Towards ETCS over FRMCS in Finland - Return of experience on LTE/5G based deployment

Digirail is the Finnish ERTMS program including railway digitalisation

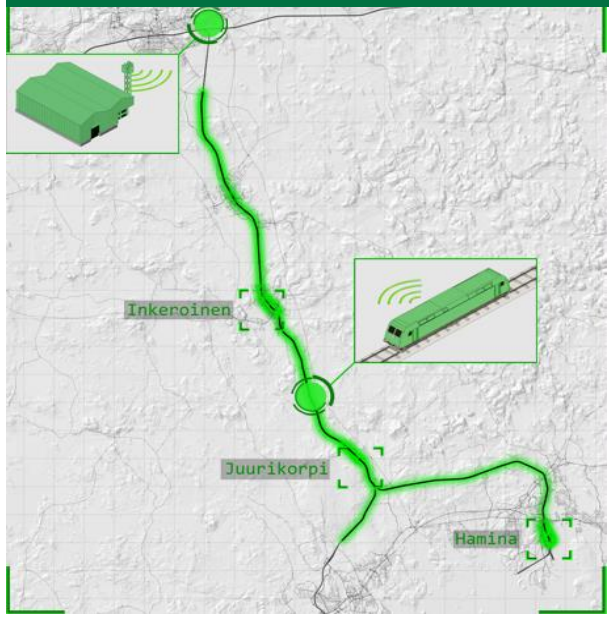
Digirail objectives – Radio network

- THE TARGET: In Finland FRMCS will be deployed in commercially available **public radio network**
    - Finland starts the process without the migration burden from GSM-R
- **FRMCS** is the corner stone
    - IP-based 5G network
    - Readiness for other ”Game changers”
    - Enabler of digitalisation
- The outmost target is contribute to interoperable **European ETCS and FRMCS**
    - Public radio network’s reliability and availability are at suitable level for railway use
    - Real ETCS L2 system train controlling can be managed through public radio network

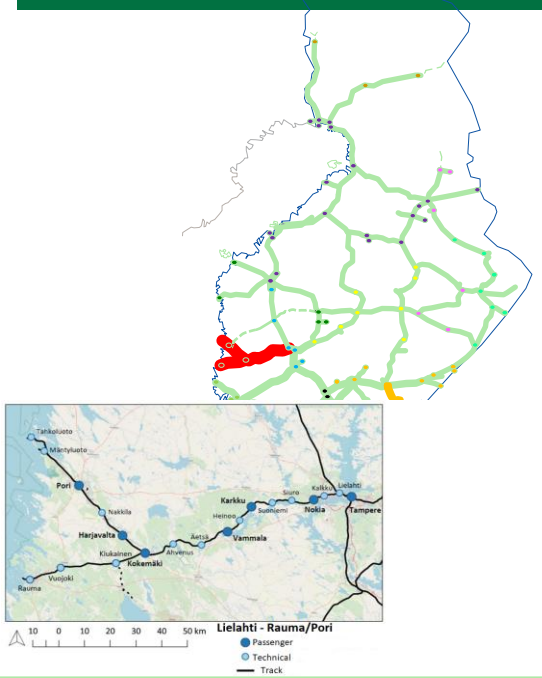
Roadmap towards radio based system

2022

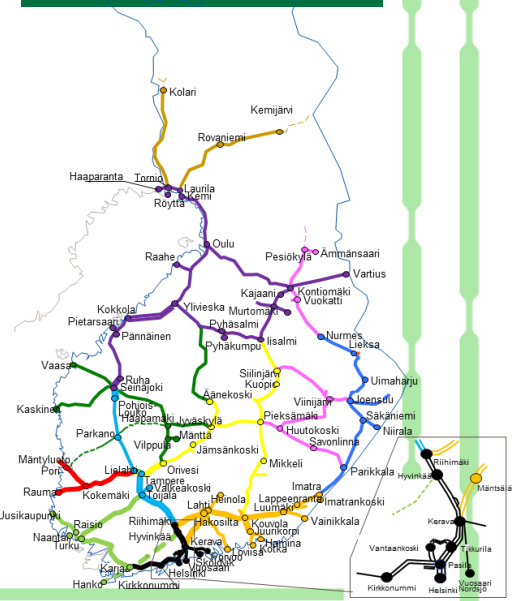
2021 - 2024



2024-2027



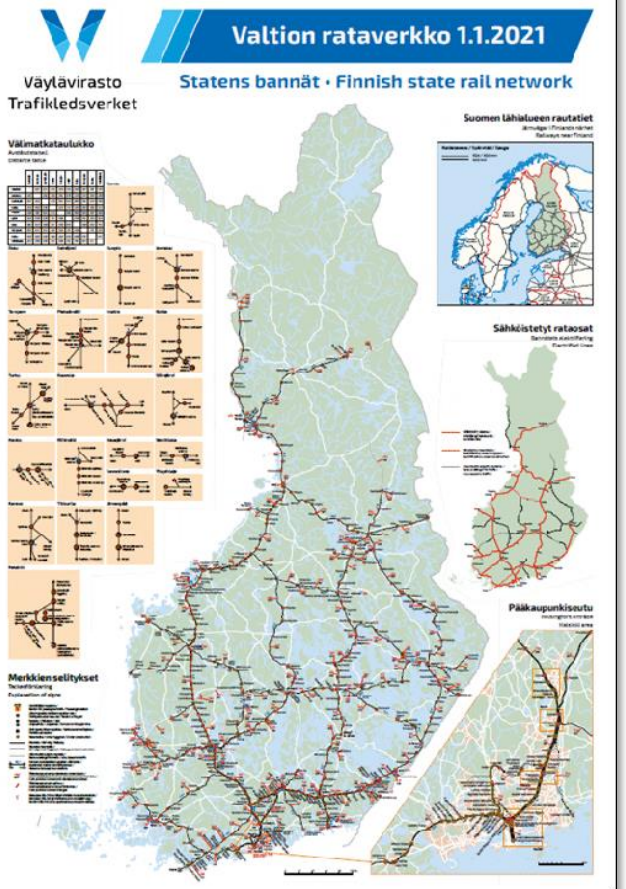
2028 - 2040



- **TestLab**
  - 1st iteration was launched at the beginning of 2022.
- **TestTrack – Real system**
  - Length: 54 km
  - Stations: 3
  - ETCS-level: ETCS L2
  - Radio Network (testing purposes):LTE based
- **1st track section**
  - Lielahti-Rauma/Pori
  - Approx.190 kilometers of single track line
  - 18 stations
  - Radio Network. According CCS-TSI / ”pre-FRMCS” 4G/5G
- **Roll Out**
  - FRMCS roll out before track infrastructue will be deployed
  - Rolling stock upgrades accordingly

Starting Situation 2021

6000 Track Kilometers:



3 public Mobile Network Operators: countrywide 4G coverage, spotted 5G coverage

”There are 18 kms of tracks having no coverage” – Theoretical calculated result

TRAFICOM
Finnish Transport and Communications Agency

Planned testing to be done in order to find out real coverage, quality and ETCS capacity of public mobile networks

DIGI RAIL

DIGI RAIL

Measurement division

Testing control and project lead

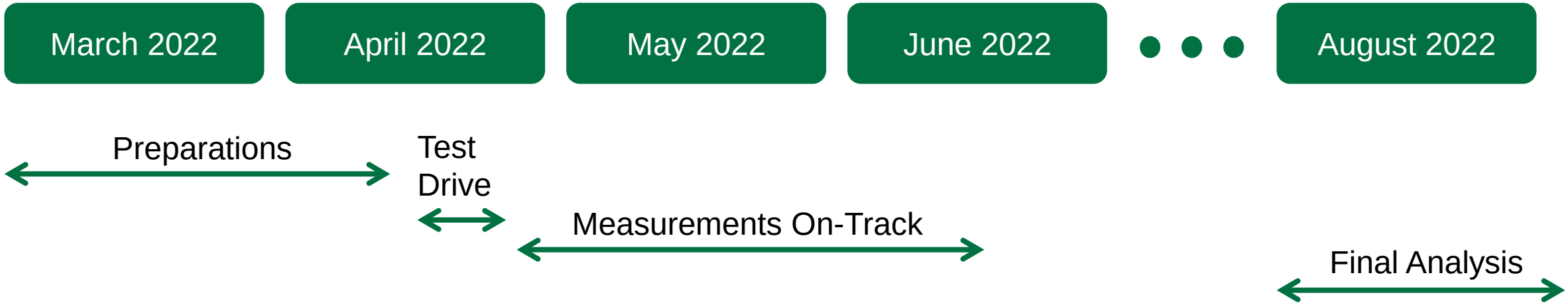
Measurement Vehicle and driving

Mobile Network measurements and reporting

Items to measure

- ❑ **3 existing networks** are measured simultaneously
- ❑ **Priority SIM cards** in use: Guaranteed Bit Rate (GBR) of 50 kb/s with traffic priority handling
- ❑ **RF scanning:** all networks and their frequencies measured
- ❑ **Sample data** of currently used cells (ID, power level, quality, interference) collected with 50 m granularity on vehicle side
- ❑ **Simulated ETCS traffic** with correct message length & structures sent and received

Measurement Project Timeline



- Preparations and Test Drive are expected to be completed before Easter 2022
- Measurements On-Track will start after Easter 2022 and are expected to be completed during June 2022
- Final analysis of the measurement results is expected to be complete during August 2022

- During the measurements, intermediate weekly reports are produced about proceedings and findings

Measurement System

Items to Measure:

IP and Application Measurements

Success rate, Elapsed time	Success rate, Elapsed time	Success rate, Elapsed time	Success rate, Elapsed time
TCP Session Establishment	**TCP Stream Test**	**DNS Query Test**	**HTTP Request Test**
Delay, Jitter, Packet loss	Delay, Jitter, Packet loss, GBR, Connection break	Delay, Jitter, Packet loss	Delay, Jitter, Packet loss, Connection break

Passive Network Measurements

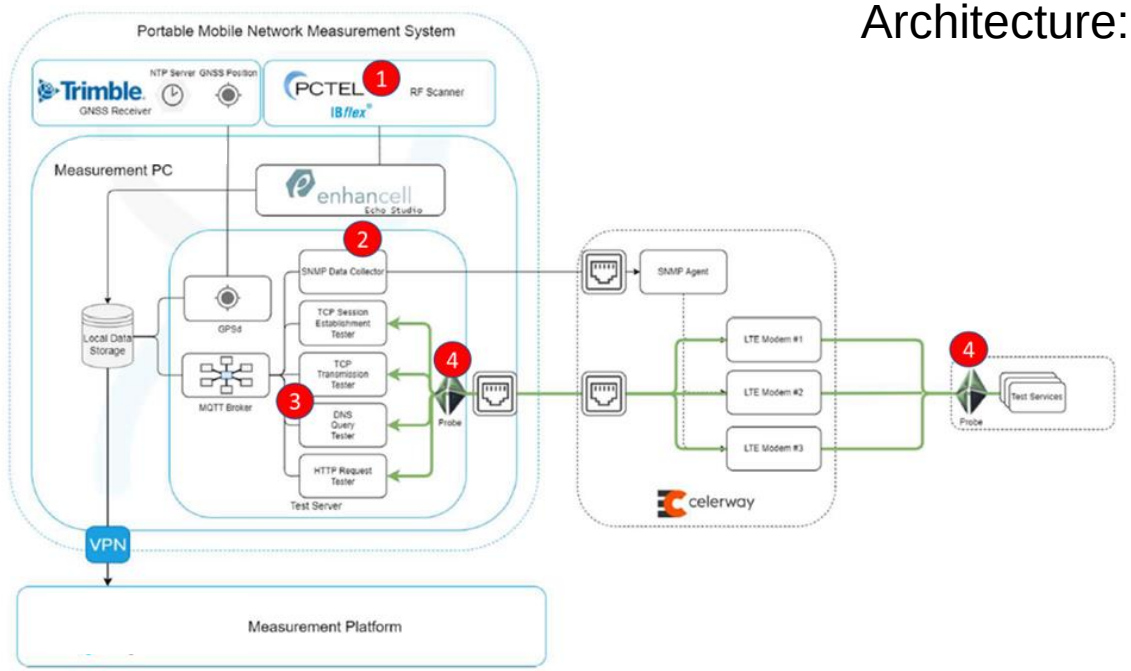
SNMP Data Collector

DNA: PCI, RSSI, RSRP, RSRQ, SINR, Frequency, Band, Bandwidth, + Neighbor cells	elisa: PCI, RSSI, RSRP, RSRQ, SINR, Frequency, Band, Bandwidth, + Neighbor cells	Telia: PCI, RSSI, RSRP, RSRQ, SINR, Frequency, Band, Bandwidth, + Neighbor cells

RF Scanner

PCI RSSI RSRP RSRQ SINR	PCI RSSI RSRP RSRQ SINR	PCI RSSI RSRP RSRQ SINR	PCI RSSI RSRP RSRQ SINR	PCI RSSI RSRP RSRQ SINR	PCI RSSI RSRP RSRQ SINR	PCI RSSI RSRP RSRQ SINR
700 MHz	800 MHz	900 MHz	1800 MHz	2100 MHz	2600 MHz	3500 MHz

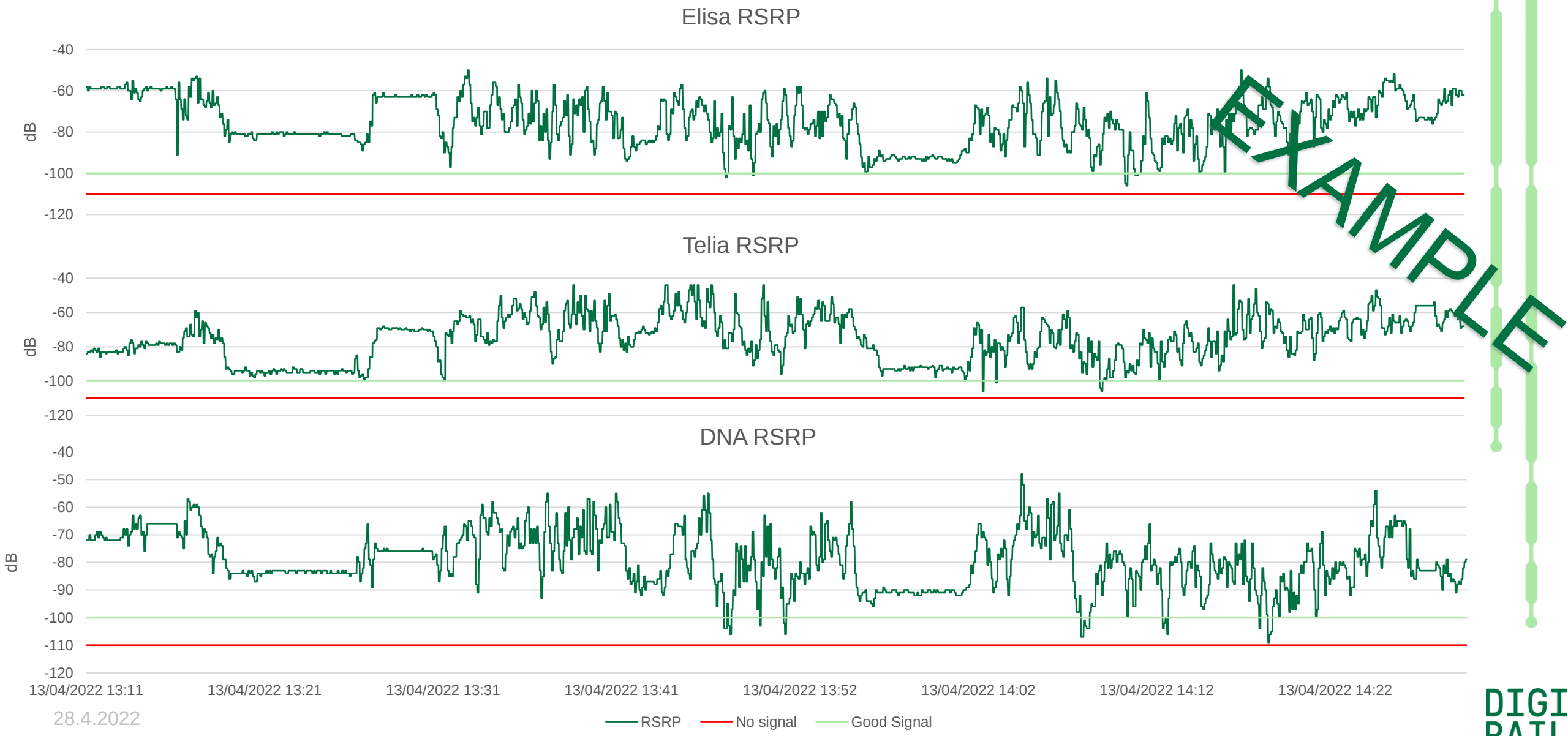
Architecture:



Three public mobile networks are measured simultaneously and measurement data is collected by SNMP. RF scanning provides same information with all frequency areas. IP application measurements show how simulated ETCS traffic behaves with mobile transport.

1. RF Scanner
2. SNMP Data Collector
3. Test Tools for IP Application Traffic Generation
4. Probe for Passive Network Measurements

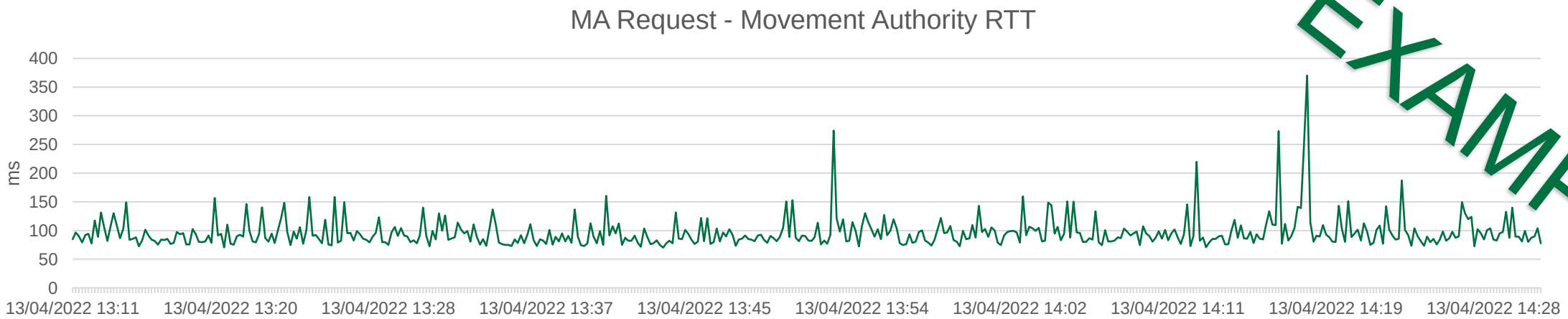
Preparation for testing: Test drive – Signal levels



EXAMPLE

Preparation for testing: Test drive– ETCS Communication

Simulated ETCS Traffic:
- Round-trip time is measured from Movement Authority Request to Movement Authority
- New Movement Authority Request is done in every 10s



EXAMPLE

Another research line in Digirail
Train Positioning – Vehicle Locator

- Different positioning methods are needed
  1. Satellite position + inertia
     - RTK-GNSS, DGNSS, EGNOS, GALILEO HAS, EGNOS HA (v 3.x)
     - Odometry
  2. LiDAR + sensor maps
  3. RADAR + sensor maps
  4. IMU
  - Cameras (visible and non-visible spectrum), Ground Penetrating Radar, speed radar, RfID
- Sensor fusion to improve the system

- Installation: H1/2022
- Tests: H1/2022 → H2/2022 → H1/2023

Accuracy	Hit rate: ~ 50%	Hit rate: ~ 99,7%	Integrity	Service availability
GNSS	1 – 1.5 m	4.4 m	No	Yes
EGNOS	1 m	2.9 m	Yes	Yes
DGNSS	0.4 – 0.6 m	1.2 – 1.8 m	No	Yes
RTK (motion)	0.2 m	< 0.8 m	Yes**?**	Yes
EGNOS HA, v 3.x	0.2 m	< 0.8 m	Yes	2027
Galileo HAS v1	0.2 m	< 0.8 m	No	2024
Galileo HAS v 2	0.2 m	< 0.8 m	Maybe	?

Shedule is open for 3D localization system (incl. digital map)

- When CCS TSI is ready, 2025, 2027?

- **Good map with topography and toplogy is needed** to use modern 3D localization system effectively. → Current 1-dimensional maps support only location from balises.
- **GNSS jamming** has happened in past weeks in Finland → airplanes were not able to land to some airports (use EGNOS service) → **Railways can not rely only for GNSS + inertia!**

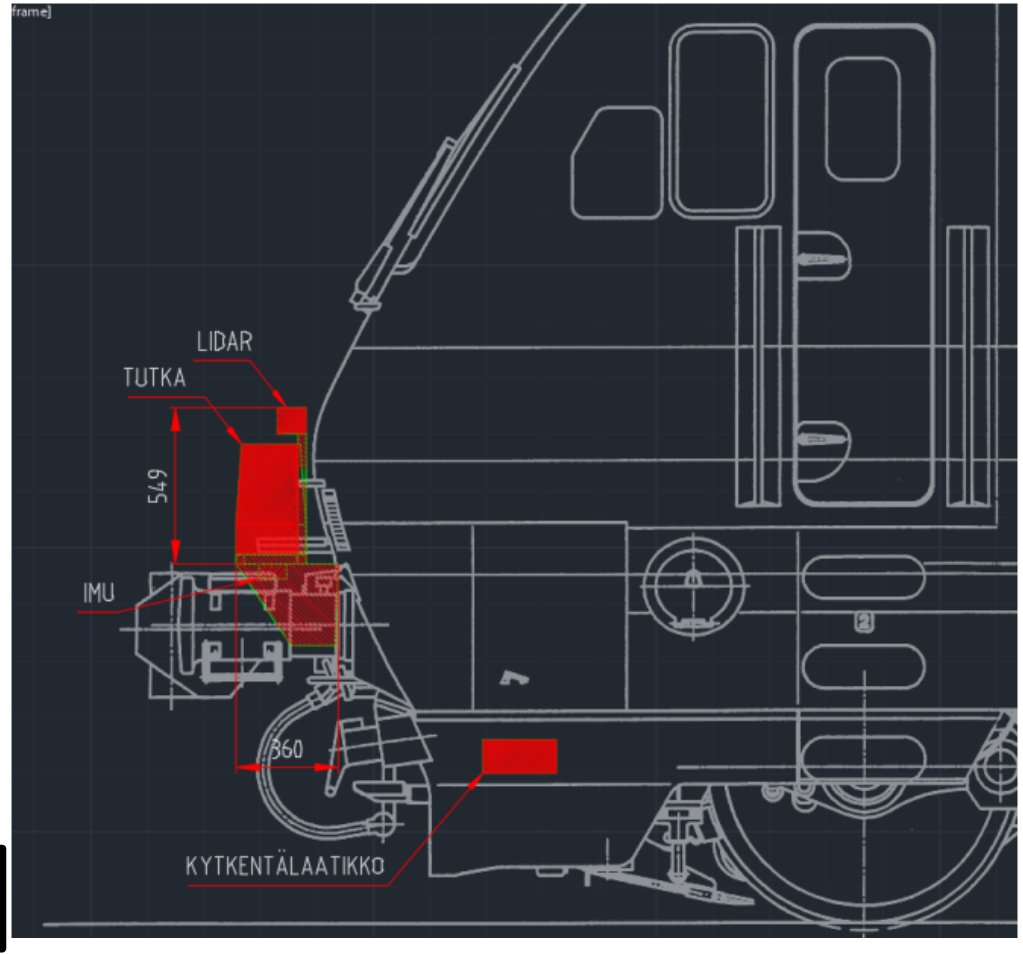
DIGI RAIL

Another research line in Digirail
Test Setup at Sr2 Locomotive

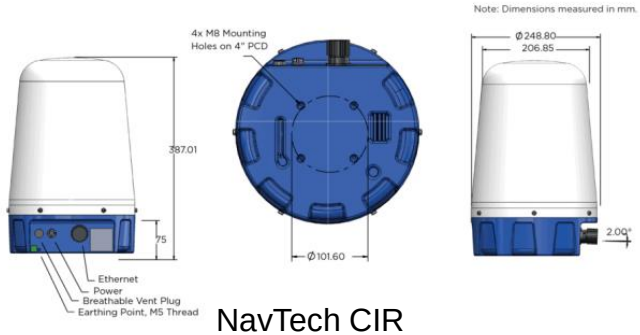
Main components

- PC with sensor fusion software
- RTK GNSS
- Radar
- LiDAR
- IMU
- Router
- 2x pulse sensors for tacho information
- Antennas for RTK and LTE

Tests will start summer 2022



Velodyne ultra puck



NavTech CIR

IMU Sensor
High performance accelerometer + Super-stable gyro

Digirail 2019-2040

Foundation for the future railway traffic is formed now

A SOLUTION THAT STANDS THE TEST OF TIME

- AI-based optimisation of traffic management
- real-time refining of data
- continuously updated capacity and schedule data
- dynamic reactions

FOR THE ENVIRONMENT

- Reduced CO2 emissions
- Shifting transport volumes to the rails from other modes of transport
- Energy efficiency through capacity optimisation and more economical and energy-saving driving

FOR BUSINESS

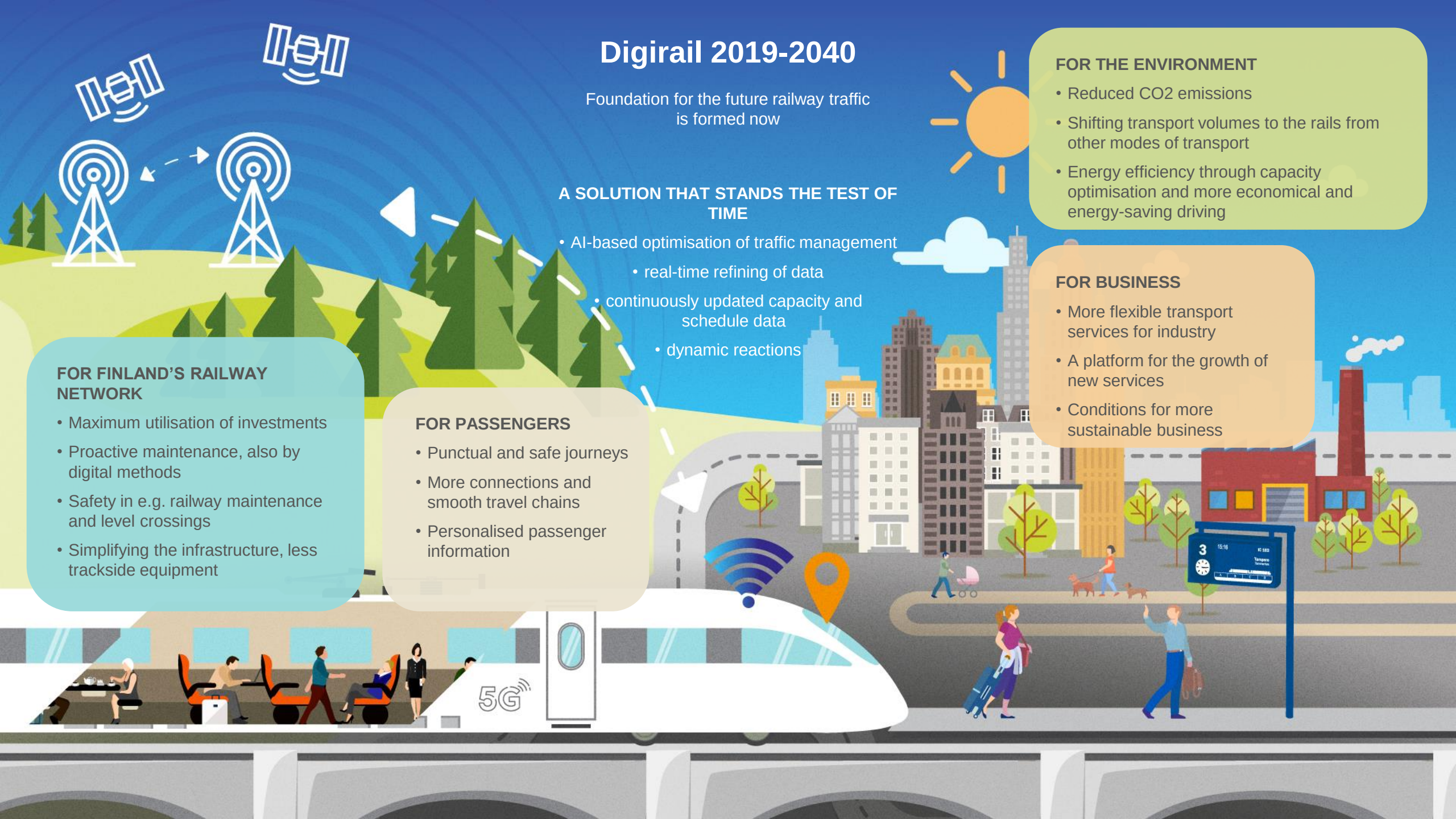
- More flexible transport services for industry
- A platform for the growth of new services
- Conditions for more sustainable business

FOR FINLAND'S RAILWAY NETWORK

- Maximum utilisation of investments
- Proactive maintenance, also by digital methods
- Safety in e.g. railway maintenance and level crossings
- Simplifying the infrastructure, less trackside equipment

FOR PASSENGERS

- Punctual and safe journeys
- More connections and smooth travel chains
- Personalised passenger information



Thank you!