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# Geodetic Infrastructure and Procedures for Vertical Land Motion & Sea Level Rise monitoring

## Current Capabilities and Future Solutions

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Alex Lapadat

PhD Candidate, Mathematical Geodesy and Positioning group, TU Delft, Netherlands

Advisor: prof. dr. Ramon Hanssen

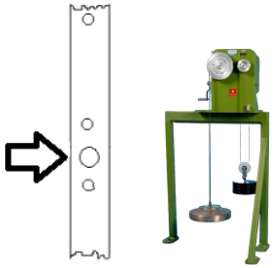
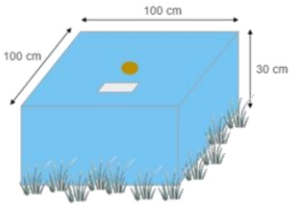
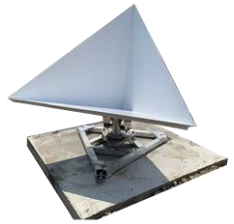
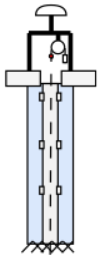
Collaborators:

**NL**: S. van Diepen, F. van Leiejn, B. Alberts, B. van Goor, L. Huisman, H. van der Marel, T. Kremers, H. Ekkelenkamp; **SG:** E. Mulder, L. Y. Mok, V. Khoo, T. Ny, F. Lujia;

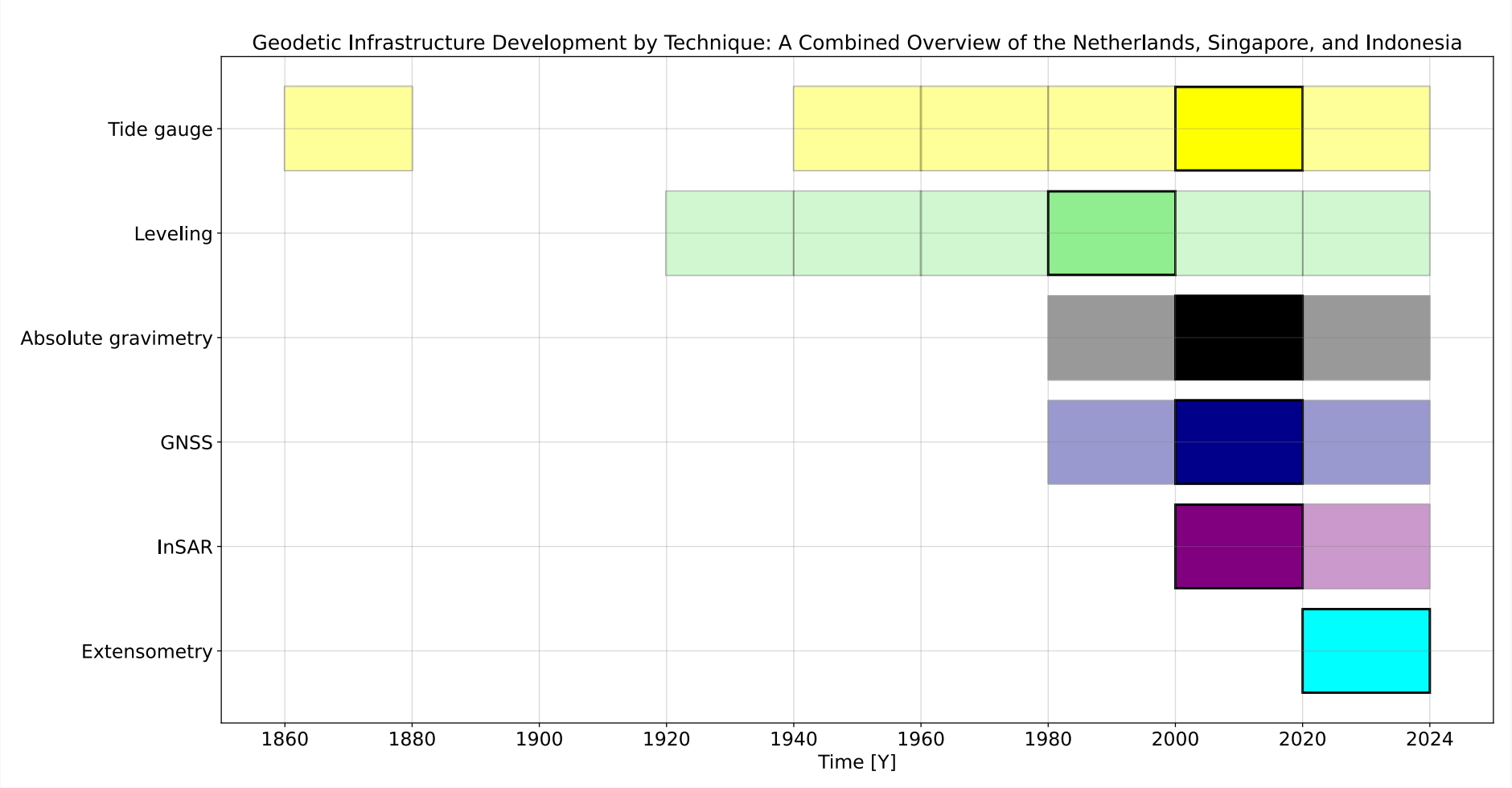
**ID**: H. Andreas, B. Triyogo, B. Bramanto, O. Maulita, I. Septiawan, B. Triarahmadhana;

## Capabilities: Techniques & Infrastructure

## Geodetic techniques & infrastructure measuring elevations

| Techniques | Spirit Leveling | Tide Gauges | Absolute Gravimetry | GNSS | InSAR | Extensometry |
|---|---|---|---|---|---|---|
| **Infrastructure** |  |  |   |  |  |  |
| **Limitations** | Elevation difference btw bolts/ points | Water level change wrt. physical mark | Gravity of a bolt/ point | Position fictive point of the antenna | Displacement wrt. fictive pixel | Displacement wrt. to physical mark |

# The development of Geodetic Infrastructure by Technique



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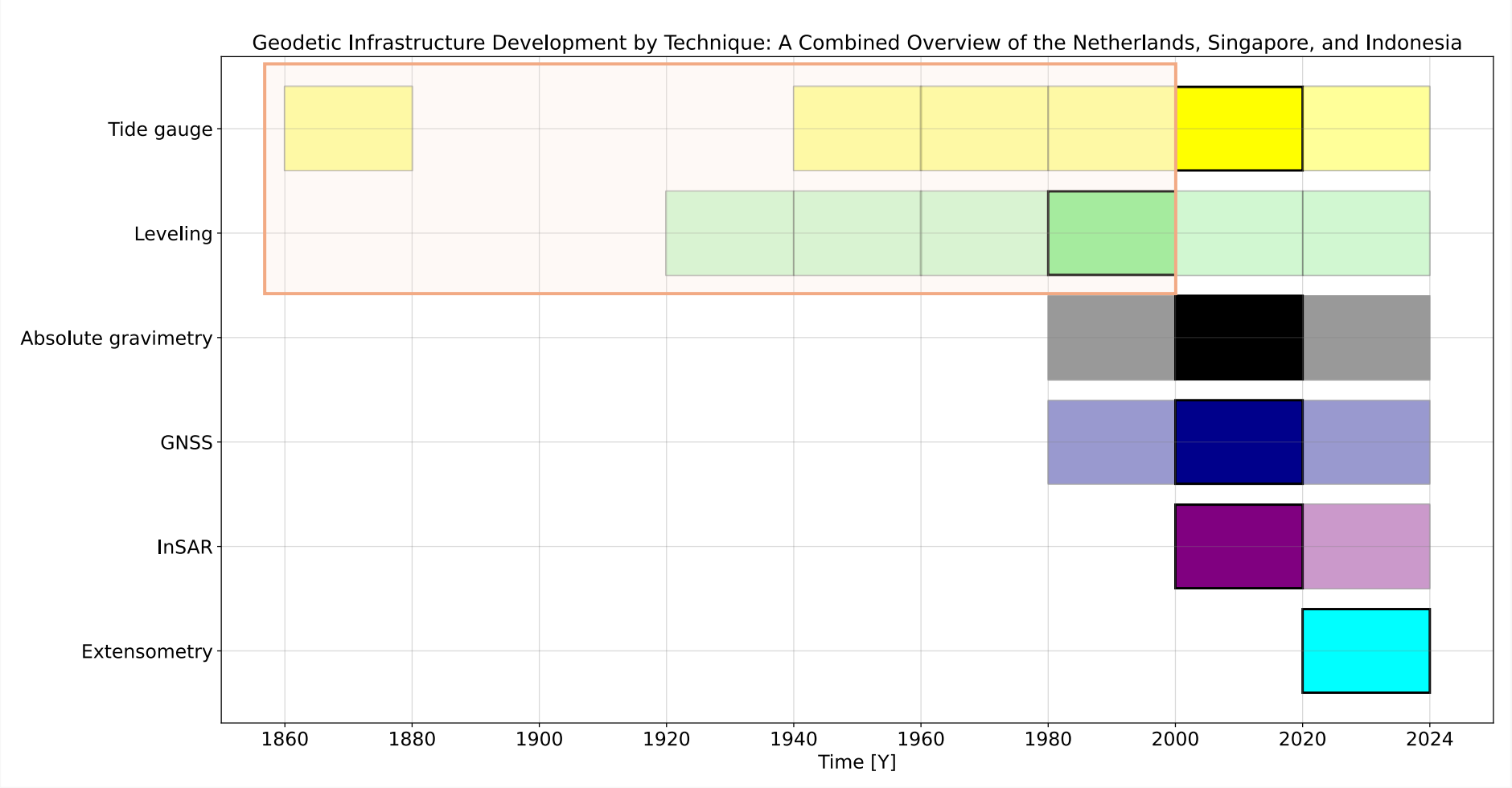

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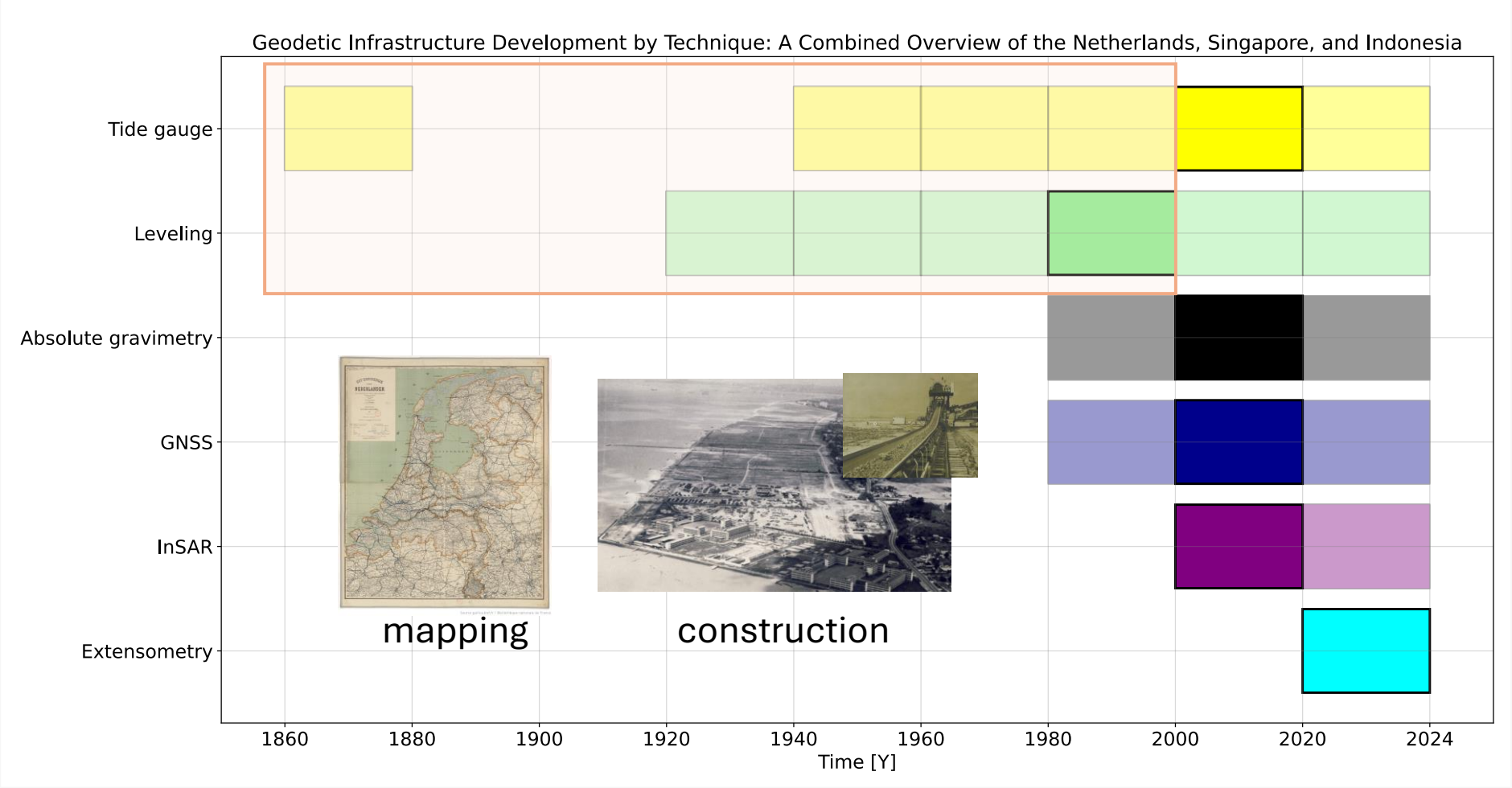
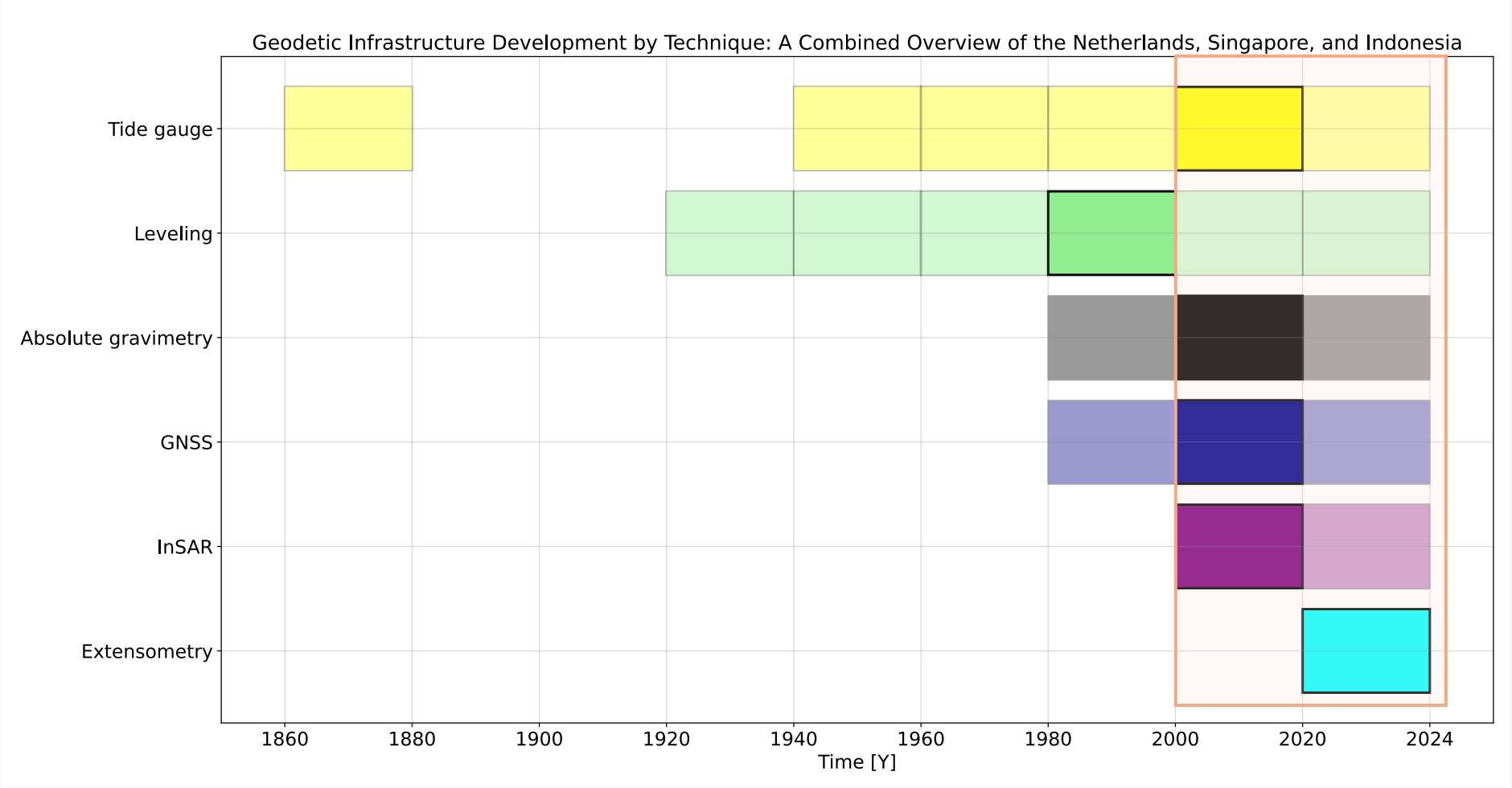



1860-2000: establishing leveling based vertical reference frames for mapping and construction applications.

# The development of Geodetic Infrastructure by Technique



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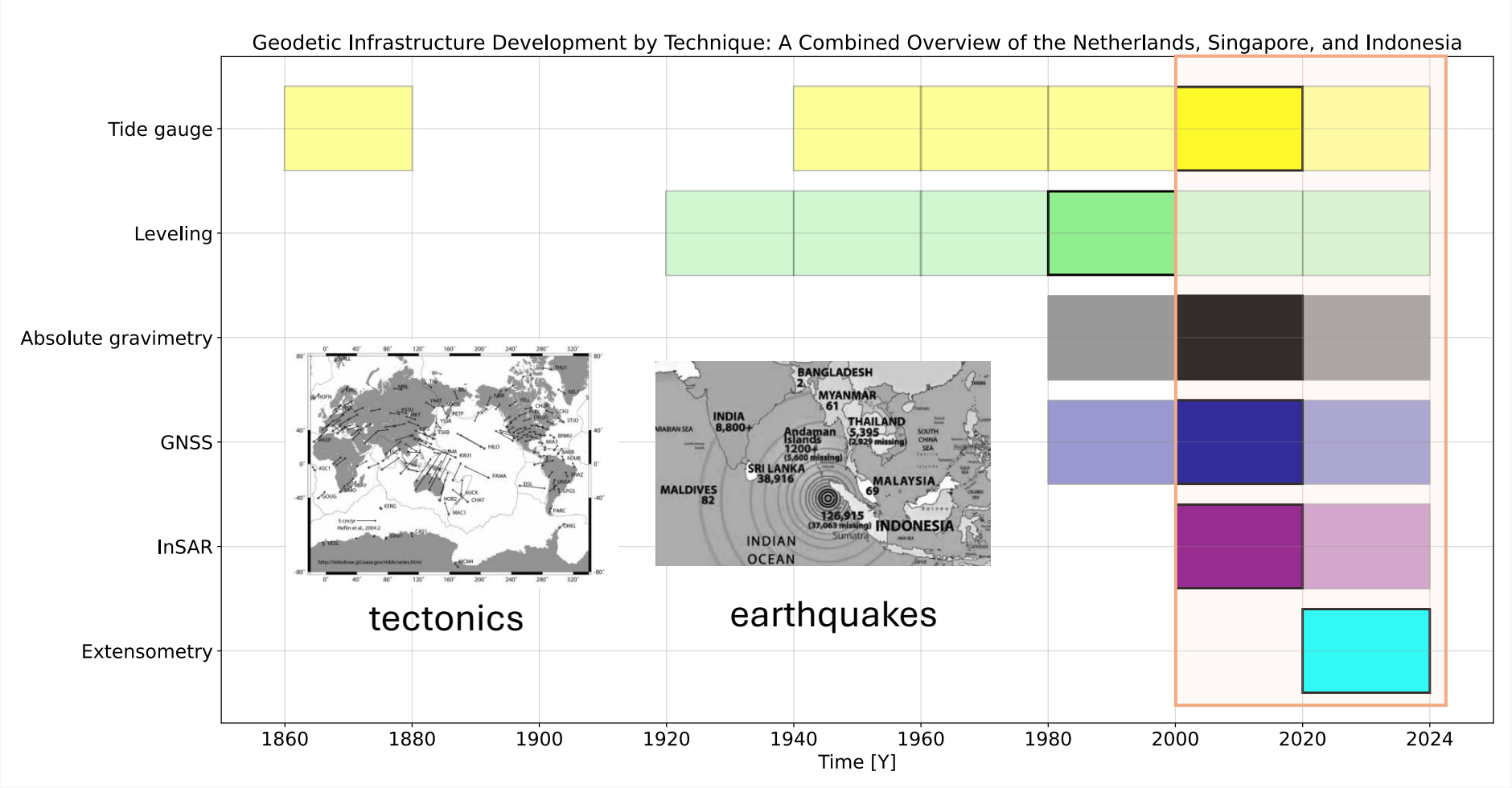



2000-2024: establishing continuous monitoring infrastructure to improve precision, reduce costs, study dynamic processes and develop early warning systems.

# Example of novel geodetic infrastructure & products

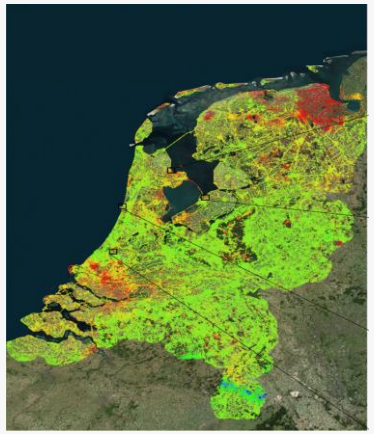
## NL

### Integrated Corner Reflectors

### Radar transponders

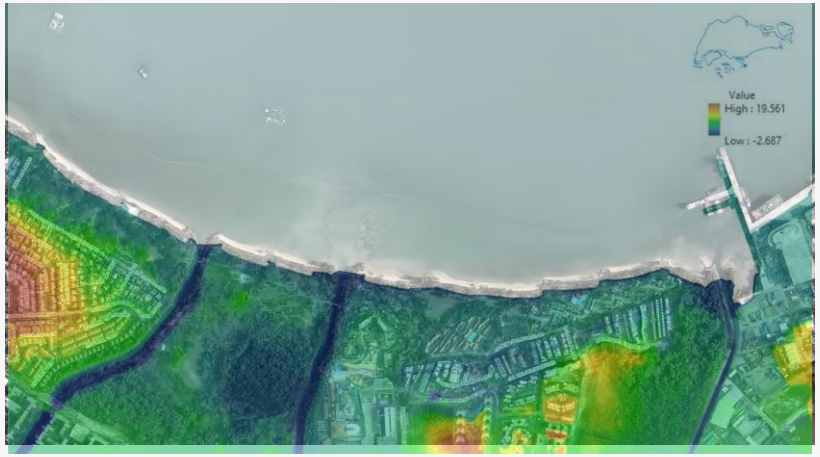
Mahapatra, Pooja, et al. "InSAR datum connection using GNSS-augmented radar transponders." *Journal of Geodesy* 92 (2018): 21-32.

### National Subsidence map



## SG

### National DEM & Orthophoto plan



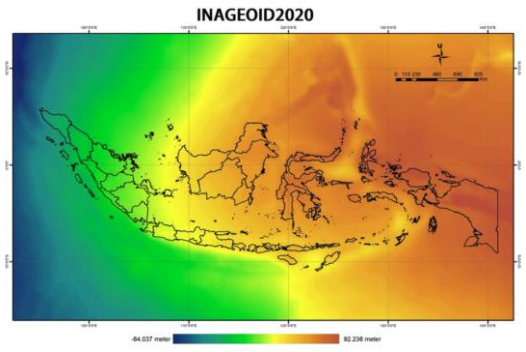

Courtesy to : Singapore Land Authority

## ID

### Extensometers

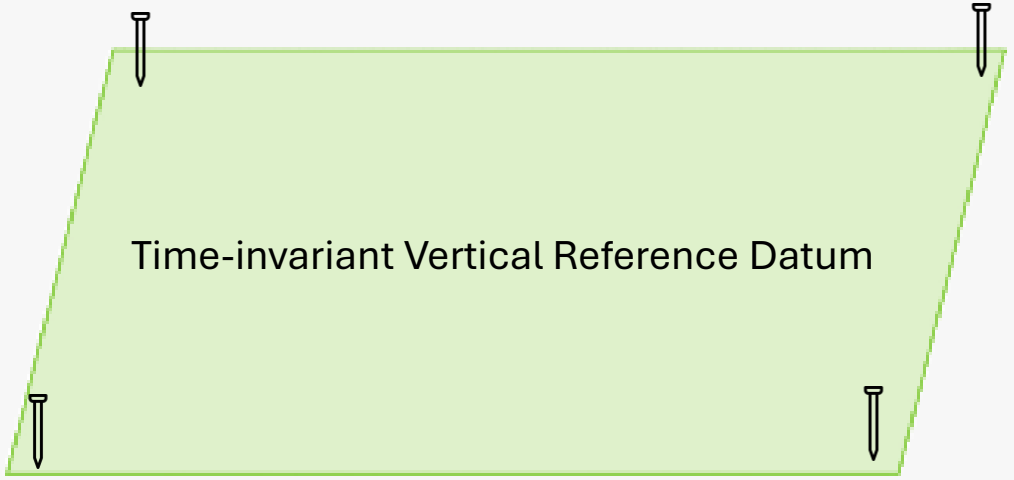

H. Andreas, 2024. Establishing Monitoring System of Land Subsidence and Coastal Inundation in Case Study Jakarta

### National Geoid model



Capabilities: Techniques & Infrastructure → **Datum Problem**

## The problem of different datums




**NL:** NAP (1682)

**SG:** SHD (1934.5)

**ID:** JKVN (1985)

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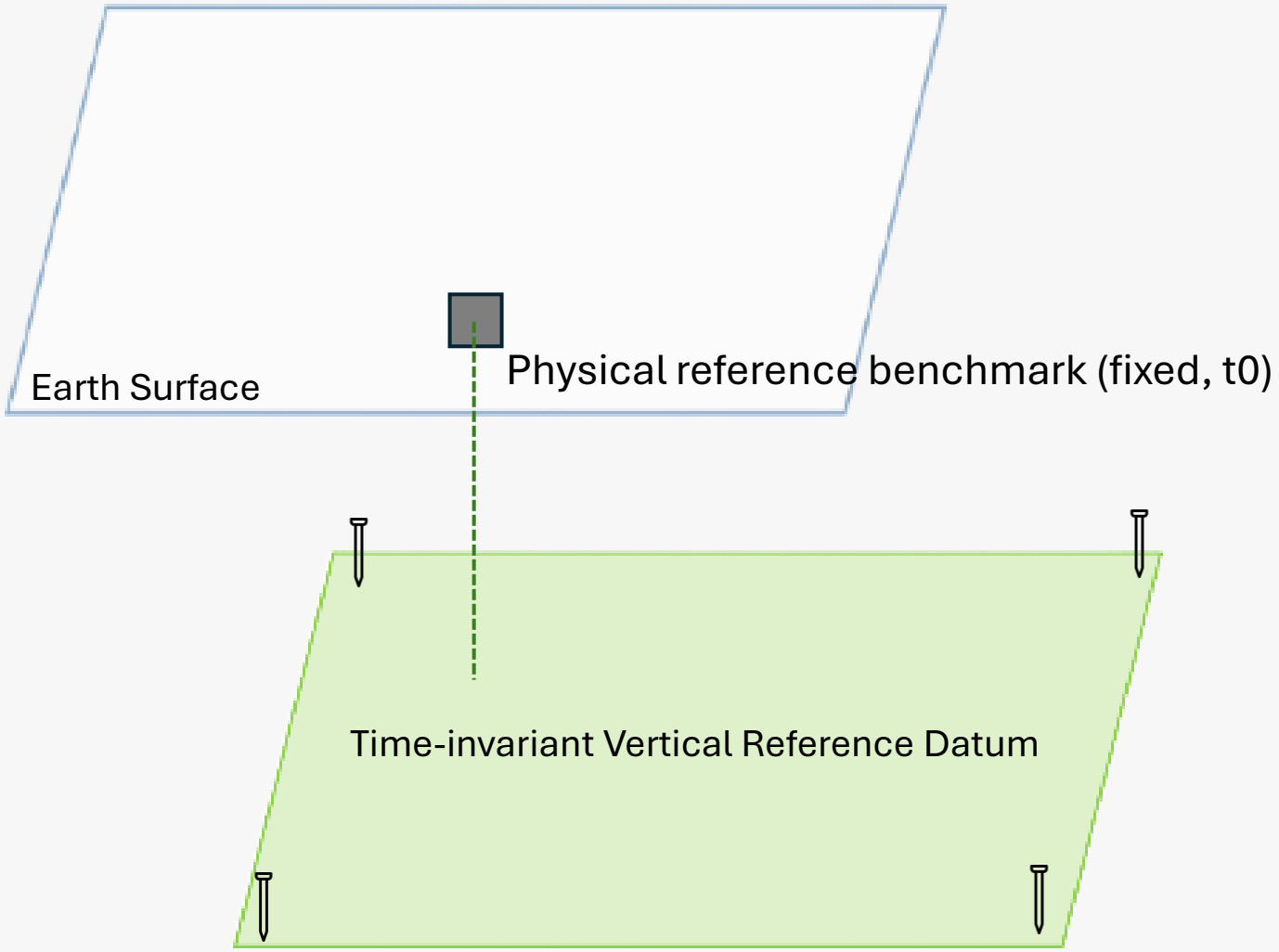

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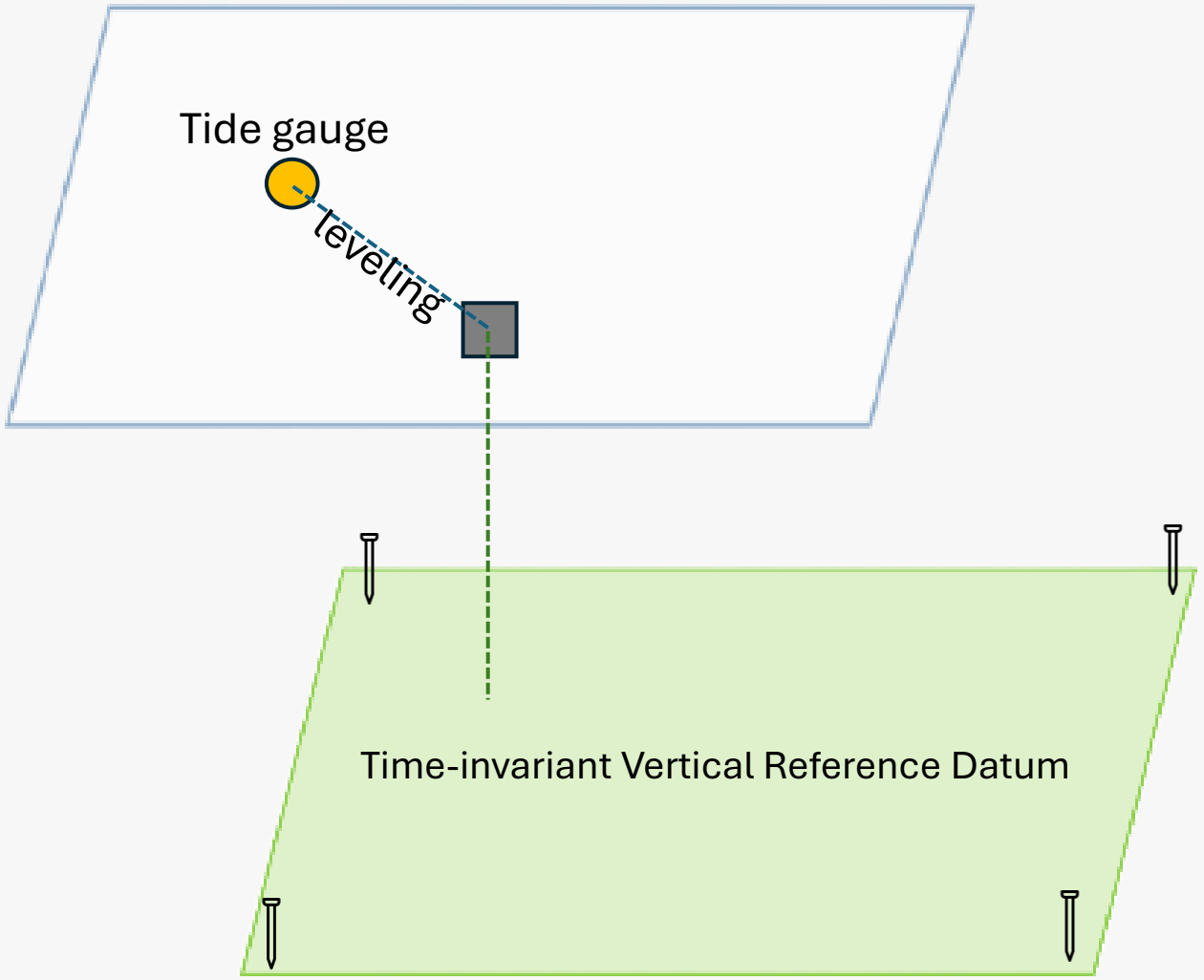

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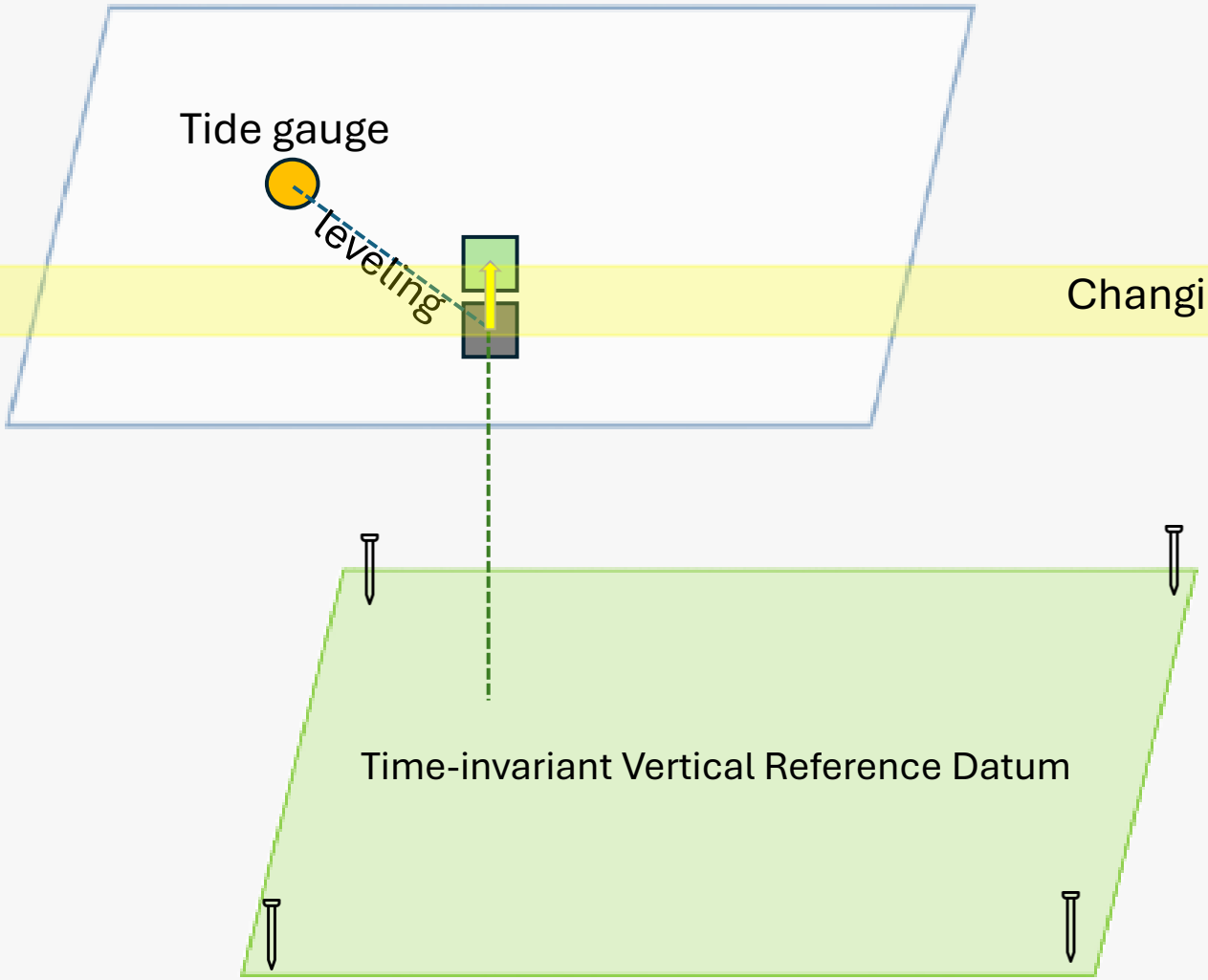


Changing in reference, not accounted for

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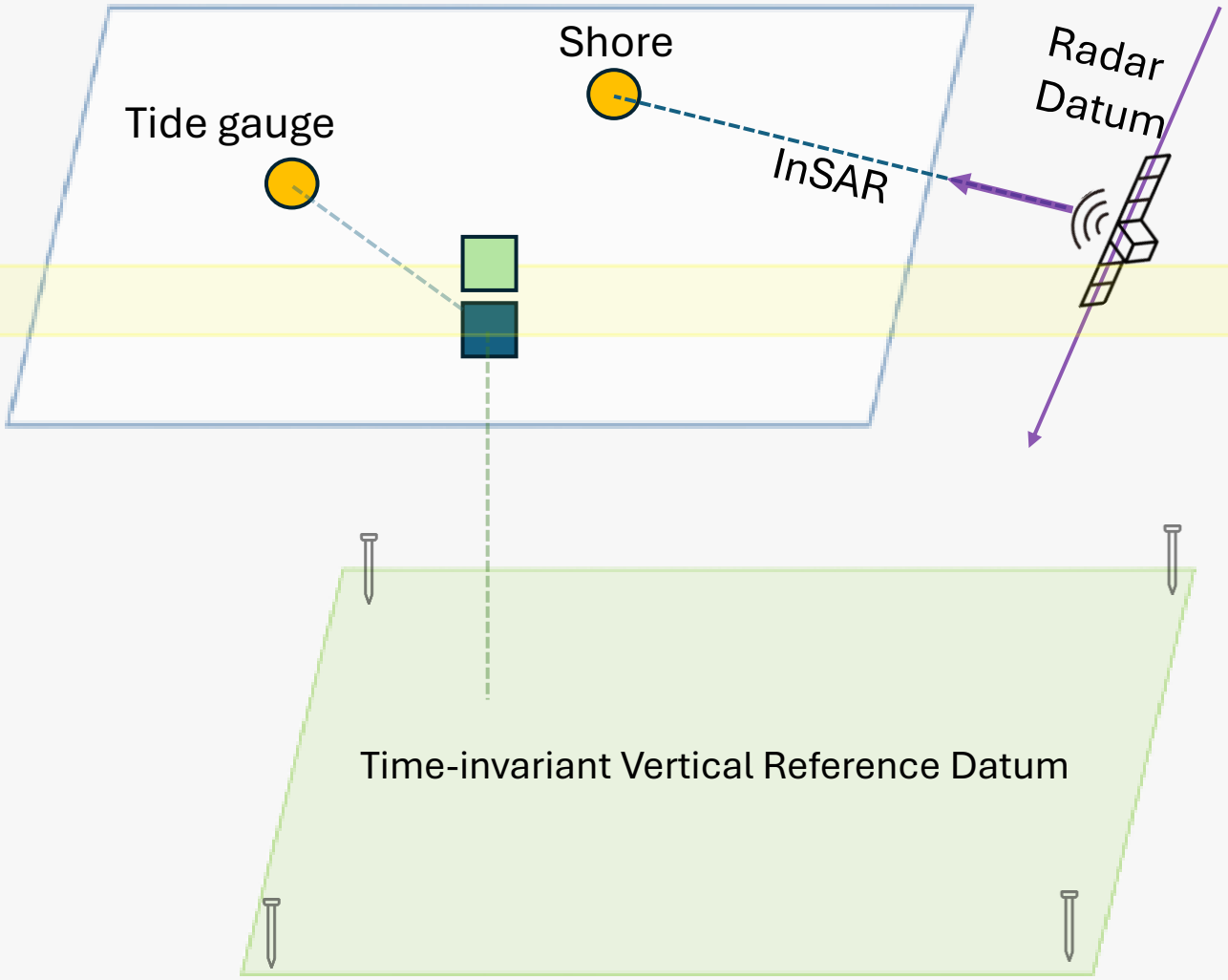

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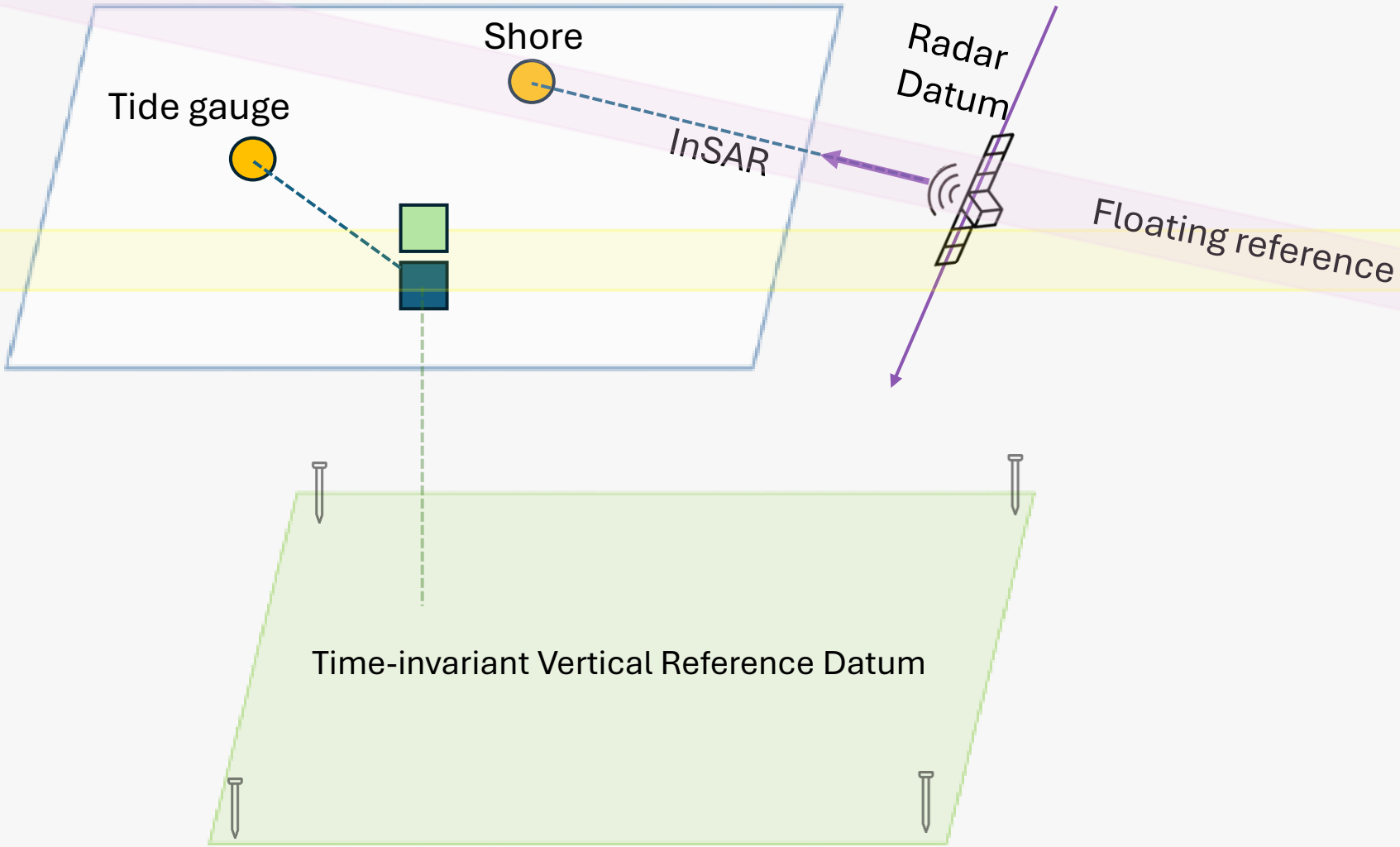

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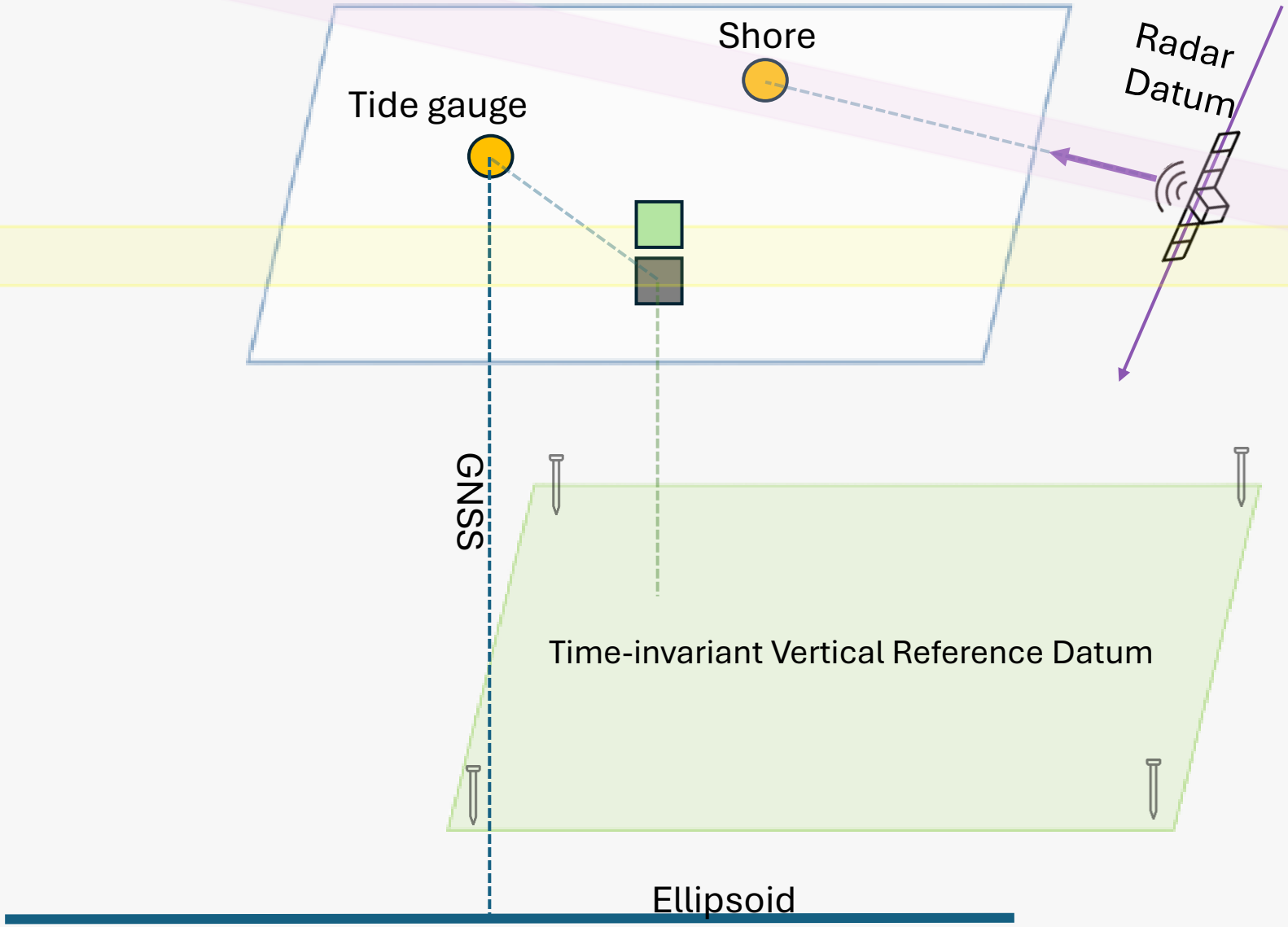

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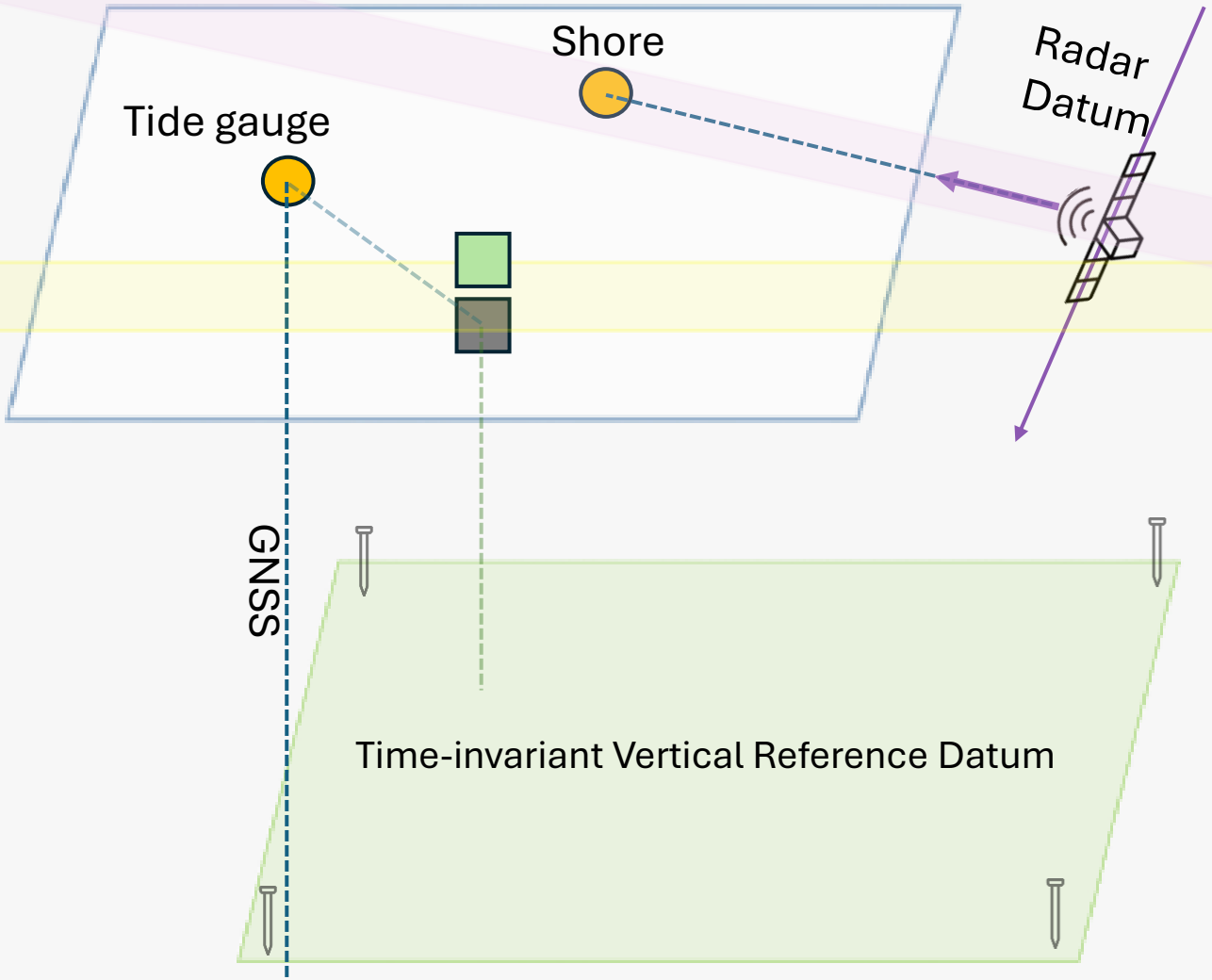

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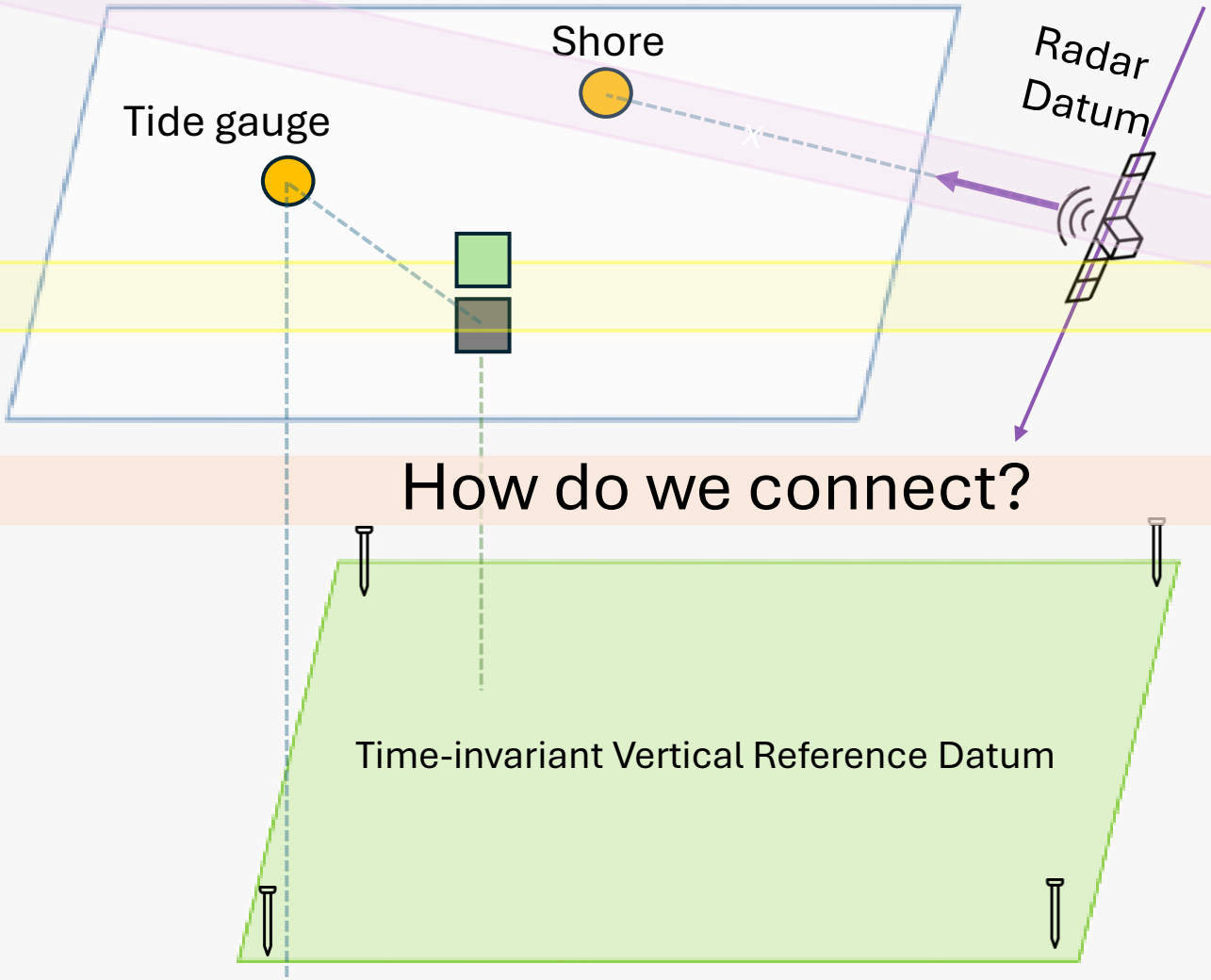


Capabilities: Techniques & Infrastructure → Datum Problem → **Solutions**

Historic data

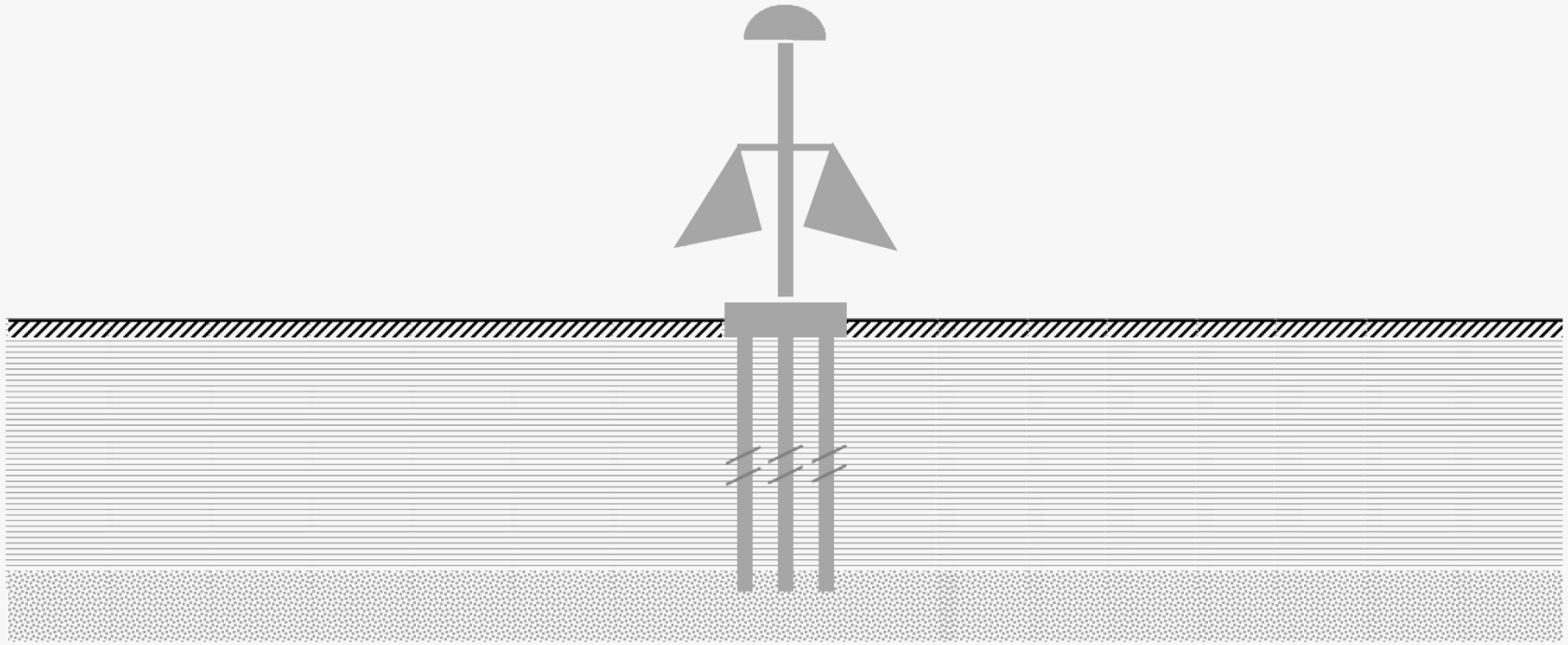
Past

Continuous monitoring

Present

## Solutions: link to physical interpretable reference points!

The Integrated Geodetic Reference Station (IGRS)

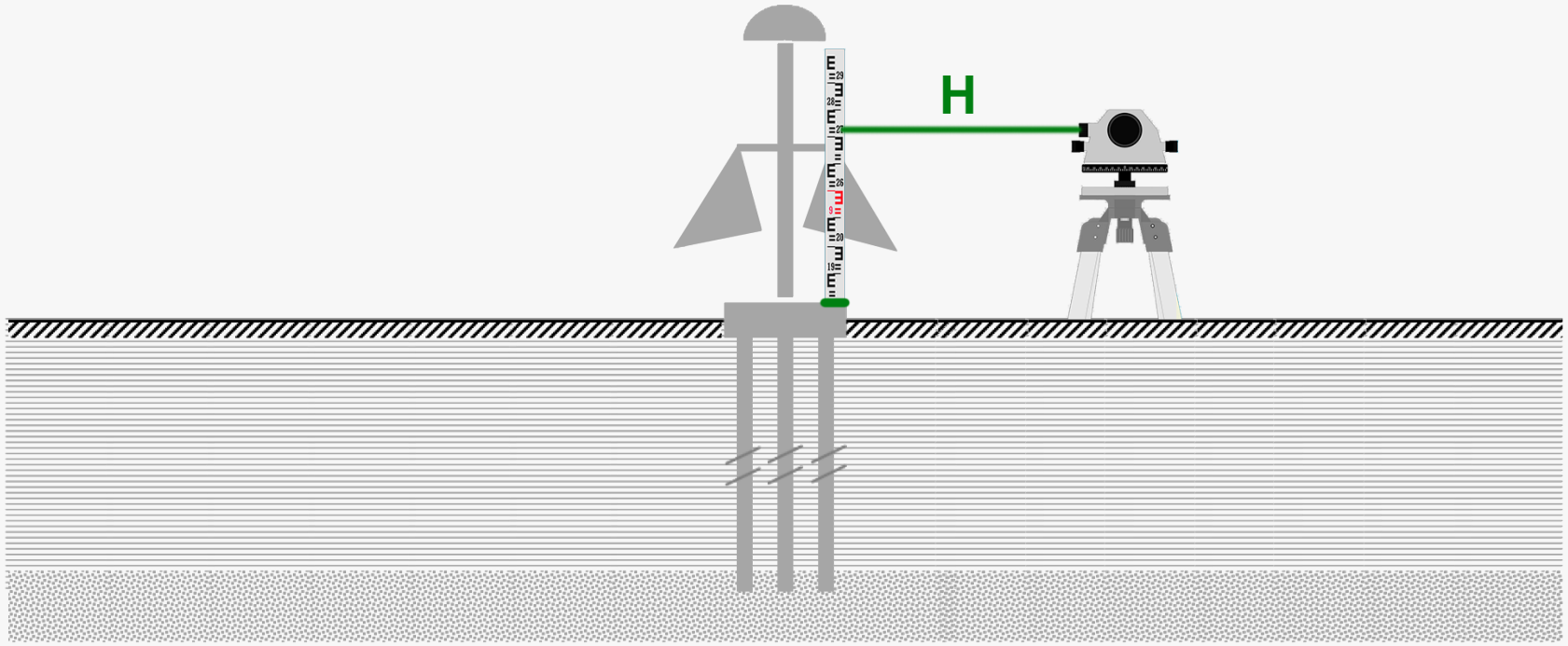


Provides the opportunity to **integrate** multiple geodetic techniques to the **same point** in space, which is **continuously monitored**.

## Solutions: link to physical interpretable reference points!

The Integrated Geodetic Reference Station (IGRS)

Spirit leveling



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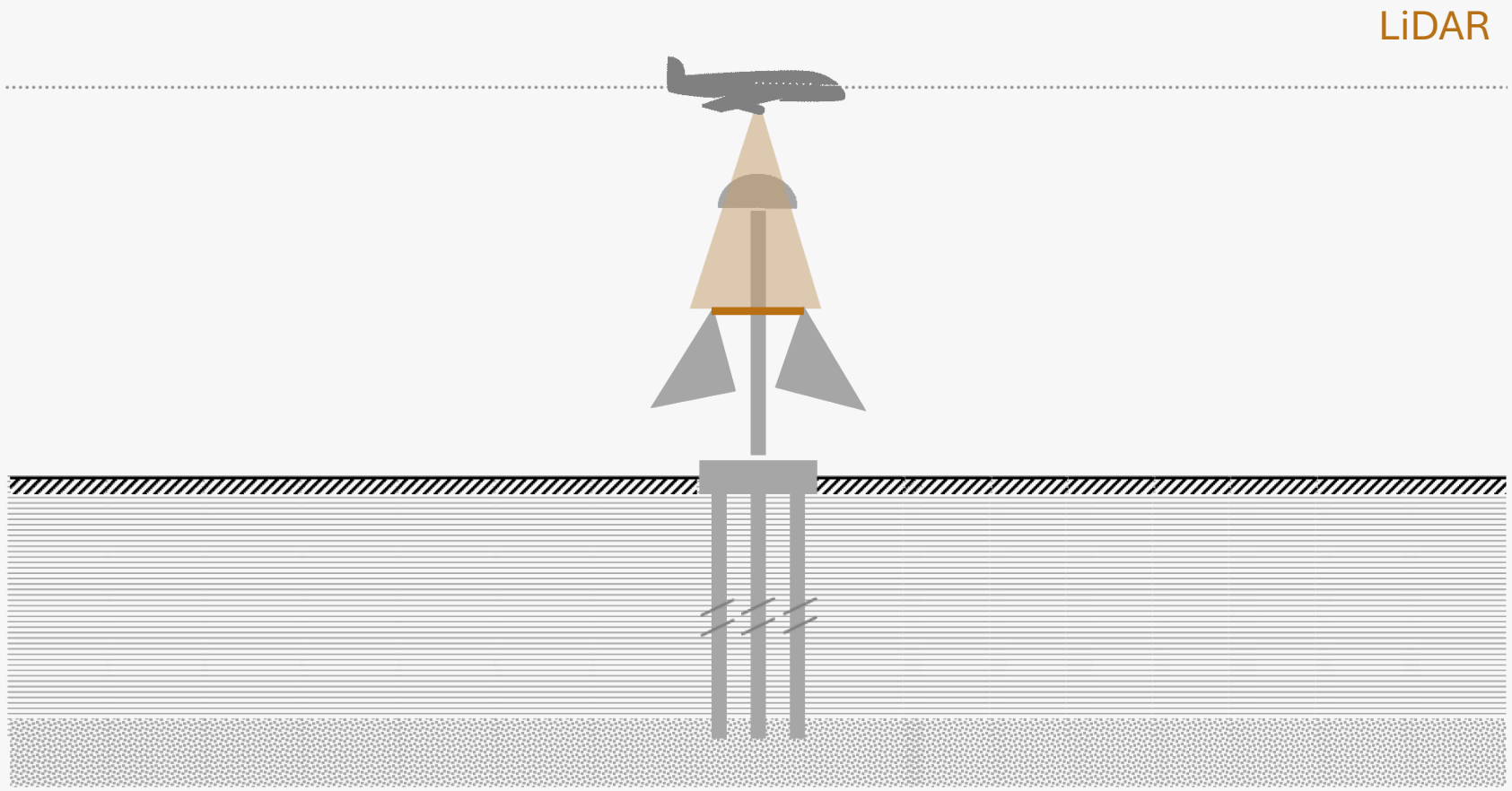

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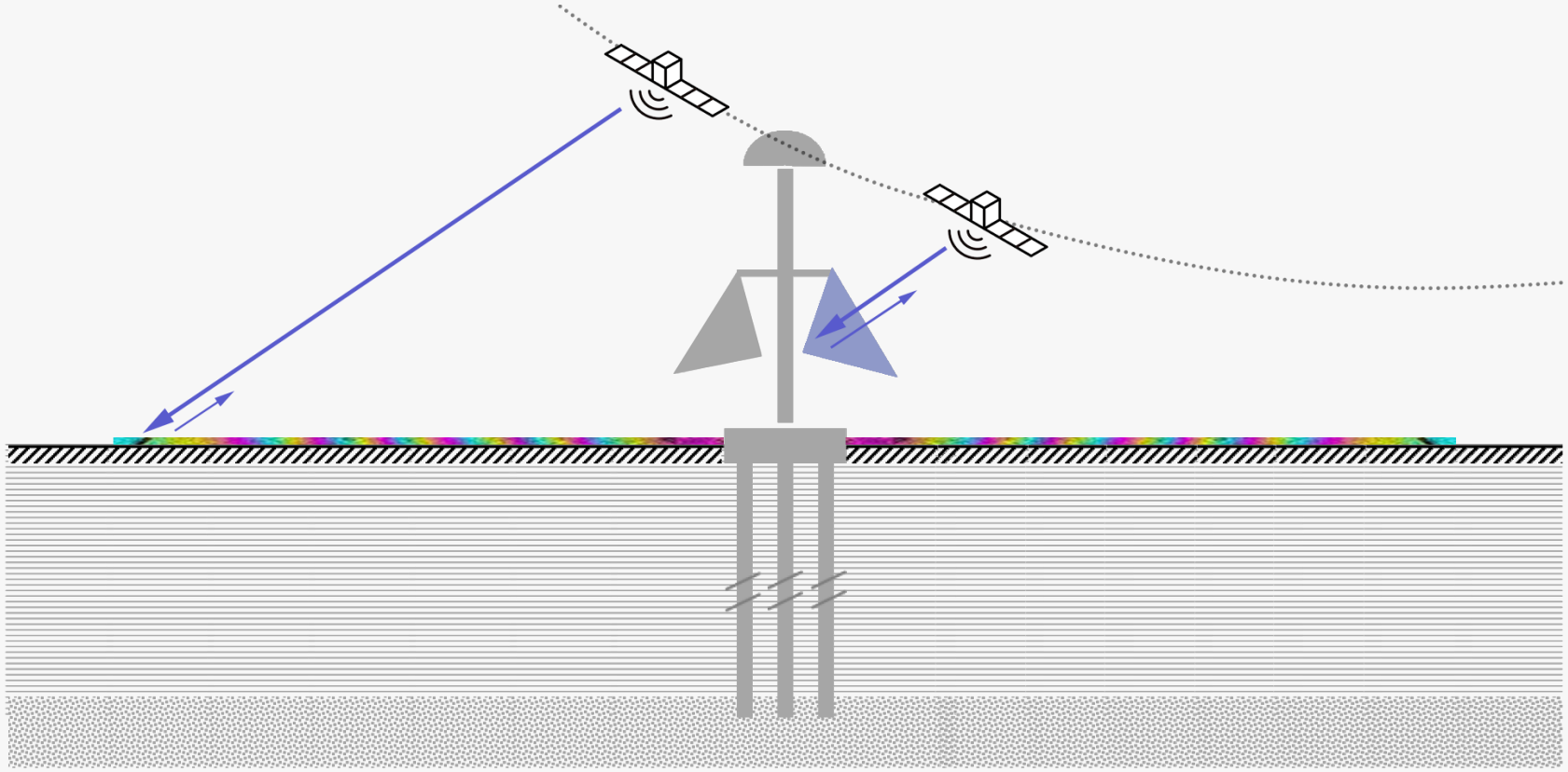
InSAR



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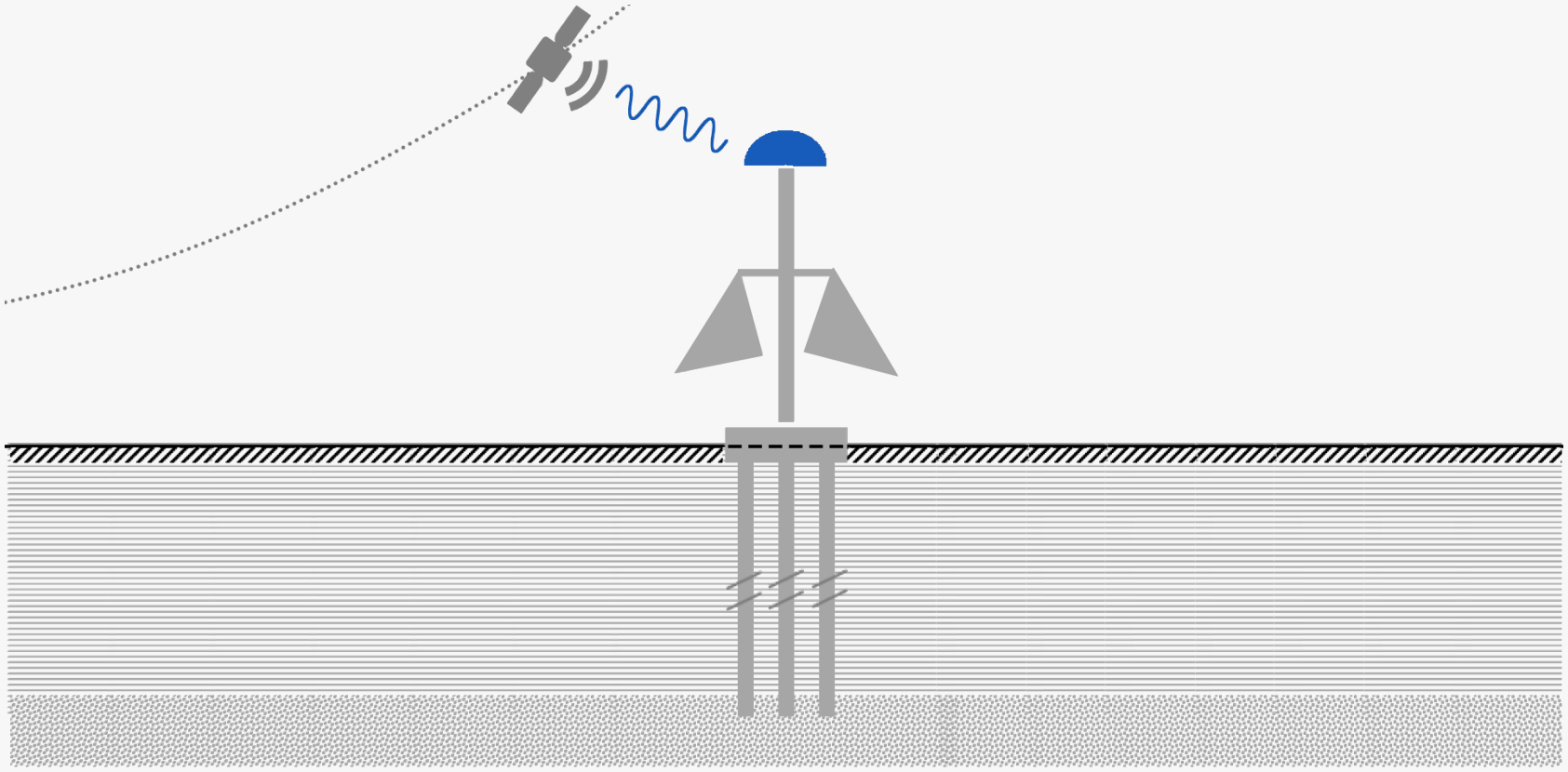
GNSS



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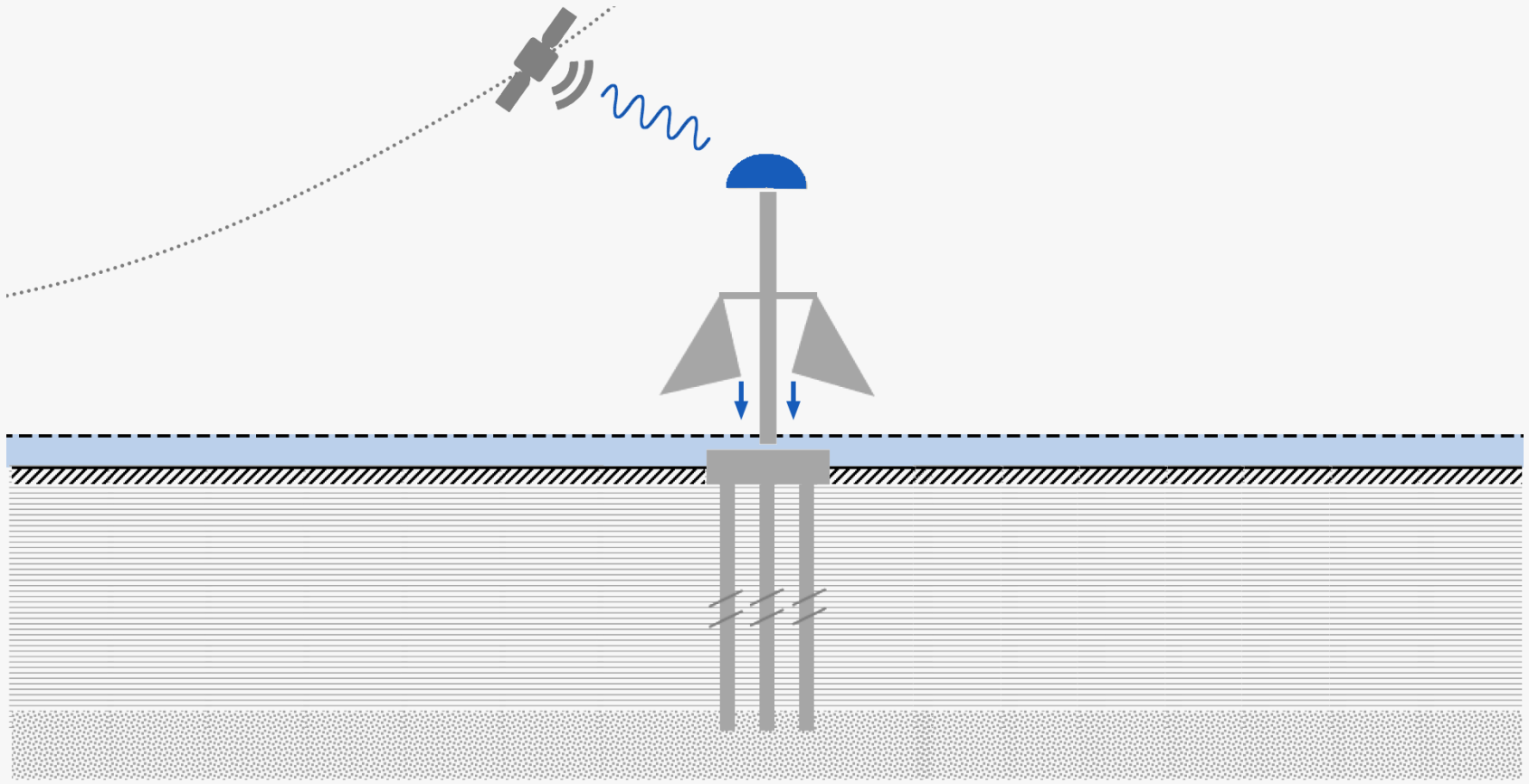
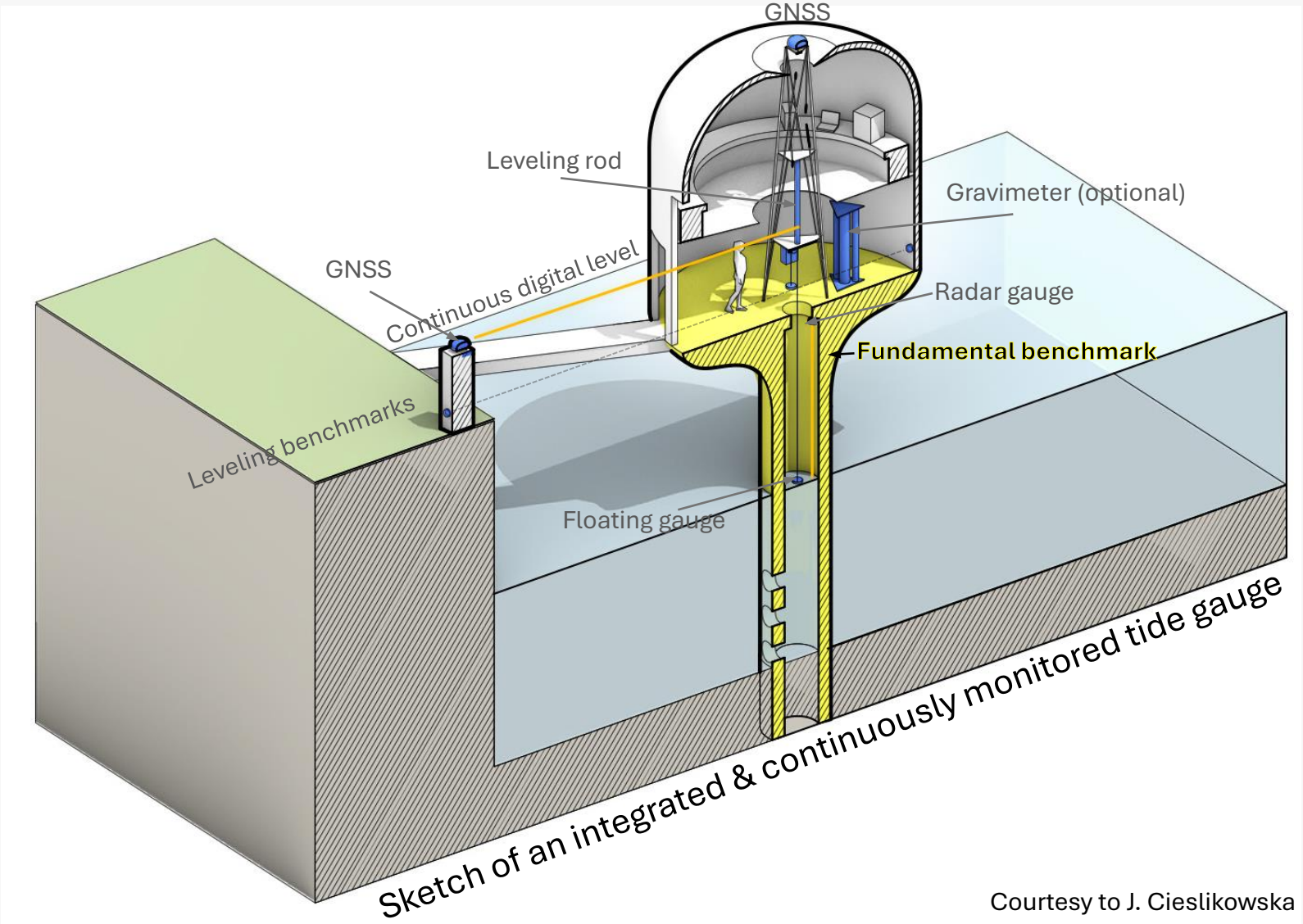
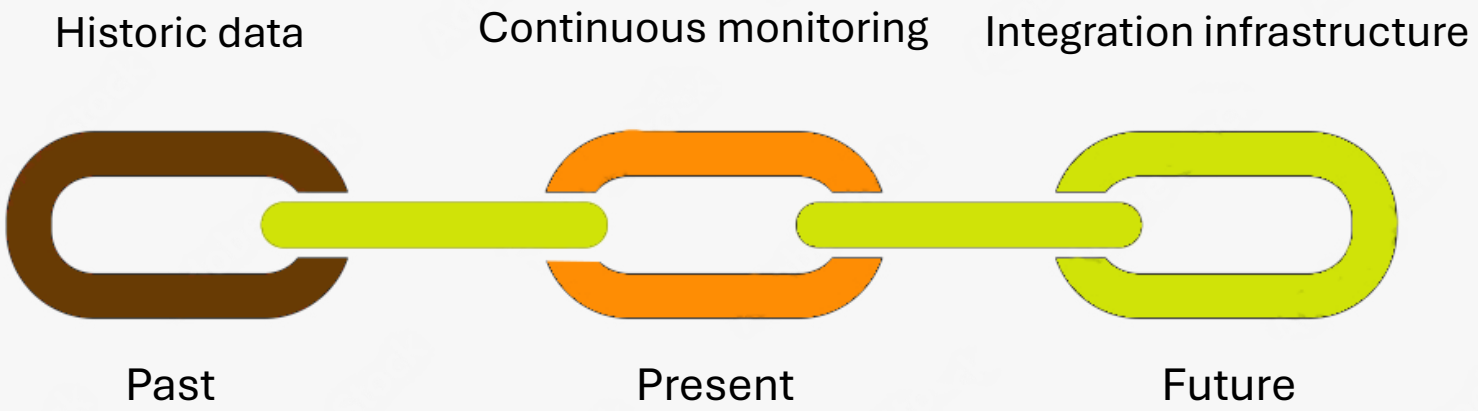


## Solutions: in the future more integrated infrastructure




Courtesy to J. Cieslikowska


Historic data
Continuous monitoring
Integration infrastructure
Past
Present
Future

Capabilities: Techniques & Infrastructure → Datum Problem → Solutions → **Conclusions**

## Conclusions

We have remarkable geodetic infrastructure,
but geodetic techniques work in **independent Datums**!

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**Looking Ahead:**

- **Build** and **maintain integrated infrastructure** to study vertical land motion and separate it from sea level changes.

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**From fragmented frameworks to unified solutions—integrated geodesy for generations.**

Alex Lapadat
A.M.Lapadat@tudelft.nl