### ON THE NEED FOR COLLOCATED REFERENCE BENCHMARKS FOR GEODETIC DATUM CONNECTION

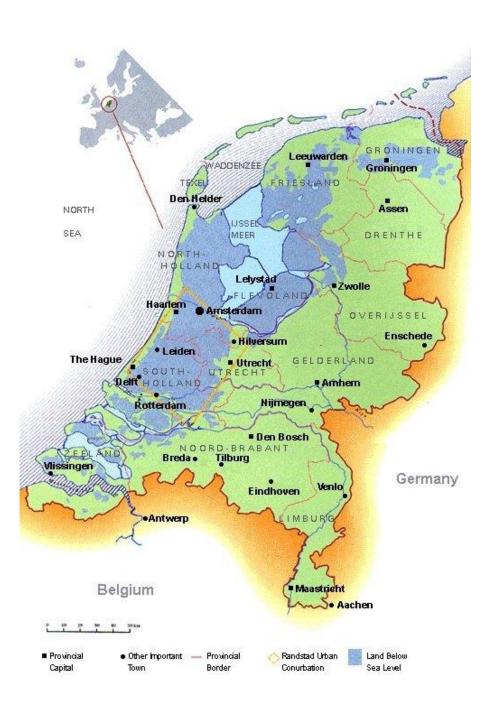
COLLOCATION AND INTEGRATION OF SEVEN INDEPENDENT GEODETIC TECHNIQUES USING THE IGRS (INTEGRATED GEODETIC REFERENCE STATION)

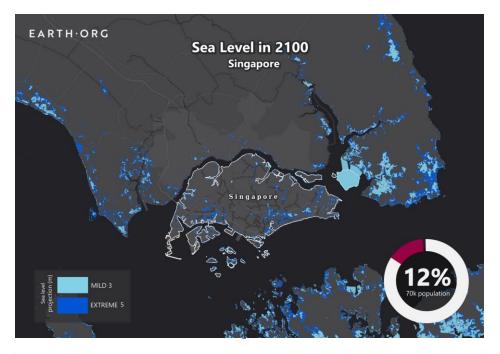
#### **Ramon Hanssen**

Antoni van Leeuwenhoek professor in Geodesy and Earth Observation Delft University of Technology, the Netherlands

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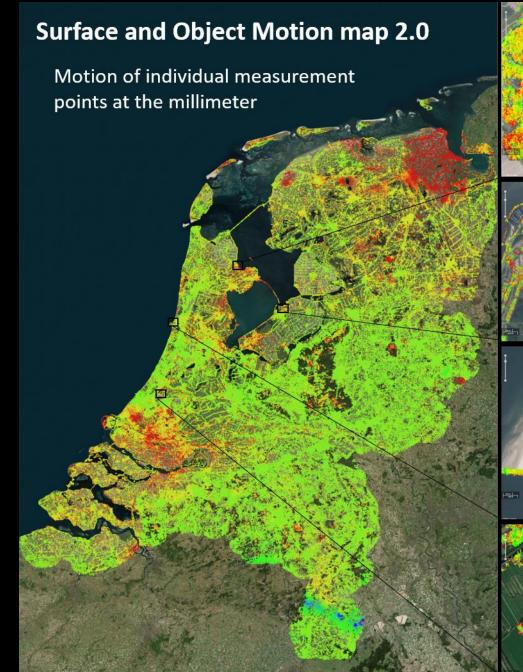
International Seminar on United Nations Global Geospatial Information Management "Effective Land Administration", Singapore, 17-19 May 2022

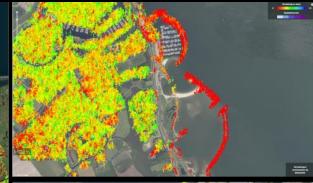




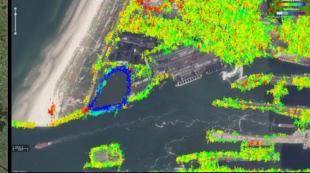


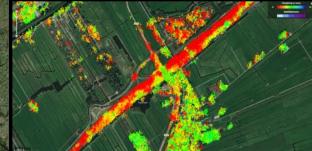
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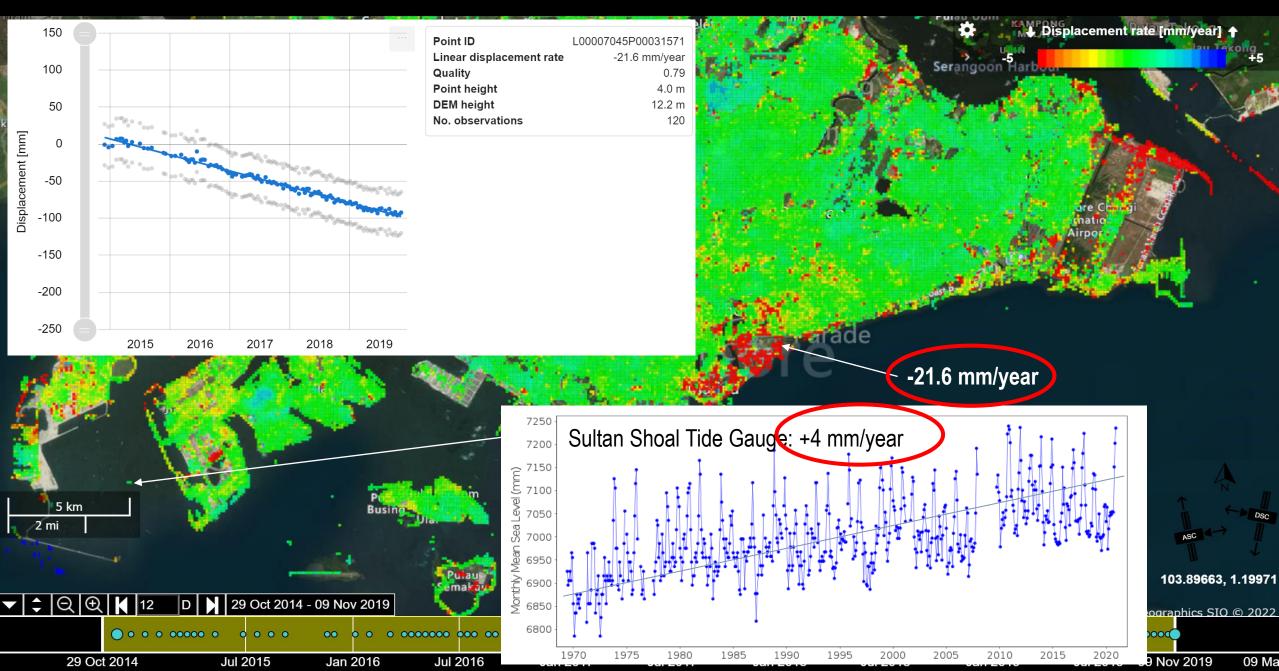


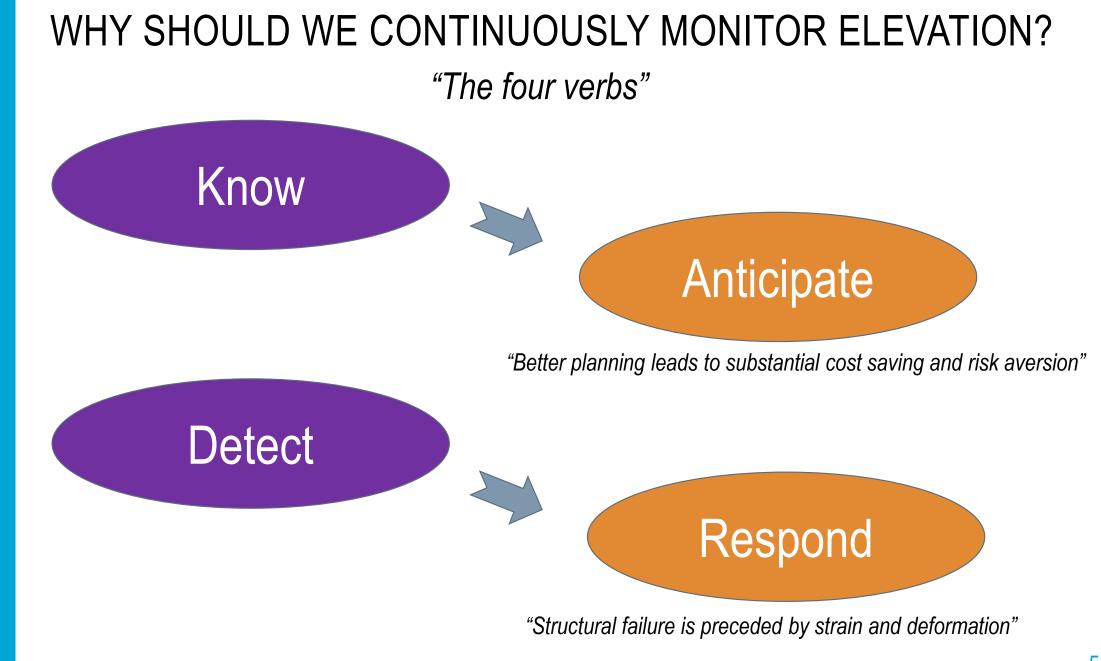




#### **SkyGeo** singapore InSAR results

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#### SINGAPORE

- >30% below the 5 m elevation
- Exposed to the increase of sea level rise rate due to global warming: ~4-5 mm/year (Tkalich et al, Ocean Sci. 2013)
- Some areas 25 mm/year subsidence

Geodetic Technique	Benchmarks	Mode	Sensitive for
Leveling	Physical 1	Lagrangian	Deep
GNSS	Physical 2	Lagrangian	Deep
InSAR	Virtual	Lagrangian	Deep + Shallow
Tide gauge	Physical 3	Eulerian	Water
Airborne Laser scanning	Virtual	Eulerian	Deep + Shallow



All techniques use different datums, different benchmarks, different modes, with different sensitivities

#### THE PROBLEM

- Geodetic deformation estimates are very precise, but we don't always know what we are measuring
- Different techniques measure different signals
- Combinations of techniques are necessary
- Combination is possible in the *parameter space*, or in the *observation space*
- Parameter space datum connection suffers from idealization differences

### THE CHALLENGE

• Combination in the *observation space* requires a clear, identifiable collocated target, exhibiting uniform dynamic behavior



#### INTEGRATED GEODETIC REFERENCE STATION (IGRS)

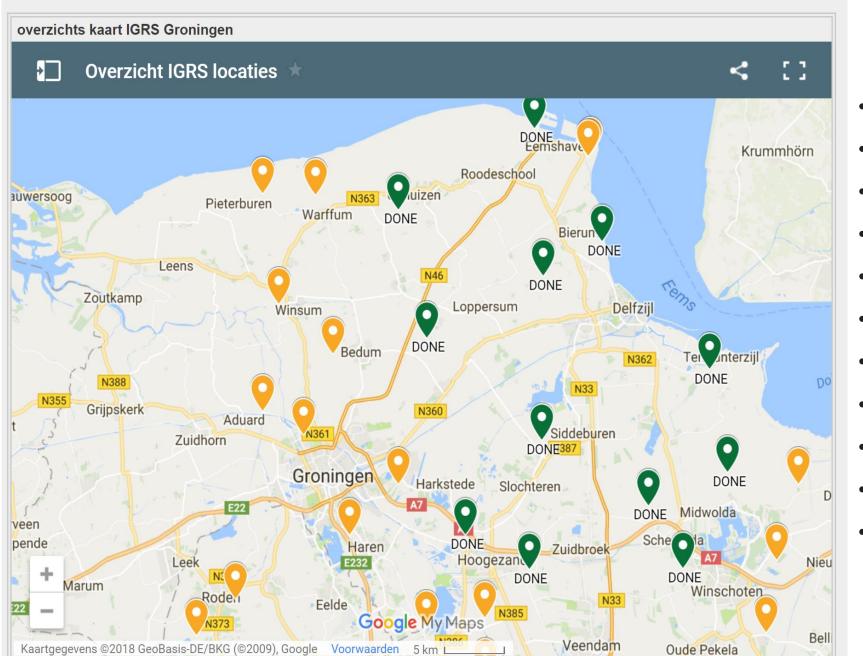


7 geodetic techniques collocated

- 1. GNSS
- 2. InSAR
- 3. Leveling
- 4. Airborne laser scanning
- 5. Photogrammetry
- 6. Tachymetry
- 7. Relative gravimetry

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#### IGRS Integrated Geodetic Reference Stations Groningen



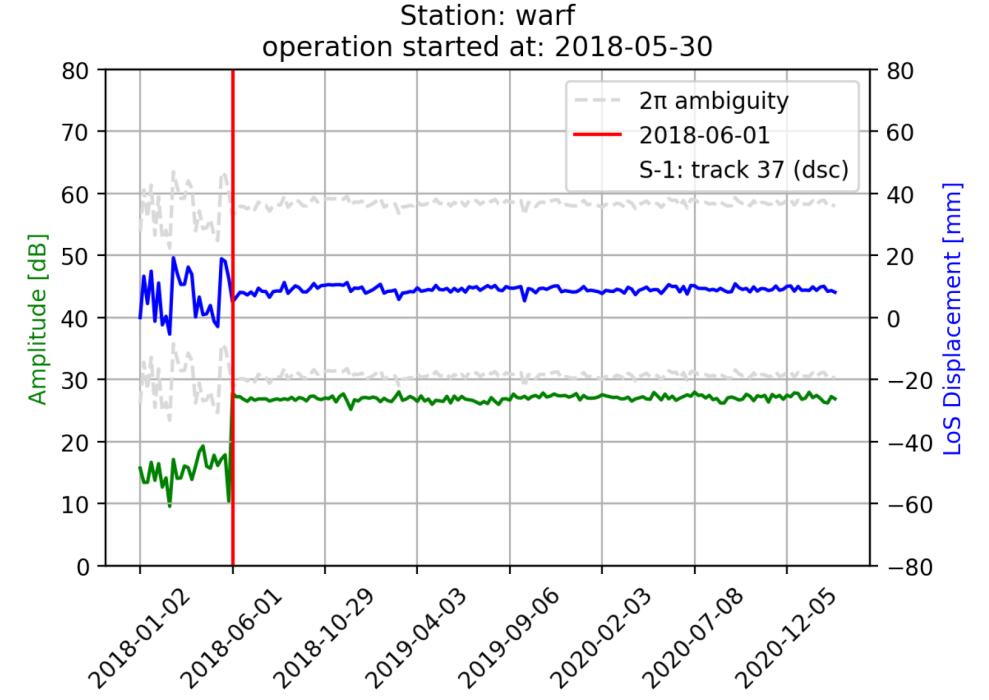
- Serves currently
- Radarsat-2
- Sentinel-1a
- Sentinel-1b
- TerraSAR-X
- TanDEM-X
- Paz
- Cosmo-1
- Cosmo-2
- Cosmo-3
- Cosmo-4

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#### **IGRS GRONINGEN**

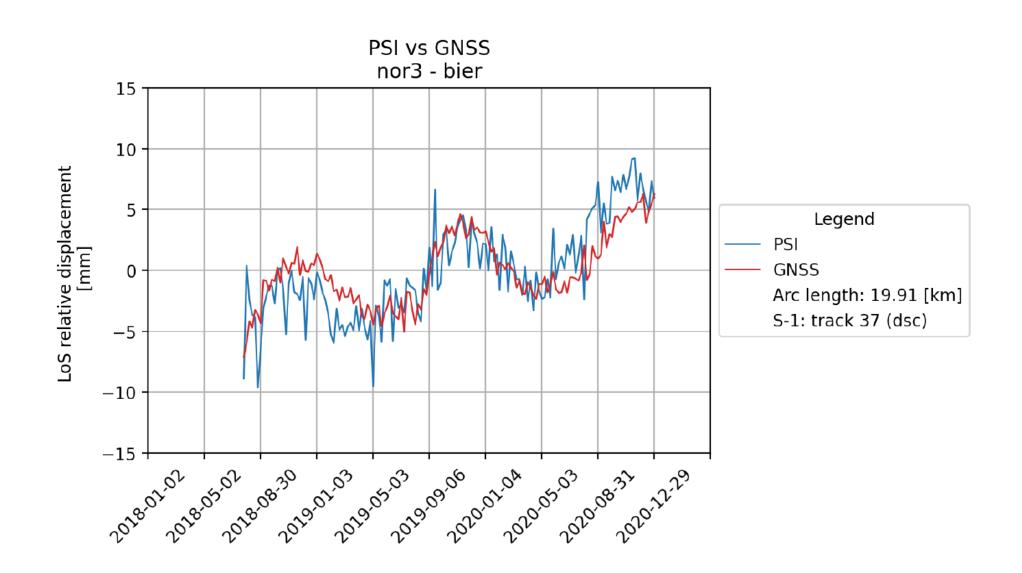


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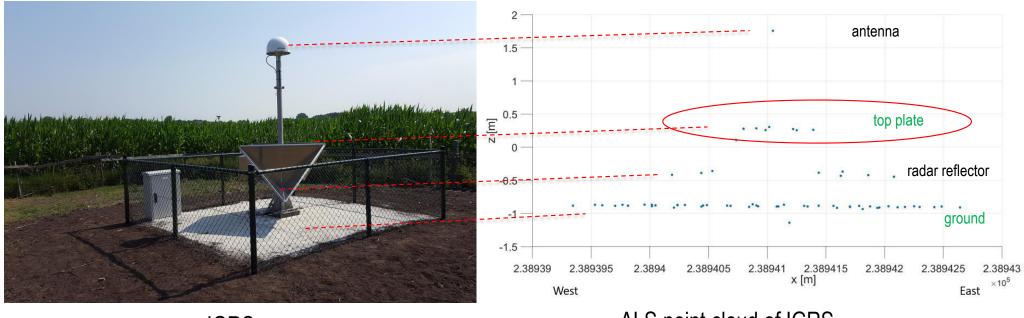
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#### COMPARISON GNSS AND INSAR RESULTS



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#### LINKING WITH AIRBORNE LASER SCANNING



IGRS

ALS point cloud of IGRS



### INTEGRATED GEODETIC REFERENCE STATION (IGRS)

Collocation and integration of seven independent geodetic techniques: the devices combines

(i) a GNSS antenna and receiver,

(ii) double back-flip radar reflectors for ascending and descending orbits,

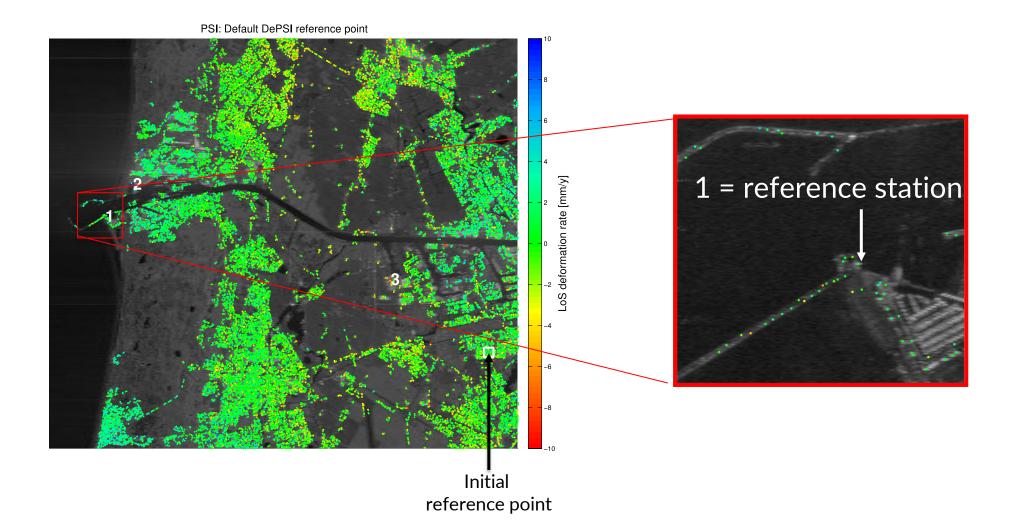
(iii) an airborne laser scanning target and (iv) a photogrammetric benchmark,

(v) a triangulation benchmark, (vi) a leveling benchmark, and (vii) a relative gravity benchmark.

A single mechanical construction is used.

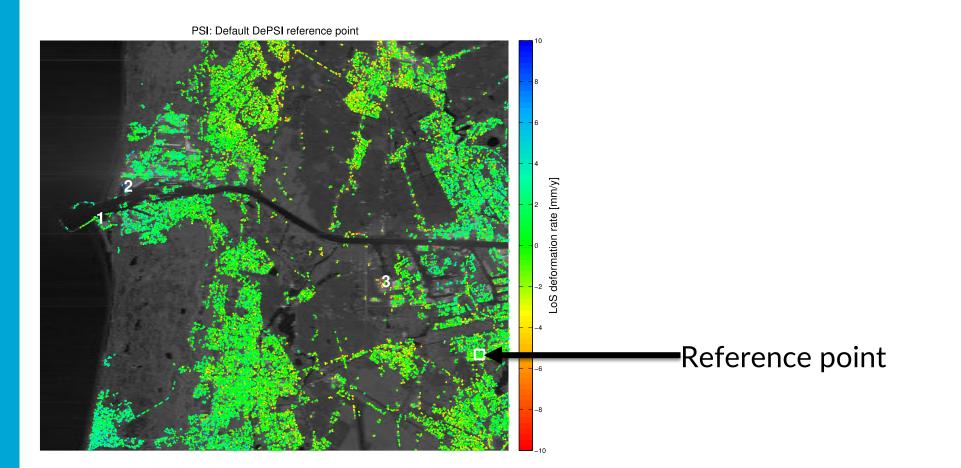
- The main application is to solve the problem of datum connection in the observation space.
- Ideally suited for use at new installations

#### GEODETIC DATUM CONNECTION



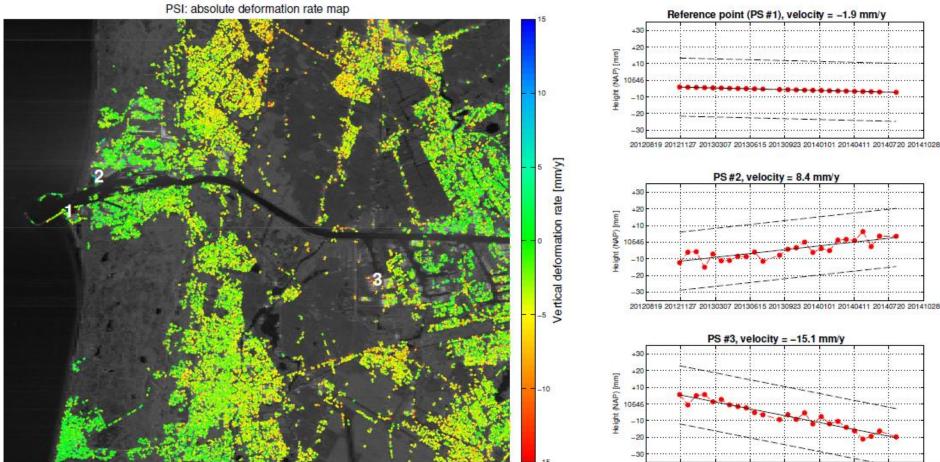
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#### THE STANDARD APPROACH





#### 'RELATIVE' $\rightarrow$ 'ABSOLUTE' VELOCITIES



20120819 20121127 20130307 20130615 20130923 20140101 20140411 20140720 20141028

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Mahapatra, P. Van der Marel, H. Van Leijen, F, Samiei-Esfahany, R. Klees, R and R.F. Hanssen Connecting InSAR to a Global Geodetic Datum, *IEEE Trans. Geosci Rem Sens*, 2016,



### OPPORTUNITIES

- 1. Tide gauge / GNSS / InSAR transponders; *relevance: sea level rise in relation to land subsidence*
- 2. Maintenance of the leveling benchmark network, *relevance: benchmark loss*
- 3. Optimization of leveling surveys, *relevance: survey when and where it is needed*
- 4. Systematic deformation monitoring; *relevance: subsidence, building health and safety*
- 5. Change detection: *relevance: detecting illegal dumping*



#### CONCLUSIONS

• The Integrated Geodetic Reference Station serves 7 collocated geodetic techniques, enabling reliable (assumption-free) datum connection

- It achieves sub-mm precision
- Test bed and validation for the (Dutch) Ground Motion Service

 For more information on the design: feel free to contact: <u>R.F.Hanssen@tudelft.nl</u>

