

Shift2Rail / M20

Distributed Power System based on mobile
network communication

M20



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Grant Agreement
Number **826087**



Starting Point

- Shift2Rail project FFL4E: Future Freight Loco for Europe
- aim: prototype of Long Train setup with 2 TU's and GSM-R data transmission (CSD calls)
- radio modules were developed and provided by Funkwerk



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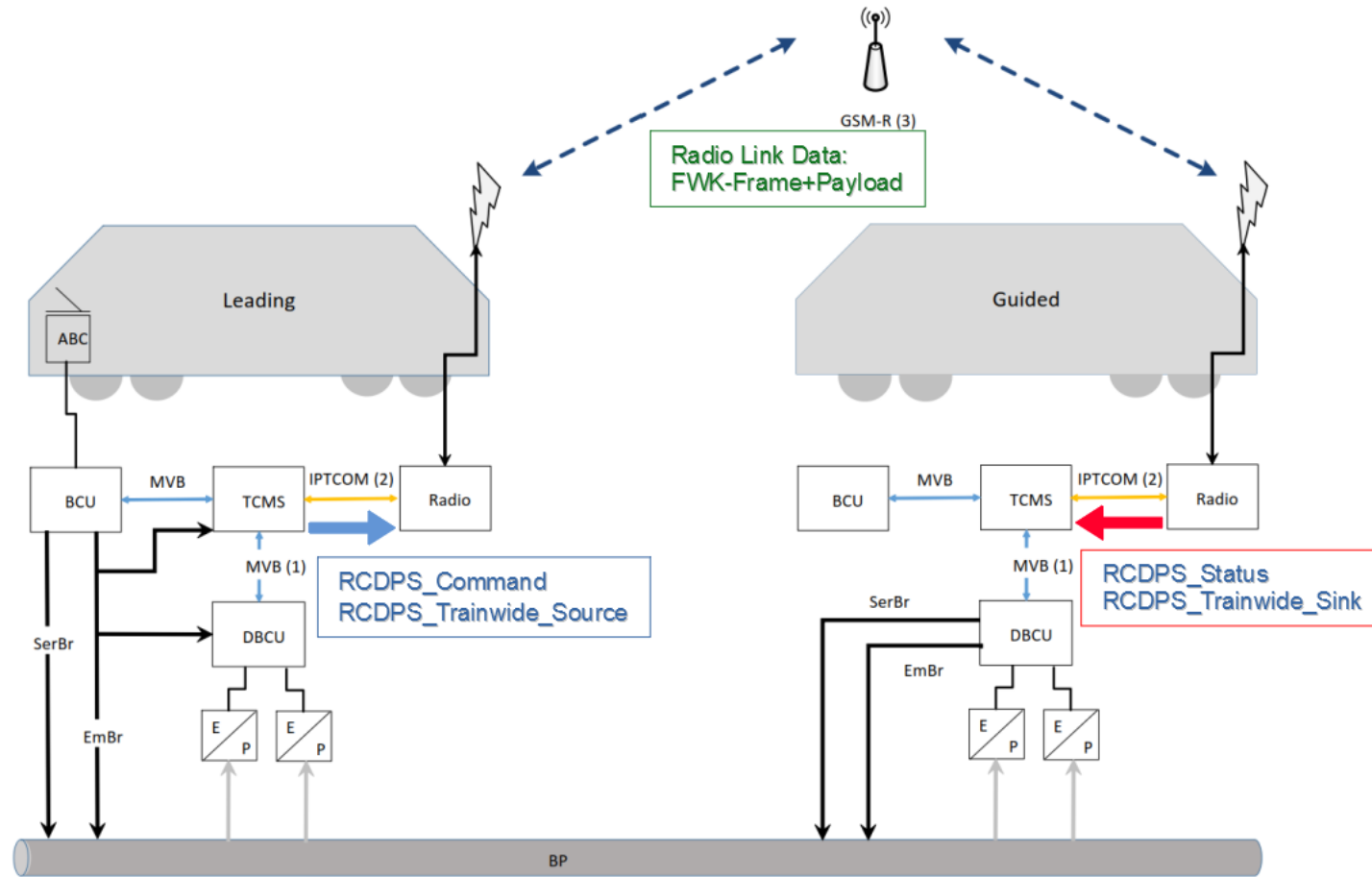
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Shift2Rail: FFL4E and M20

- FFL4E provides results of radio integration and performance measuring for two loco setup:
 - Leading Loco (Traction Unit) makes a CSD call via GSM-R to Guided Loco (to the well known phone number of Guided Loco)
 - Guided Loco receives the CSD call
 - The CSD call is permanently established
- M20 started by analyzing results of FFL4E
- Aim: 1,500 m long trains with up to four Locos

M2O: GSM-R setup



M2O: radio integration

- To achieve an abstraction layer, the radio communication is controlled by on-board industrial IP network
- Like concepts of FRMCS, the radio module “RCDPS” establishes automatically a link over radio network
- IPTCom is used to communicate radio link status changes or requests to establish or terminate the radio link
- IPTCom is used to transmit the payload between TCMS and RCDPS

GSM-R performance

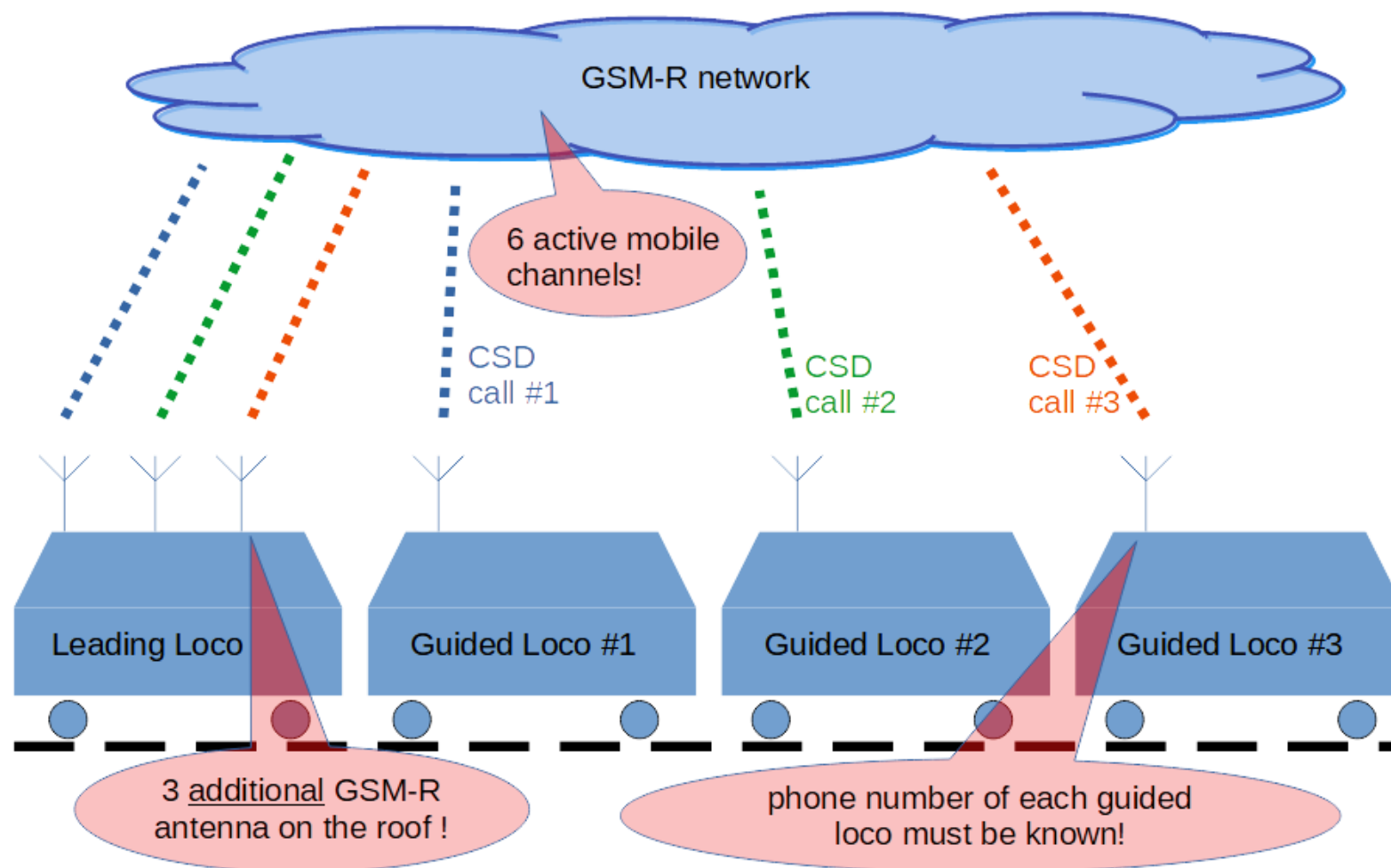
- Latency between radio module on leading TU and radio module on guided TU:
 - Funkwerk laboratory: 750 ms (+/- 30%)
- Latency between Train Controller Unit (CCU) and Radio Controller (RCDPS) for both TU's (end-to-end **with** radio communication):
 - Funkwerk laboratory: 1100 ms
 - FFL4E test run 2019: 1600 ms

GSM-R limitations

Limited to two traction units because of:

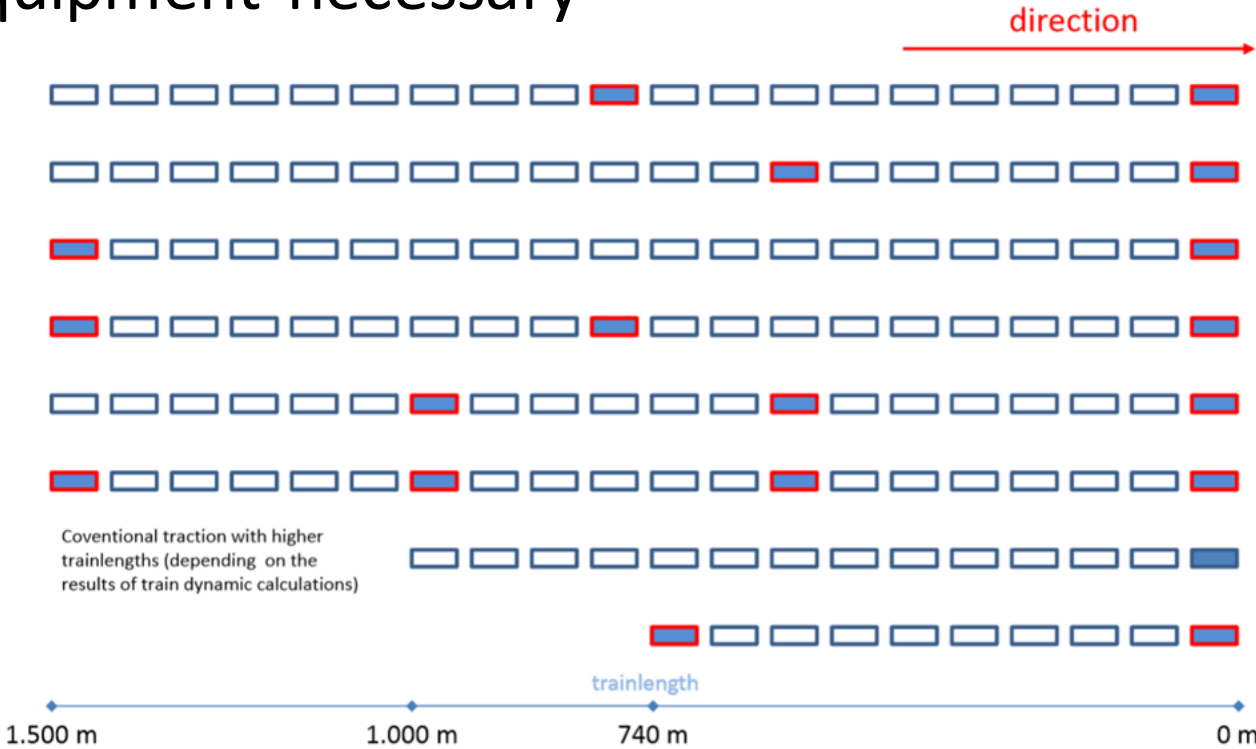
- For each Guided Loco a dedicated GSM-R module is needed on Leading Loco with drawbacks:
 1. Additional GSM-R modules to be installed – dedicated leading locos are not replaceable
 2. Additional antenna on the roof – no free places!
 3. Additional GSM-R SIM cards
- Per each guided loco a CSD call is to be established:
 - A long train with 4 locos uses 3x CSD calls with 6x active channels (per cell)
 - Resources in GSM-R network are very limited – preemptions would occur and interrupt long train communication
- Pure performance as seen in slide before

GSM-R limitations



M20 Concept for up to four Locos

Variable combination of train consists – no dedicated leading loco equipment necessary



Each Loco (Traction Unit) is equipped with **one** additional radio module **RCDPS** with only **one** additional **antenna** on the roof



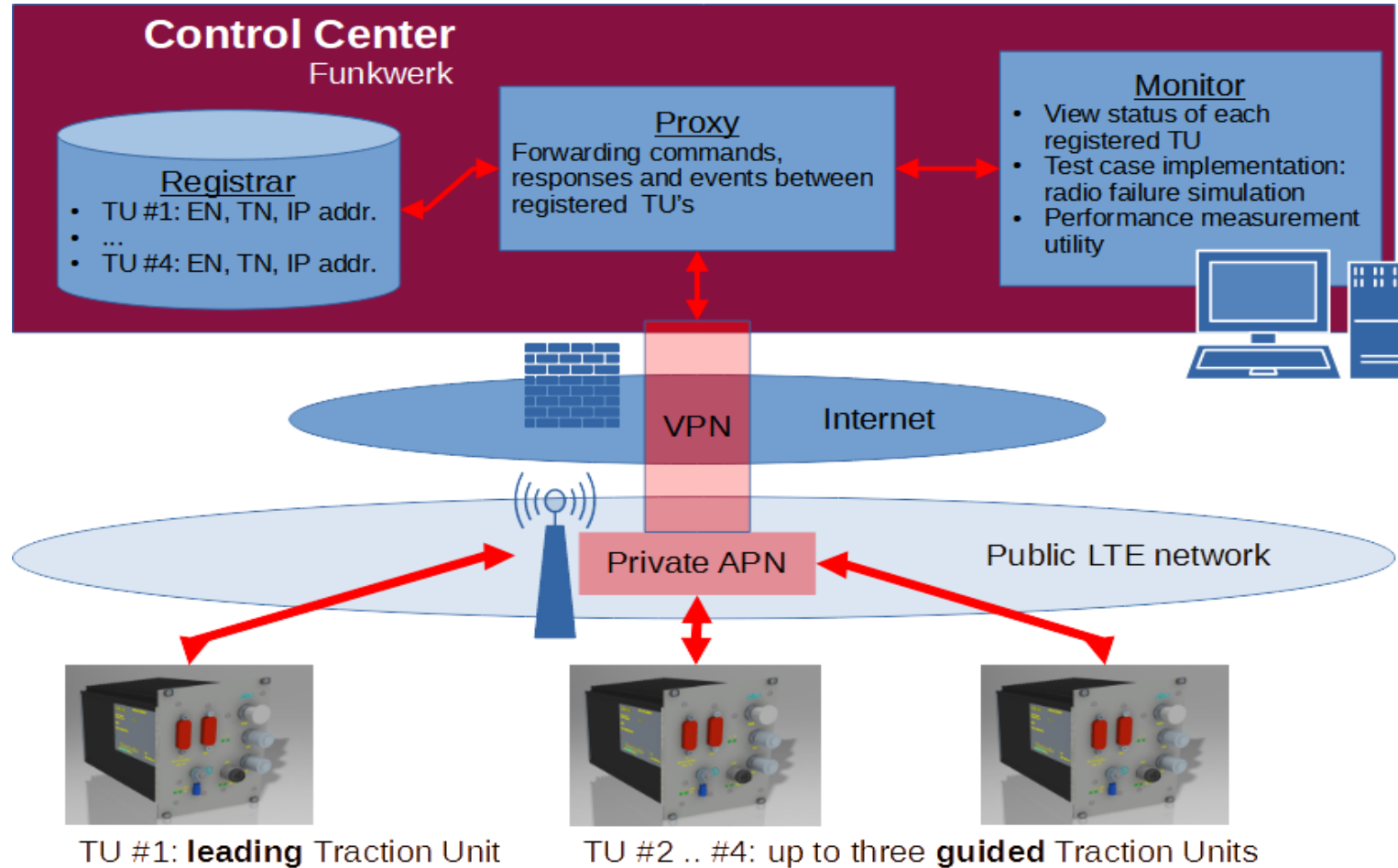
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Solution: LTE / 4G based concept



M2O and FR8Rail II

Cooperation with Shift2Rail partner project FR8Rail II:

- joint development of IPTCom based on communication specification for Bombardier locos
- layer concept addressing functional safety and IT / cyber security
- integration of Funkwerk RCDPS in Bombardier locos
- coordination of safety issues



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Safety and Security Layer

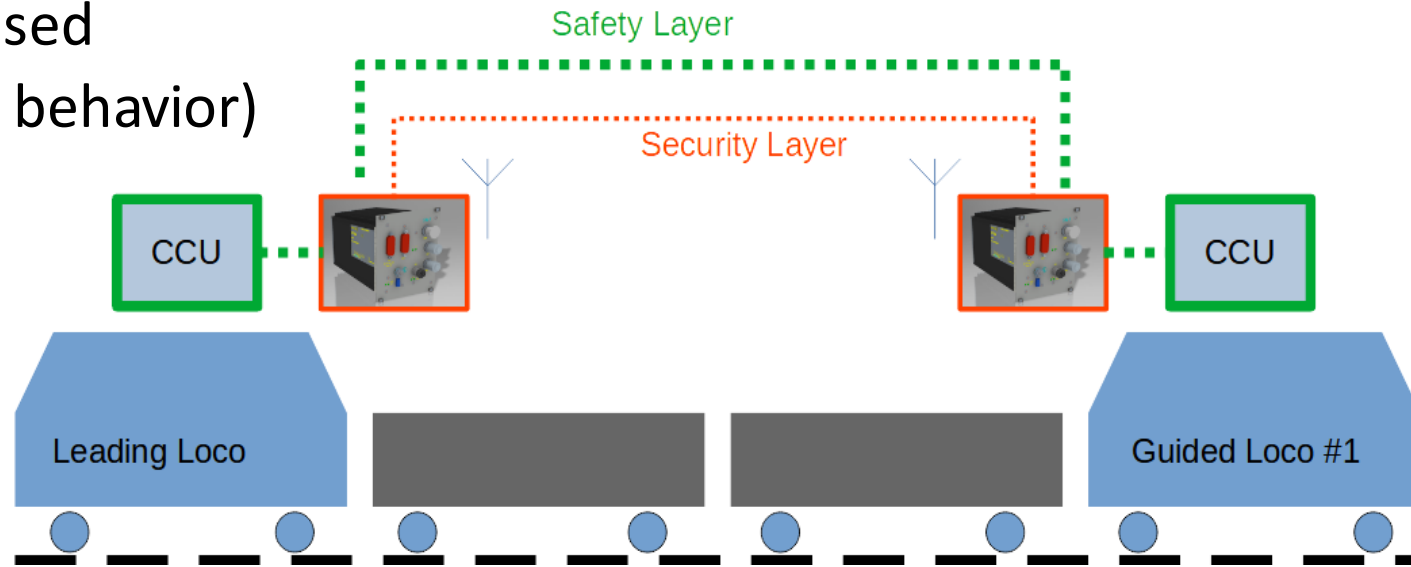
M2O / Funkwerk responsible for **Security Layer**:

- Onboard integration of RCDPS as standard IPTCom device (without special security measures)
- Radio link over public LTE network using private APN (separating traffic from other public mobiles)
- No direct communication between mobiles
- Traffic is only forwarded to Traction Unit which are registered to the same Train Number
- Traffic rules are enforced by central application (Funkwerk Control Center)
- Multiple train consists can be registered in parallel with separation of traffic

Safety and Security Layer

FR8Rail II / Bombardier responsible for **Safety Layer**:

- Onboard integration of RCDPS as standard IPTCom device (real time protocol)
- Payload contains elements of SDTv2 protocol for safety reason
- 64 ms message cycle end to end is used
- Latency limits are defined (real time behavior)
- Safe state is entered after:
 - timeout of communication
 - radio link error

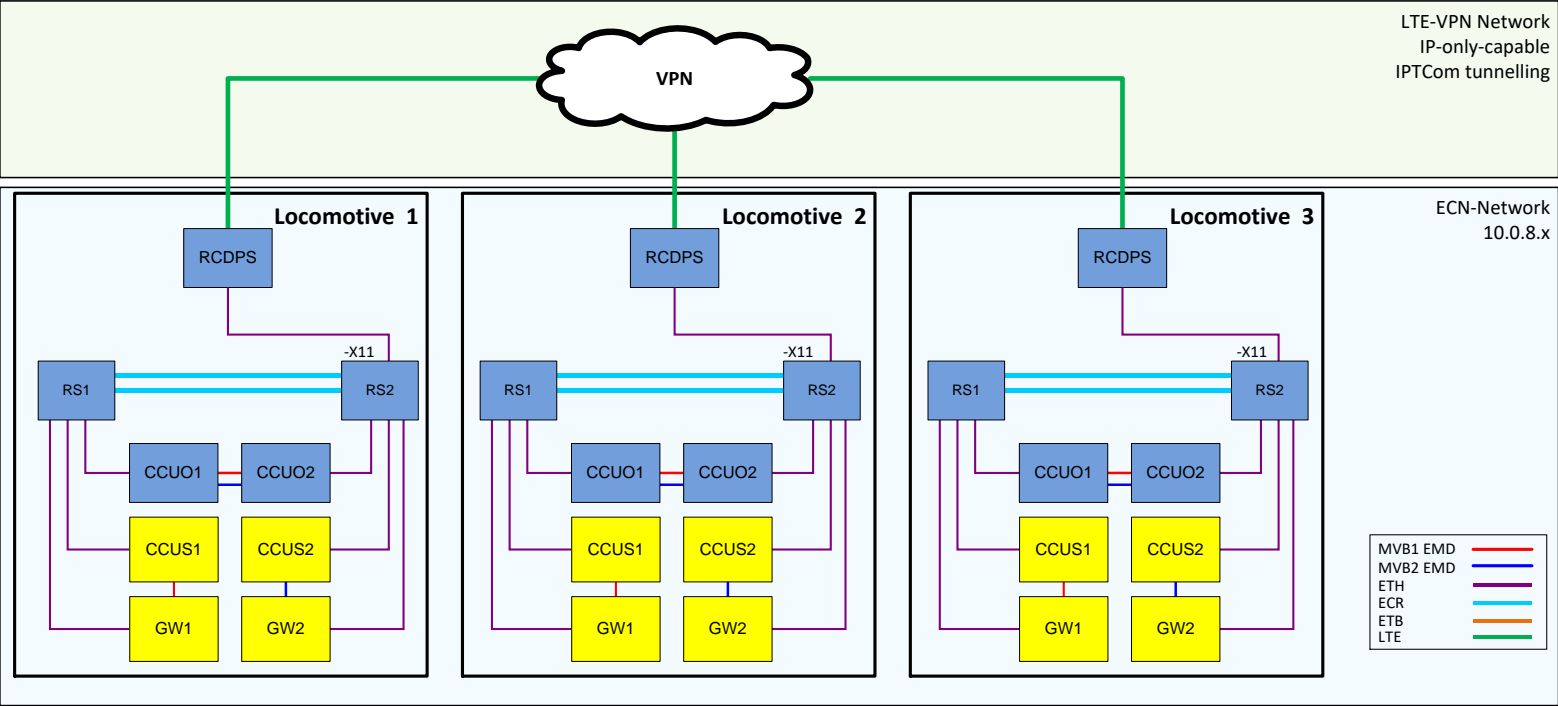


Funkwerk part in M20

- creating a communication model for on-board and radio communication
- calculation of latencies
- measurement to support the communication model and calculation
- development of RCDPS prototype hardware (onboard devices, lab test sets)
- providing hardware for lab testing and equipment for test runs
- development of RCDPS Software
- development of RCDPS Control Center

Long Train on-board communication infrastructure

FR8Rail II: Three Bombardier locos will be equipped with one Funkwerk RCDPS LTE radio module each



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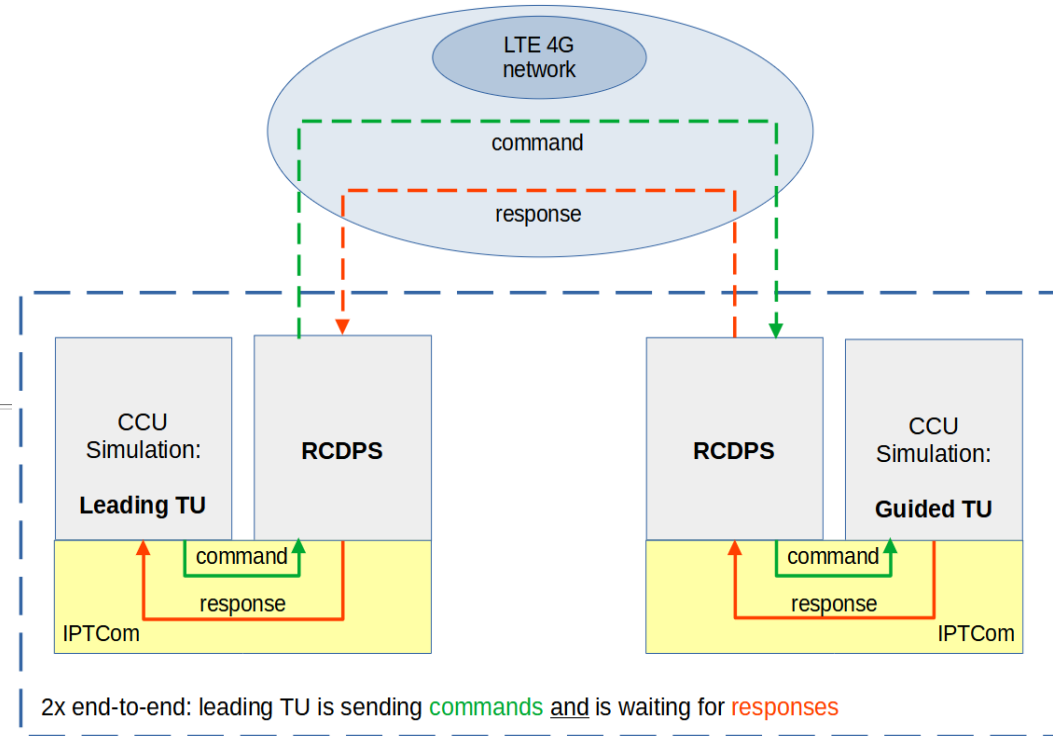
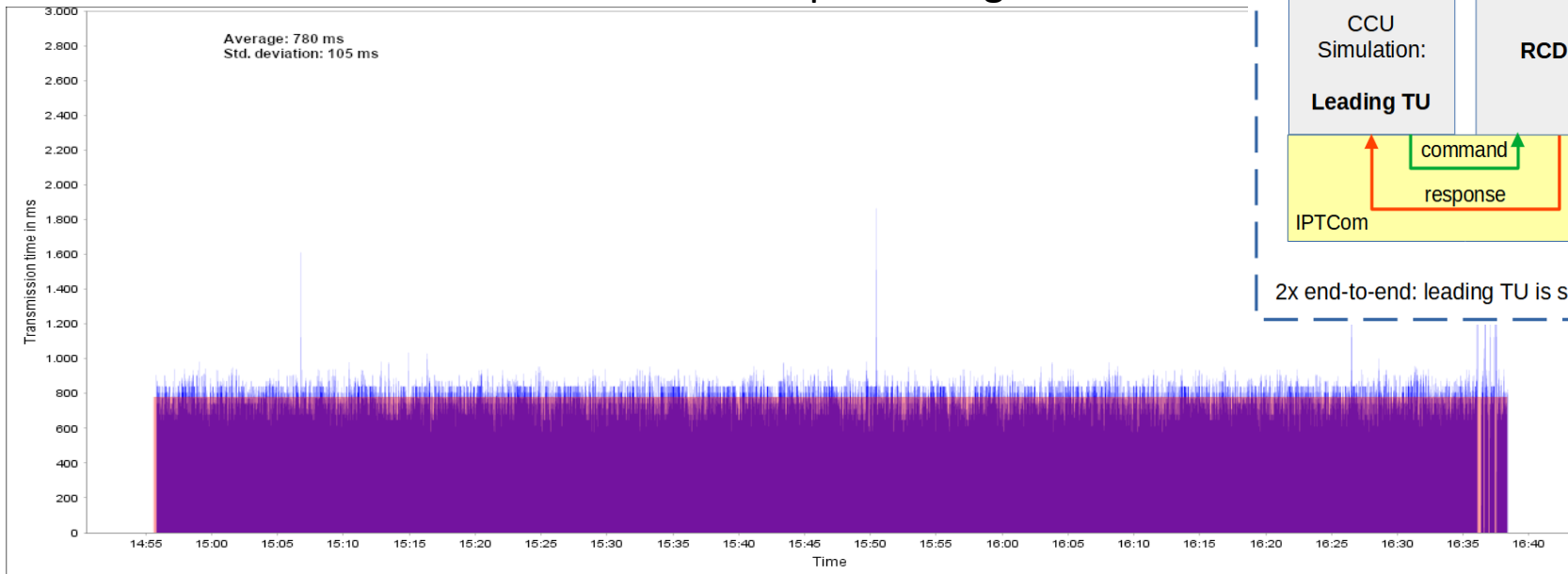
Setting up a Long Train

- Steps on each loco to setup a logical Long Train:
 1. enter a train number TN
 2. start the radio communication
 3. wait for status ready
 4. perform initial tests
- Automatic actions take place (step 2..3):
 - register loco with Engine Number, Train Number and IP address
 - forward traffic between already registered locos within a train consist

LTE / 4G Performance

Laboratory test:

- Using public LTE network and RCDPS prototypes
- **Average latency over radio link: 70 ms**
- **Average latency end-to-end between TCMS: 390 ms**
- Figure below shows two times end-to-end measurement including simulation of on board communication and processing time



Long Trains and FRMCS

- M2O and FR8Rail II have started a request to add Long Trains as Use Case for FRMCS
- Long Trains concept based on RCDPS/LTE is FRMCS ready
- Upgrade to 5G possible by exchanging the 4G modem inside RCDPS

