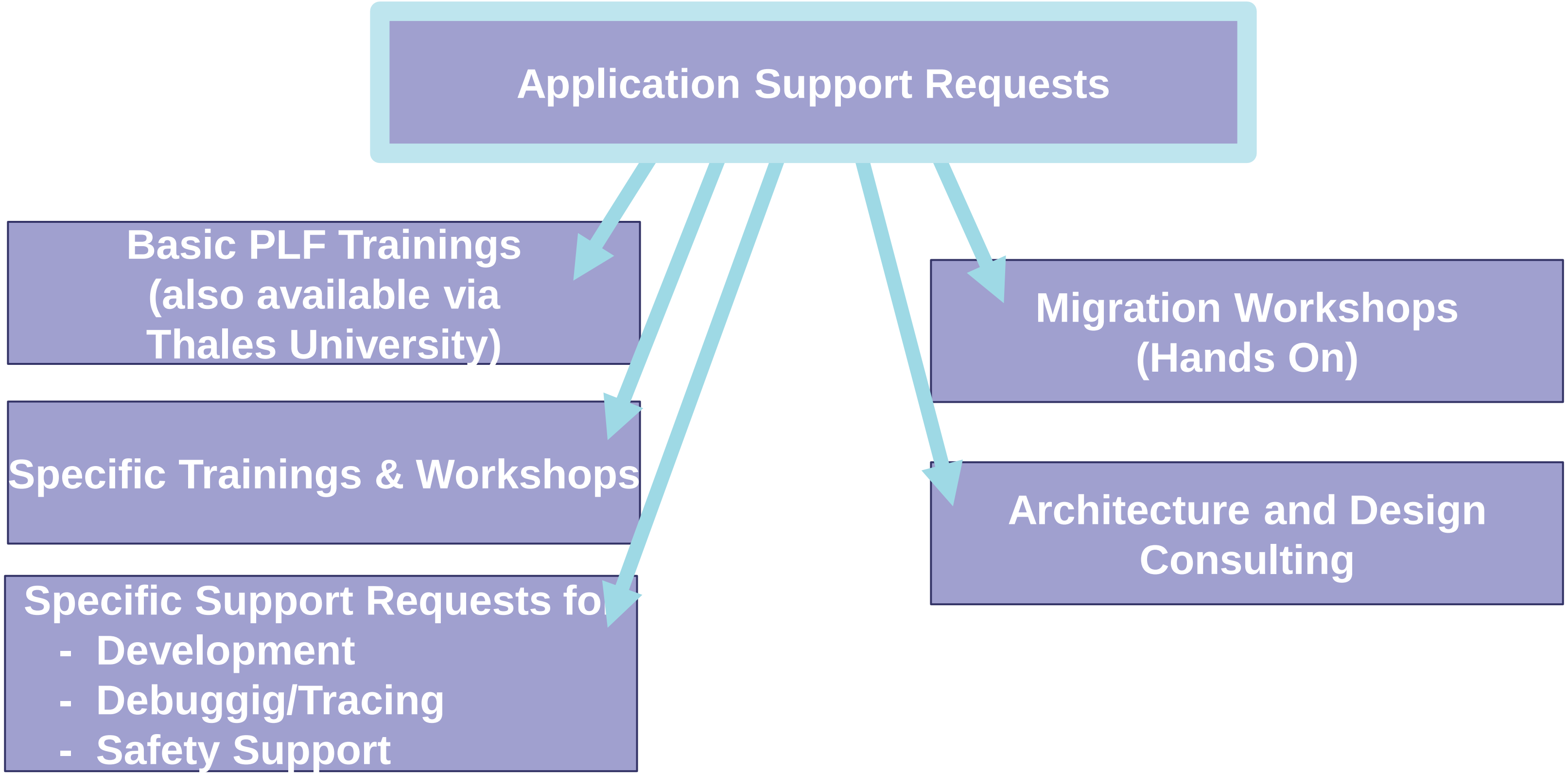
- ~~Certify TAS Platform HW~~

  Any suitable industrial server
- Certify TAS Platform SW
- Certify Generic Application
- Certify Specific Application
- …



Open for „3rd party“ products, „Secured by Thales“!

TAS Platform Application Support & Trainings



Application Support Requests

Basic PLF Trainings (also available via Thales University)

Specific Trainings & Workshops

Specific Support Requests for

- Development
- Debuggig/Tracing
- Safety Support

Migration Workshops (Hands On)

Architecture and Design Consulting