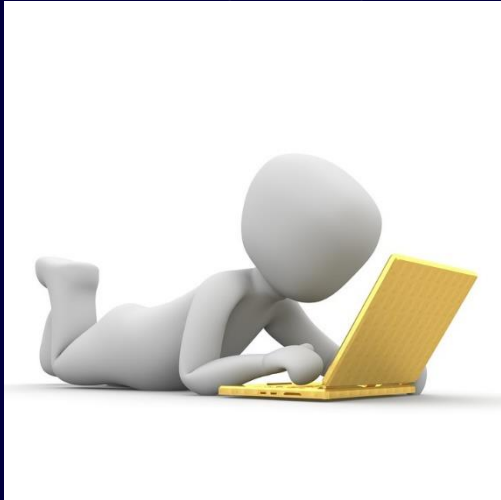# Update of rail user requirements
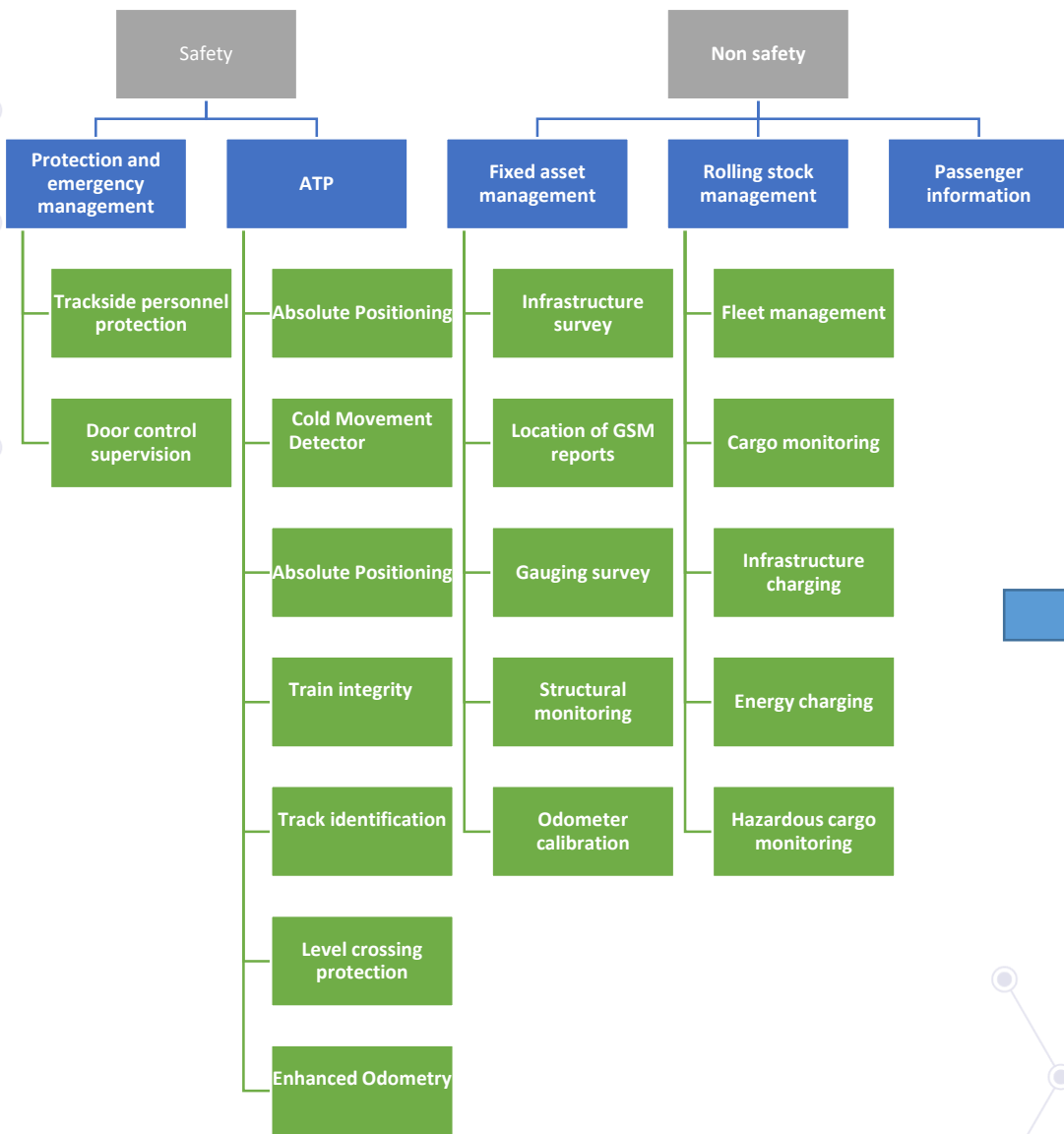
UCP – Rail Segment

Juliette Marais

Background

- Existing Report (2018)

- Updated in 2019 after UCP.

- Annex added after UCP 2020

- Rail not discussed @UCP 2021

1. The list of applications

Safety | Non safety

Protection and emergency management | ATP | Fixed asset management | Rolling stock management | Passenger information

- Trackside personnel protection
- Door control supervision

- Absolute Positioning
- Cold Movement Detector
- Absolute Positioning
- Train integrity
- Track identification
- Level crossing protection
- Enhanced Odometry

- Infrastructure survey
- Location of GSM reports
- Gauging survey
- Structural monitoring
- Odometer calibration

- Fleet management
- Cargo monitoring
- Infrastructure charging
- Energy charging
- Hazardous cargo monitoring

Sub-segments	Applications	Types of Application/ Level of Investigation	
MAINTENANCE IMPROVEMENT	Condition-based maintenance	A	●
	Infrastructure monitoring	A	●
	Predictive maintenance	A	●
ATTRACTIVENESS ENHANCEMENT	Passenger information systems	A	●
	Public Transport – Tram and Light Rail	C	○
SAFETY RELATED	Enhanced Command & Control Systems (CCS)	A	●
	Trackside personnel protection systems	A	●
	Hazardous cargo monitoring	B	◑
	Door Control supervision	B	◑
TRAIN DRIVING OPTIMISATION	Rail fleet management	A	●
	Driver Advisory Systems (DAS)	A	●

Table 1 Applications and level of investigation

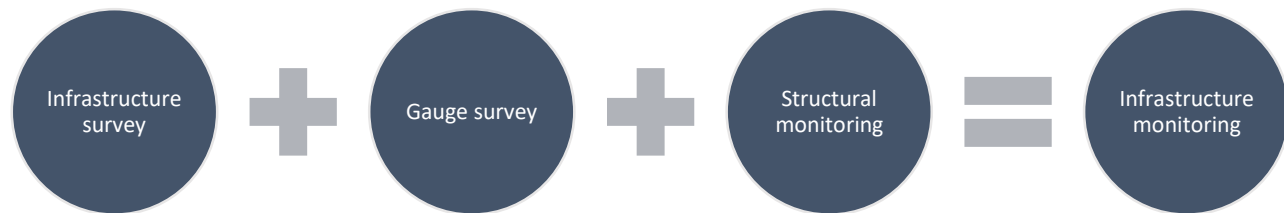# What's new? What is removed?

NEW

- Driver Advisory System
- Condition-based maintenance
- Predictive maintenance

- Infrastructure charging
- Energy charging
- Location of GSM reports

Merged

- Train integrity

- Level crossing protection

Cargo monitoring ➕ Fleet management ⟰ Rail fleet management

Infrastructure survey ➕ Gauge survey ➕ Structural monitoring ⟰ Infrastructure monitoring

Still postponed

Objectives of this session
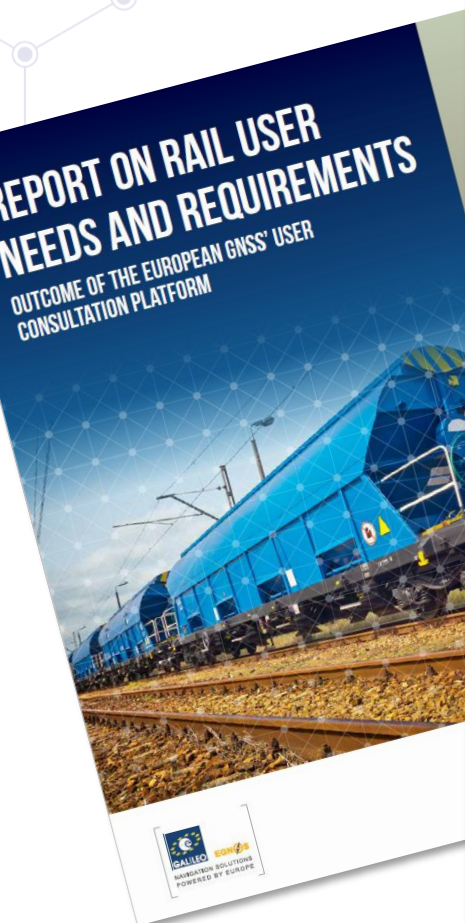
Table 11: Requirements for Train Integrity and train length monitoring

Table 12: Requirements for Track Identification

1. Update the list of applications?
   Add/Remove?

2. Add new requirements
   Some values proposed, to be validated
   Some values missing: do you have some inputs?

3. Update existing requirements
   if you have new inputs?

2. What are we discussing?

What are we discussing?

GNSS user requirements for XXX

Accuracy	Horizontal	
	Vertical	Non-applicable
Availability	Urban canyon	Yes, XX%
	Natural canyon	Yes, XX%
	Canopy	Yes, XX%
	Indoor	Yes, XX%
	Better than 95%	High/Low?
	Better than 99%	High/Low?
Robustness		TBD 🔴 NEW
Integrity and reliability		Low?High?Very high?
Size, weight, autonomy (when smartphone or handheld based)	Relevance 🔴 NEW	Yes/No?
	Time a device can run	TBD
TTFaF	In hot start 🔴 NEW	Xs
Service area	Geographical coverage	Over the whole EU network
Update rate		Xs
TTA	Time between the occurrence of the failure and its presentation to the user	Xs
SIL		If appropriate SIL level

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Definitions (1/2)

- **Accuracy**: can be horizontal/vertical, sometimes along track/across track

- **Availability**: : the percentage of time the position, navigation or timing solution can be computed by the user.

- **Integrity** is the probability of a user being exposed to an error larger than the alert limits without timely warning.

- **Time-To-Alarm**: is the time between the occurrence of the failure and its presentation to the user.

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Definitions (2/2)

- **TTFF- Time to first fix**: Accounts for the time elapsed from the GNSS receiver switch-on until the output of a navigation solution within a certain performance

- **Update rate**: Time interval between 2 positions **Robustness**: relates to spoofing and jamming and how the system can cope with these issues.

- **SIL** refers to the reliability of the system. The SIL level is expressed in the basic 4 levels

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3. First set of questions…

Robustness – a new requirement in the RUR

- **Robustness** relates to spoofing and jamming and how the system can cope with these issues. It is a more qualitative than quantitative parameter and depends on the type of attack or interference the receiver is capable of mitigating. Robustness can be improved by authentication information and services.

- For which applications is it relevant?

Application	Y/N	Application	Y/N
Driver Advisory System		ECCS - Track identification	
Trackside personnel protection		ECCS - Cold Movement detection	
Rail fleet management		ECCS - Enhanced odometry	
Passenger information		Door control supervision	
Hazardous cargo monitoring			

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Size, weight, autonomy – new requirements in the RUR

- Which of these applications relies on smartphones or handheld devices?

Application	Y/N	Application	Y/N
Driver Advisory System	🔴	ECCS - Track identification	
Trackside personnel protection	🔴	ECCS - Cold Movement detection	
Rail fleet management	🔵	ECCS - Enhanced odometry	
Passenger information		Door control supervision	
Hazardous cargo monitoring	🔵		

- Do some of the « N » still require specific autonomy, size, or weight?

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Vertical accuracy

- Is there any existing requirement related to vertical accuracy?

- Can we consider it as not applicable for every application or do you see any application where it could be useful?

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4. Focus on new applications

- The DAS – Driver Advisory System
  - ➜ first draft to be discussed
- Condition-based maintenance
- Predictive maintenance
  - ➜ a proposed table based on previously collected requirements for cargo monitoring

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Driver Advisory Systems - DAS

Driver Advisory Systems (DAS) are a proven means of reducing energy consumption in the rail freight sector.

- Standalone DAS (S-DAS) advises drivers using a static timetable, manually loaded in advance, and so is unaware of subsequent changes

- Connected DAS (C-DAS) takes data from Traffic Management (TM) systems and automatically sends changes in real-time to the DAS system onboard the train.

Today relies on COTS cheap Rx but what would be the optimal requirements?

Do we need to make the req. evolve for CDAS?

If track is known?

GNSS user requirements for Driver Advisory System		
Accuracy	Horizontal	1m for track distinction
	Vertical	NA
Availability	Urban canyon	Yes
	Natural canyon	Yes
	Canopy	Yes
	Indoor	Yes
	Better than 95%	High
	Better than 99%	High
Robustness		TBD
Integrity and reliability		Low
Size, weight, autonomy (when smartphone or handheld based)	Relevance	Yes
	Time a device can run	8-10h (daily service of a driver)
TTFaF	In hot start	1 min
Service area	Geographical coverage	Over the whole EU network
Update rate		1s
TTA	Time between the occurrence of the failure and its presentation to the user	10s

Condition and Predictive-based maintenance

- Condition Based Maintenance is a maintenance strategy to monitor the real-time condition of tracks and trains. These results are large data sets that give away key information to support decision-making and enable efficiency gains.

- CBM suggests a prognostic attitude towards maintenance, that can be realized by constantly monitoring the conditions of an asset, consequently allowing triggering maintenance activities only if any potential asset degradation is detected [1].

- Predictive maintenance builds on condition-based monitoring to optimize the performance and lifespan of equipment by continually assessing its health in real time. Predictive maintenance techniques are designed to help determine the condition of in-service equipment in order to predict when it is going to fail and plan repairs before the need to be unexpectedly taken out of service for emergency or unnecessary routine maintenance [2].

[1] Emanuele Fumeo, Luca Oneto, Davide Anguita, Condition Based Maintenance in Railway Transportation Systems Based on Big Data Streaming Analysis, Procedia Computer Science, Volume 53, 2015
[2] https://www.globalrailwayreview.com/article/68263/predictive-maintenance-opportunity-rail/, https://www.railwaysignalling.eu/corrective-preventive-and-predictive-maintenance-for-railway-applications

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These req. have been agreed for cargo monitoring. Is it ok?

GNSS user requirements for Condition-based maintenance		
Accuracy	Horizontal	10-20 m-level longitudinal
	Vertical	NA
Availability	Urban & natural canyons, canopy, indoor	Yes
	Better than 95%	High
	Better than 99%	Medium
Robustness		**TBD**
Integrity and reliability		Low
Size, weight, autonomy (when smartphone or handheld based)	Relevance	Yes?
	Time a device can run	TBD
TTFaF	In hot start	TBD
Service area	Geographical coverage	Over the whole railway network
Update Rate		60s (fleet), 30 min (cargo) - TBD
TTA	Time between the occurrence of the failure and its presentation to the user	30s

Trackside personnel protection

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Identified application: GNSS for continuous control of the min distance between equipment
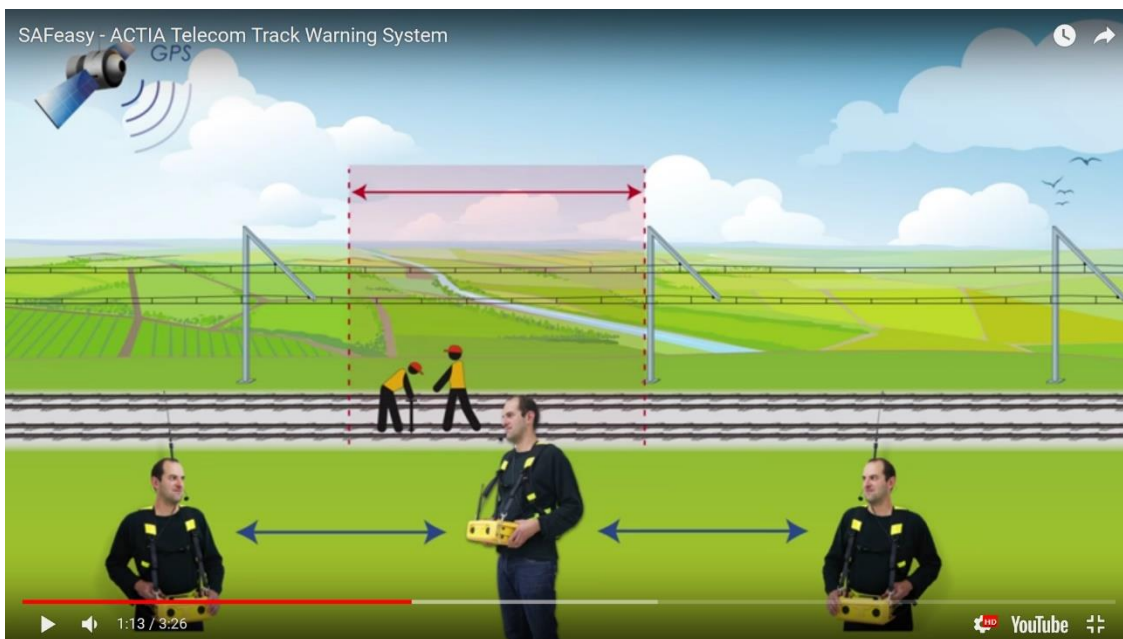
GNSS user requirements for trackside personnel protection

Accuracy	Horizontal	1 to 10 m-level The PNT shall provide a small relative accuracy
	Vertical	Non applicable
Availability	Urban & natural canyons, canopy, indoor	Yes
	Better than 95%	High
	Better than 99%	High?
Robustness		TBD
Integrity and reliability		High
Size, weight, autonomy (when smartphone or handheld based)	Relevance	Yes?
	Time a device can run	TBD
TTFaF	In hot start	Some minutes
Service area	Geographical coverage	available over the whole EU Rail network
Update rate		5 - 10s
TTA	Time between the occurrence of the failure and its presentation to the user	10 - 30s
SIL	For ATO application	SIL2 corresponding to a failure rate of 10^{-7}/hr

NEW

5. Refining previous requirements...

GNSS user requirements for fleet management

Accuracy	Horizontal	10 to 20 m-level longitudinal after track identification
	Vertical	Non-applicable
Availability	Urban & natural canyons, canopy, indoor	Yes
	Better than 95%	High
	Better than 99%	High
Robustness		TBD
Integrity and reliability		Low
Size, weight, autonomy ~~(when smartphone or handheld based)~~	Relevance	Yes?
	Time a device can run	TBD
TTFaF	In hot start	TBD
Service area	Geographical coverage	Over the whole EU rail network
Update Rate		60s
TTA	Time between the occurrence of the failure and its presentation to the user	30s

NEW

GNSS user requirements for Passenger information

Accuracy	Horizontal	100 m-level
	Vertical	Non-applicable
Availability	Urban & natural canyons, canopy, indoor	Yes
	Better than 95%	High
	Better than 99%	Medium
Robustness		TBD
Integrity and reliability		Low
Size, weight, autonomy ~~(when smartphone or handheld based)~~	Relevance	No?
	Time a device can run	TBD
TTFaF	In hot start	Less than 10s
Service area	Geographical coverage	Over the whole EU network
Update rate		1s

GNSS user requirements for Hazardous cargo monitoring

Accuracy	Horizontal	1-10 m-level
	Vertical	Non-applicable
Availability	Urban & natural canyons, canopy, indoor	Yes
	Better than 95%	High
	Better than 99%	Medium
Robustness		TBD
Integrity and reliability		High
Size, weight, autonomy (when smartphone or handheld based)	Relevance	Yes?
	Time a device can run	TBD
TTFaF	In hot start	TBD
Service area	Geographical coverage	Over the whole EU network
Update rate		15 min
TTA	Time between the occurrence of the failure and its presentation to the user	10 - 30s

Safety critical functions

- Enhanced Command and Control Systems
  - Track identification
  - Cold Movement detection
  - Enhanced odometry
- Door control supervision

GNSS user requirements for Track Identification

Accuracy	Horizontal	1.9 or 2.25m maximum depending on the inter-track distance
	Vertical	Non-applicable
Availability	Urban & natural canyons, canopy, indoor	Yes, 99,99%
	Better than 95%	High
	Better than 99%	High
Robustness		TBD
Integrity and reliability		Very high
Size, weight, autonomy (when smartphone or handheld based)	Relevance	No?
	Time a device can run	TBD
TTFaF	In hot start	5s
Service area	Geographical coverage	Over the whole EU network
Update rate		1s
TTA	Time between the occurrence of the failure and its presentation to the user	10-30s
SIL		SIL 2-4

MEMO

The CMD delivers a SIL4 function to supervise vehicle movement during the power off phase, transmitting the information to the ETCS on-board system.

GNSS user requirements for Cold Movement Detection		
Accuracy	Horizontal	Longitudinal accuracy < 1m As long as track identification is ensured The PNT shall provide a relative accuracy < 1m
	Vertical	Non-applicable
Availability	Urban & natural canyons, canopy, indoor	Yes, 99,99%
	Better than 95%	High
	Better than 99%	High
Robustness		TBD
Integrity and reliability		Very high
Size, weight, autonomy (when smartphone or handheld based)	Relevance	No?
	Time a device can run	TBD
TTFaF	In hot start	5s
Service area	Geographical coverage	Over the whole EU network
Update rate		1s
TTA	Time between the occurrence of the failure and its presentation to the user	< 10s
SIL		SIL 4 that corresponds to a failure rate of 10^{-9}/hr

MEMO

Enhanced Odometry Odometry is the use of data from moving sensors to estimate change in position over time. The 'enhanced odometry' concept refers to the use of sensors based on novel technologies, such as GNSS, in the estimation of train speed (GRAIL-2)

GNSS user requirements for Enhanced Odometry		
Accuracy	Horizontal	Travelled distance ±5m + 5% of the distance since the last balise
	Vertical	Non-applicable
Availability	Urban & natural canyons, canopy, indoor	Yes, 95%
	Better than 95%	
	Better than 99%	
Robustness		TBD
Integrity and reliability		TBD
Size, weight, autonomy (when smartphone or handheld based)	Relevance	TBD
	Time a device can run	TBD
TTFaF	In hot start	TBD
Service area	Geographical coverage	Over the whole EU network
Update rate		TBD
TTA	Time between the occurrence of the failure and its presentation to the user	< 5s
SIL		TBD

The purpose of this application is to enable the opening of specific doors at particular stations.

GNSS user requirements for Door Control Supervision

Accuracy	Horizontal	1-10 m-level
		When using ATO: 1m
	Vertical	Non-applicable
Availability	Urban & natural canyons, canopy, indoor	Yes
	Better than 95%	High
	Better than 99%	Medium?
Robustness		TBD
Integrity and reliability		High
Size, weight, autonomy (when smartphone or handheld based)	Relevance	No?
	Time a device can run	TBD
TTFaF	In hot start	TBD
Service area	Geographical coverage	Over the whole EU network
Update rate		TBD
TTA	Time between the occurrence of the failure and its presentation to the user	10 - 30s
SIL		TBD? SIL 2?

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Any regret?

©Maurizio Quarello, Au bout des rails, Ed. Sarbacane, 2009

- Application that has not been mentioned?

- Some great update on existing requirements to share?