



# VIRTUAL CERTIFICATION

## Simulation Framework and Train Virtualisation

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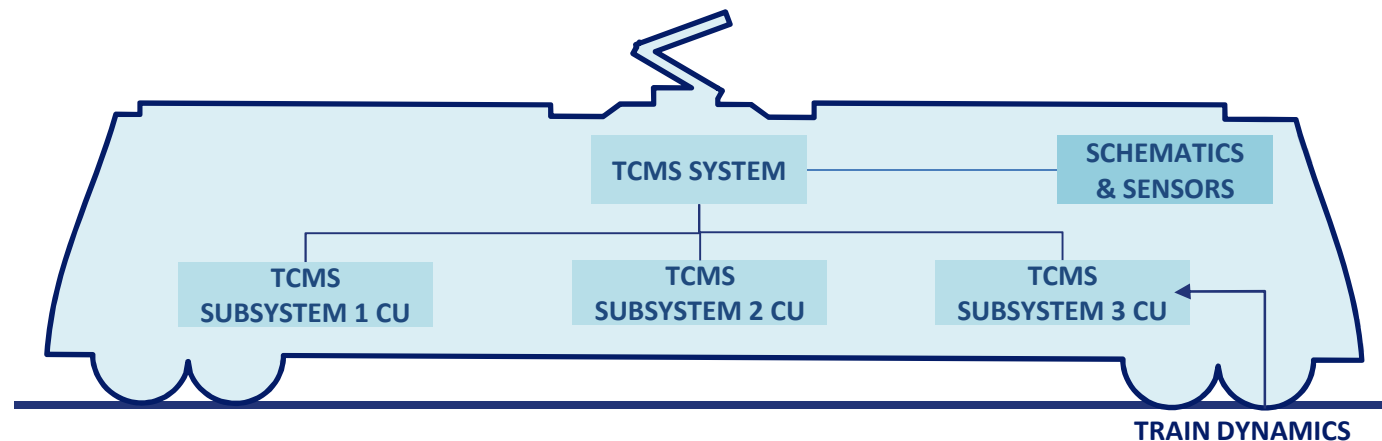
**Safe4RAIL – SAFE architecture for Robust distributed Application Integration in rolling stock (730830)**

**CONNECTA – CONTRIBUTING TO SHIFT2RAIL'S NEXT GENERATION OF HIGH CAPABLE AND SAFE TCMS AND BRAKES (730539)**

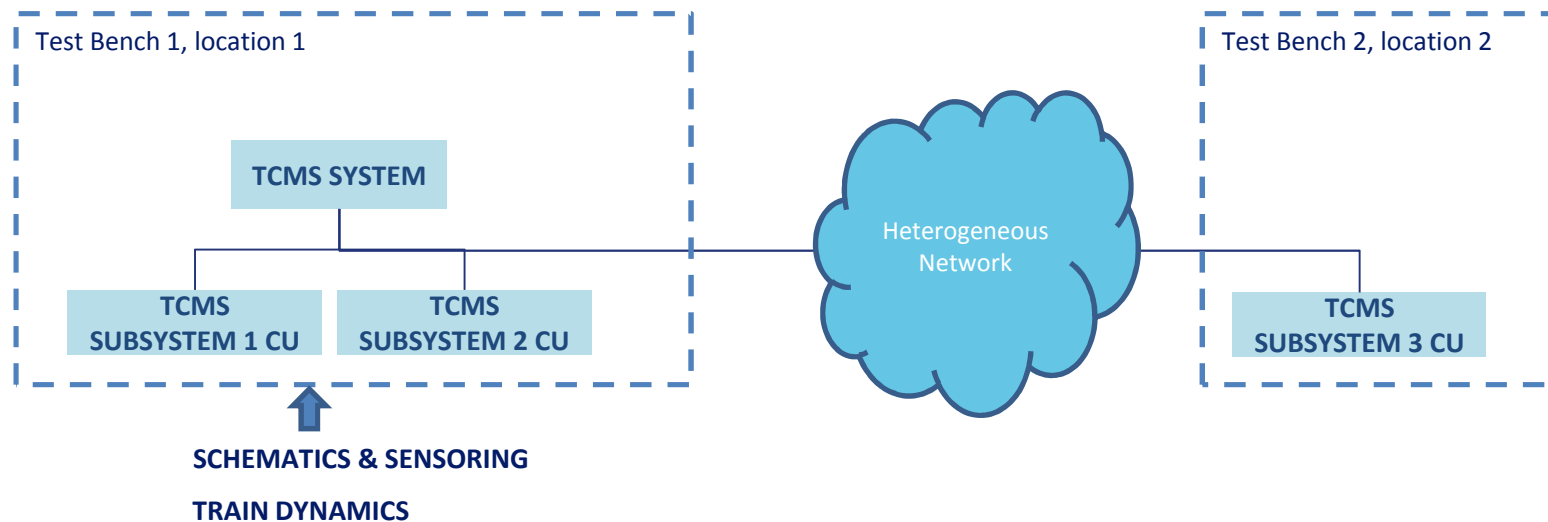
139

# What is VIRTUAL CERTIFICATION?

- It is the VALIDATION/CERTIFICATION of a TCMS SYSTEM and its subsystems in a lab environment with local/distributed virtual/real devices.



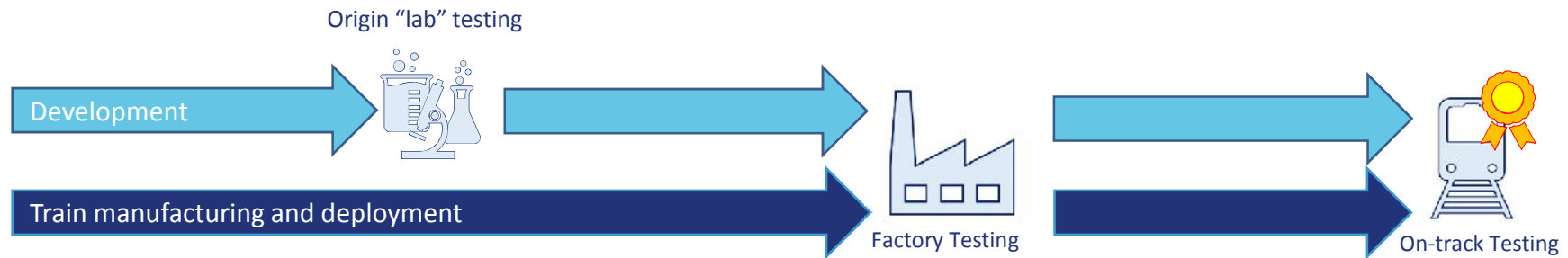
# What is VIRTUAL CERTIFICATION?





# Why VIRTUAL CERTIFICATION?

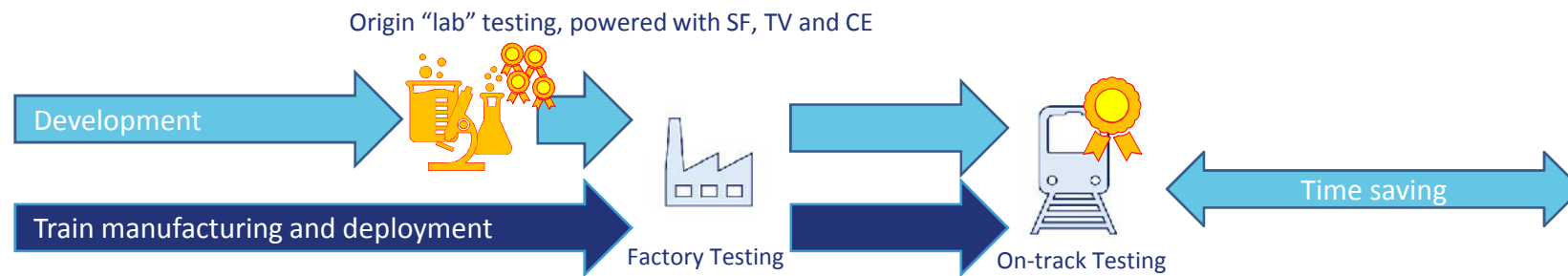
Current state





# Why VIRTUAL CERTIFICATION?

Future state



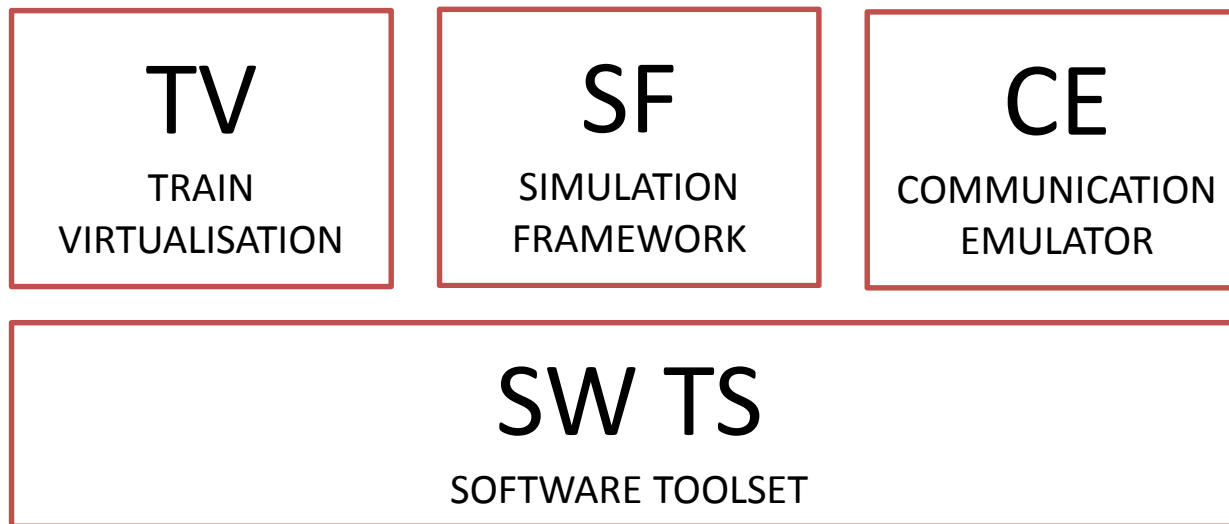


# Why VIRTUAL CERTIFICATION?

Today	With VIRTUAL CERTIFICATION
TCMS system integration test with its subsystem are done with the real system and subsystems.	TCMS system integration with its subsystems will be done in a lab environment with some real devices and some simulated devices. The devices will be located locally or remotely.
TCMS system and subsystem integration with the train is done with the real train in track.	TCMS system and subsystem integration with the train will be done in a lab environment with simulated train environment information: schematics, wiring, train dynamics, etc.
Certification of the train is done with the real train in track	Partial or complete certification of a train will be done in a lab with simulated and distributed devices, simulated environment information.

# VIRTUAL CERTIFICATION in detail

- VIRTUAL CERTIFICATION BUILDING BLOCKS





# VIRTUAL CERTIFICATION in detail

	TV TRAIN VIRTUALISATION	SF SIMULATION FRAMEWORK	CE COMMUNICATION EMULATOR	SW TS SOFTWARE TOOLSET
High Level Requirements	CTA 1	CTA 1	CTA 1	CTA 1
Low Level Requirements Arch&Desing	CTA 1	CTA 1	S4R	CTA 1
Implementation	CTA 1	CTA 2	S4R	CTA 1

Safe4RAIL – SAFE architecture for Robust distributed Application Integration in roLling stock (730830)

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# SIMULATION FRAMEWORK



- SF (SIMULATION FRAMEWORK)

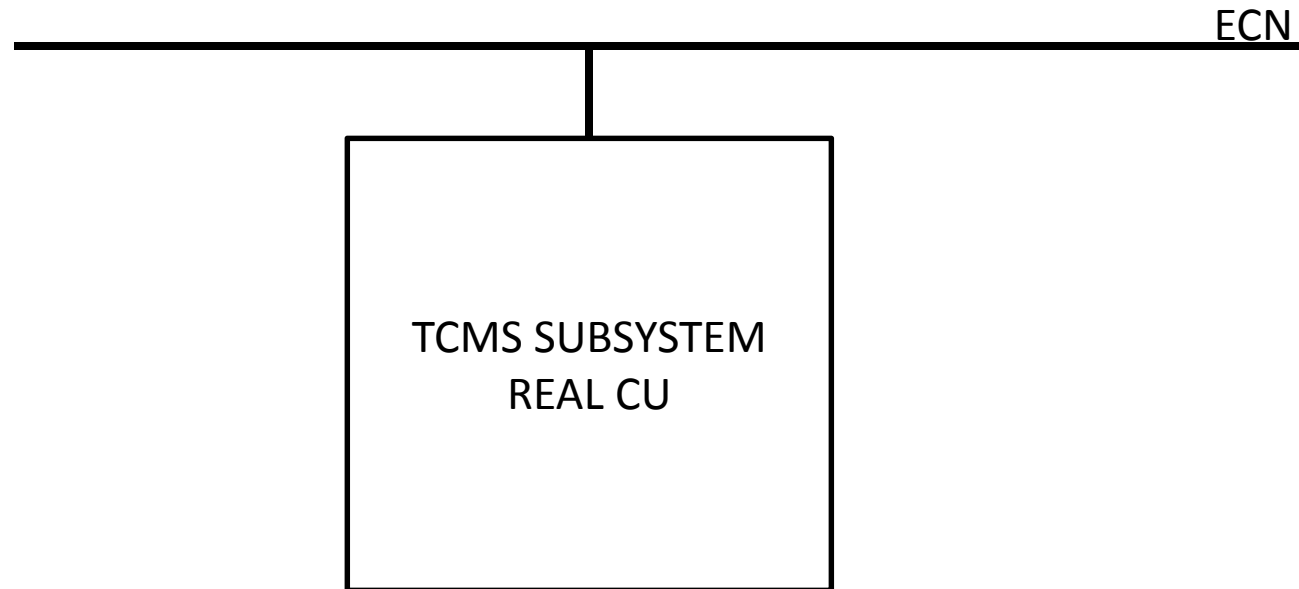
- SW MODULE FOR THE INTEGRATION OF:

- REAL AND SIMULATED END DEVICES
- TRAIN ELECTROMECHANIC SIMULATIONS (TRAIN DYNAMICS, SCHEMATICS)
- MONITORING AND CONTROL FUNCTIONS OF THE SW TS



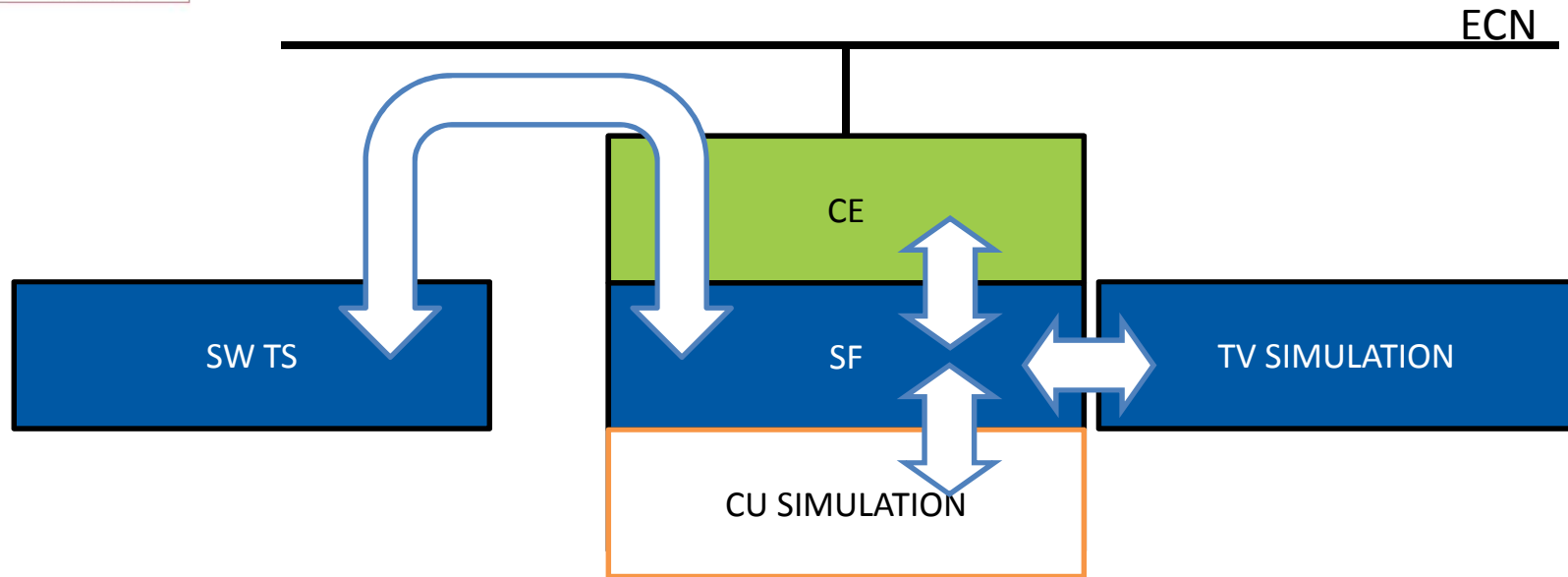


# SIMULATION FRAMEWORK





# SIMULATION FRAMEWORK



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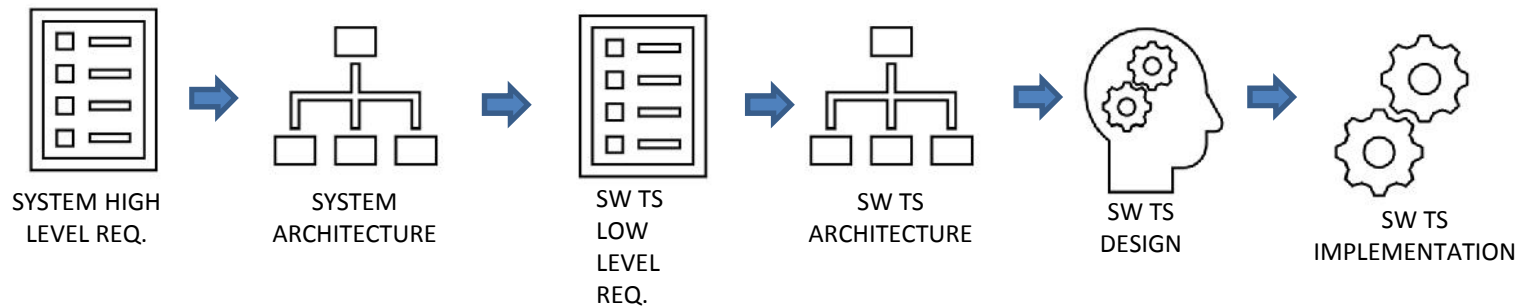
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# SOFTWARE TOOLSET



- **SW TS (SOFTWARE TOOLSET)**

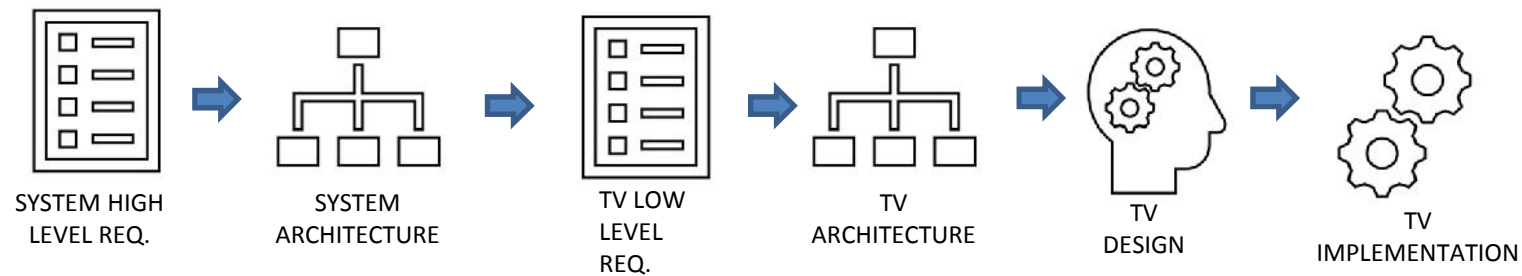
- SW TOOL FOR
  - SIMULATION AND TEST SCENARIO CONFIGURATION
  - MANAGEMENT AND CONTROL OF SIMULATIONS
  - TEST AND SIMULATION EXECUTION



# TRAIN VIRTUALISATION

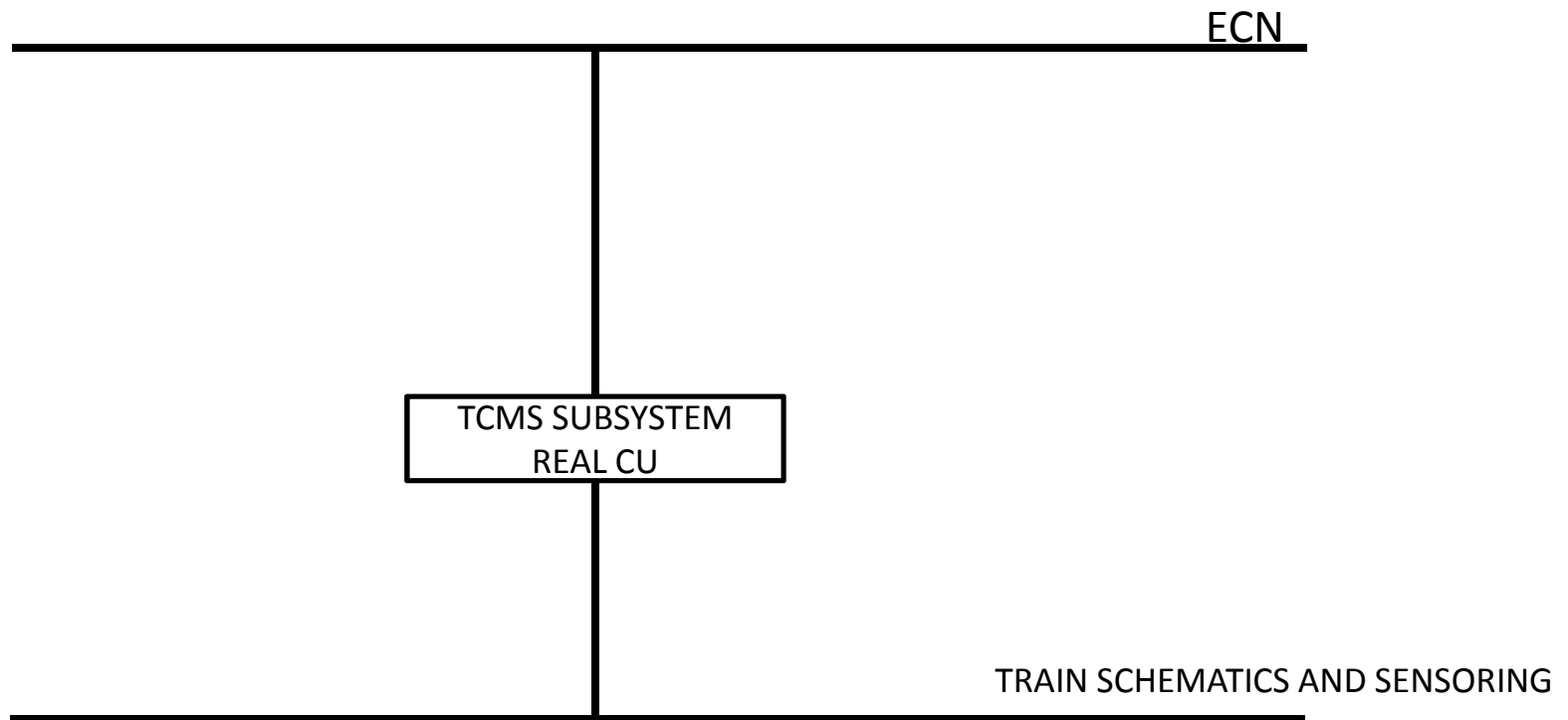


- **TV (TRAIN VIRTUALISATION)**
  - SW FOR THE SIMULATION OF TRAIN BEHAVIOUR (DYNAMICS, PHYSICS AND ELECTRICAL)





# TRAIN VIRTUALISATION



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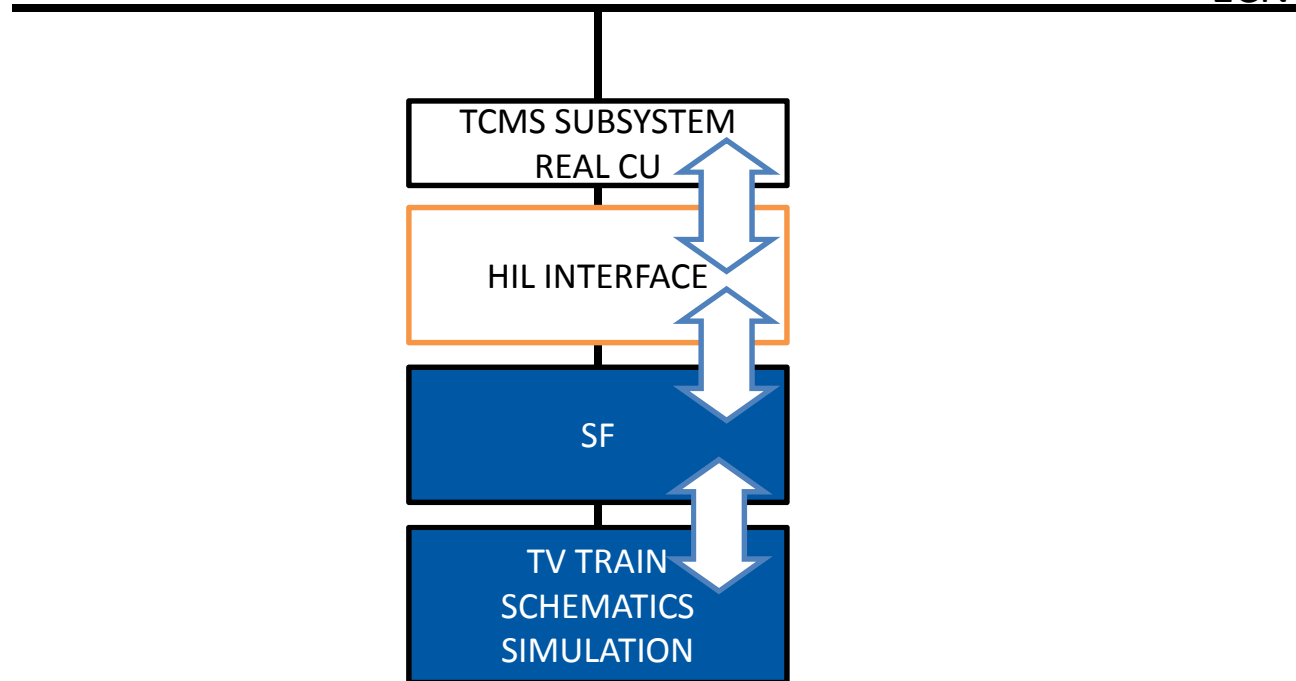
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# TRAIN VIRTUALISATION



ECN



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# COMMUNICATIONS EMULATOR

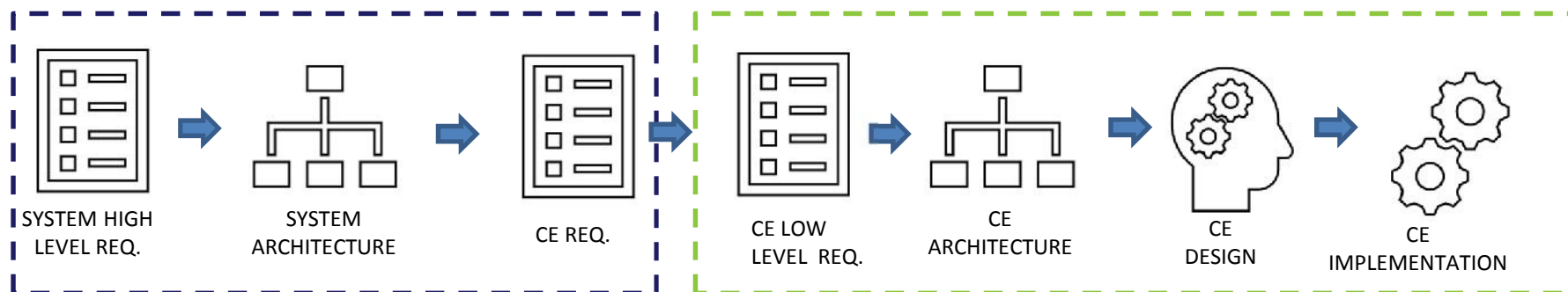


## CE (COMMUNICATION EMULATOR)

- SW FOR COMMUNICATION PURPOSE THAT ALLOWS THE EXCHANGE OF DATA BETWEEN REAL AND SIMULATED, LOCAL AND DISTRIBUTED DEVICES AND WITH THE SW TS.
- CTA DEFINED THE HIGH LEVEL REQUIREMENTS AND S4R DID THE LOW LEVEL REQUIREMENTS, ARCHITECTURE AND IMPLEMENTATION.
- MORE DETAILED INFORMATION IN THE NEXT SLIDES

CTA

S4R

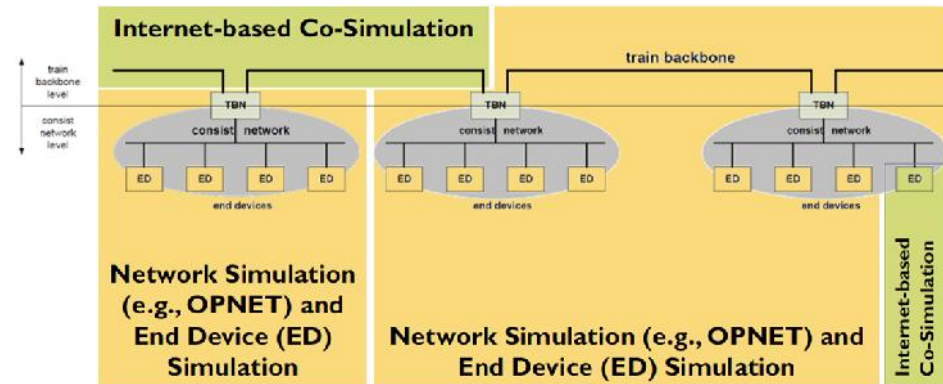




# COMMUNICATION EMULATOR



- Focus lies on the virtualization of a train via heterogeneous communication networks
- Co-Simulation of end device and network models on a network-centric abstraction level





# COMMUNICATION EMULATOR Concept



- Design of a simulation bridge between real and simulated devices
  - Local or geographically distributed devices
  - Connection via heterogeneous communication networks (Internet, Local Area Networks, etc.)
- Definition of a generic interface based on Ethernet



# COMMUNICATION EMULATOR Concept



- Synchronization and data exchange between devices
- Configuration for different protocols and real/simulated devices
- Mechanisms for monitoring and fault-injection (EN 50159)
- Management of delays introduced by the heterogeneous network
  - Measure delays and stop simulation if threshold exceeded
  - Estimate future input packets and forward packet to device if delay too large



# COMMUNICATION EMULATOR subsystems

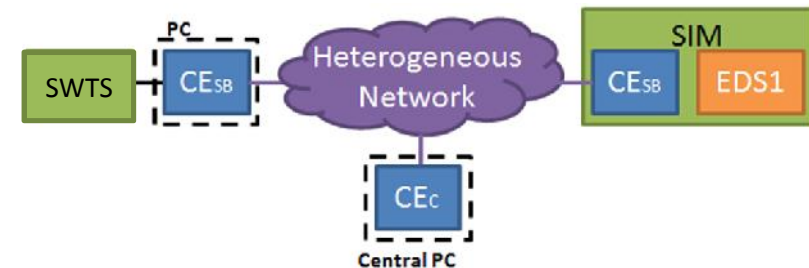
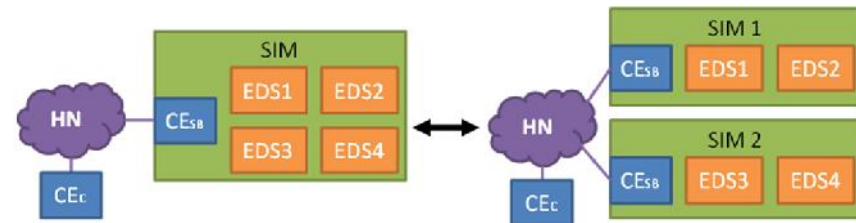


- Communication Emulator Simulation Bridges (CESB)
  - Connect real and simulated devices
  - Create communication channel
  - Based on High Level Architecture simulation standard (IEEE 1516-2010)
- Central Communication Emulator (CE<sub>C</sub>)
  - Manages data exchange and synchronization of simulation bridges
  - Hosts an instance of the Runtime Infrastructure
  - Central component of the High Level Architecture
- Heterogeneous Network
  - Used to connect the simulation bridges
  - Internet, Local Area Network, etc.

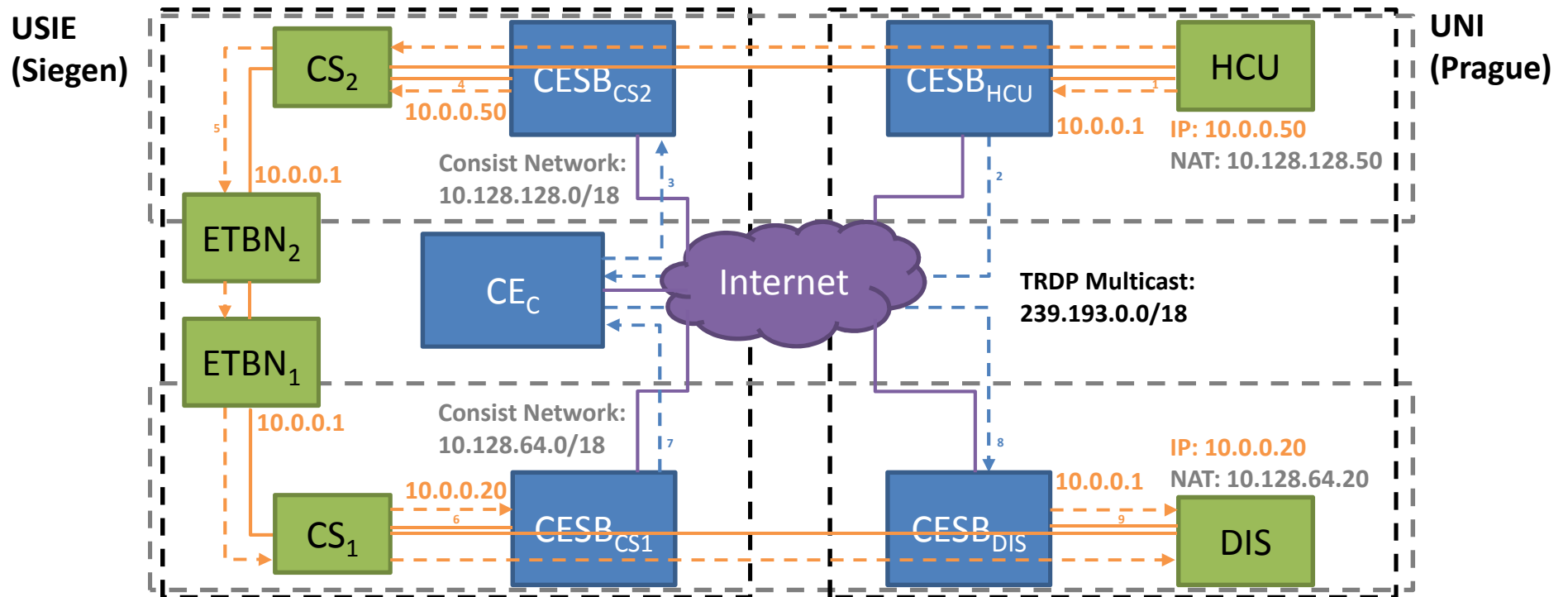
# COMMUNICATION EMULATOR Usage



- Simulation host handles multiple End Device Simulations (EDS)
  - Simulated system can be distributed between multiple hosts
  - Connection via Simulation Bridges (CESB)
  - CE<sub>c</sub>: Central Communication Emulator
  - HN: Heterogeneous Network
- Simulation host is controlled by Software Toolset (SWTS)
  - Commands are sent via CESBs
- Connection of real devices also possible (Hardware-In-The-Loop) → Demo



# COMMUNICATION EMULATOR Demo



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## Next station is

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- Design and implementation of the SM
- Implementation of two test benches (urban and regional trains)
- Integration of all VIRTUAL CERTIFICATION building blocks

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161



## Conclusions

- In order to validate the development to use it for the validation /certification of a train, first we need to test and compare the results with those of a real environment.
- Validation of time sensitive requirements by means of distributed devices may be not achievable with the current technology.
- Standardisation of this technology is highly recommended by the experts in order for all the stake holder to accept the virtual certification.
- Integration activities must be carried out in CTA 2 in order to have a whole working system.