

Kajtdagarna 15-16/5, 2023
Tomas Rosberg



AGENDA -

Forskningsresultat

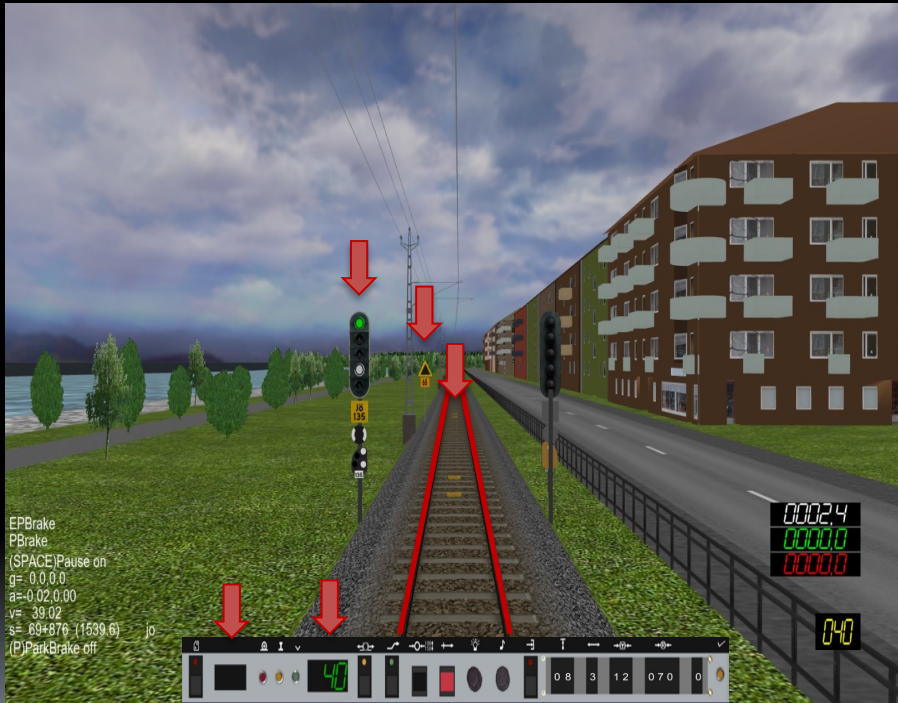
1. ATC bromsbeteende
2. Metodutveckling mätteknik ERTMS
3. Hastighetsfiltrering ERTMS

Framtid

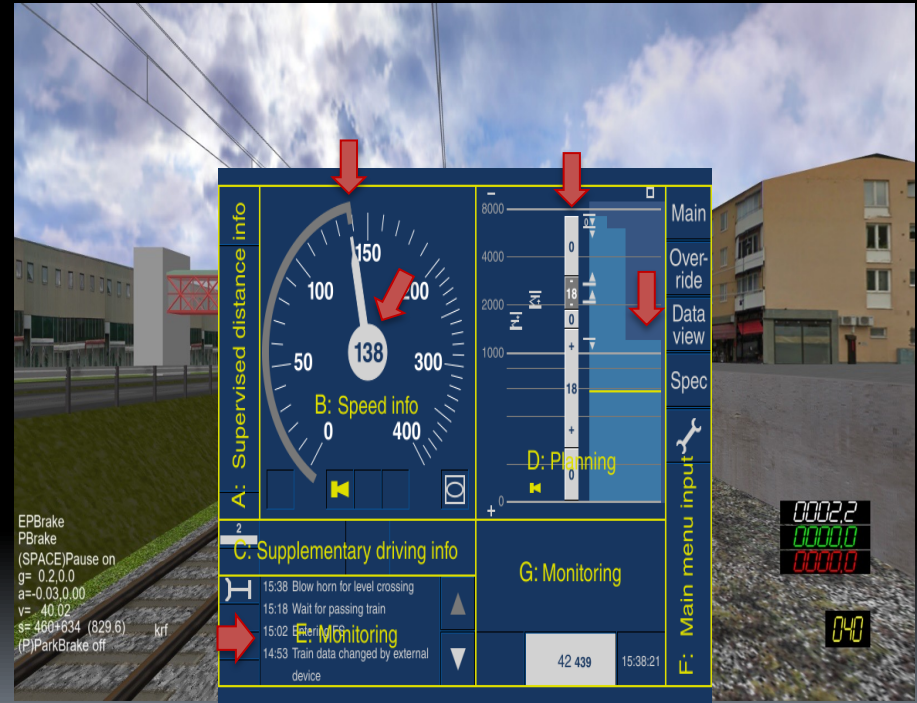
4. Hur mycket tid sparar vi genom att låta ATO bromsa?
5. Vilka datamängder behövs för ATO?
6. Framtidens förarsimulator
7. Fjärrstyrda tåg



Lineside vs. in-cab - Driver Perspective



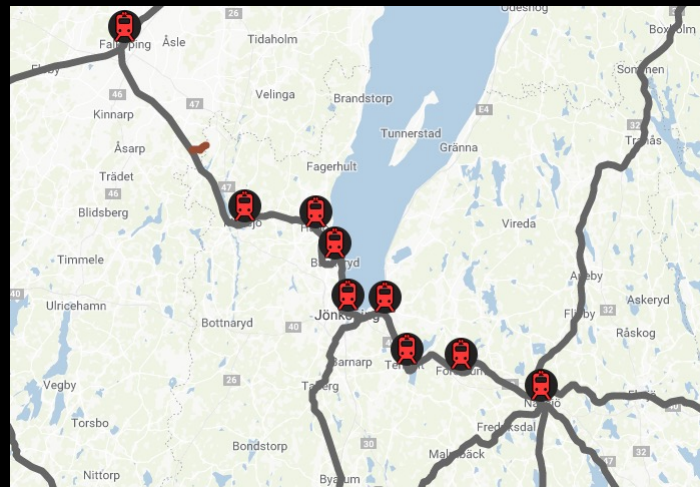
Lineside, optical signaling,
ATC



In-cab, ERTMS, ETCS

ATC STUDIE

LINESIDE SIGNALING, BRAKE
BEHAVIOR AND RUNNING TIME



Train deceleration

Train type	Transport Adm (Today)	Pachl et. al. (2014)	Rosberg/Thorslund (2020)
Passenger trains	-0.6 m/s ²	-0.38 m/s ²	-0.41 m/s ²

MÄTTEKNIK ERTMS

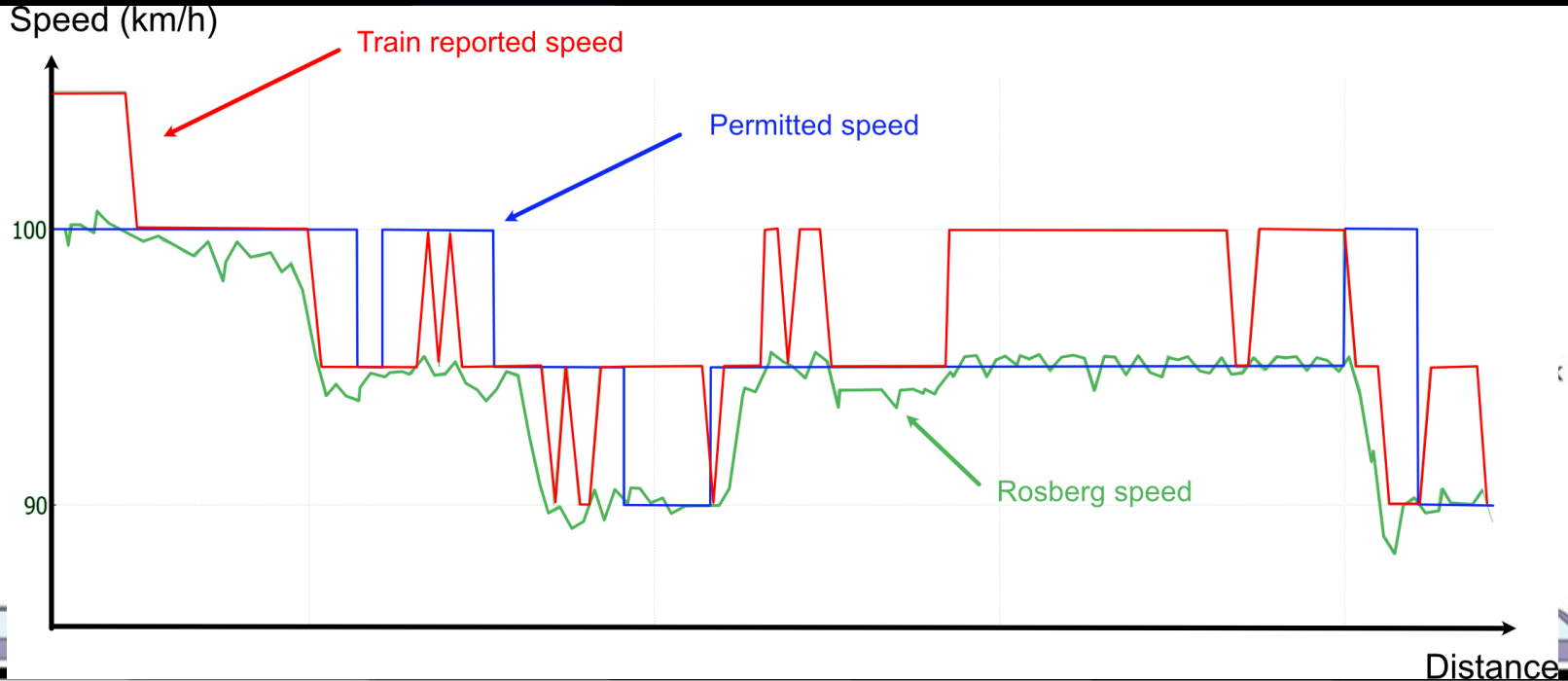
TRAIN MEASUREMENTS IN AN ERTMS ENVIRONMENT

EPA Tool

Accuracy:

$$v_{measured} = v_{train} + 0.07 \pm 1.66 [k m/h]$$

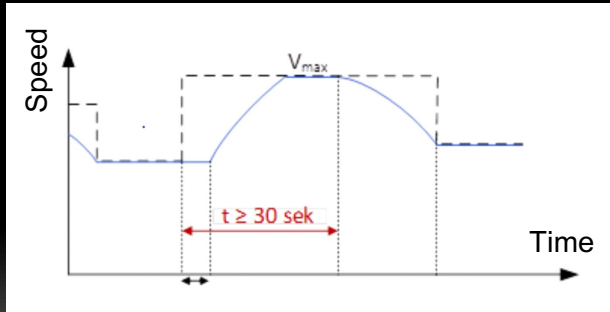
$$a_{measured} = a_{train} \pm 0.05 [m/s^2]$$



Effects of ERTMS speed-filters

-> Train drivers in Sweden reported many implementation problems

- **Speed profile, Visual focus, Increased workload**
- **Hidden braking curves**
- **Marker board confusion**



Driver:

- How is the driver affected?

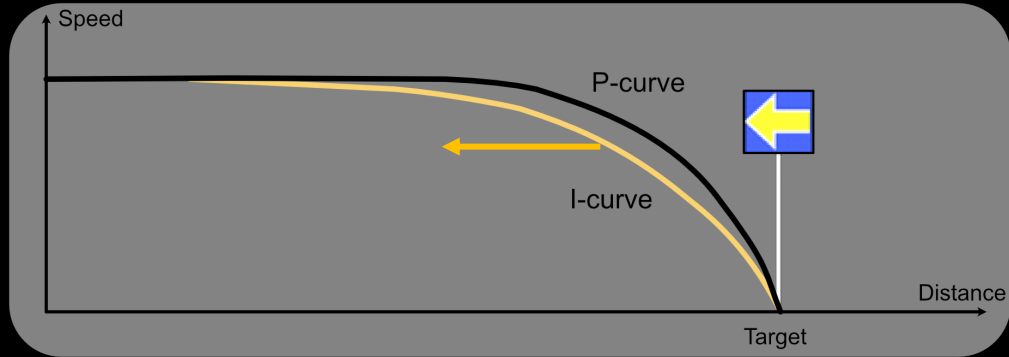
Energy:

- How is the train energy affected?

Capacity:

- How is the capacity affected?

SIMULATOR STUDY –
ERTMS SPEED FILTERING



Time from P-curve in the
beginning of the braking
phase

4.9 seconds

Time from P-curve in the end
of the braking phase

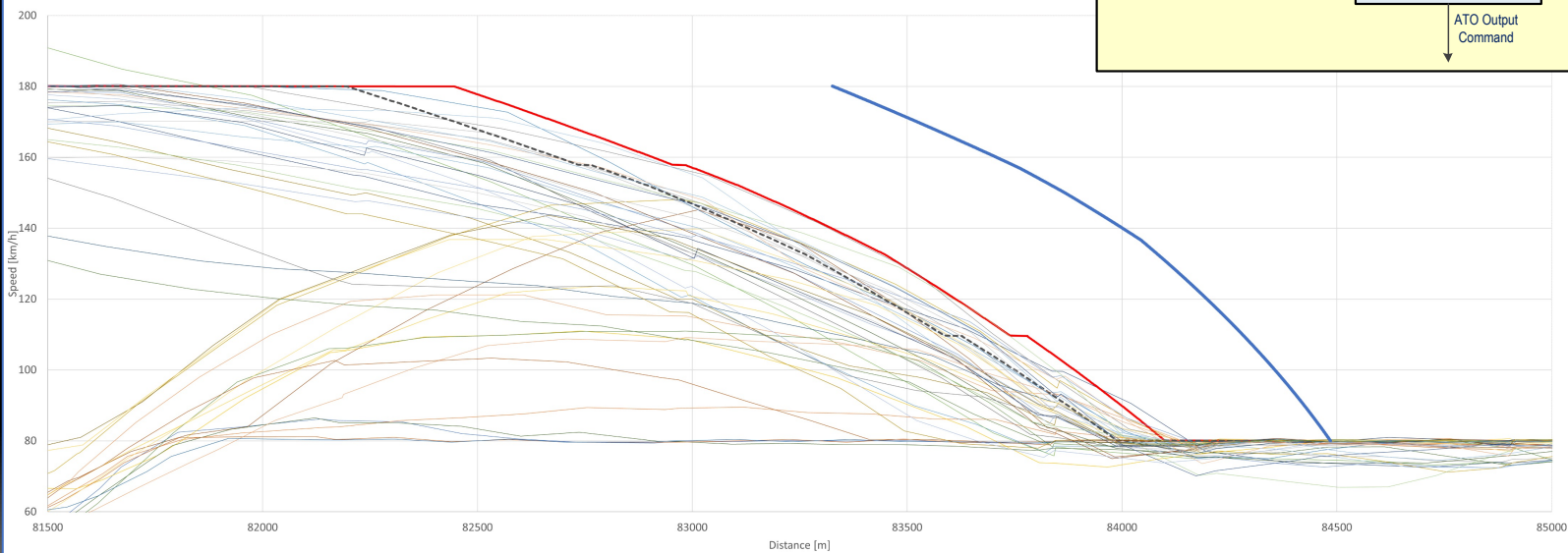
1.9 seconds

ATO OCH BROMSNING

Speed distance 2019 for EMUs at Ådal line. Brak

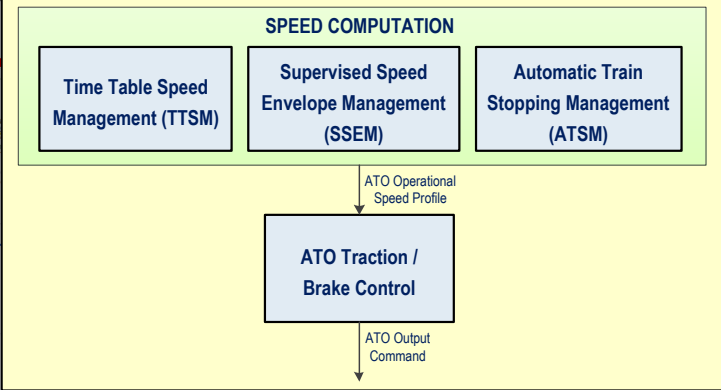


Speed distance 2019 for EMUs at Ådal line. Braking, from 180 to 80 km/h

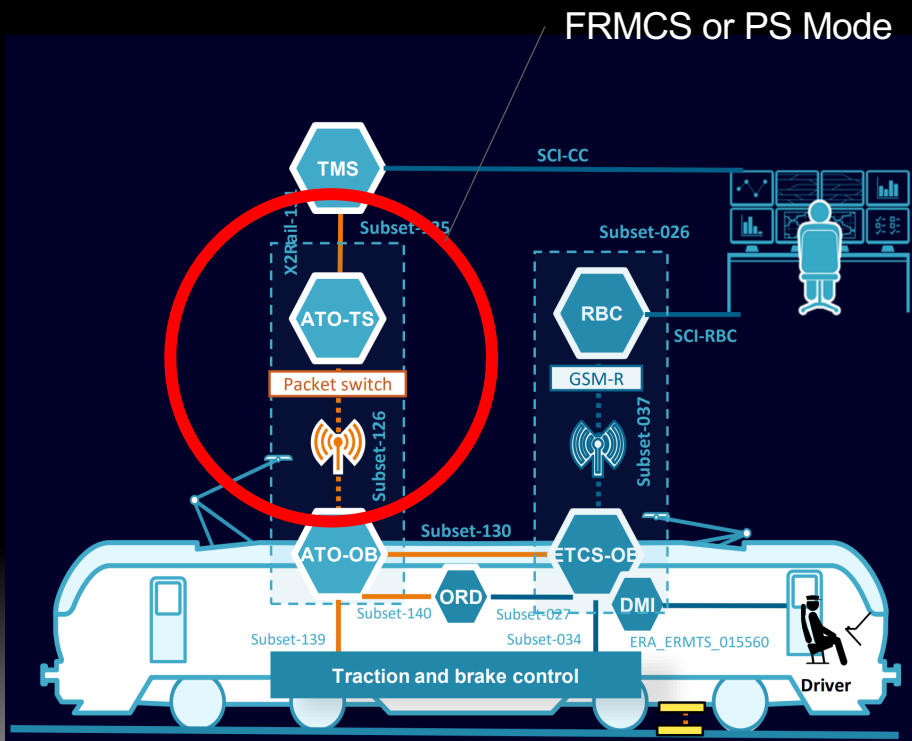


- 7406_191031
- 7406_191101
- 7412_191101
- 7406_191112
- 7412_191112
- 7406_191113
- 7410_191114
- 7406_191104
- 7412_191104
- 7412_191105
- P 1
- 7406_191106
- 7412_191106
- 7406_191107
- 7412_191107
- 7406_191108
- 7412_191108
- P 2
- 7406_190902
- 7412_190902
- 7406_190903
- 7412_190903
- 7406_190904
- 7412_190904
- 7406_190905
- 7412_190905
- 7406_190906
- 7412_190906
- 7406_1900805
- 7406_1900806
- 7412_1900806
- 7412_1900806
- 7406_1900701
- 7406_1900603
- 7412_1900603
- 7406_1900502
- 7412_1900502
- 7406_1900402
- 7412_1900402
- 7406_190304
- 7412_190304
- 7406_190201
- 7412_190201
- 7412_190103
- 7406_190104
- 7406_181204
- 7412_181204
- EBO 1
- EBO 2

ATO DRIVING FUNCTION



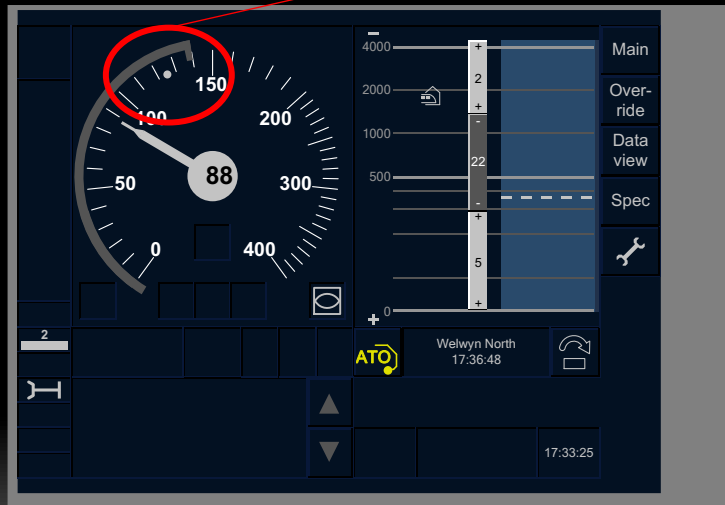
Datamängder för ATO



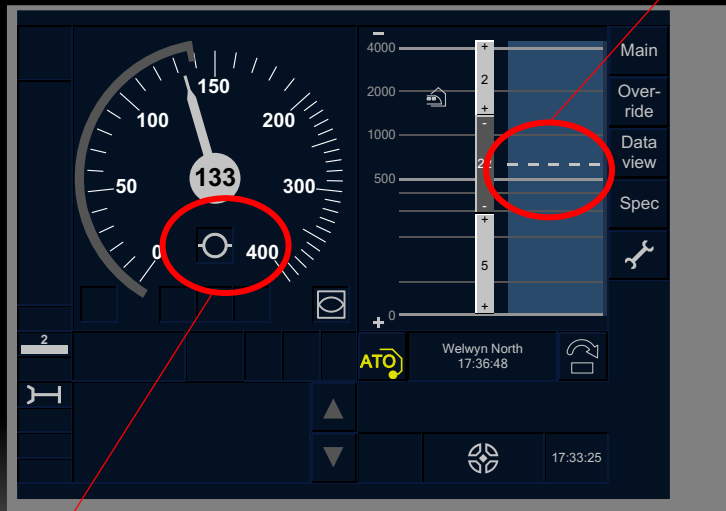
Use Case	Message Type	UL/DL	Data Rate
Voice	Audio	50/50	24 kbps
ETCS	Position Report	UL	10 kbps
	Movement Authority	DL	10 kbps
ATO	Journey Profile	DL	10-50 kbps
	Segment Profile	DL	100 kbps
	Status Report	UL	1 kbps
Remote Driving	Video & Audio Stream	UL	1 – 7 Mbps
	Control Data	DL	10-100 kbps
Video Surveillance	Video/Audio Stream	UL	1-7 Mbps

C-DAS i ATO specifikationen

Target Advice Speed

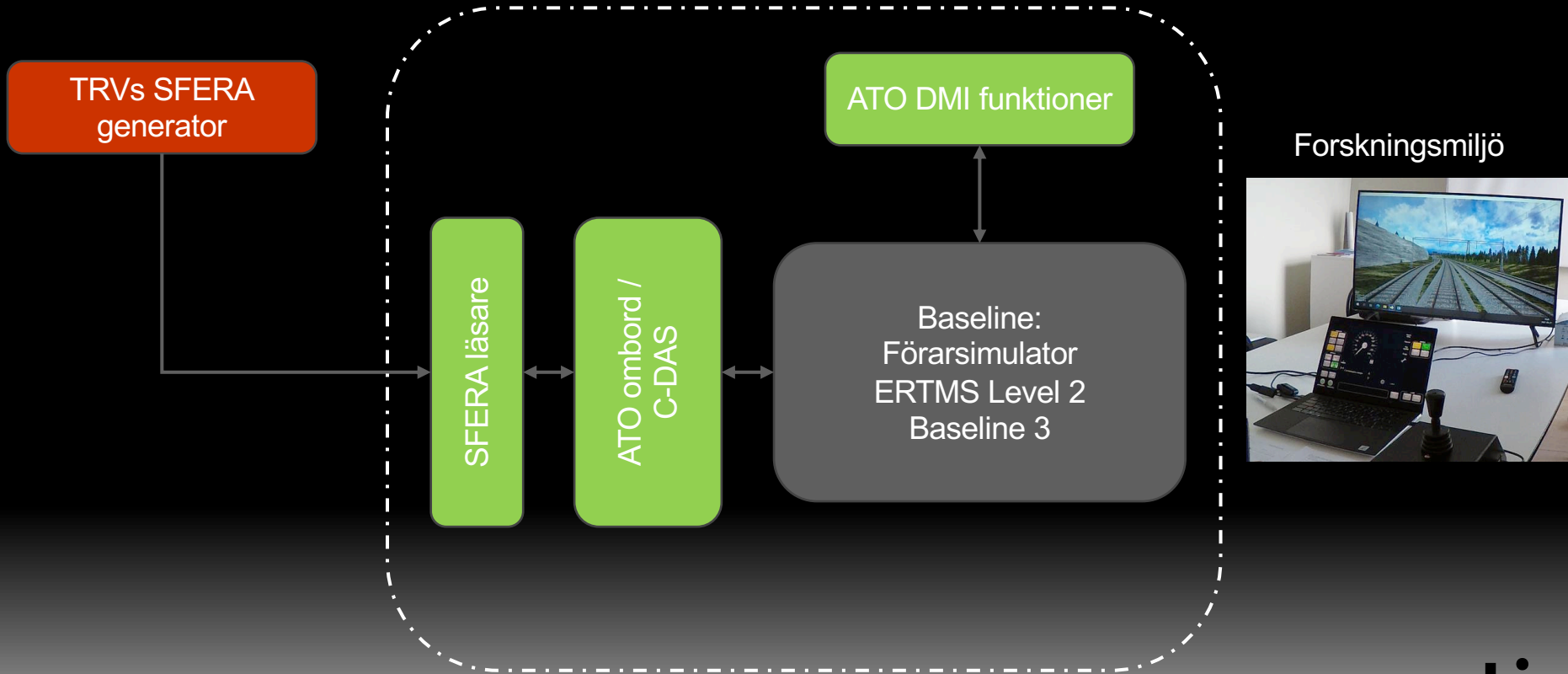


Next Advice

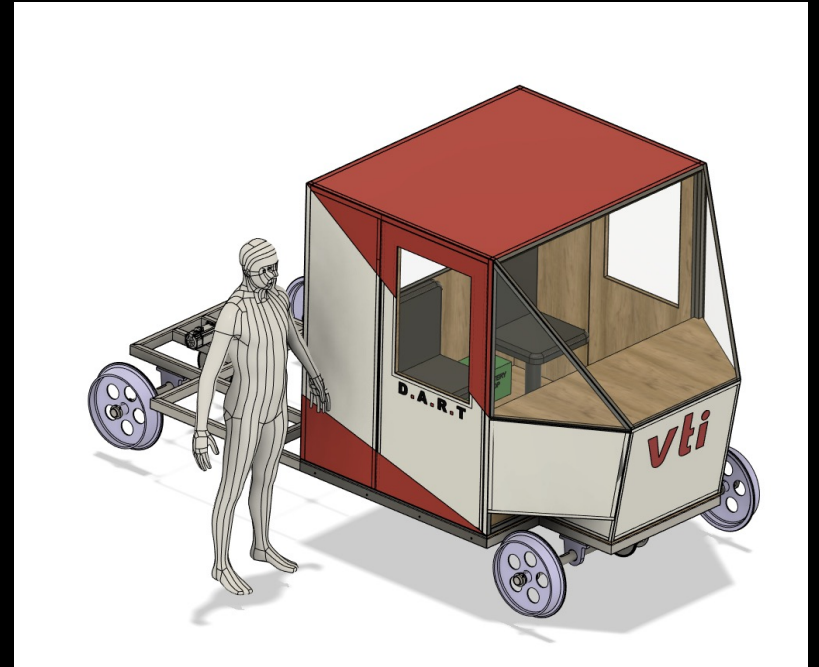
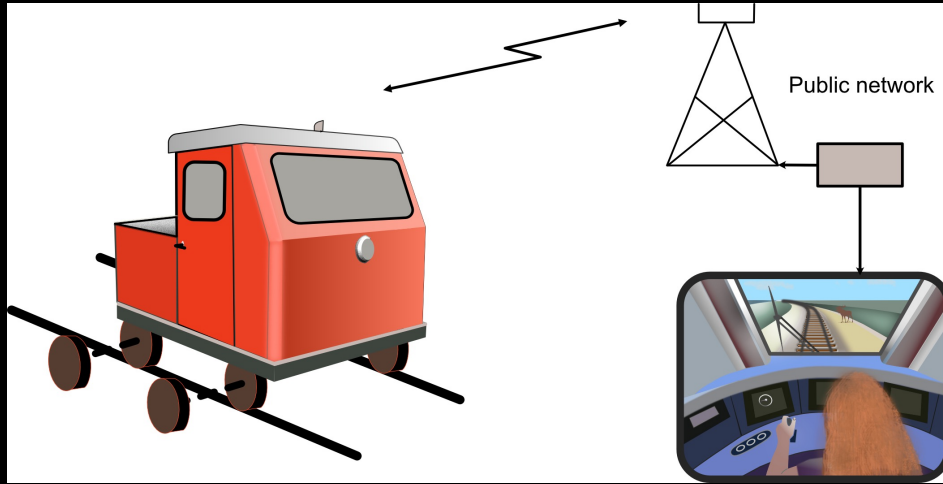


Coasting Advice

Framtidens förarsimulator



Remote driving



NTNU

vti

T
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Thanks for attention!

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