



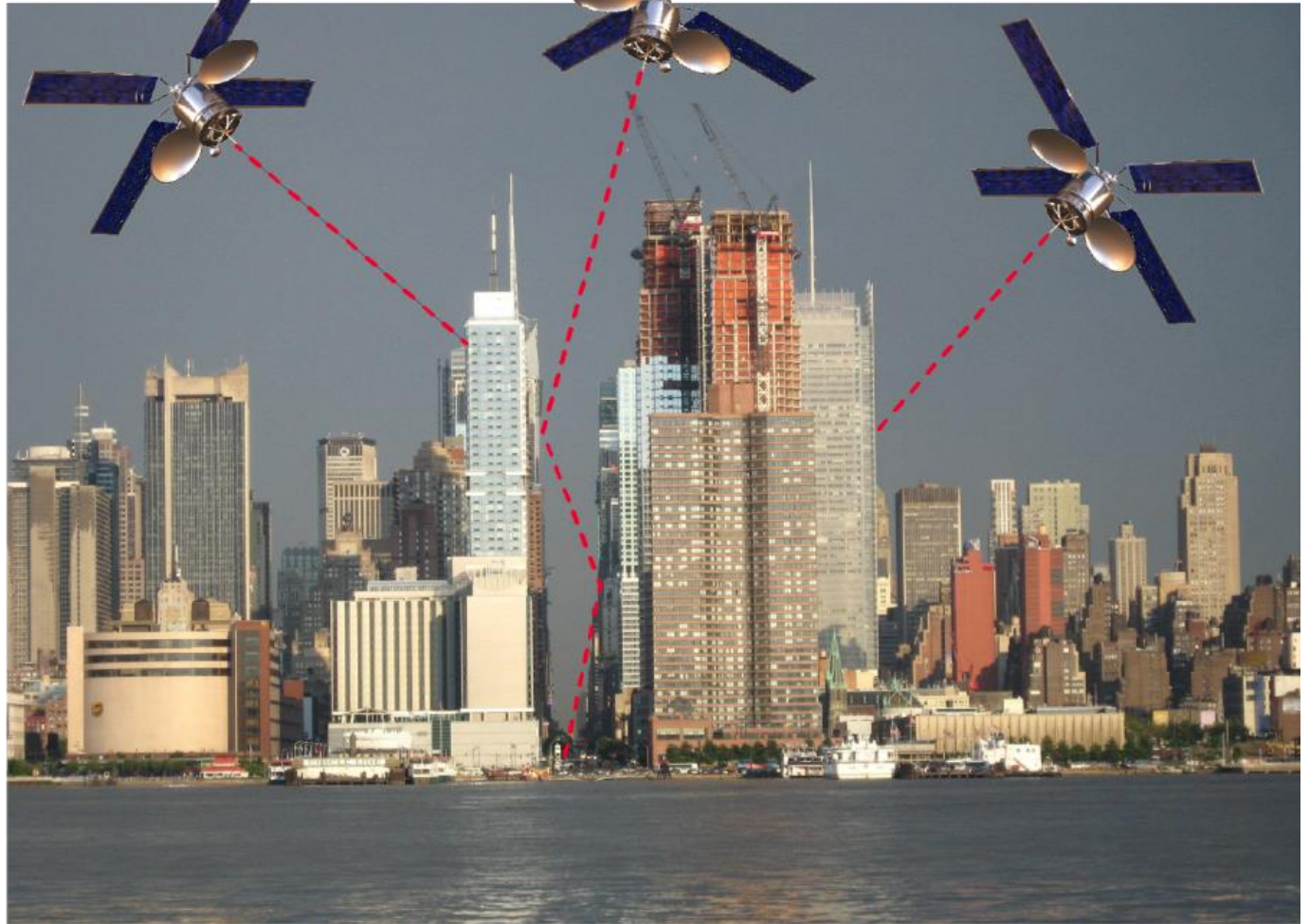
A FULLY AUTOMATIC SOLUTION TO ADJUST MOBILE MAPPING IMAGING DATA IN GNSS-DENIED URBAN AREAS

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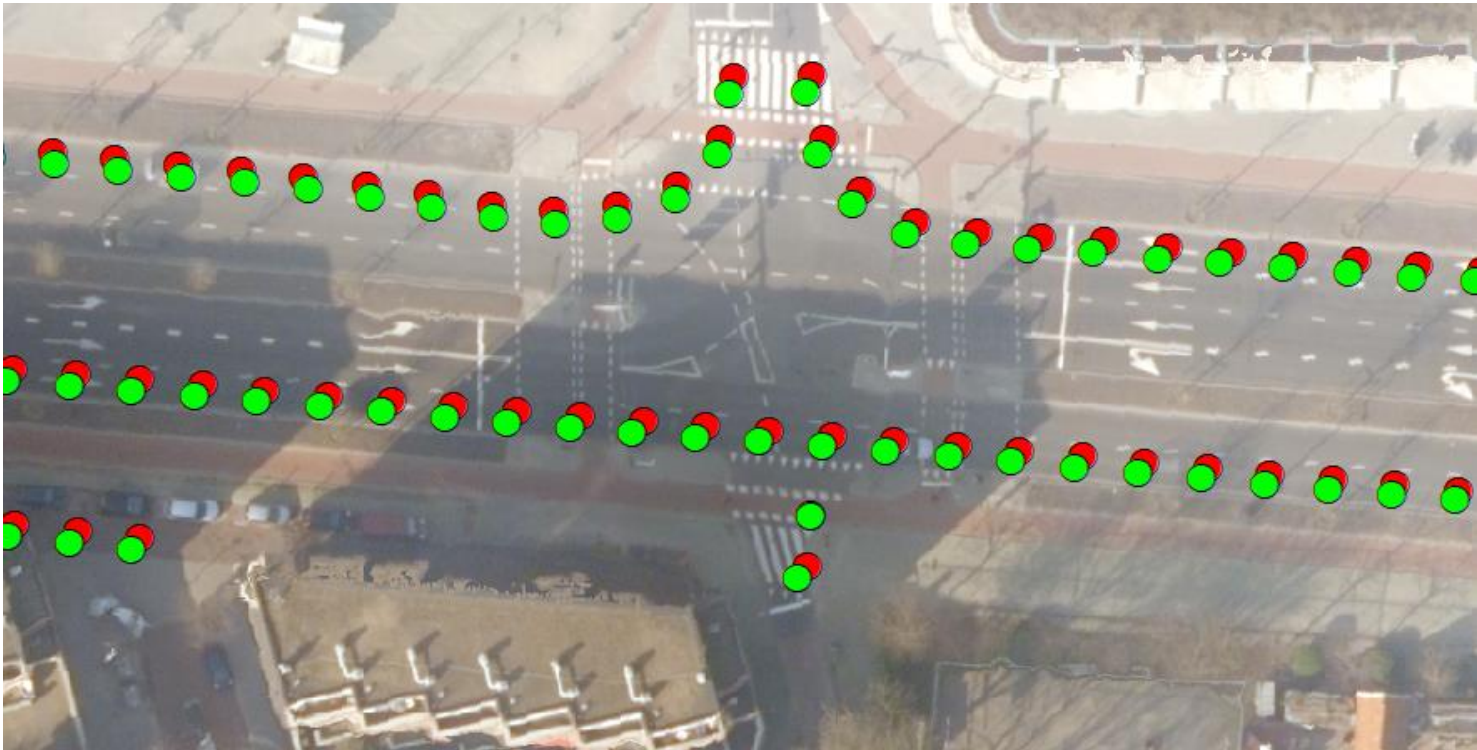
URBAN AREAS FOR MOBILE MAPPING

CHALLENGING POSITIONING SCENARIO



URBAN CANYONS

LEAD TO DETERIORATED POSITION FIXES



PROPOSED SOLUTION

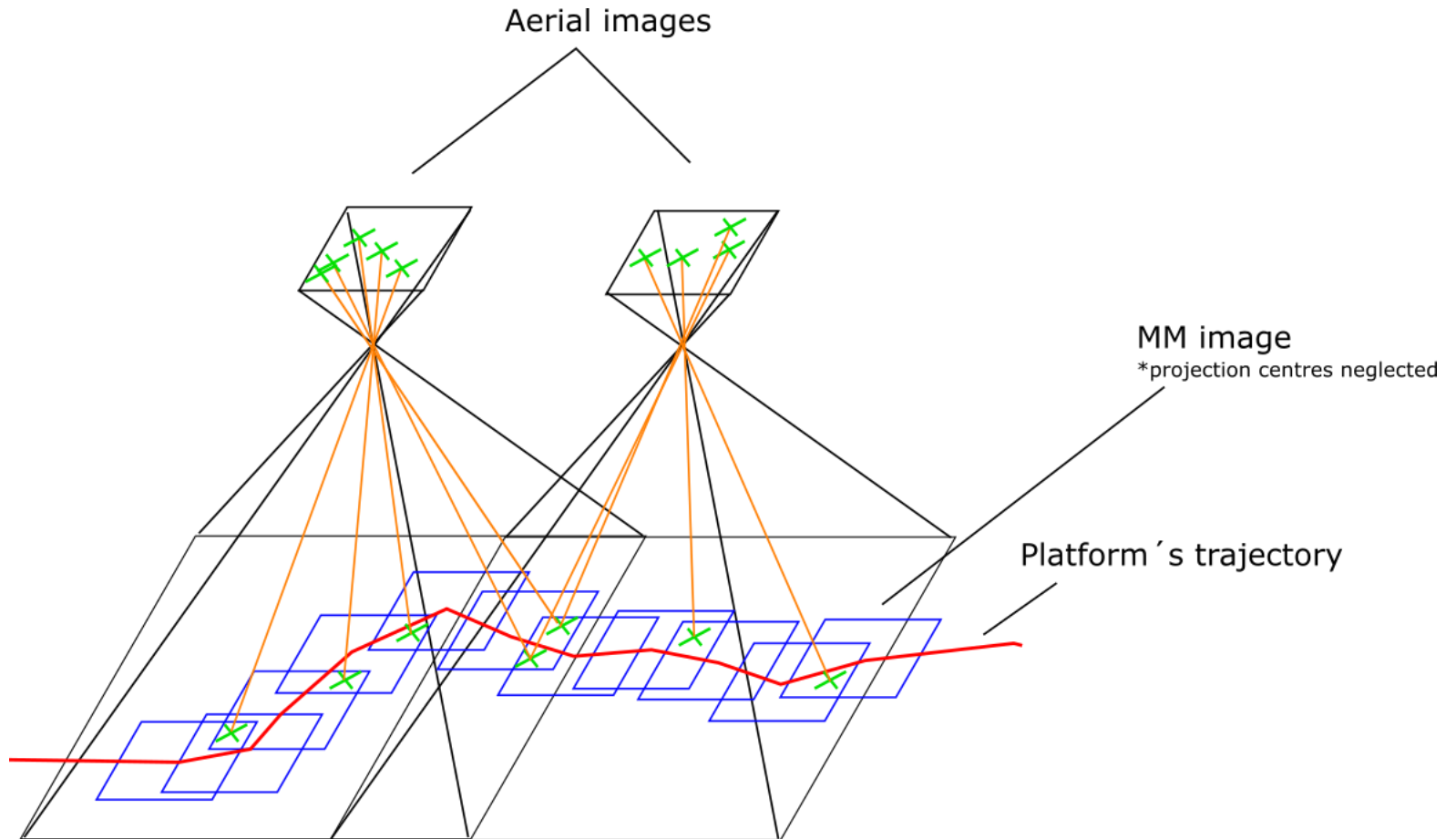
INTEGRATION OF AERIAL IMAGES INTO POSITIONING PROBLEM

- No unfavourable positioning scenario
- High resolution imagery
- Everywhere (freely) available



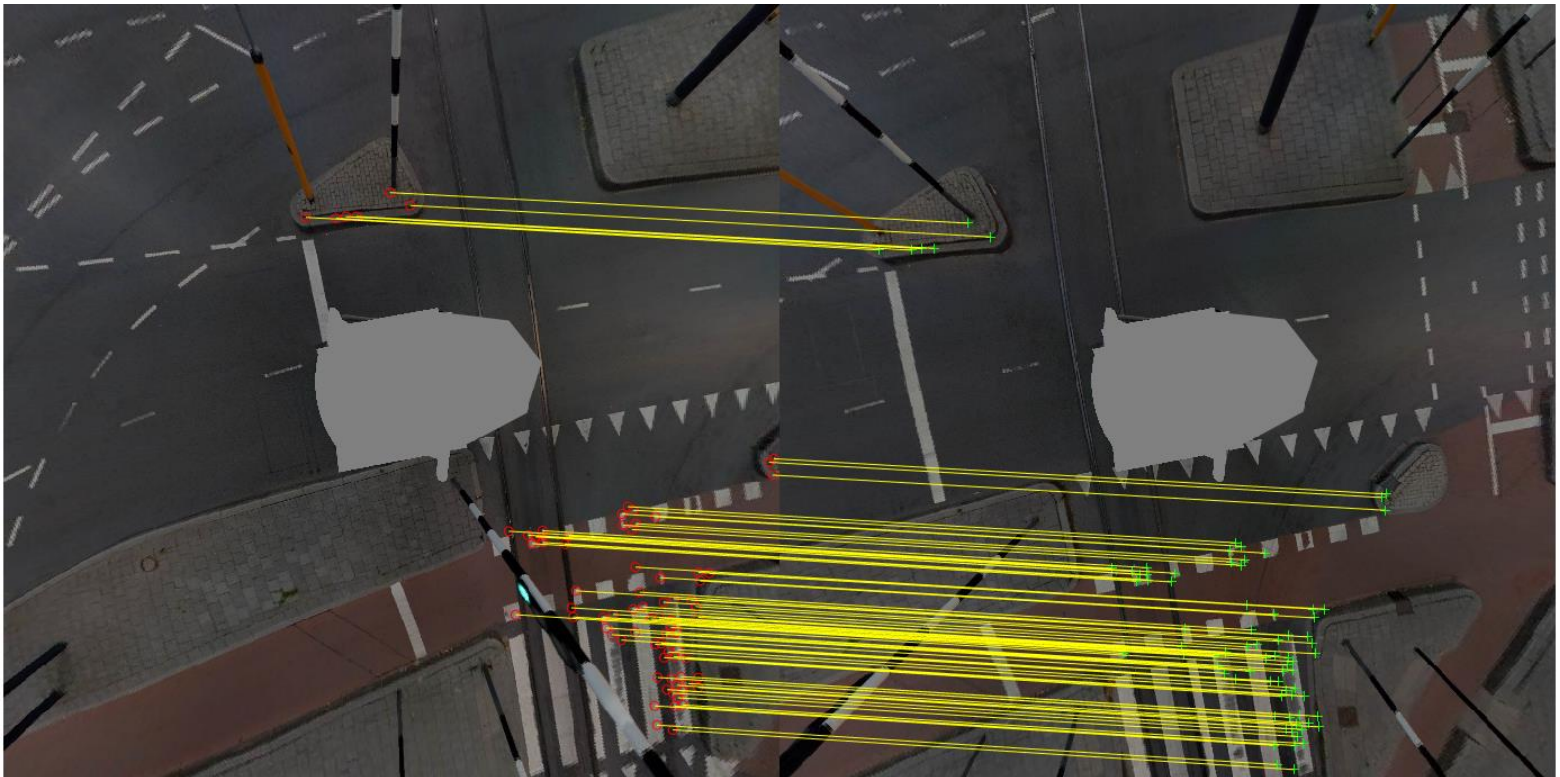
IMAGE-AIDED POSITIONING

ORIENTATION BY REGISTRATION



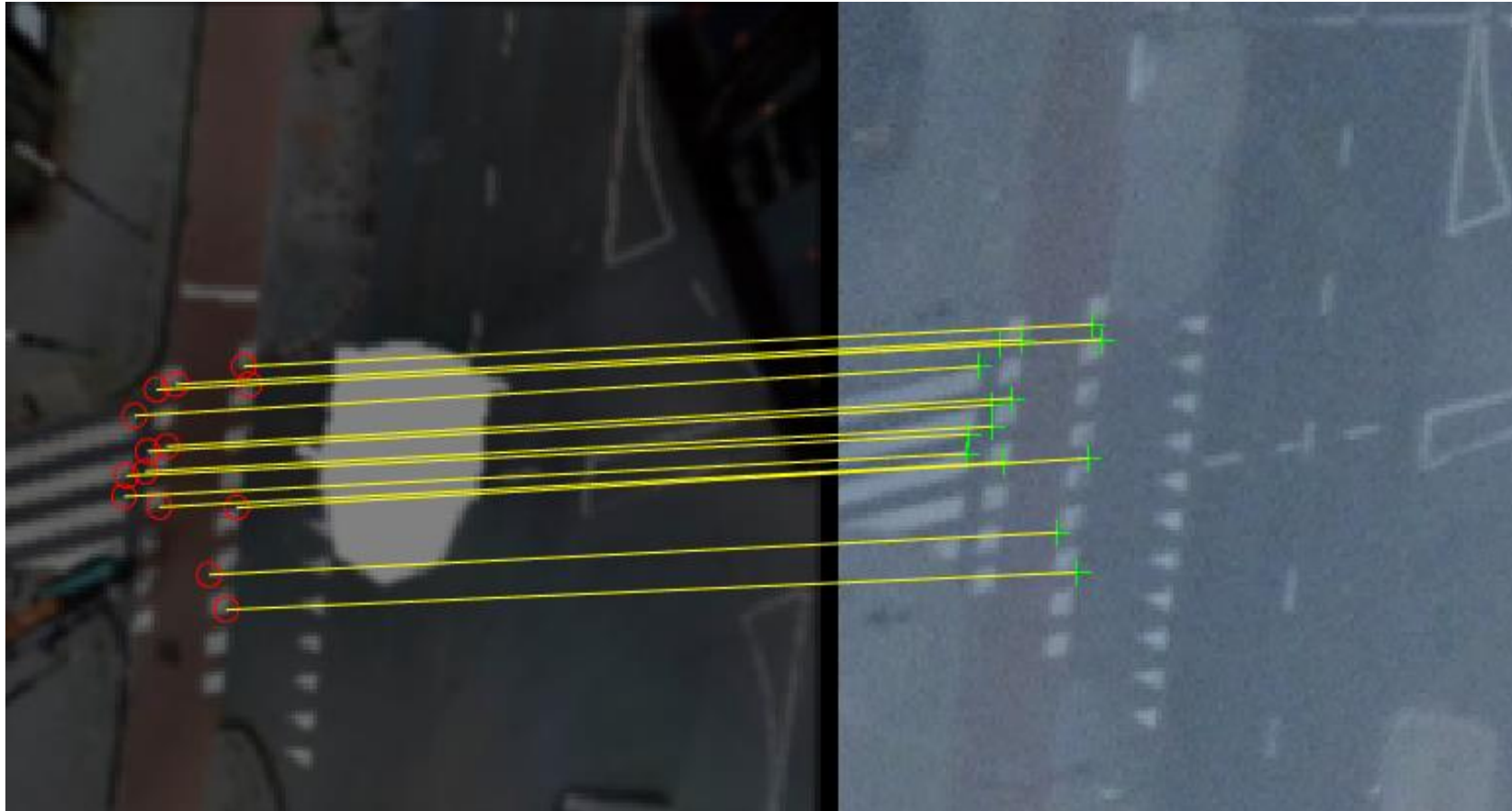
REGISTRATION STRATEGY

MM RELATIVE CONSTRAINTS – VISUAL ODOMETRY



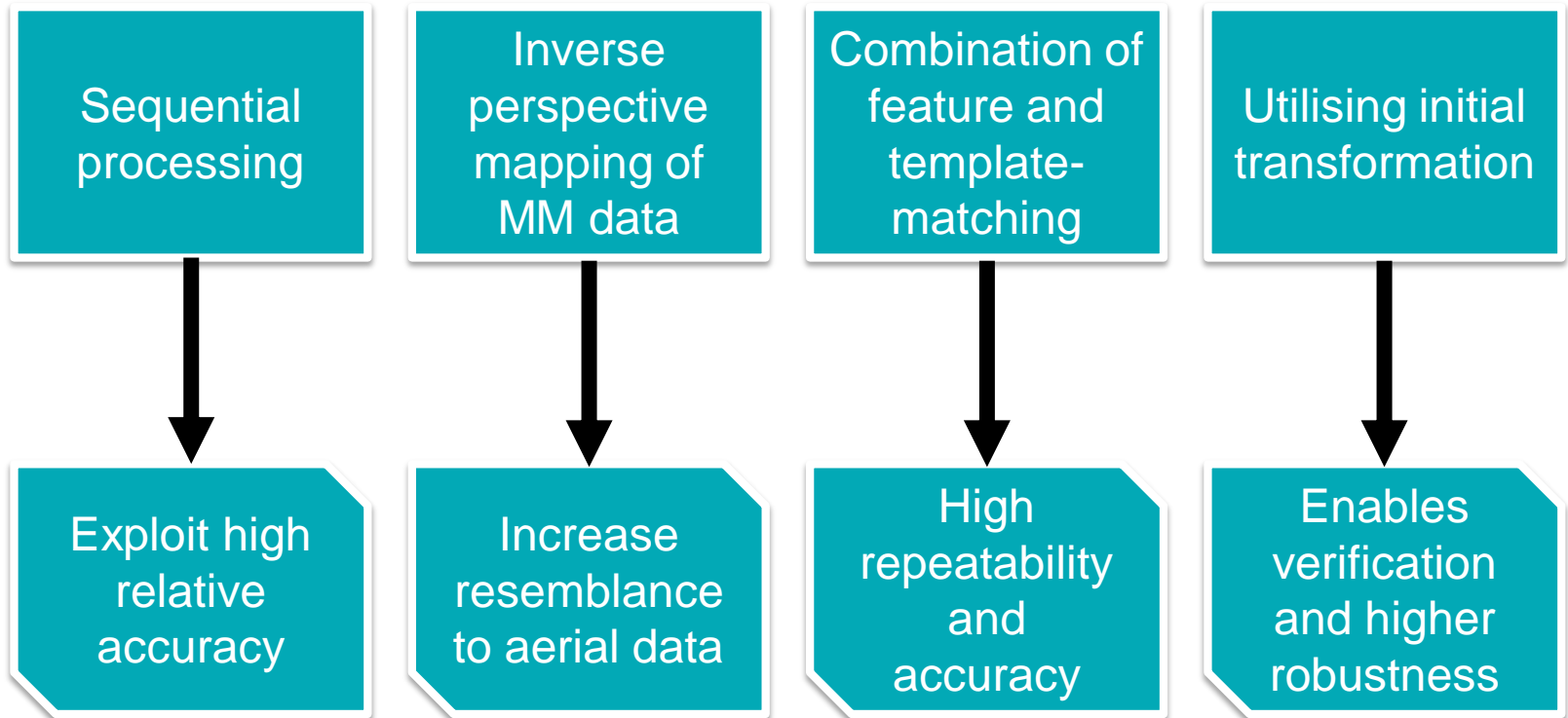
REGISTRATION STRATEGY

NON-STANDARD GEOMETRIES



REGISTRATION STRATEGY

BASIC CONCEPTS



Jende et al. (2017), Fully automatic feature-based registration of mobile mapping and aerial nadir images for enabling the adjustment of mobile platform locations in GNSS-denied urban environments

REGISTRATION STRATEGY

TIE POINTS USED FOR ADJUSTMENT

Image correspondence
introducing ground control
(absolute constraints)

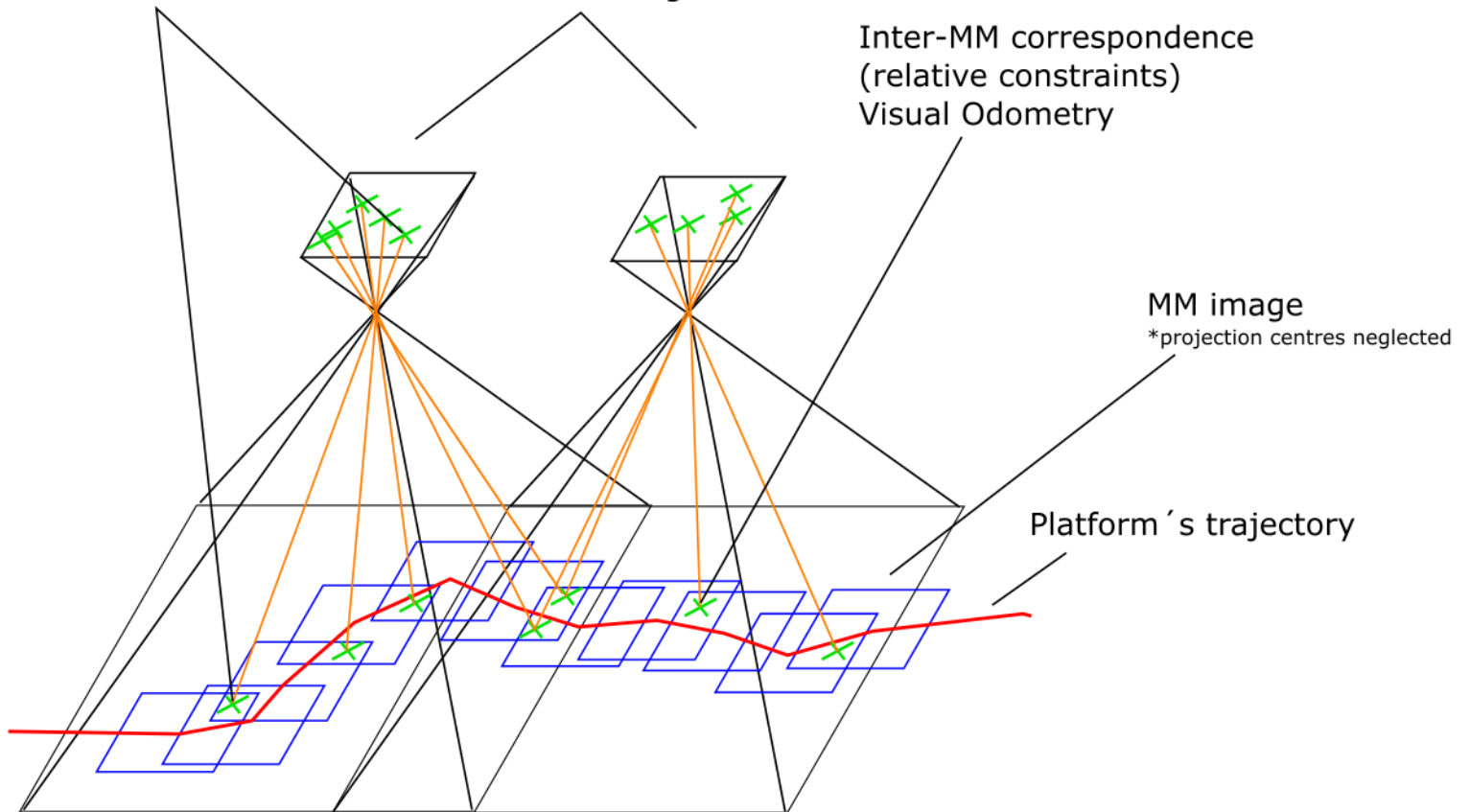
Aerial images

Inter-MM correspondence
(relative constraints)
Visual Odometry

MM image

*projection centres neglected

Platform 's trajectory



ADJUSTMENT RESULTS

ROTTERDAM STATION





SOME STATS

After Registration:

# MM img	319
# MM img /w correspondences	42
# Corr aerial to MM	365
# Corr MM to MM	12140

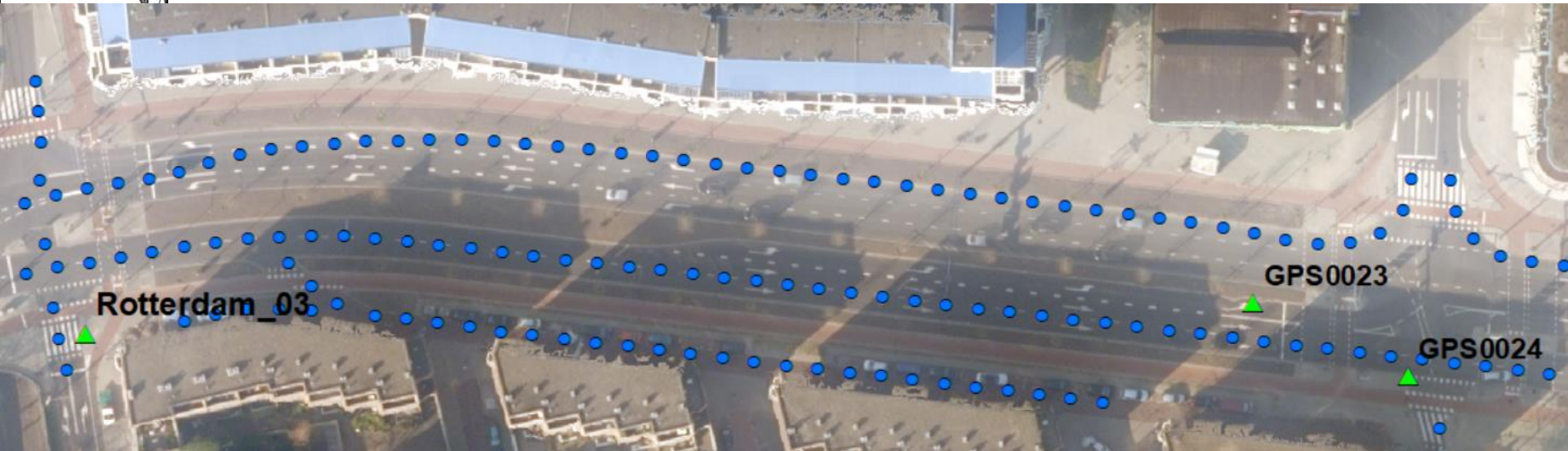
After Adjustment:

	dX	dY	dZ
Max	0,317	0,323	0,051
Min	-1,659	-1,716	-0,530
Mean	-0,323	-0,657	-0,043
STD	0,376	0,359	0,062



ACCURACY MEASURES

COMPARISON TO SURVEYED GCPS





ACCURACY MEASURES

COMPARISON TO SURVEYED GCPS

**Distance between backprojected GCP and Ground Truth
in original and updated orientation [px]:**

	original	updated
Mean	124,51	15,25
RMSE	47,06	5,76
Weighted Avg	43,57	5,23
Weighted RMSE	16,47	1,97



ACCURACY MEASURES

COMPARISON TO SURVEYED GCPS

Comparison of GCP and MM correspondence in object space [m]:

	original			updated		
	dX	dY	dZ	dX	dY	dZ
GCP #24	-0,898	-0,948	-0,056	-0,121	-0,059	-0,016
GCP #23	-0,644	0,866	0,079	0,201	-0,006	-0,023
GCP #03	-0,756	-0,782	-0,141	0,386	-0,289	0,088



DISCUSSION

Registration

- Yields reliable results (95% accuracy – please see Jende et al. (2017))
- Suitable for areas with road markings or other distinct features
- Aerial images' resolution is a limiting factor

Adjustment

- Based on tie information with aerial images
- Aerial images are not part of the block [future work]
- Not every MM requires direct correspondences, as visual odometry and/or relative orientation parameters can be employed



OUTLOOK

- Extension towards aerial oblique images is planned
 - Increase number of correspondences esp. in areas without salient features on the road surface
 - Better height accuracy due to vertical features
 - Better intersection geometry
- Details on the entire registration pipeline as well as comprehensive discussion of results will be published soon
- Adjustment is still under development
 - Extension towards 2D correspondences
 - Possible integration of IMU
 - Integration of aerial images



Thank you for your attention!

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