Optical train localization

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Optical train localization

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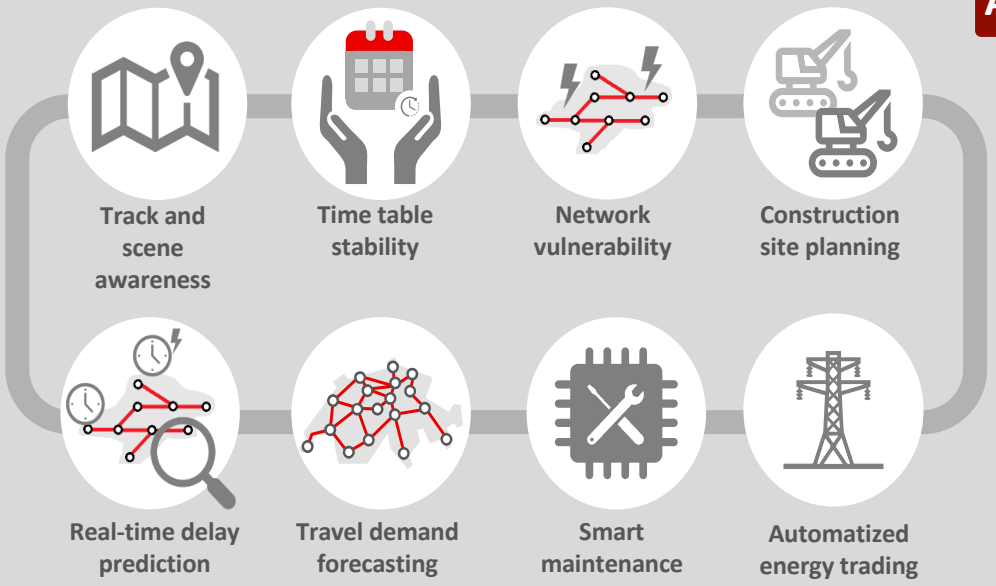

Autonomous traffic management

Adrian Egli
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> @ SBB booth

Erik Nygren
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> @ FLATland challenge
(Challenge track, 15:35)

Delay prediction

Mayra Bermudez
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> @ SBB booth

Nima Riahi
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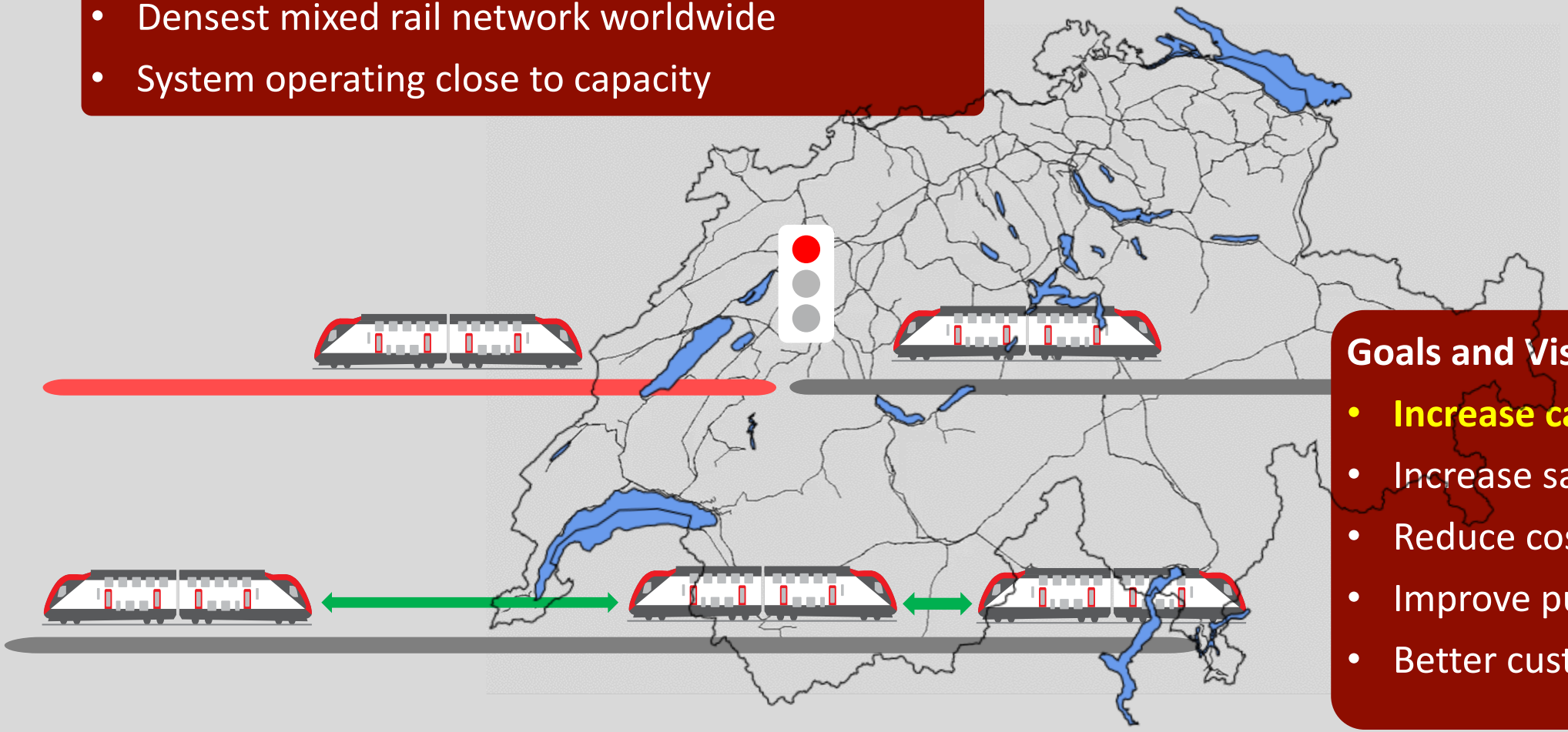
> @ Workshop «Theory meets Practice»

SmartRail 4.0

Goals and Vision 2040

- Densest mixed rail network worldwide
- System operating close to capacity

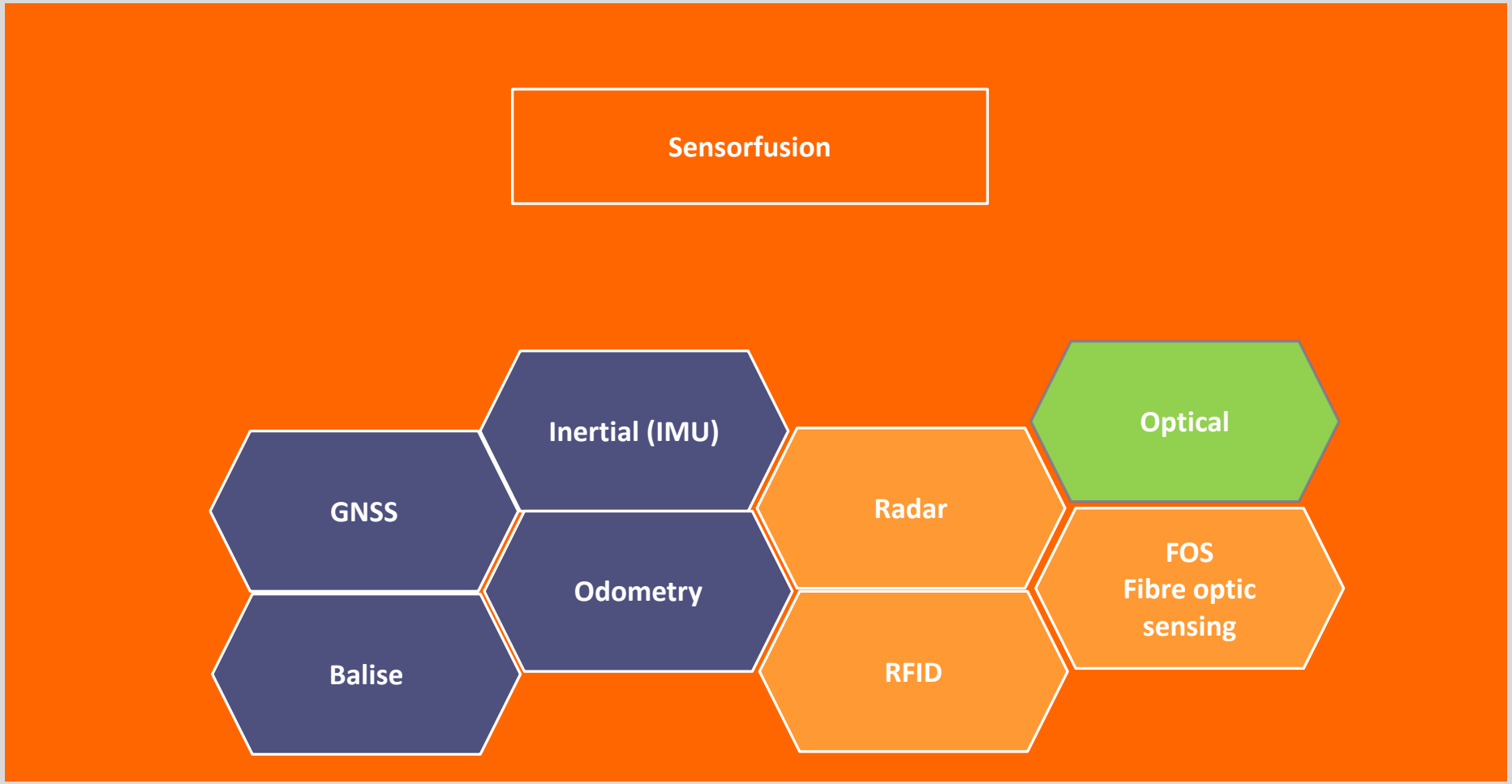


Goals and Vision 2040!

- **Increase capacity**
- Increase safety
- Reduce costs
- Improve punctuality
- Better customer service

Increase safety and capacity by precise train localization

Reliable localization using sensor fusion



Optical train localization

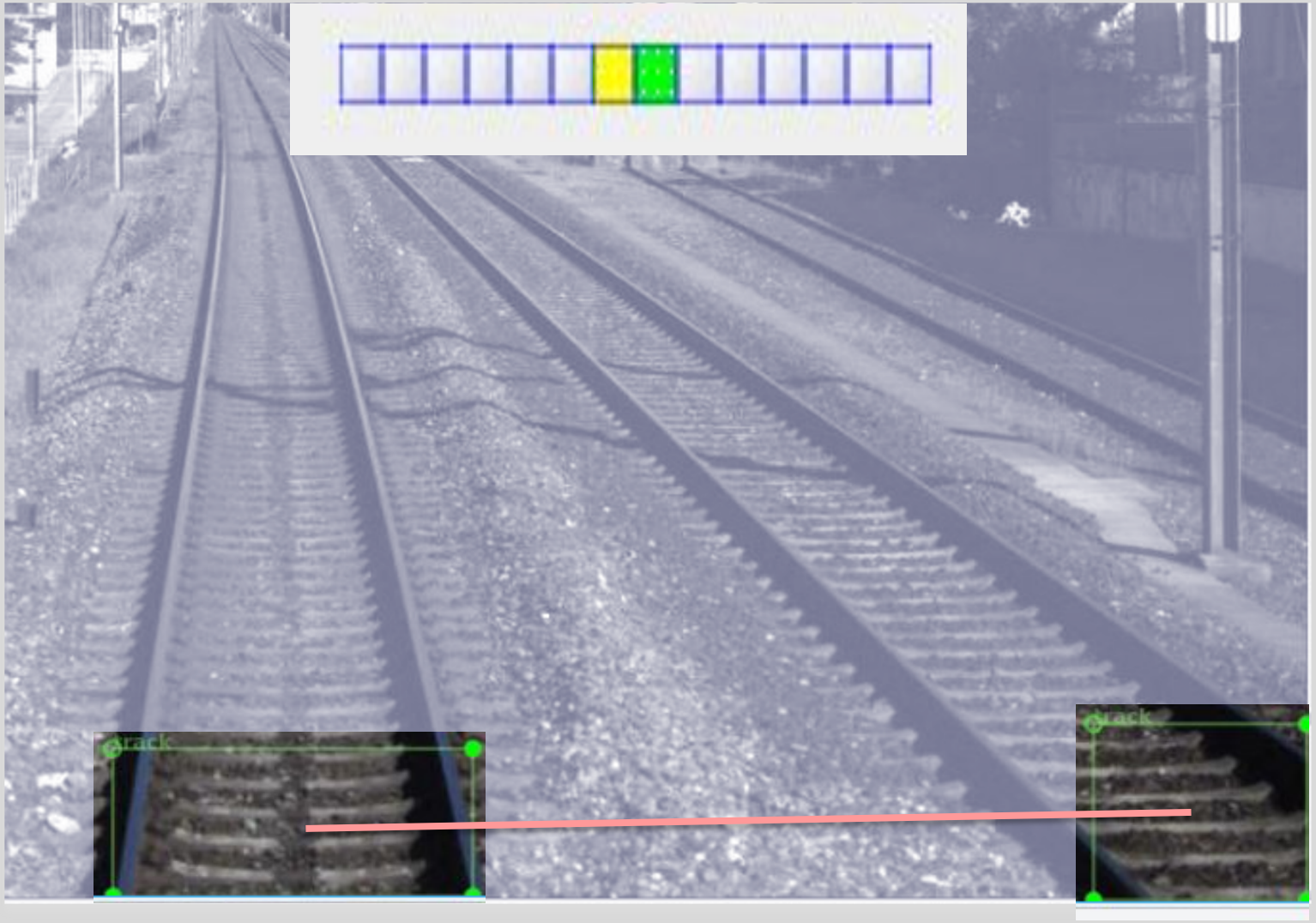
Motivation and advantages

Motivation

- Current approach (Balise) depends on additional external hardware
- **In dense urban environments (near stations) GNSS not precise enough for lateral localization (track wise positioning)**
- GNSS requires permanent connection
- **GNSS interference (jam signals) in urban environments**
- Odometry and IMU have to be periodically recalibrated (w. GNSS or Balise)
- **Position of Balise is not exact and can vary with time**

Iteration 1:

Network learns ‘tracks’



Initial setup

- Training data from measurement vehicle
- Front camera
- YOLO CNN for object detection

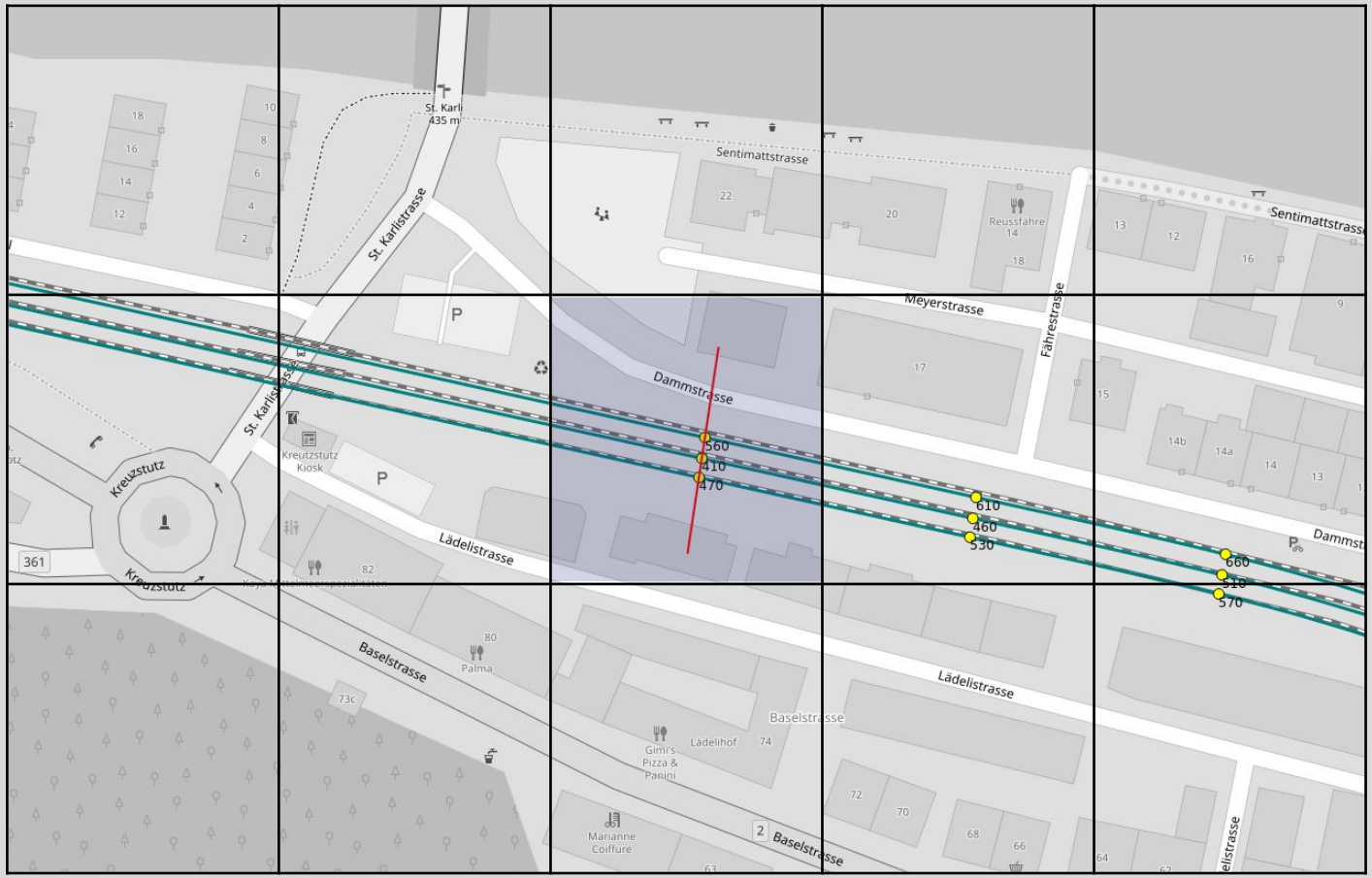
Iteration 1:

Network learns ‘tracks’

- Track selectivity ☑ recognition rate > 95%
- Tested at different weather conditions (fog, snow, …) ☑
- Classification of other objects (signals, balise, …) ☑

Iteration 2:

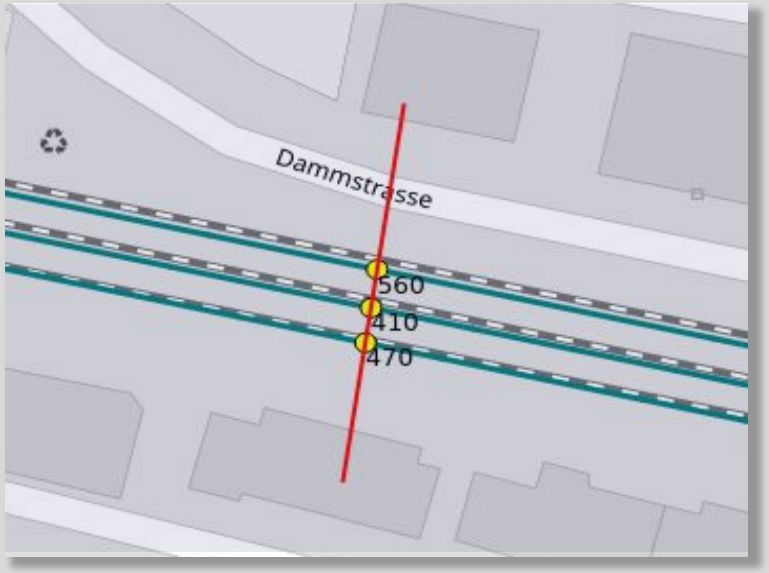
Track selective mapping

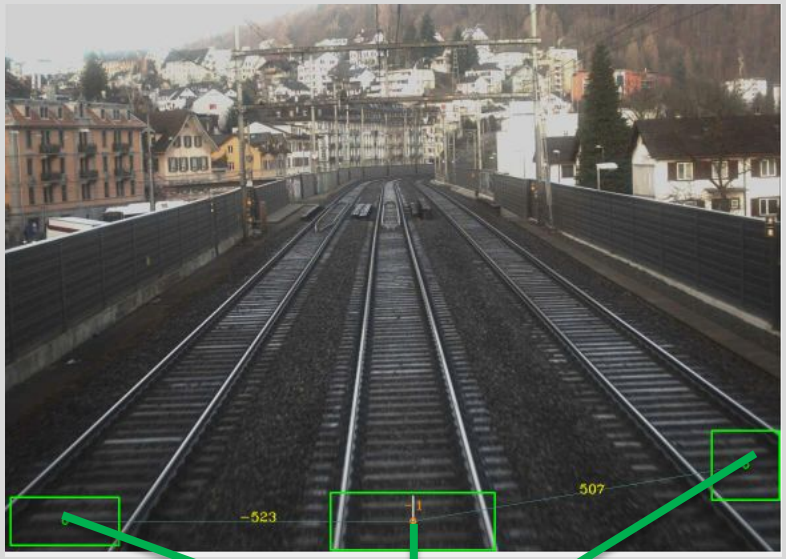


- **Integration via topology database (DfA) to obtain track layout**
- **Longitudinal position from GNSS (square in track topology)**
- **…**

Iteration 2:

Track selective mapping





Matcher algorithm / topology lookup

Track selective train localization

- Integration via topology database (DfA) to obtain track layout
- Longitudinal position from GNSS (square in track topology)
- Lateral position (track selectivity) from optical detection
- Integration of longitudinal and lateral positions matcher algorithm / topology lookup

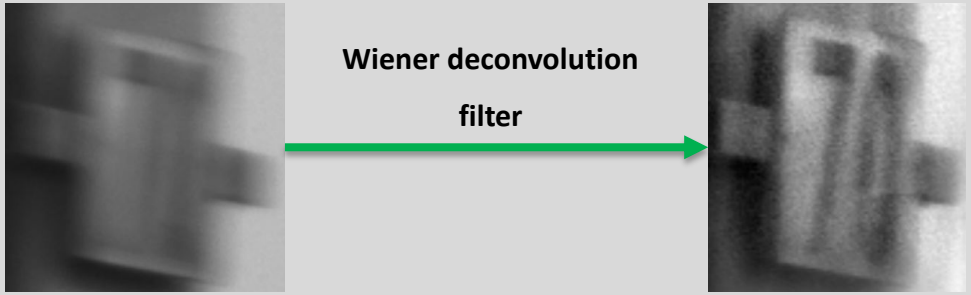
Iteration 3:

GNSS independent longitudinal position

Detect longitudinal position by km-sign on poles

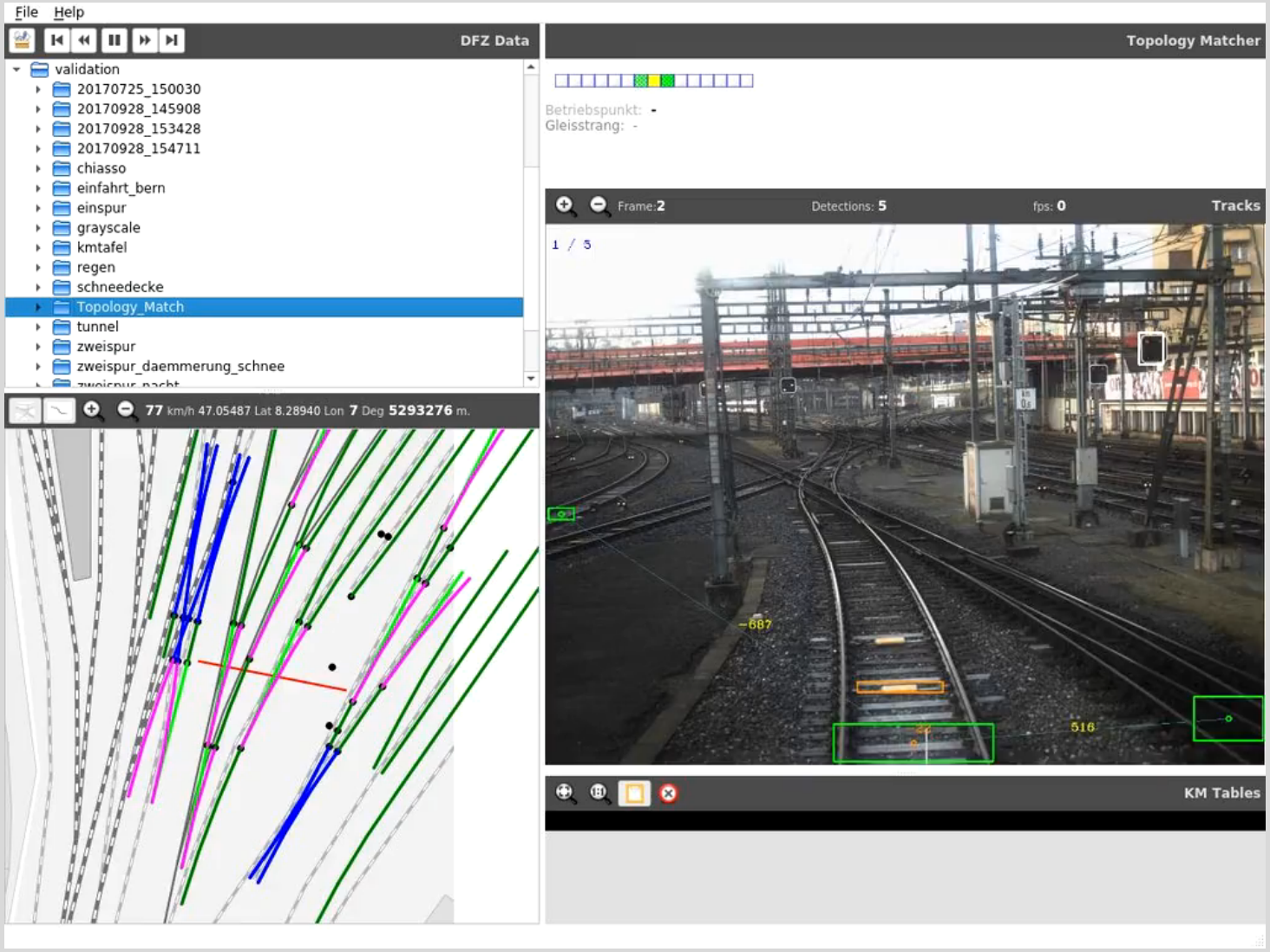
- Pole position is exactly measured in topology database
- Poles have short distance to train
- Km-signs not readable from front camera

  > use 45° side camera
- YOLO network to detect and read km-signs
- Obtain longitudinal position by topology database mapping algorithm



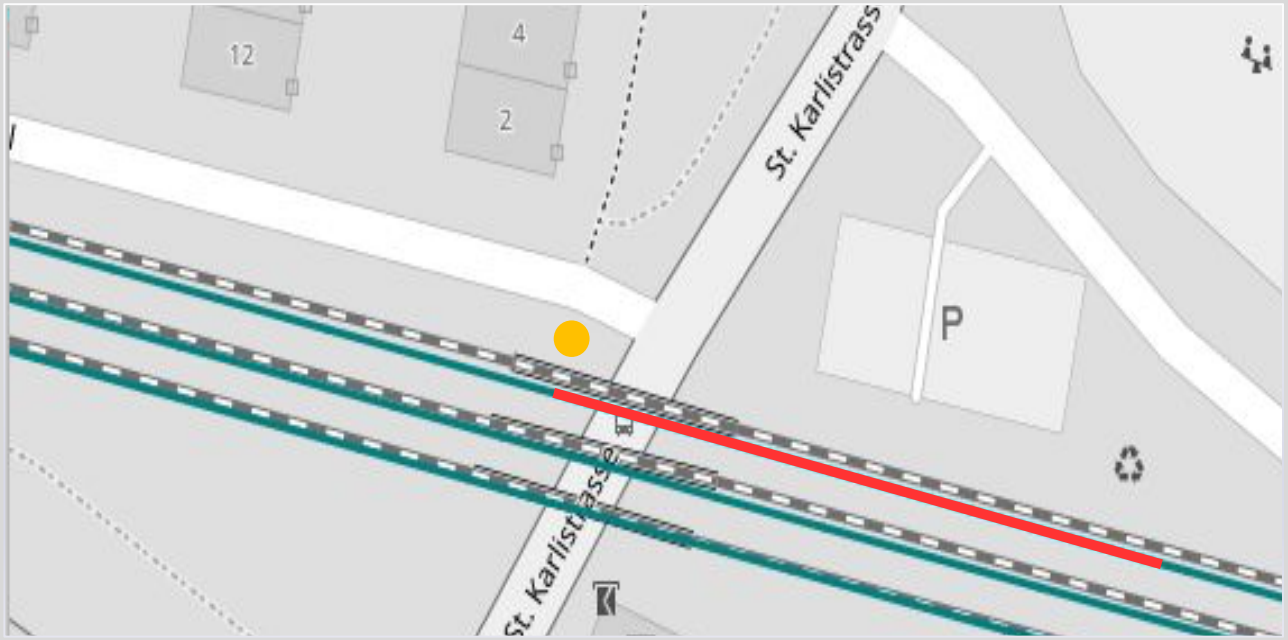
Iteration 3:

GNSS independent longitudinal position



Iteration 4 (future work):

Exact longitudinal position by train-pole distance estimation



Optical distance estimation

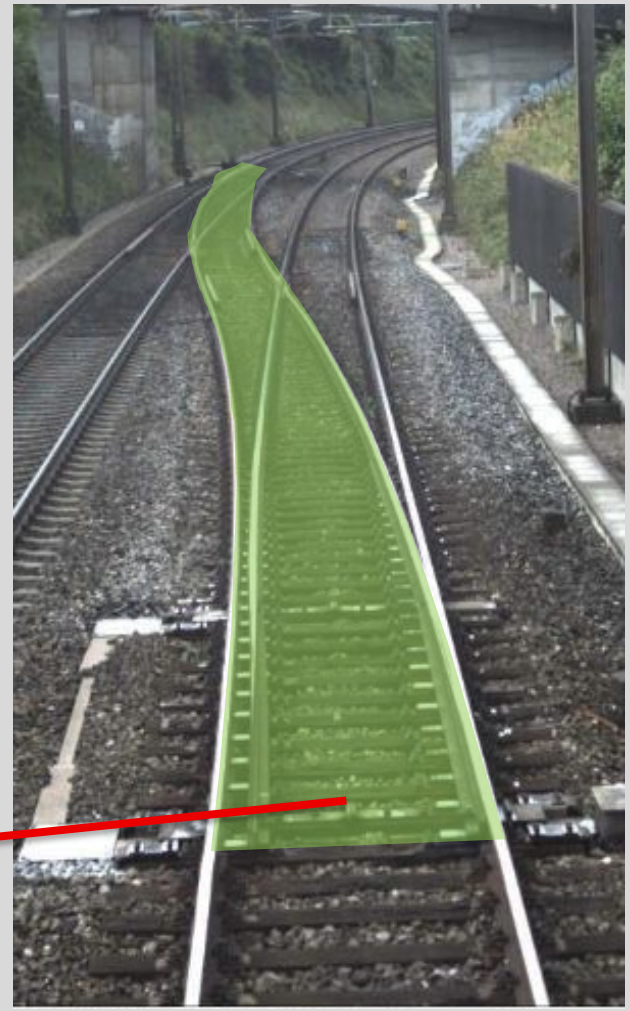
- **Stereo camera system (front and 45° side camera)**
  - Limited recognition of km-sign if front camera
  - Only limited overlap of field of view between the two cameras
  - Requires exact relative calibration of cameras
- **Stereo camera system (two 45° side cameras)**
  - Requires additional camera and exact relative camera calibration
- **Sequential information from 45° side camera**
  - Requires additional sensor to estimate movement between sequential images
- **Single image from 45° side camera**
  - Distance based on size of km-sign
  - Distance based on geometric information (pole position in image and topology database)
  - Distance from Deep Learning approach

Iteration 4 (future work):

Prediction of pathway / position

Optical pathway prediction by recognizing tracks and switch positions

- Recognition / segmentation of active track
- Recognition of switch position
  - Matching with topology can lead to optical pathway / position prediction
- Additionally, switch-train distance estimation can lead to improved longitudinal position



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Iteration 4 (future work):

Prediction of pathway / position

Current status:

- Track segmentation using CNN's
- Semantic segmentation trained on RailSem19* data-set
- Switch position not viable by classification
  - > Use segmentation approach
  - > Generate segmentation data-set with only active track

* O. Zendel, M. Murschitz, M.Zeilinger, D. Steininger, S. Abbasi, C. Beleznai: **RailSem19:** A Dataset for Semantic Rail Scene Understanding. CVPR Workshops 2019: 32-40

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