Onboard Localisation of Public Transport Vehicles in Urban Environments

Vít Fanta, Jakub Kašpar, Vladimír Havlena, Zdeněk Hurák

CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

MOTIVATION

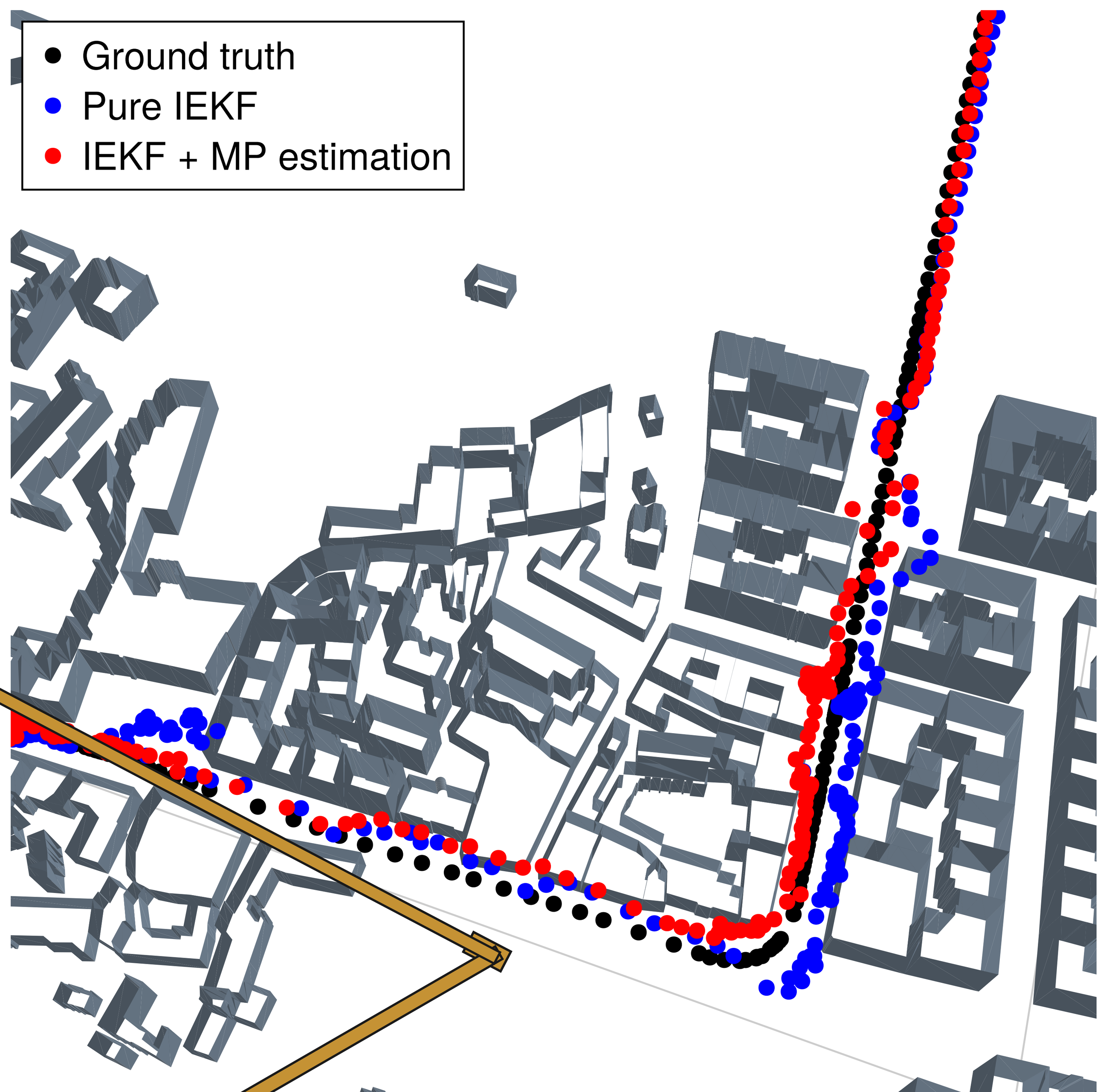
Initial motivation has stemmed from our industrial partners Škoda Digital and Herman systems: How can we improve positioning accuracy without additional sensors and how do we estimate position confidence of such position reading? Standard u-blox modules fail to provide dependable accuracy estimates in urban environments.

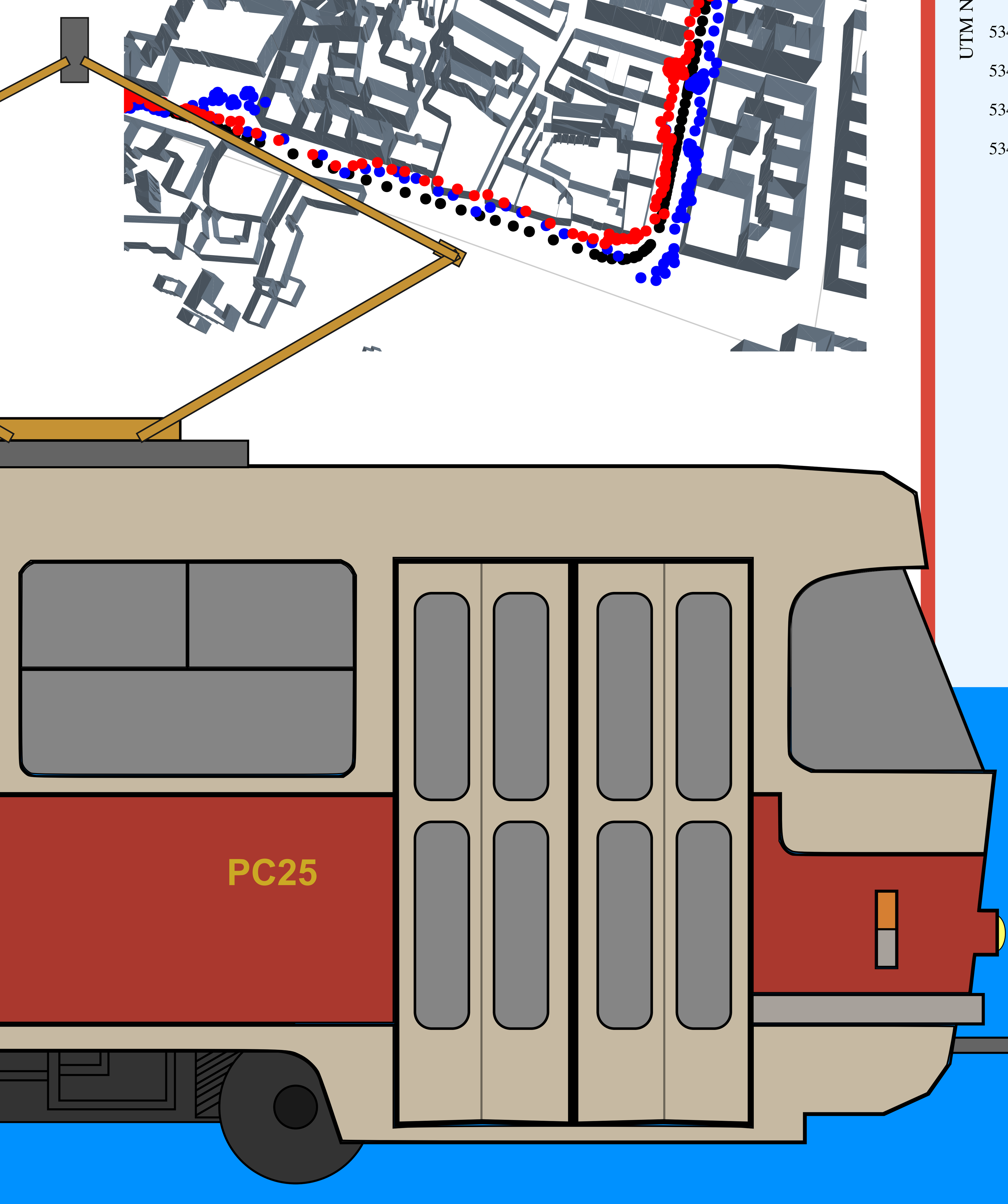
URBAN ENVIRONMENT CHALLENGES

In city settings, buildings frequently obstruct direct line-of-sight (LOS) to satellites, causing:

- Non-line-of-sight (NLOS) signal propagation
- Multi-path signal reception

Both factors degrade positioning accuracy and reliability.





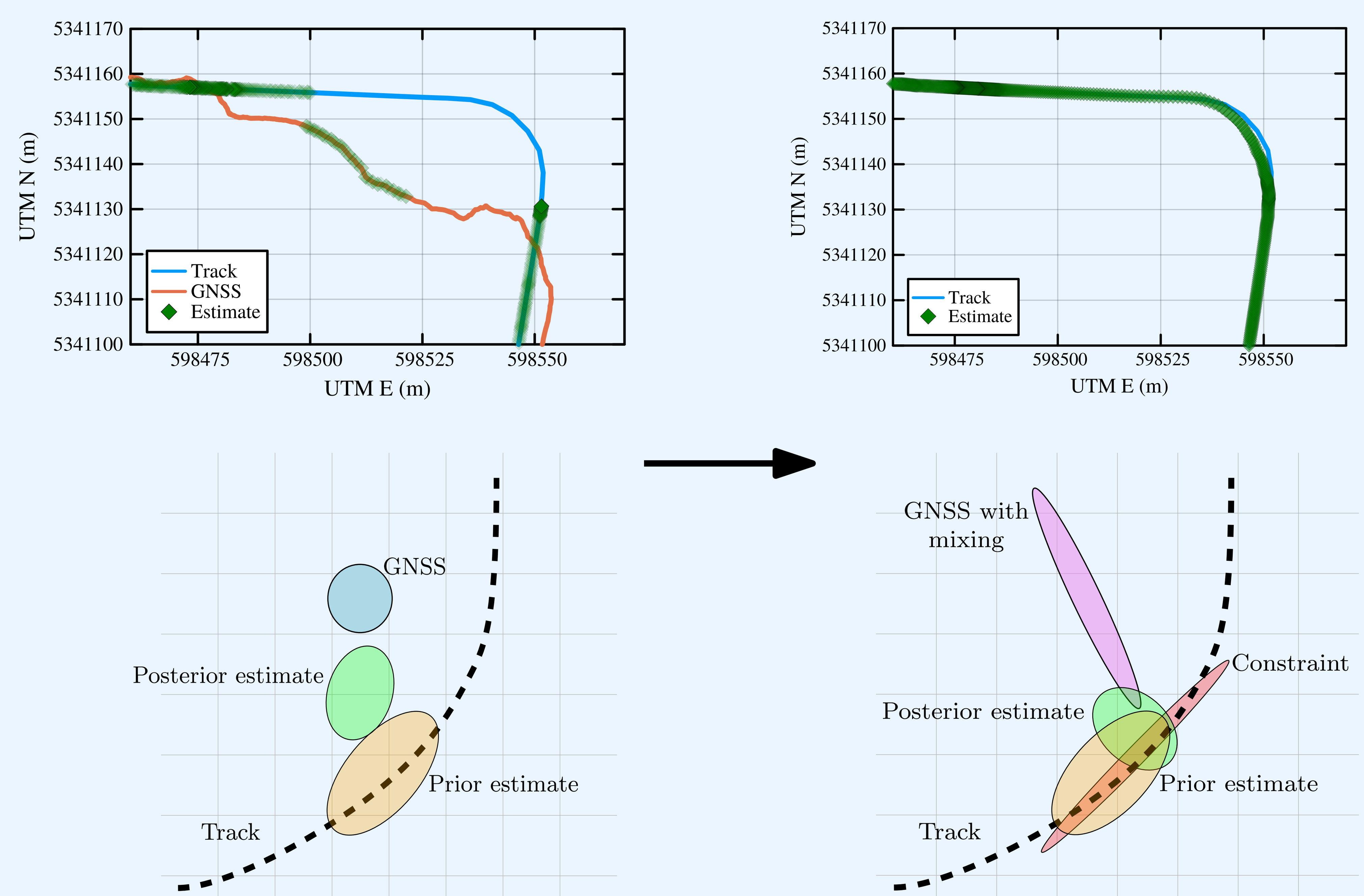
APPROACH

Rather than relying on black-box chip processing, we directly analyze raw GNSS observables (pseudoranges, Doppler measurements, satellite ephemeris) to develop custom positioning algorithms.

We improve performance by fusing GNSS, map and ephemerides.

IMPROVED LOCALISATION METHODS

- Constraint-based approach: Attracting GNSS measurements to known tram track
- Weighted pseudoranges: Reducing influence of erroneous readings
- Ray-tracing analysis: Detecting and isolating NLOS and reflected signals



Jakub Kašpar's master thesis

Root-mean-squared error (RMSE) from ground truth in simulation scenario

Weighting Scheme	Multipath Mitigation Strategy	RMS 3D Err.	RMS 2D Err.	RMS Dist. to Map	RMS Dist. Along Map
Uniform	none	21.77	9.66	8.25	**4.99**
	MP estimation	16.56	**9.36**	7.85	5.00
	MP est. + el. angle lookup	17.74	10.86	8.86	6.22
	MP est. + raytracing	**16.07**	9.84	7.31	6.89
Realini	none	17.69	9.48	**6.80**	6.57
	MP estimation	18.44	10.37	7.29	7.38
	MP est. + el. angle lookup	19.90	12.91	8.92	9.73
	MP est. + raytracing	17.72	11.40	8.01	8.29

Root-mean-squared error (RMSE) from track projection in real data

Weighting Scheme	Multipath Mitigation Strategy	RMS Distance to Tracks
Uniform	none	8.35
	MP estimation	7.79
	MP est. + el. angle lookup	12.28
	MP est. + raytracing	**6.72**
Realini	none	10.99
	MP estimation	10.62
	MP est. + el. angle lookup	12.56
	MP est. + raytracing	9.54

ECC article

Root-mean-squared error (RMSE) from ground truth in simulation scenario

	Without soft constr.	With soft constr.
With distribution mixing	6.8 m	6.0 m
Without distribution mixing	13.3 m	9.7 m

Root-mean-squared error (RMSE) from track projection in real data

	Without soft constr.	With soft constr.
With distribution mixing	9.29 m	0.91 m
Without distribution mixing	8.55 m	1.19 m
U-Blox solution	5.32 m	–

Further links: