



INFRABEL

Connected Driving Advisory Systems

Knowledge session @ RailTech Belgium

Bart Van der Spiegel

7th June 2023





Increase energy efficiency of trains

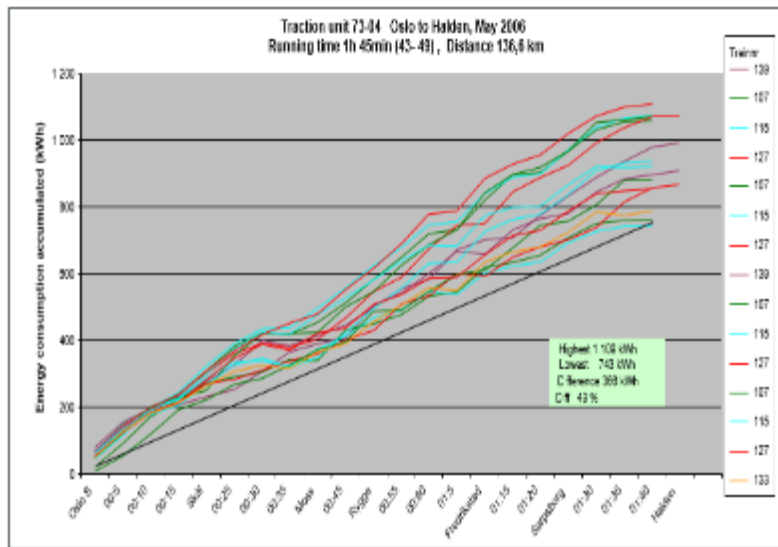
1. Driving Advisory Systems
2. SFERA-protocol
3. C-DAS-C @ Infrabel

*“You can't manage what
you don't measure”*

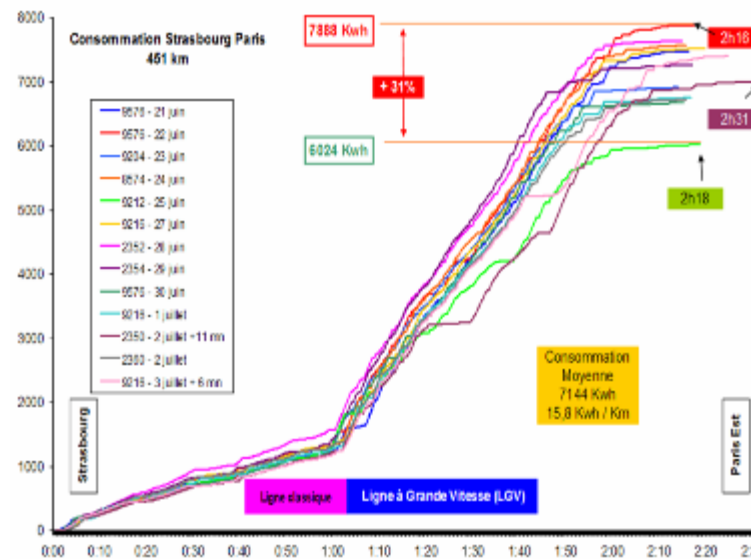
**JAN VETLE MOEN, ENERGY ADVISOR NSB AS
AT THE UIC WORLD ENERGY EFFICIENCY CONFERENCE
PORTOROŽ SLOVENIA**

Why?

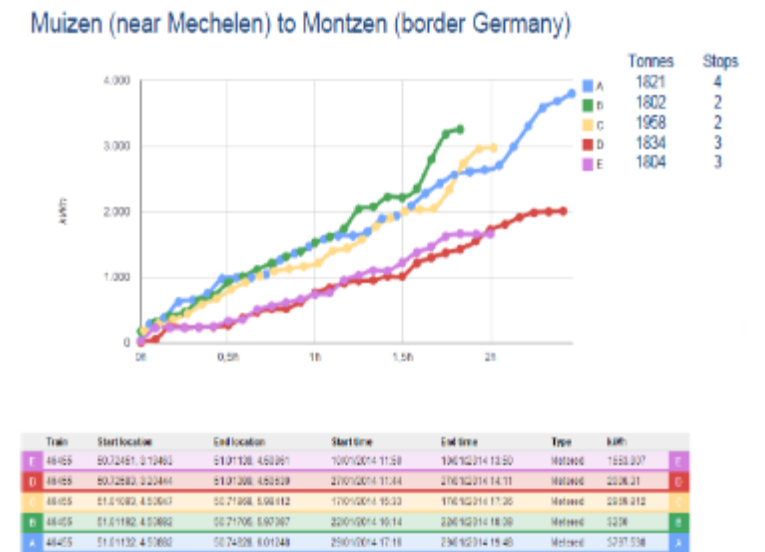
Same trains on same tracks in same period of year can have huge variation in consumptions. Without meters no return on investment of new rolling stock, eco-driving, Driving Advisory Systems and Automatic Train Operations.



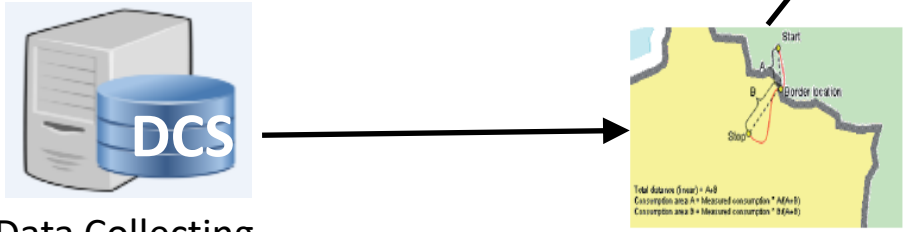
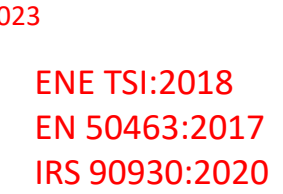
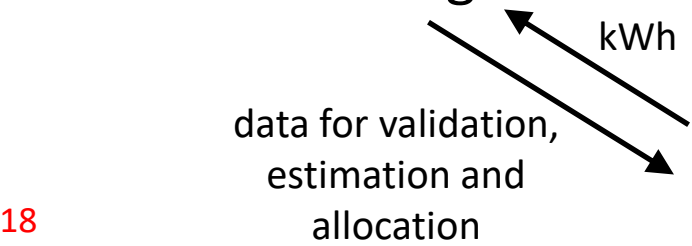
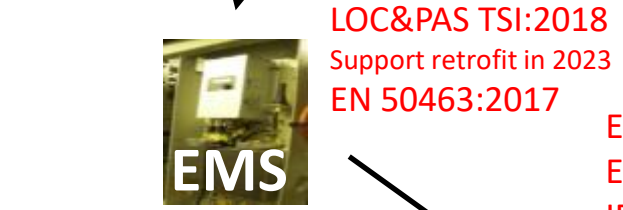
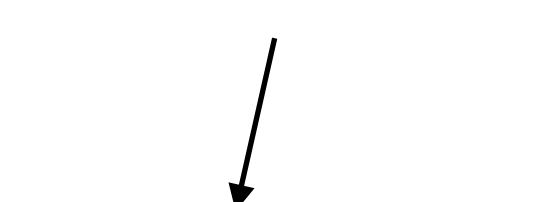
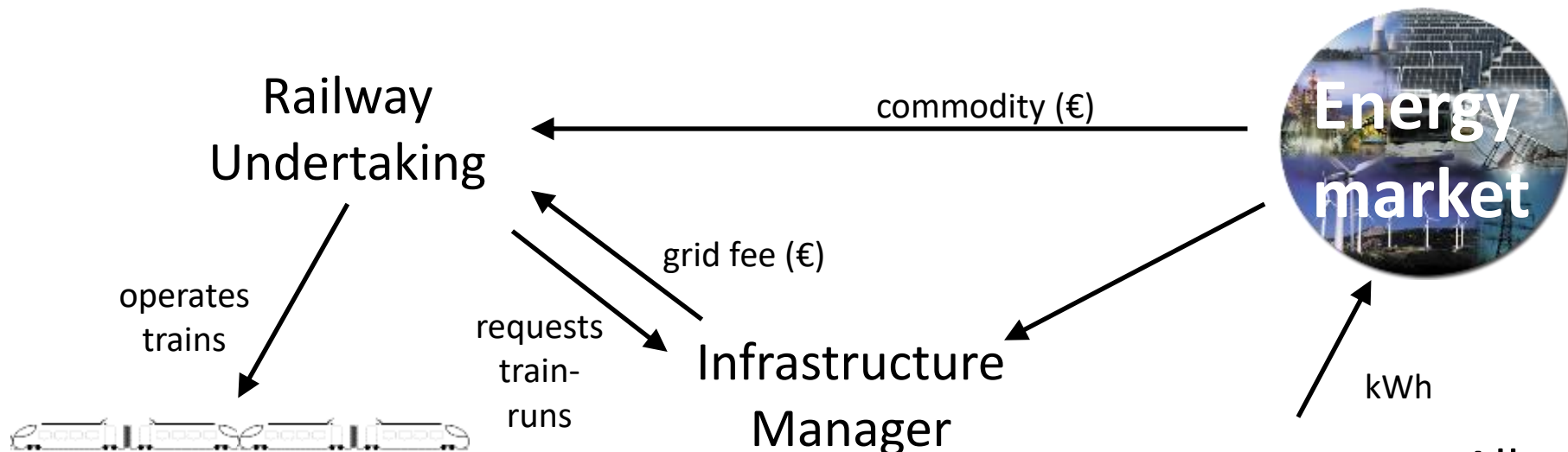
Passengers, Oslo-Halden, 2006



High speed, Strassbourg-Paris, 2010



Freight, Mechelen-Aachen, 2014



Allocate:

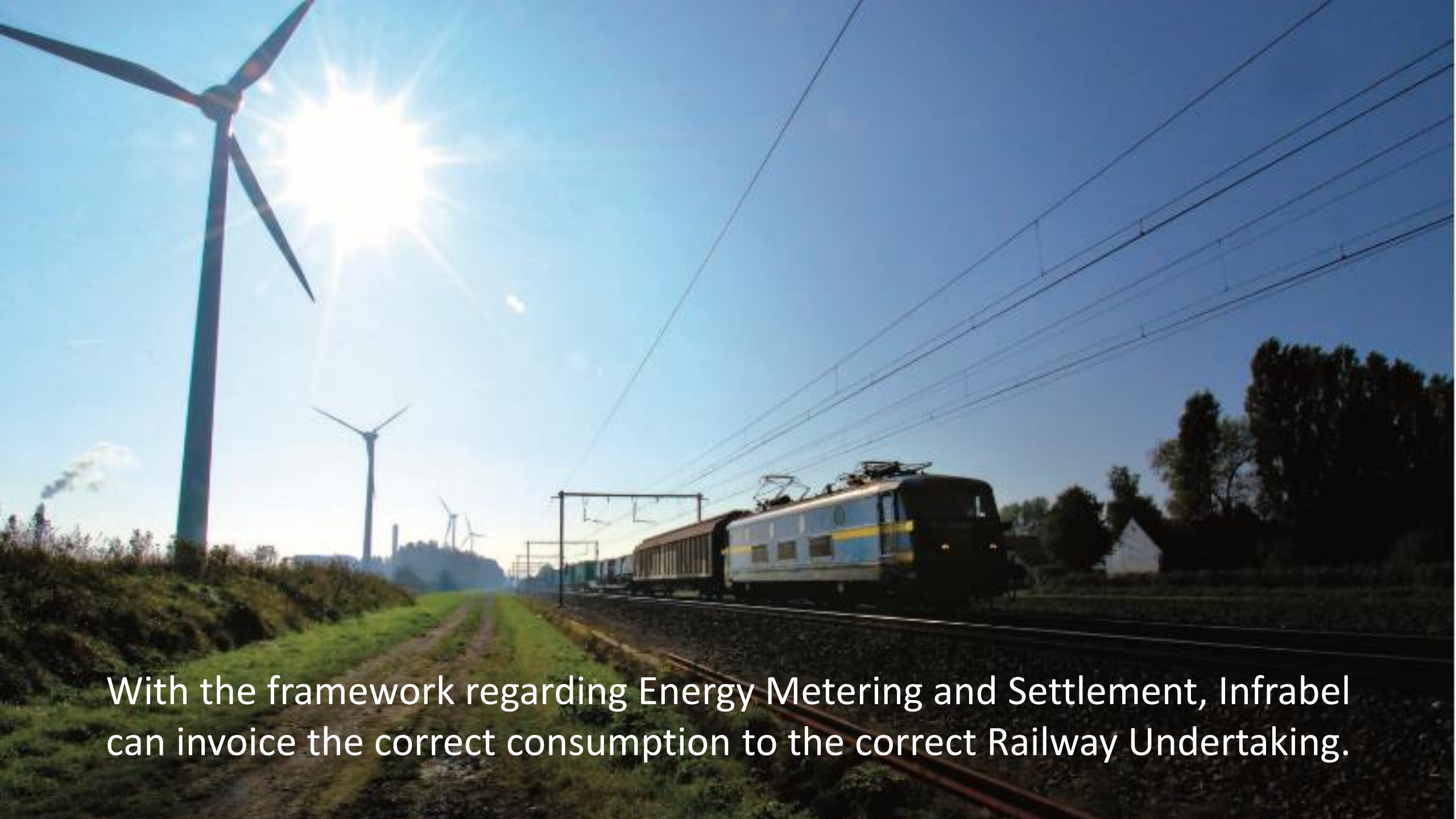
- allocate consumptions to the correct end user
- distribute to correct actors in energy market

Validate/estimate:

- validate data coming from EMS
- estimate missing data

Exchange:

- allocate consumption to country where consumption took place
- distribute to correct settlement system



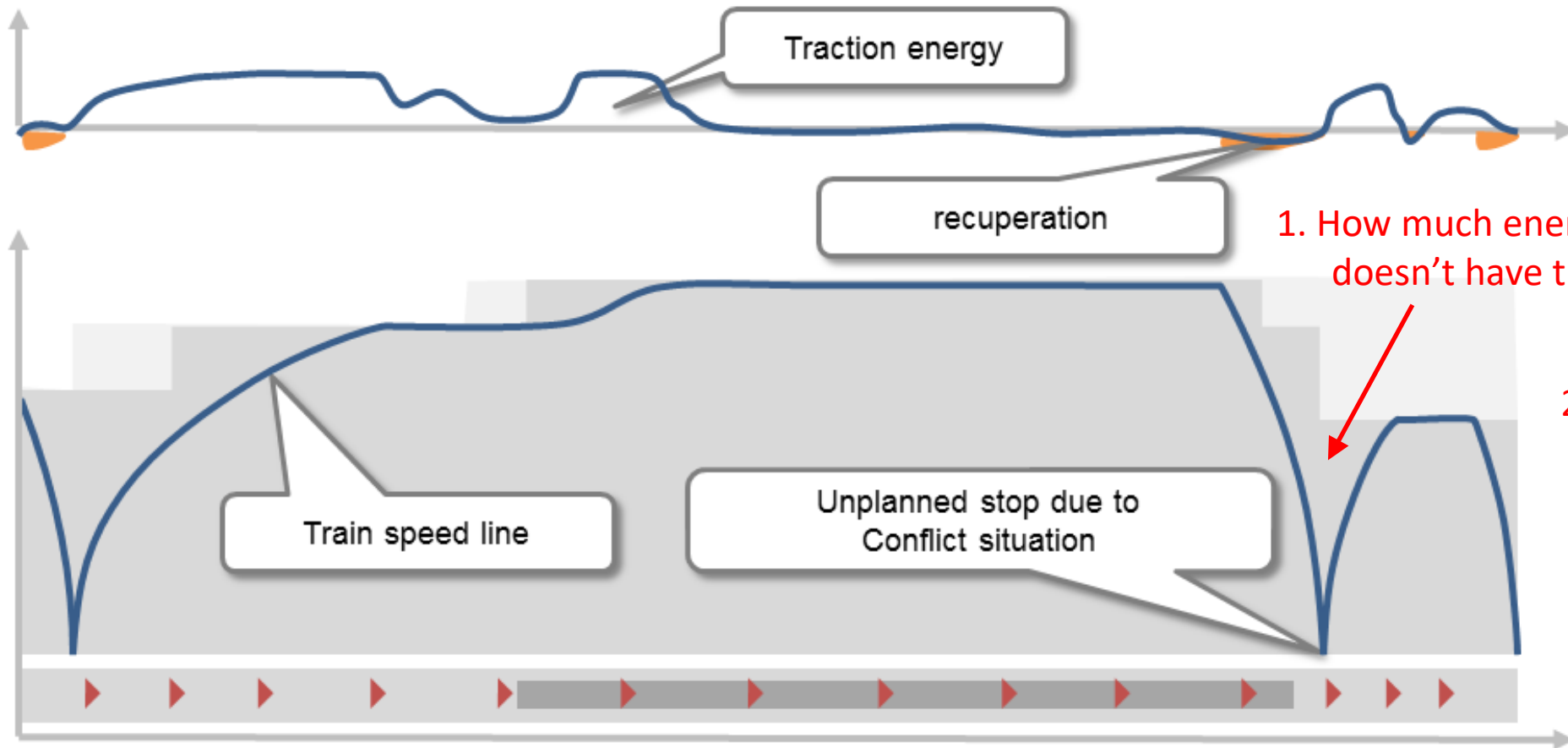
With the framework regarding Energy Metering and Settlement, Infrabel can invoice the correct consumption to the correct Railway Undertaking.



How can we help Railway Undertakings in reducing their energy consumption? Can we send information in front of an expected red sign to avoid unplanned stops?

Without connected Driving Advisory System (DAS)

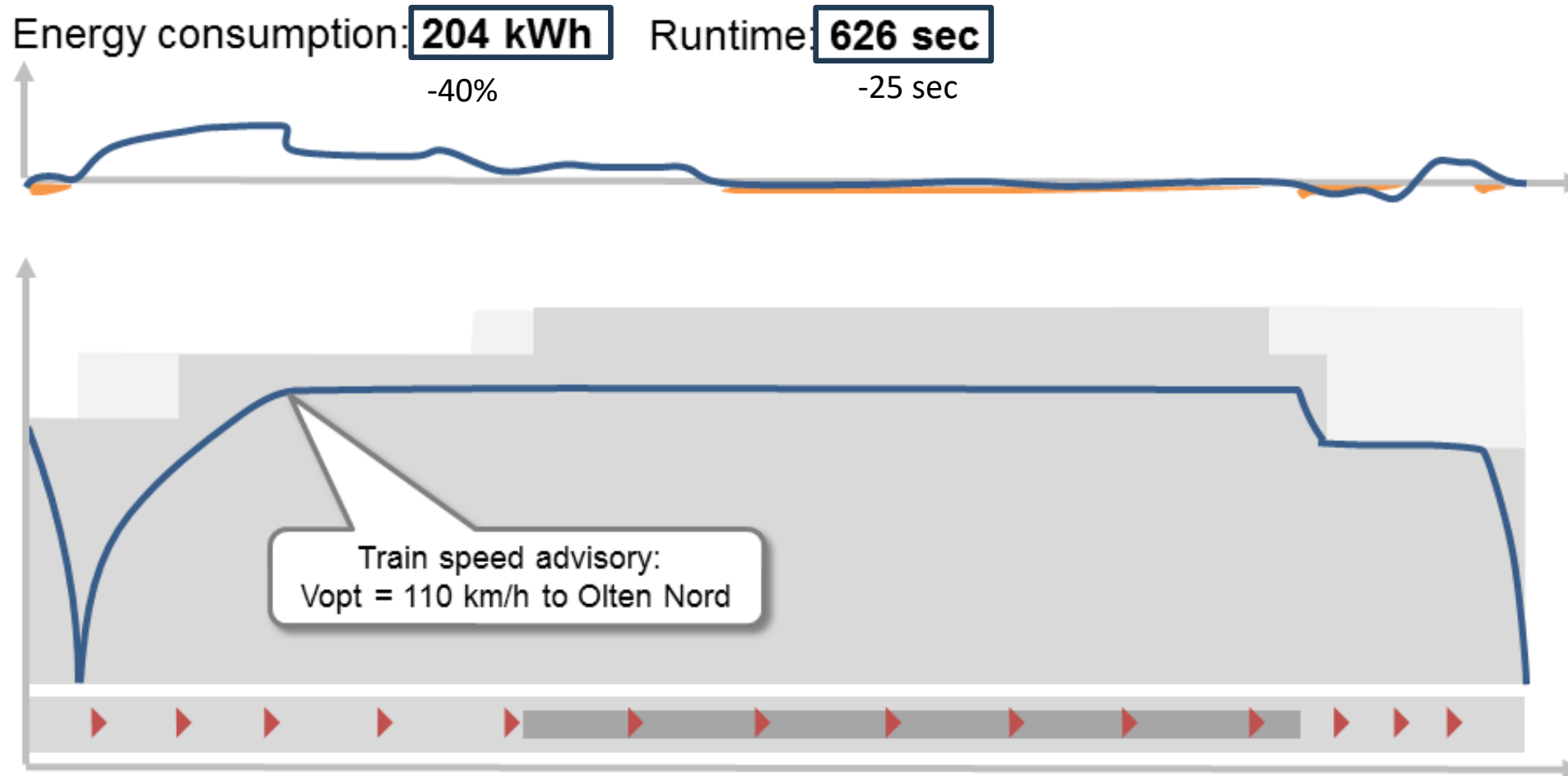
Energy consumption: **350 kWh** Runtime: **651 sec** (incl. unplanned stop)



1. How much energy can be saved if train doesn't have this unplanned stop?

2. Would this cause extra delay?

With connected Driving Advisory System (DAS)



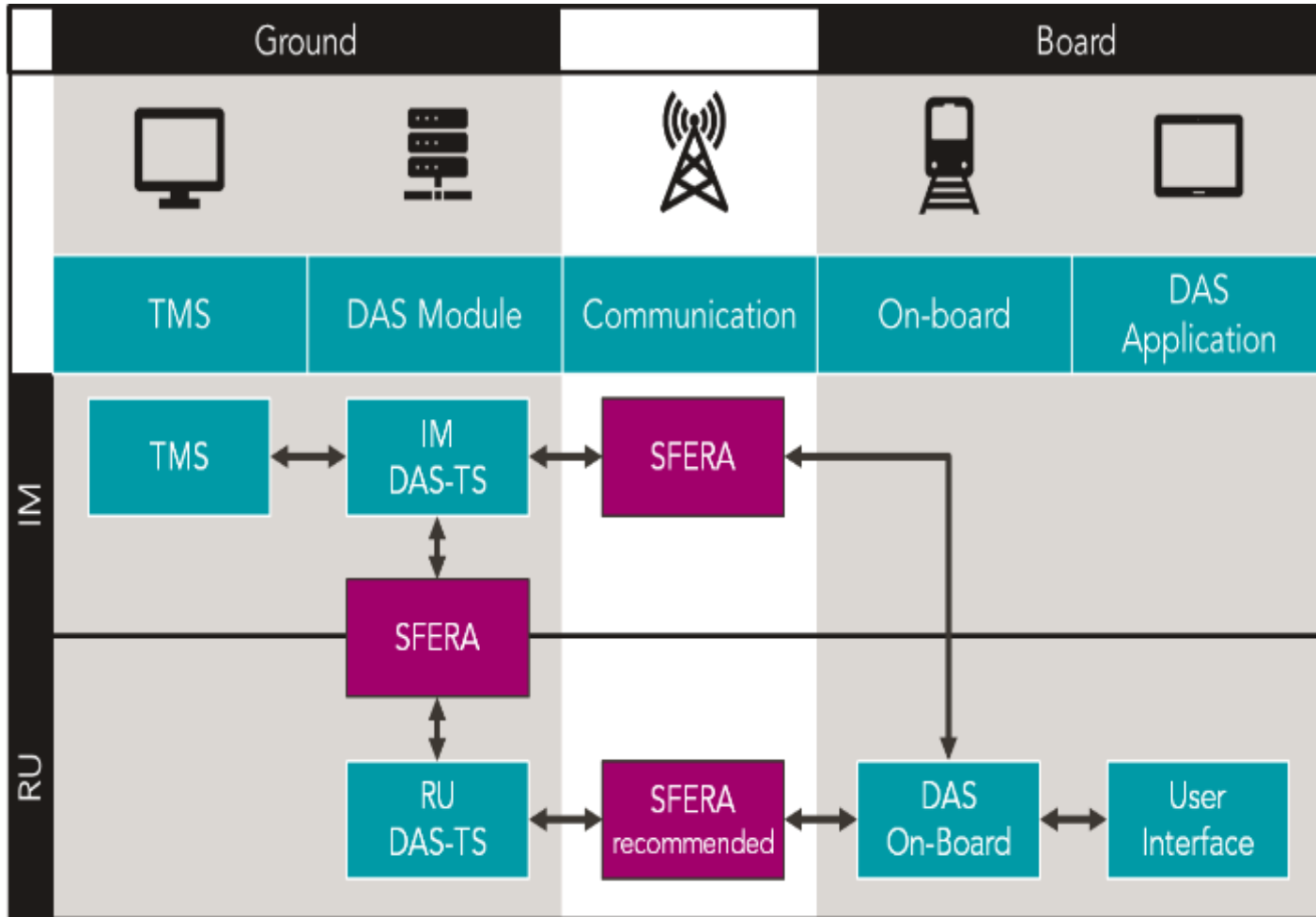
Cruising advice in this example. Coasting is regarded to be even more energy efficient.

Different types of Driving Advisory Systems

- S-DAS (stand alone DAS):
 - On-board advice based on the static timetable
 - The spare time in the timetable is used to save energy
 - Data is loaded before the train-run => no permanent radio coverage needed
 - This can only work if nearly all trains are running on time
- C-DAS-C (connected DAS with centralised advice calculation):
 - Trackside calculated advice based on the current timetable with adjustments from Traffic Management System
 - In most cases the dispatcher has to initiate this process => only applied to solve conflicts
 - Trains with C-DAS-C will get a speed advice to avoid a conflict
 - On a network with high punctuality, nearly no C-DAS-C advices will be generated
- C-DAS-O (connected DAS with on-board advice calculation):
 - On-board calculated advice based on the current timetable with adjustments from Traffic Management System
 - This combines the advantages of S-DAS and C-DAS-C
 - An advice is calculated when all trains are running on time, but also in order to avoid conflicts

IRS 90940

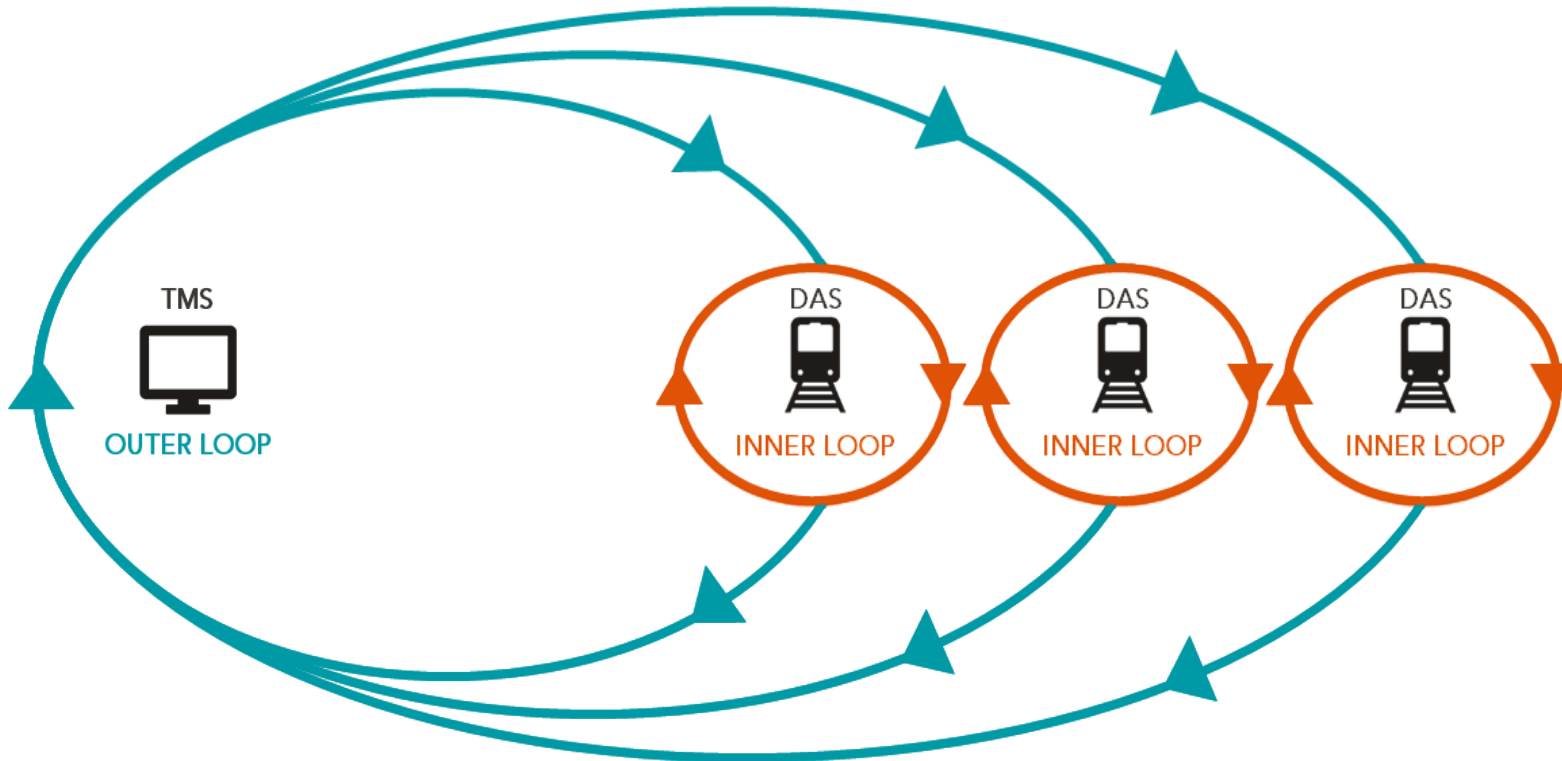
For free available on
UIC-shop



- The IRS 90940 was published in June 2020 and defines the SFERA-protocol.
- It describes a bidirectional communication between a Traffic Management System (TMS) and a DAS on-board.
- Direct or via a ground server of the RU.
- The protocol can also be used to communicate with ATO (Automatic Train Operations)
- Maintenance project is ongoing. It is still possible to join. DAS-suppliers will be able to join a user group. Contact stefanos@uic.org.

Functioning of a C-DAS-O

TRAIN PATH ENVELOPES

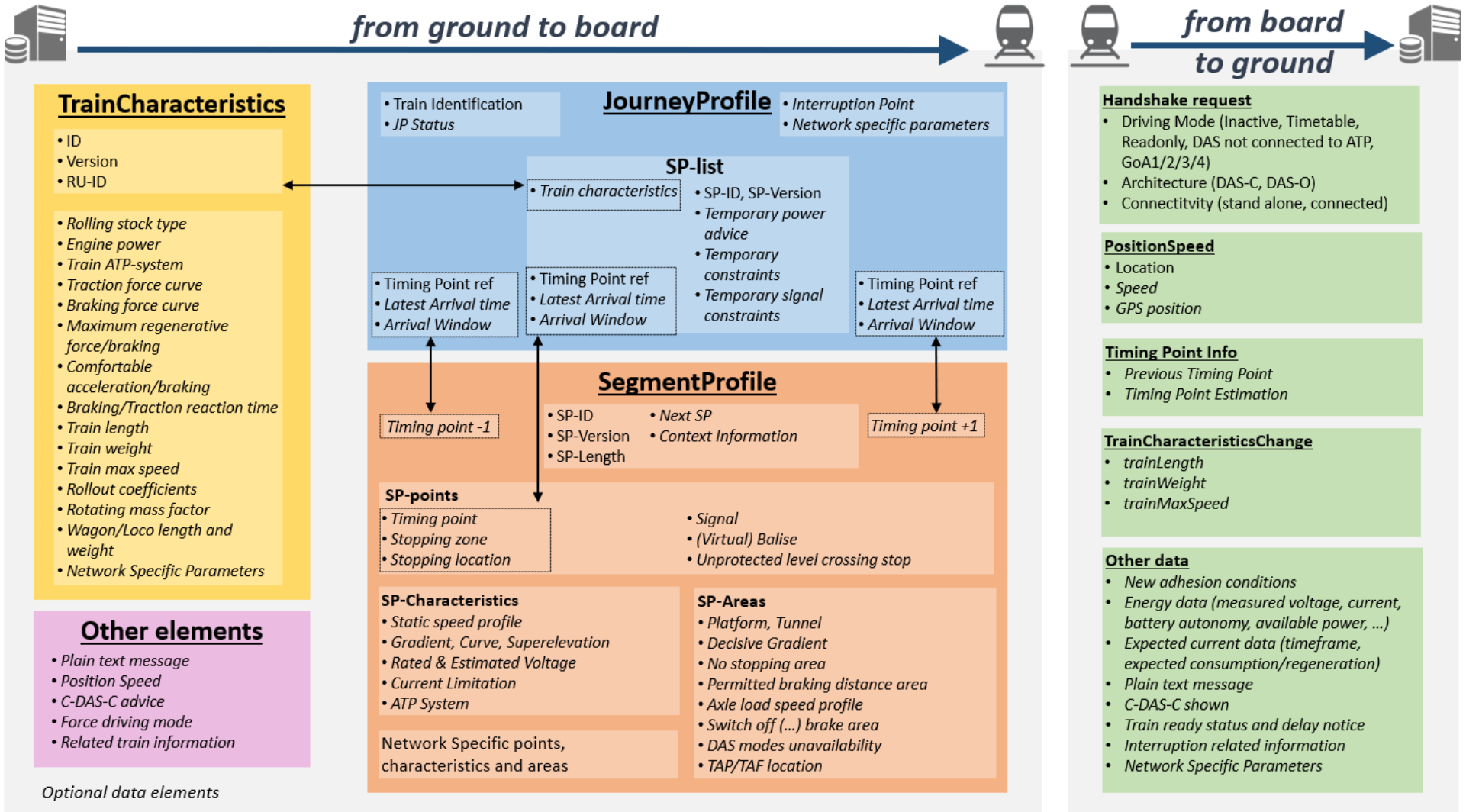


FEEDBACKS

- Updated train characteristics
- Train position
- Status reports

- Each DAS has its own optimisation algorithm.
- Each DAS sends feedback to TMS.
- TMS detects conflicts, defines optimal solution and adjusts Train Path Envelopes.
- A Train Path Envelope contains the periods of time in which a train can pass each of the significant locations of its train-run.

SFERA MESSAGE STRUCTURE

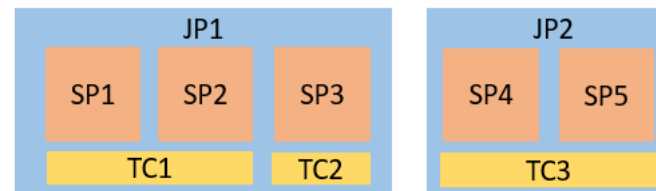


Common Header

SFERA Message Header

- Message-ID
- Timestamp
- Sender
- Recipient
- Correlation-ID

Composition



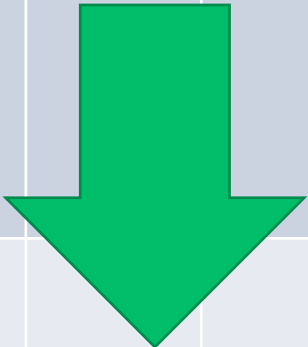

What benefits are reachable with a DAS?

- Energy savings
- CO₂ emission savings
- Higher punctuality
- Maybe even more capacity
- Less maintenance
- Small increase of safety


Situation in Belgium

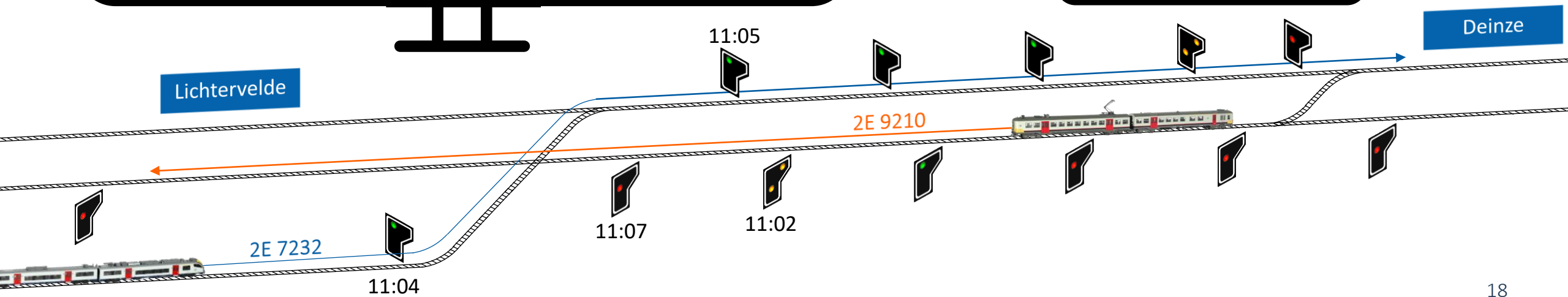
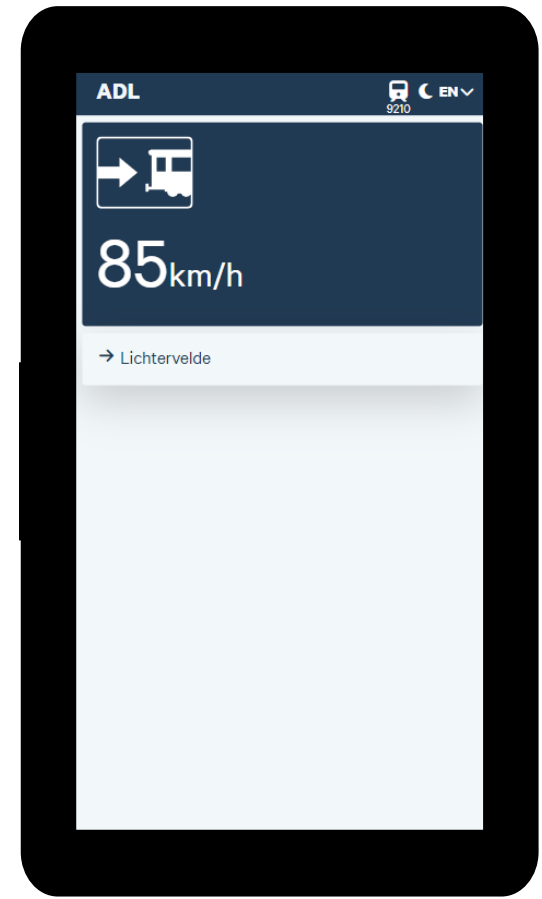
- We are using same Traffic Management System as SBB.
- We made an upgrade that went operational last year.
- This new version is able to generate C-DAS-C speed advise.
- Infrabel decides to put this operational but already use the SFERA-message structure and a simple web app on-board the trains.
- This permits further migration towards C-DAS-O but also supports apps able to communicate with different Infrastructure Managers.

Roadmap

	2021				2022				2023			
TMS core	Technical Upgrade and testing				Training							
					 <i>Go-live new TMS (without DAS)</i>							
DAS					Technical setup and communication to train, Optimising quality of advise				POC		Roll-out (freight)	

Planning TMS-DAS POC

Jan	Feb	Mar	Apr
 TMS 3.3 ("DAS ready")		<ul style="list-style-type: none">• 25/1: L166-165• 16/2: L50A/51A• TBD: L96/90C	
Test runs (Infrabel trains)			
Demo + intro (corridor L50A)			
		Test runs (corridor L50A)	



Choice of test corridor

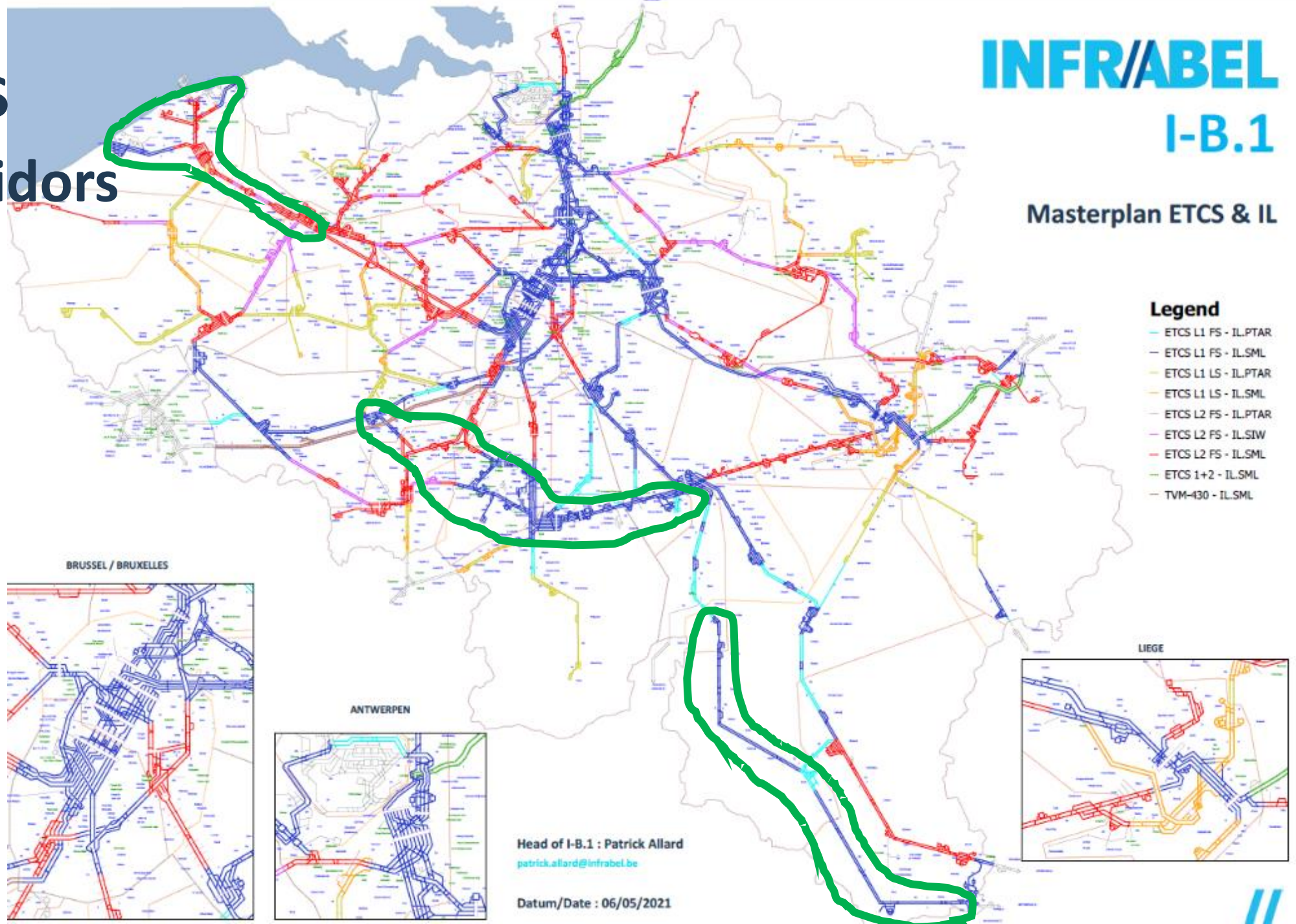
Balance between:

- Train operator preferences
- Achievable for traffic management
- Sufficient data quality (in practice this means digital interlocking for ETCS)

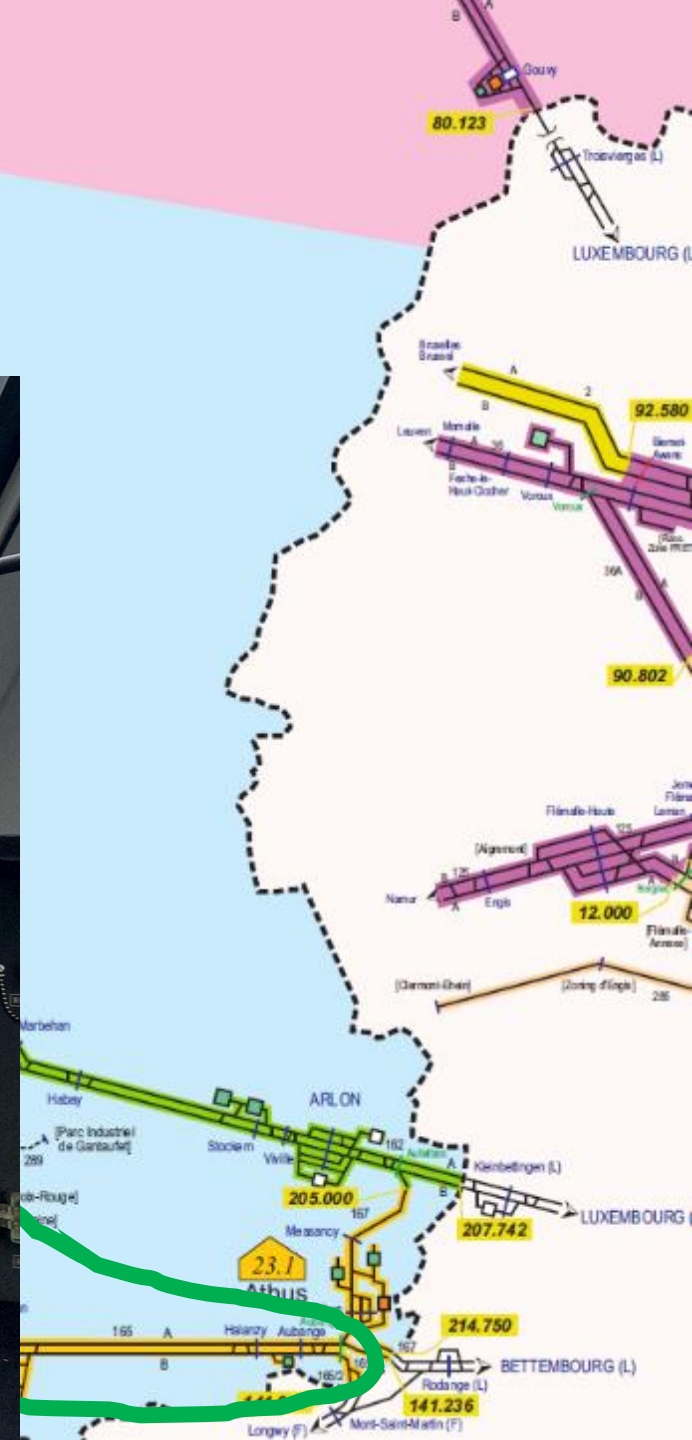
TMS-DAS Test corridors 1/2023

INFRABEL I-B.1

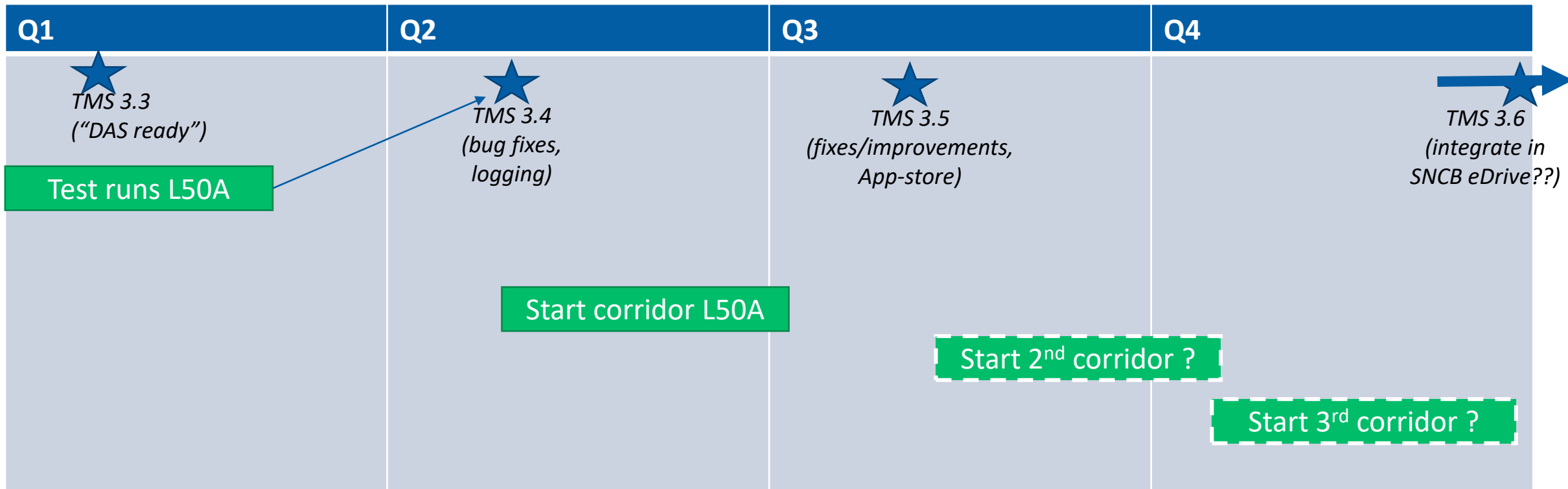
Masterplan ETCS & IL



Test corridor options



Planning TMS-DAS (ADL) 2023

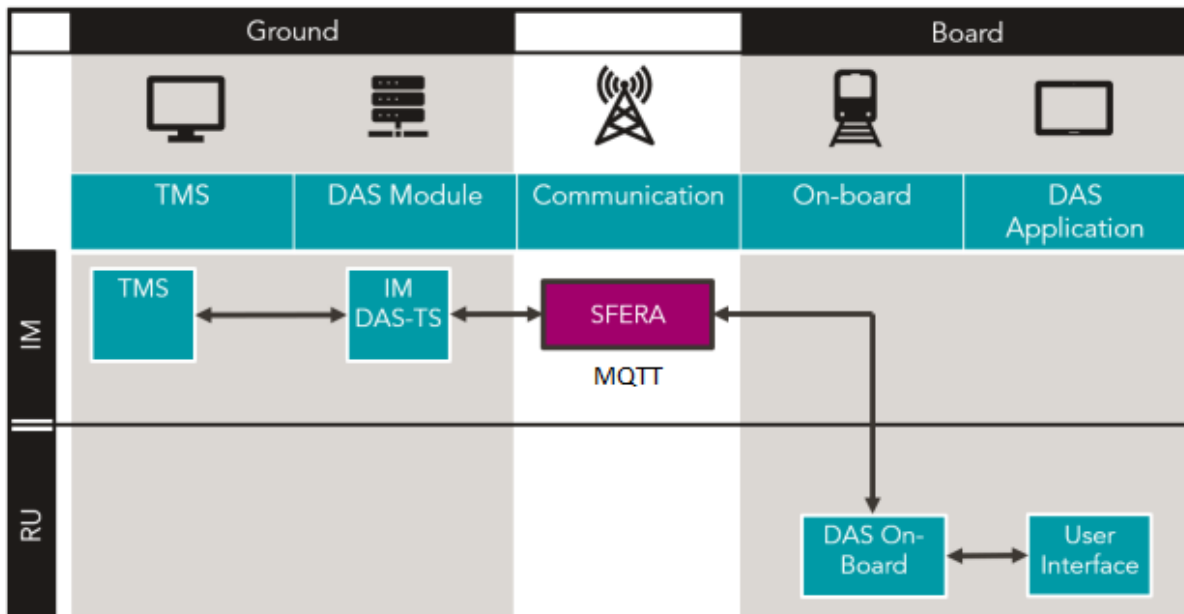


Possible next steps

what?	how?	dev work
avoid more conflicts	roll-out	easier login: native app (Cordova) easier integration: ADL as web component
	improve TMS	dispatcher user-priorities
energy efficient driving	on-board DAS	use JP/SP, integrate with 3rd party?
	driver GUI	use JP/SP, integrate with 3rd party?

Implementation

Current implementation of the Infrabel DAS solution is an IM-train setup as shown below. We have a working web-app, development of a native Android app is ongoing. The current implementation has some design choices and limitations.








TMS	RCS originally by SBB
DAS-TS	JAVA add-in to RCS implemented by Infrabel
MQTT	VerneMQ (open source MQTT broker, scalable and enterprise ready)
Identity Provider	ADFS (tool of Microsoft for single identification)
DAS On-board	Angular webapp by Infrabel

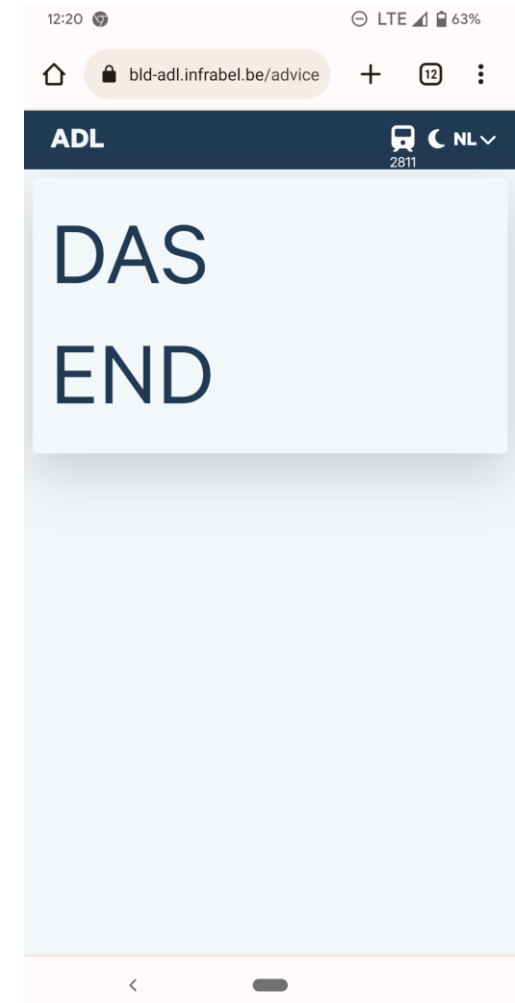
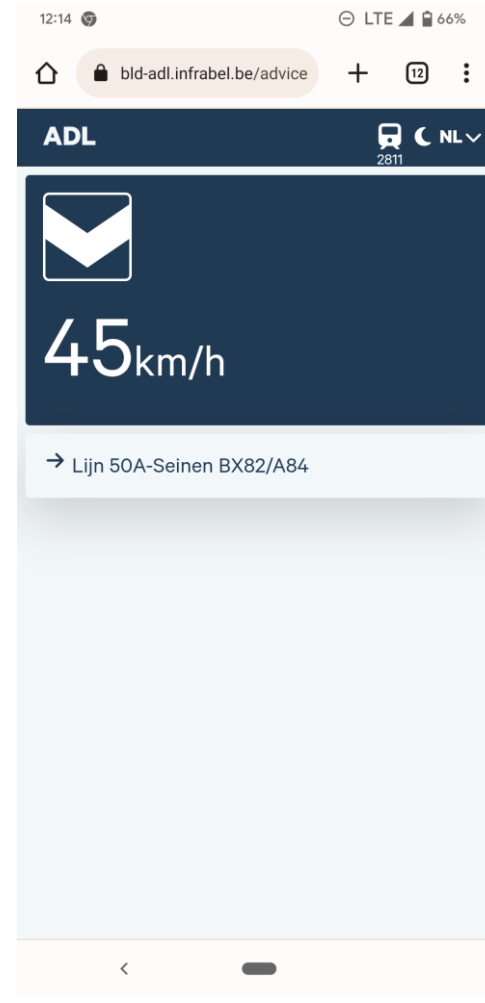
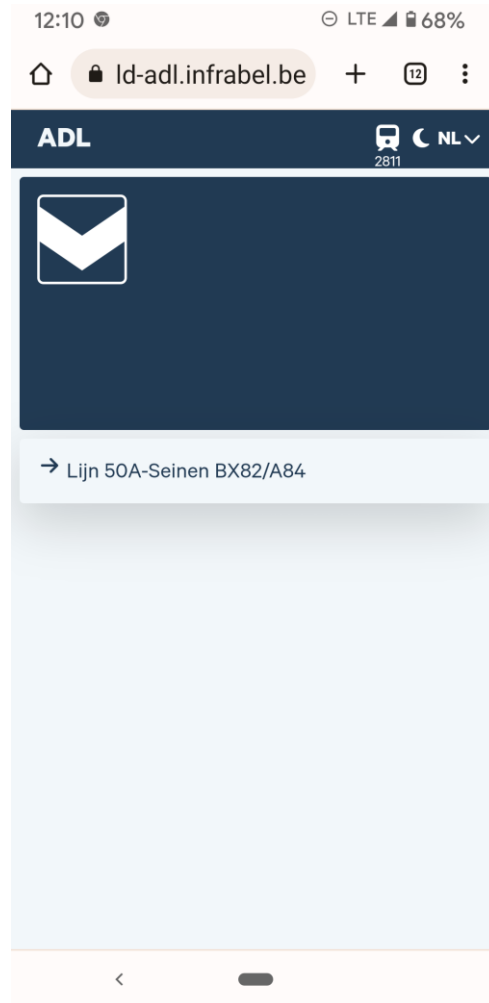
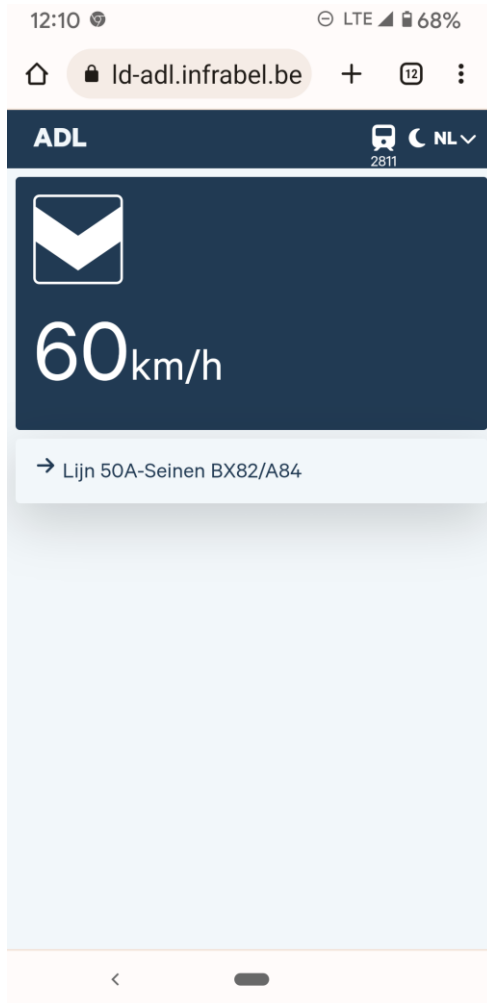
Speed advices (1)

- We (currently) only support speed advices. No Journey profiles/Segment profiles.
- Speed advices are only sent in case of conflicts or manual interventions.
- We only send advices when the train passed a signal (then we know exact passing time and can make accurate calculation and advice)
- The application blanks the speed after a short time but keeps the pictogram
- Speed advices have only a short validity, we regularly re-send the advice (while passing another signal)
- Series of speed advices is ended with an EndOfAdvice (either normal or error)
- Each reason code has a pictogram associated in the ADL application. We also use 4 'NationalUse' reason codes:
 - NationalUse1: to indicate goal is for the train to arrive on a fixed time (not as conflict resolution)
 - NationalUse2: "maximal speed"
 - NationalUse3: to indicate an error case of "EndOfAdvice"
 - NationalUse4: to indicate special case of "speedadvice": (re-)calculated speed <40km/h

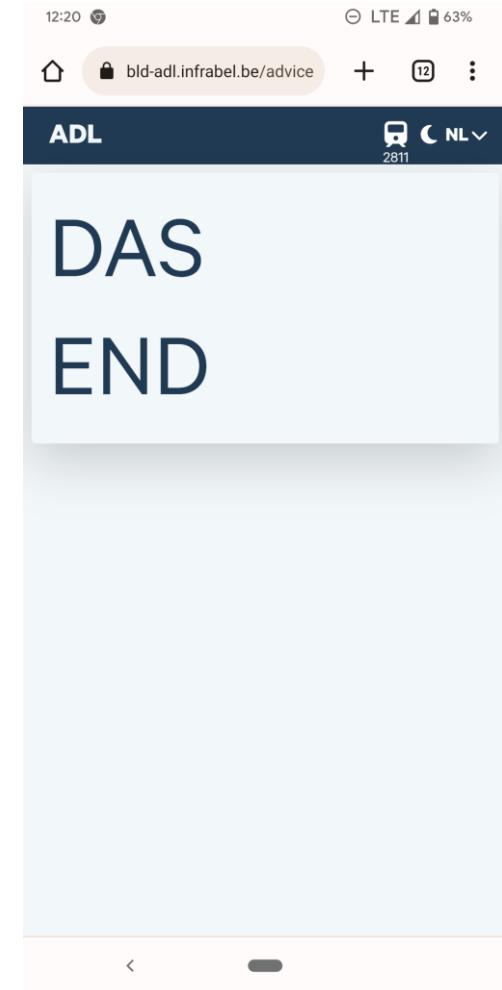
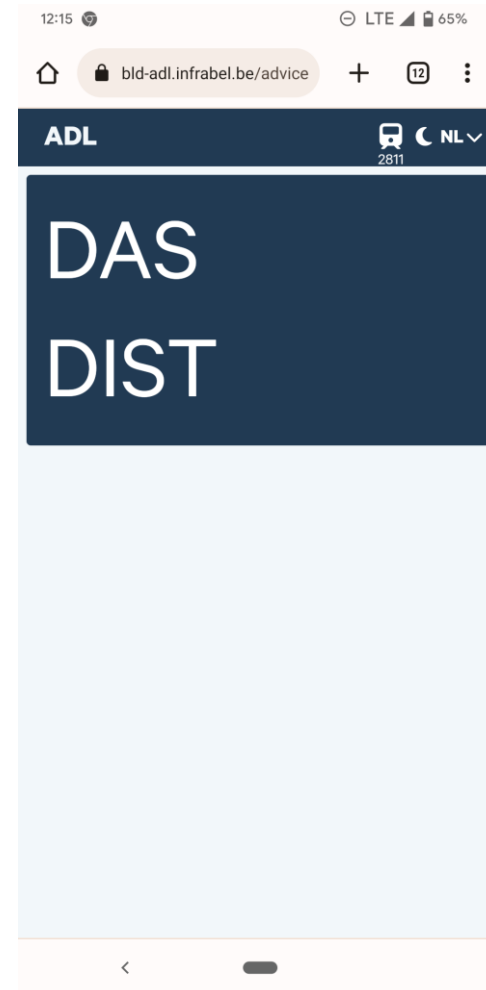
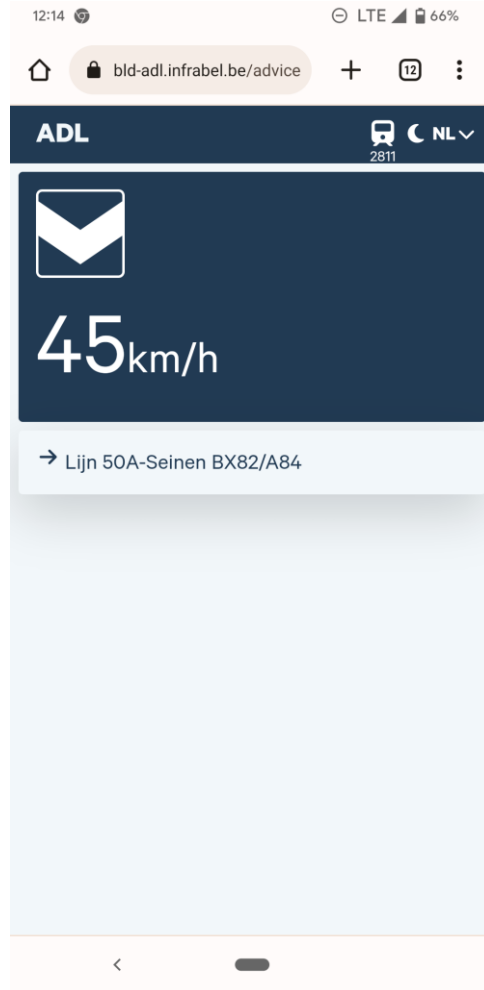
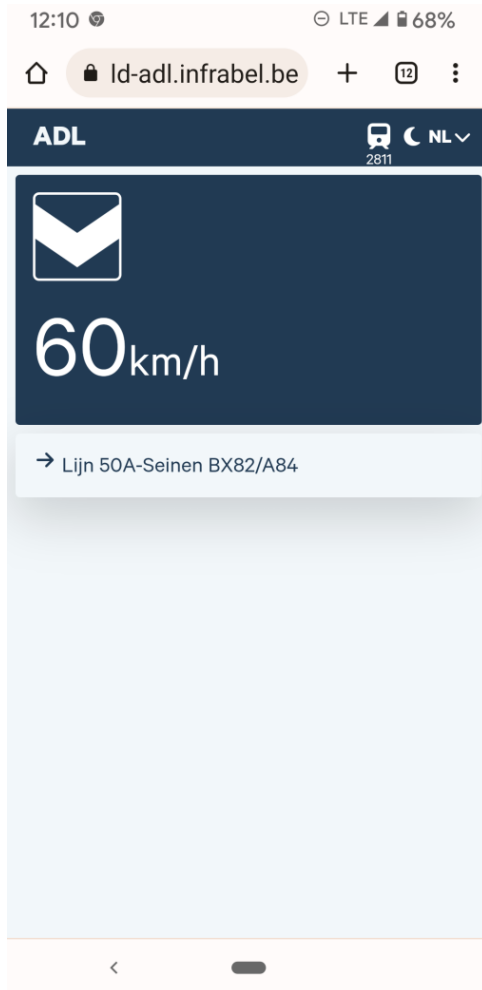
Speed advices (2)

Pictogram	Reason code	
	followTrain	The train you're on has a conflict with a train "in front" of you.
	trainFollowing	There are two conflicts: a train "in front" of you (as in the previous case) as well as a train behind you.
	NationalUse2	Maximum speed. The driver should drive as fast as allowed.
	NationalUse1	Fixed time. Please follow this speed to arrive at your destination on the time set by the dispatcher
	energyOptimisation	The driver should follow the speed advice in order to drive as energy efficient as possible.

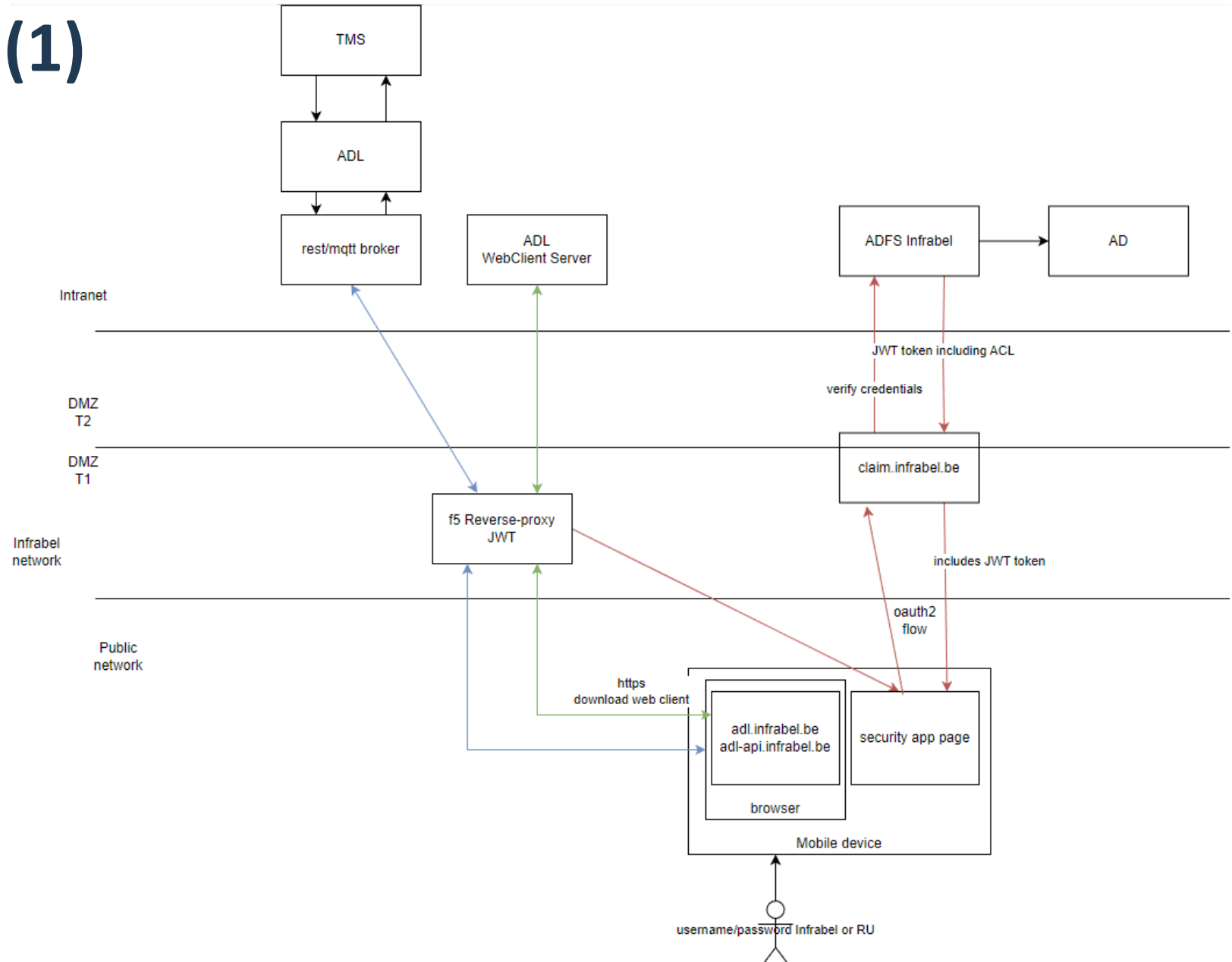
Screen shots



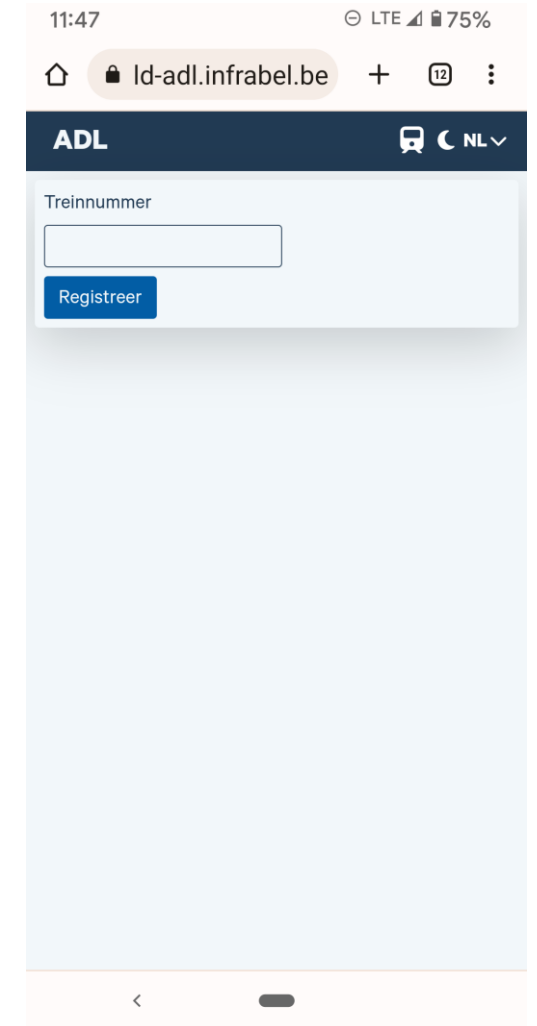
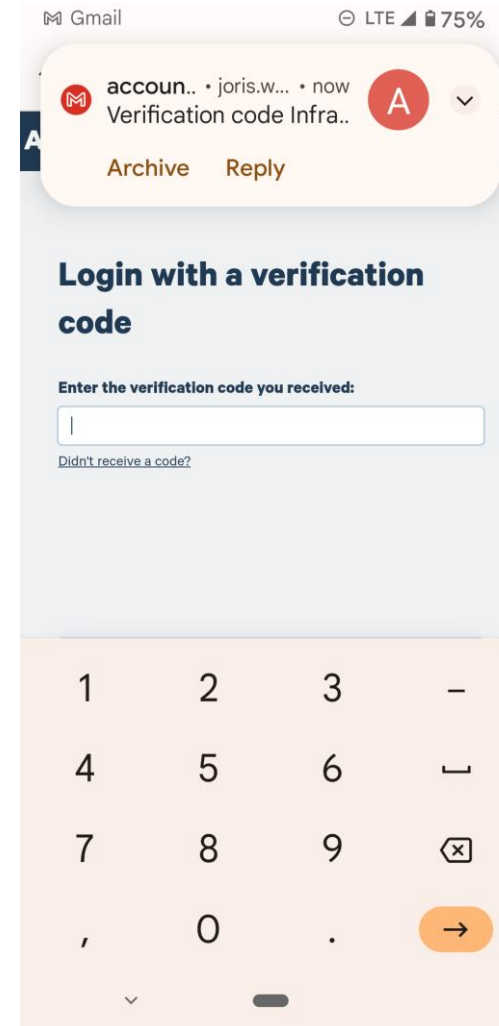
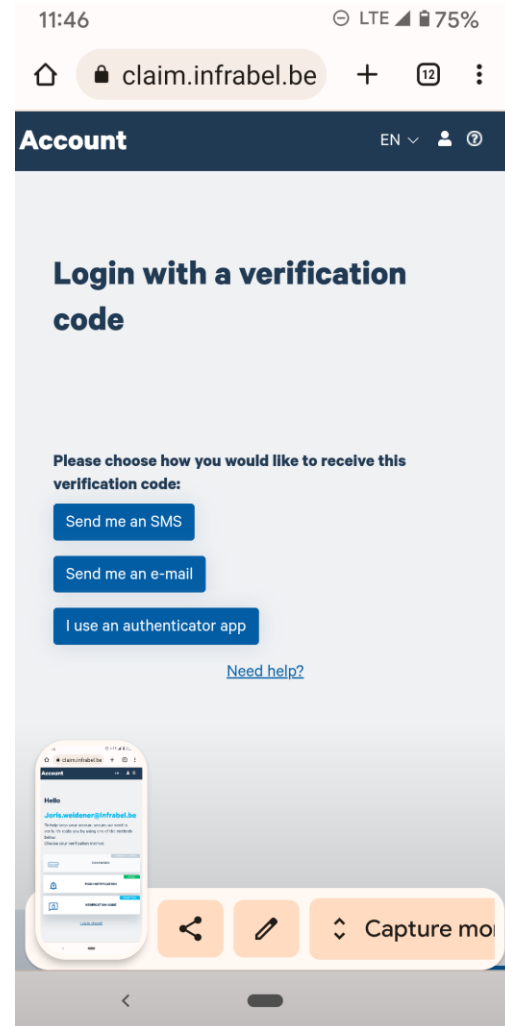
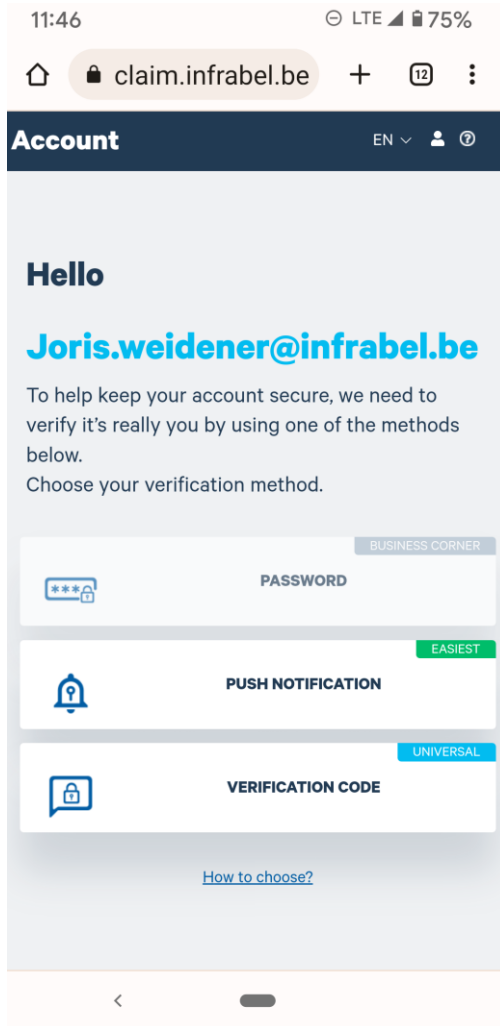
Screen shots (if train doesn't follow advise)



MQTT security (1)



MQTT security (2)

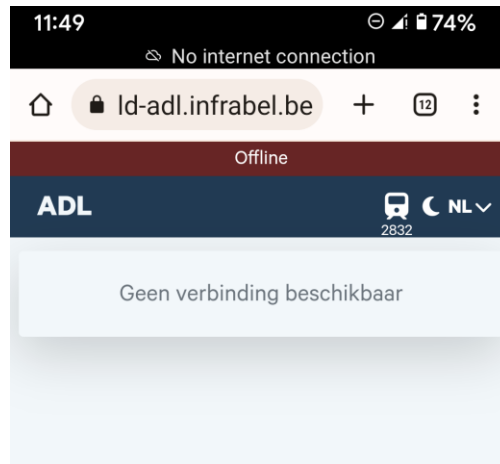


Handshake

1. Limitation on DAS Operating Modes:
 - Only “DAS not connected to ATP” is allowed as driving mode
 - Only “Ground Advice Calculation” is allowed as architecture
 - Only “Connected” is allowed as connectivity
2. There are no special provisions for multiple devices on the same train
3. Only “OwnTrain” is supported. The backend will not give any info about other trains!
4. Any DAS-OB successfully handshaking will be registered to the train they specified

Heartbeat

- To make sure the train driver knows his device is still in contact with the TMS backend system
 - So if there is an advice shown, it is still valid
 - If no advice is shown, it's because there isn't any
- To make sure the dispatcher knows which trains are capable of receiving speed advices
- For each device that performed a handshake, we regularly send SFERA_G2B_Request(DAS_DrivingModerequest)
- DAS-OB not responding for >10 minutes are disconnected (this can be visible to dispatcher)
- Our client not receiving these will show “offline”, and will try to reconnect (random interval)





Questions?

Thank you for your attention
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