Can Continuous Cartesian Connections realize local ties at 0.1 mm level?

Sten Bergstrand — *SP Technical Research Institute of Sweden*

Rüdiger Haas — *Onsala Space Observatory, Chalmers University of Technology*

E-mail: sten.bergstrand@sp.se

Phone: +46 (0)10 516 57 73

URL: www.sp.se

SP Technical Research Institute of Sweden

CHALMERS

GGOS wants local ties at 0.1 mm level.
(currently ~1 cm)

~~GGOS wants local ties at 0.1 mm level~~

Interpretation

GGOS is striving for sub-mm accuracy and local ties must not be a limiting factor.
How good can local ties get?
What is the best practice?

Global Geodetic Observing System (GGOS)

- Provides geodetic infrastructure necessary for monitoring global change research.
- **Integrates different geodetic techniques** in order to ensure long-term, precise monitoring of the observables.
- Provides the observations to maintain a **stable, accurate and global** reference frame
- Crucial for all Earth observations and many practical applications, e.g time keeping, data transfer…

The Hows, Whats and Buts of Local ties

- *Recommended:* Pearlman M.R. (2008) (ed.)
  Report of TLS (Terrestrial Laser Scanner) Workshop,
  http://ilrs.gsfc.nasa.gov/docs/TLS_2008Workshop_Report.pdf

- Relate coordinate differences between the different techniques' reference points
  - geometric relations with respect to a local geodetic survey system.
  - full covariance information in temporal AND spatial domains
- Continuous, i.e automated monitoring systems

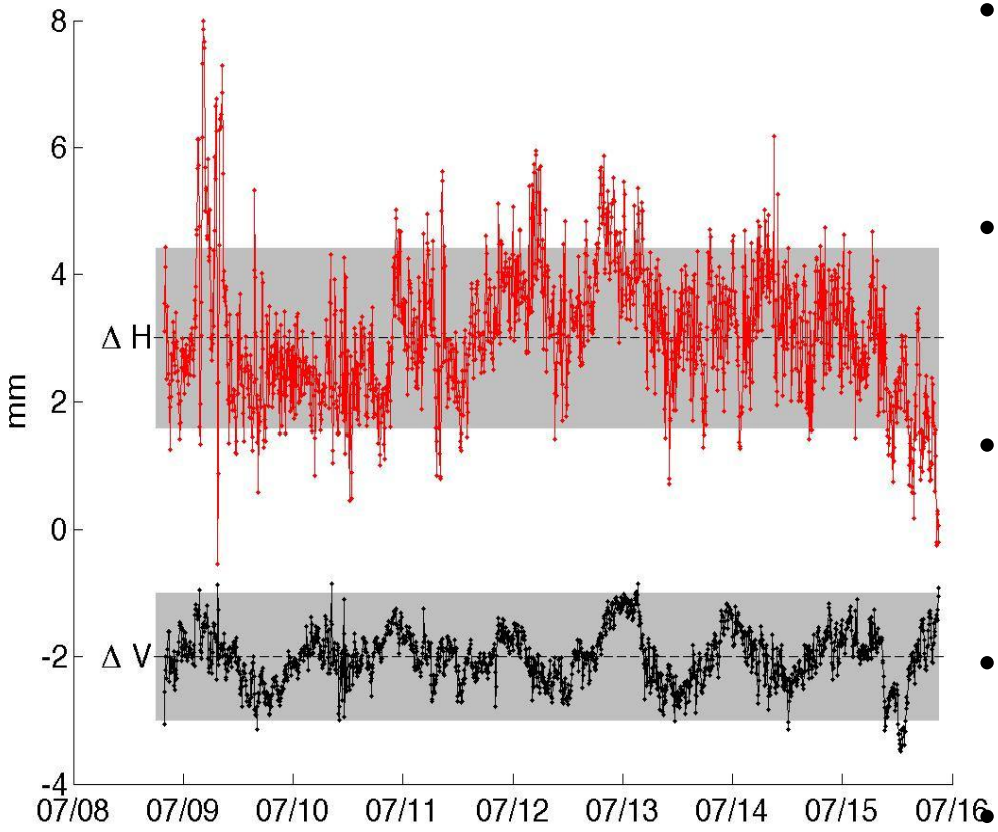
- Space geodesy dependent of measurements of imaginary points
  - Projections of elevation axis on azimuth axis (SLR, VLBI)
  - Phase center of antennas (GNSS,DORIS)

Cold Magics – Continuous Local Deformation Monitoring at an Arctic Fundamental Station

SP Technical Research Institute of Sweden

CHALMERS

Cold Magics – Continuous Local Deformation Monitoring at an Arctic Fundamental Station



- VLBI – GNSS local tie at Ny Ålesund, 2009
- PC-controlled single robotic total station monitoring system
- Movements larger than uncertainty bands
- Indication of diurnal movements
- No 0.1 mm local ties this way…

SP Technical Research Institute of Sweden

CHALMERS

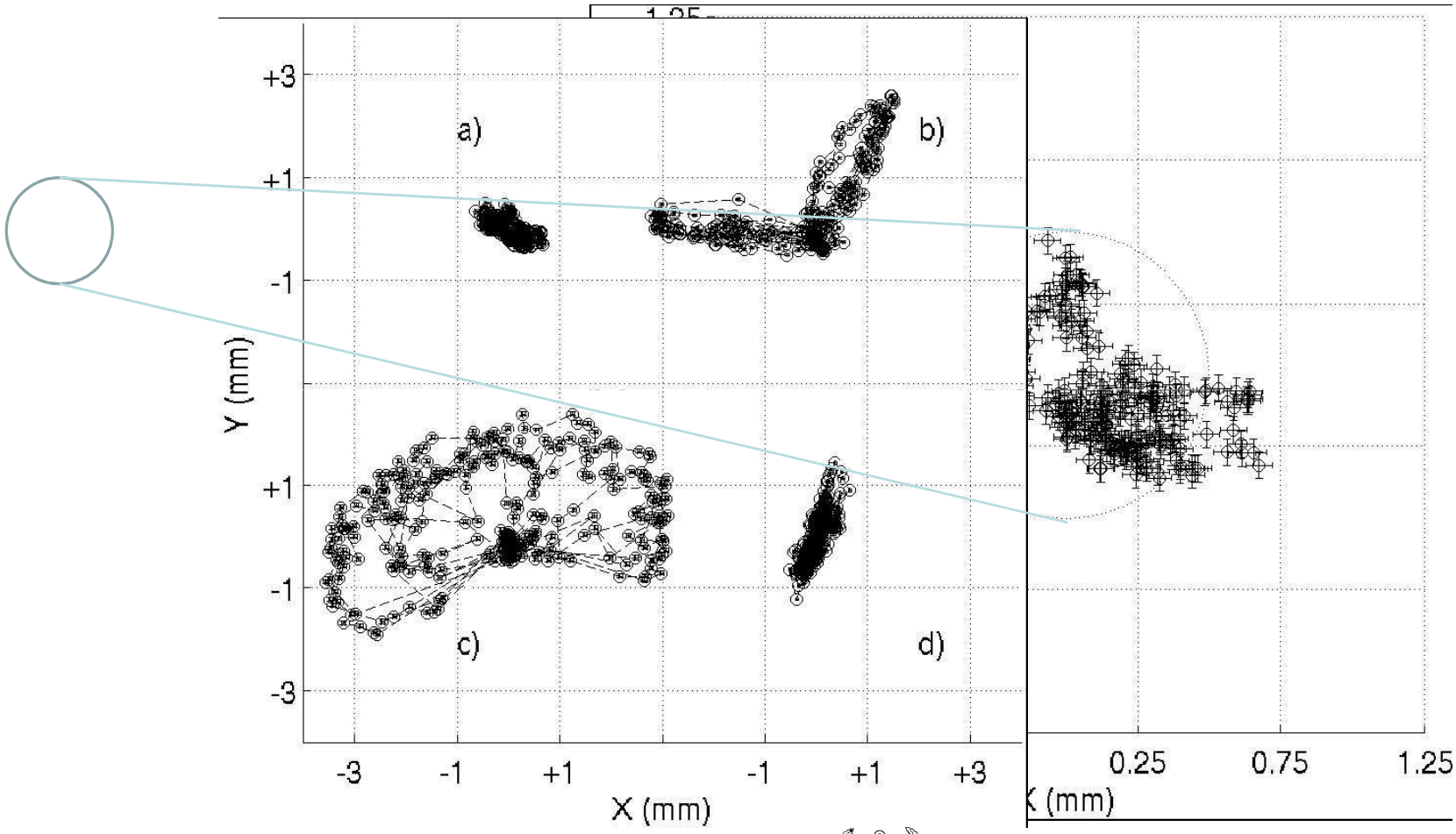
Evaluation of GNSS monument stability

- To appear in REFAG2010 Proceedings
- PC-controlled double robotic total station monitoring
- Length scale calibrated and verified interferometrically
- Solar flux measurements

SP Technical Research Institute of Sweden

CHALMERS

Evaluation of GNSS monument stability



SP Technical Research Institute of Sweden

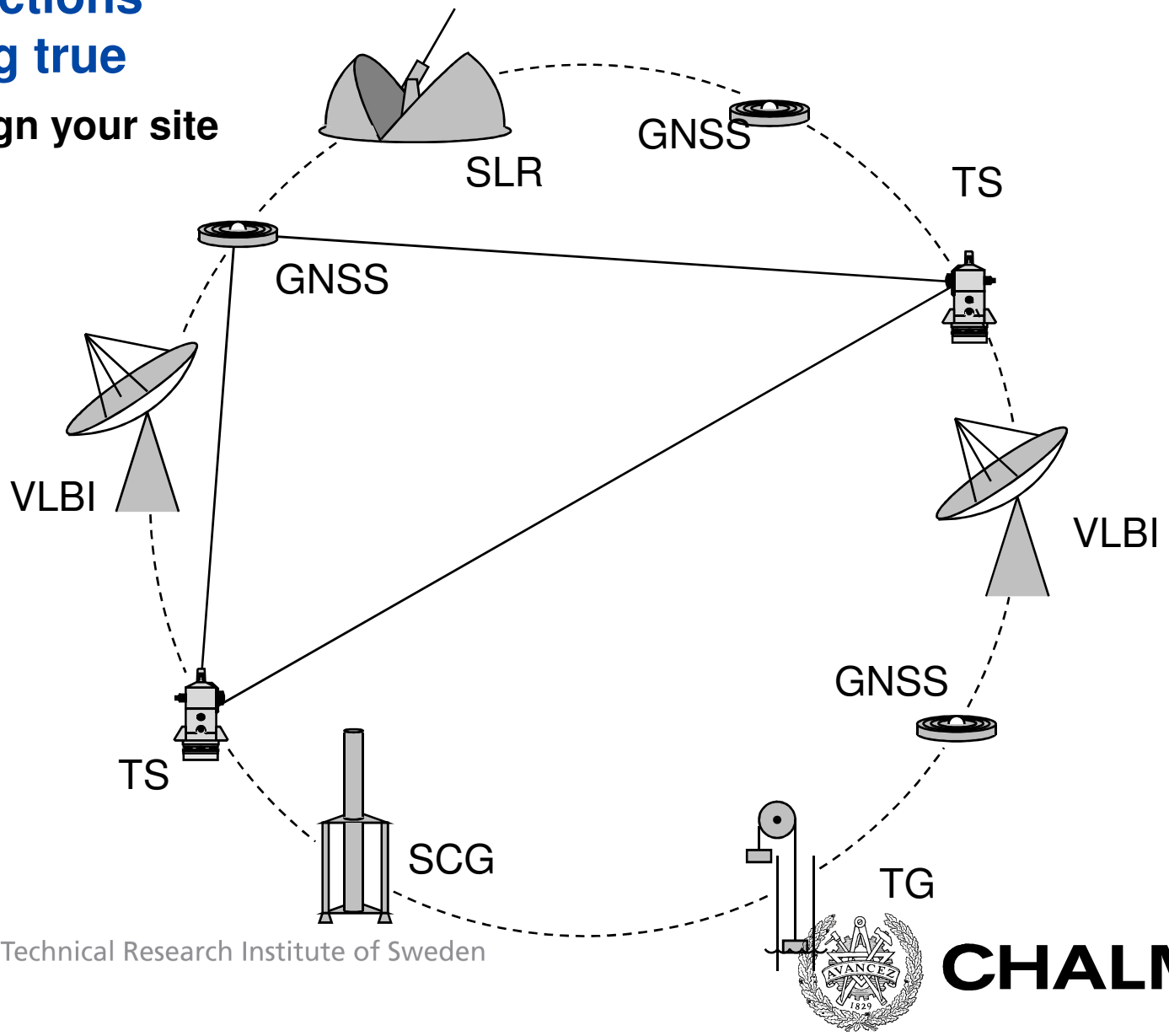
CHALMERS

Continuous Cartesian Connection basics

- Measurements of same temporal order as perturbations
- Transformations between global Cartesian coordinate systems with Local Truly Cartesian (LTC) coordinate systems
- Avoid measuring redundant parameters: Simplify!
- Get partners – detailed knowledge in several fields is needed.
- Use state of the art equipment for every measurement task:
  - Laser trackers for interferometric length measurements
  - Robotic total stations for monitoring
  - Monitor environmental parameters densely
- Utilize best practice methods, modify them if unavoidable
- Separate observable from connecting vector.
- Method described in submitted paper

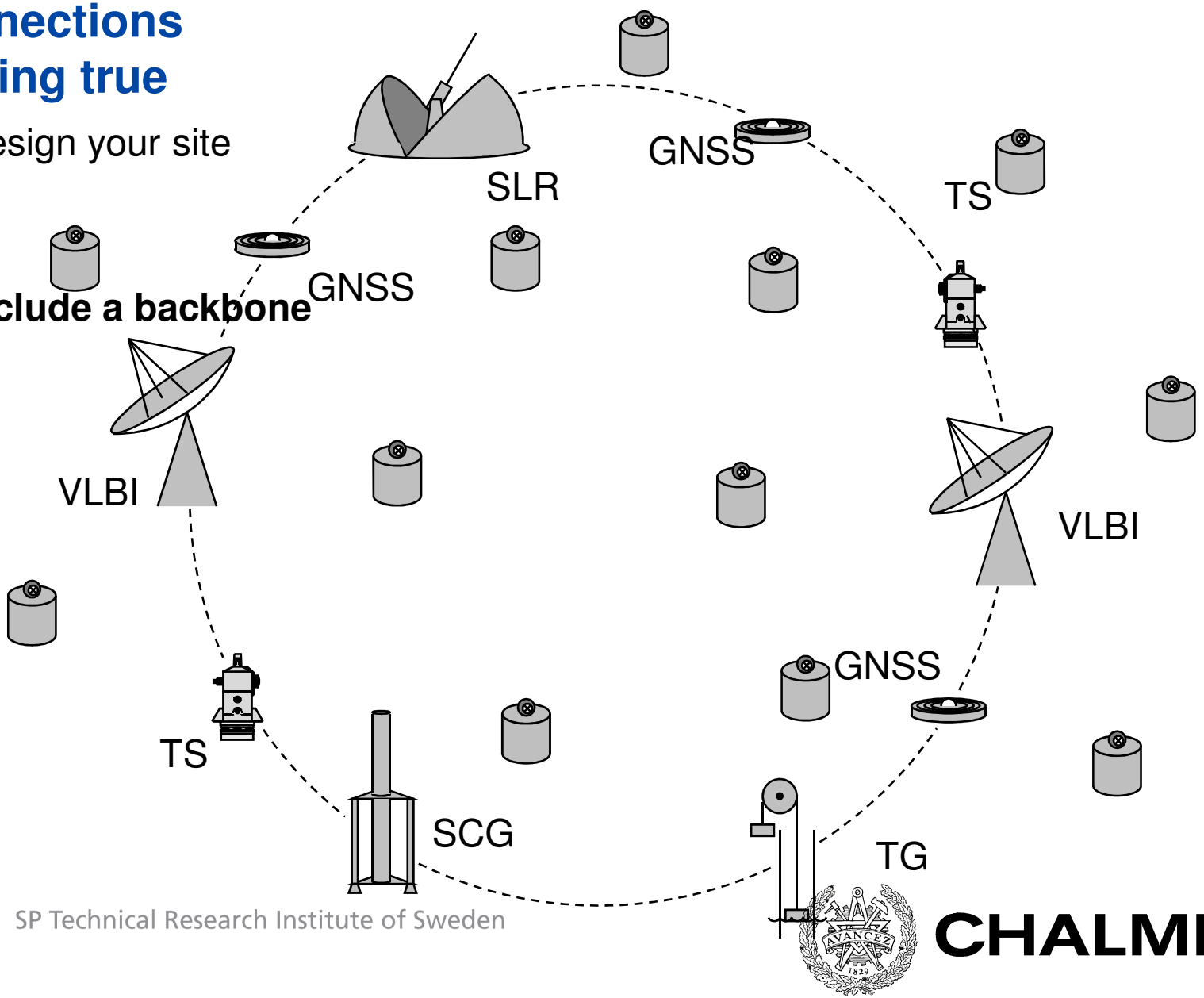
Continuous Cartesian Connections coming true

1. **Design your site**



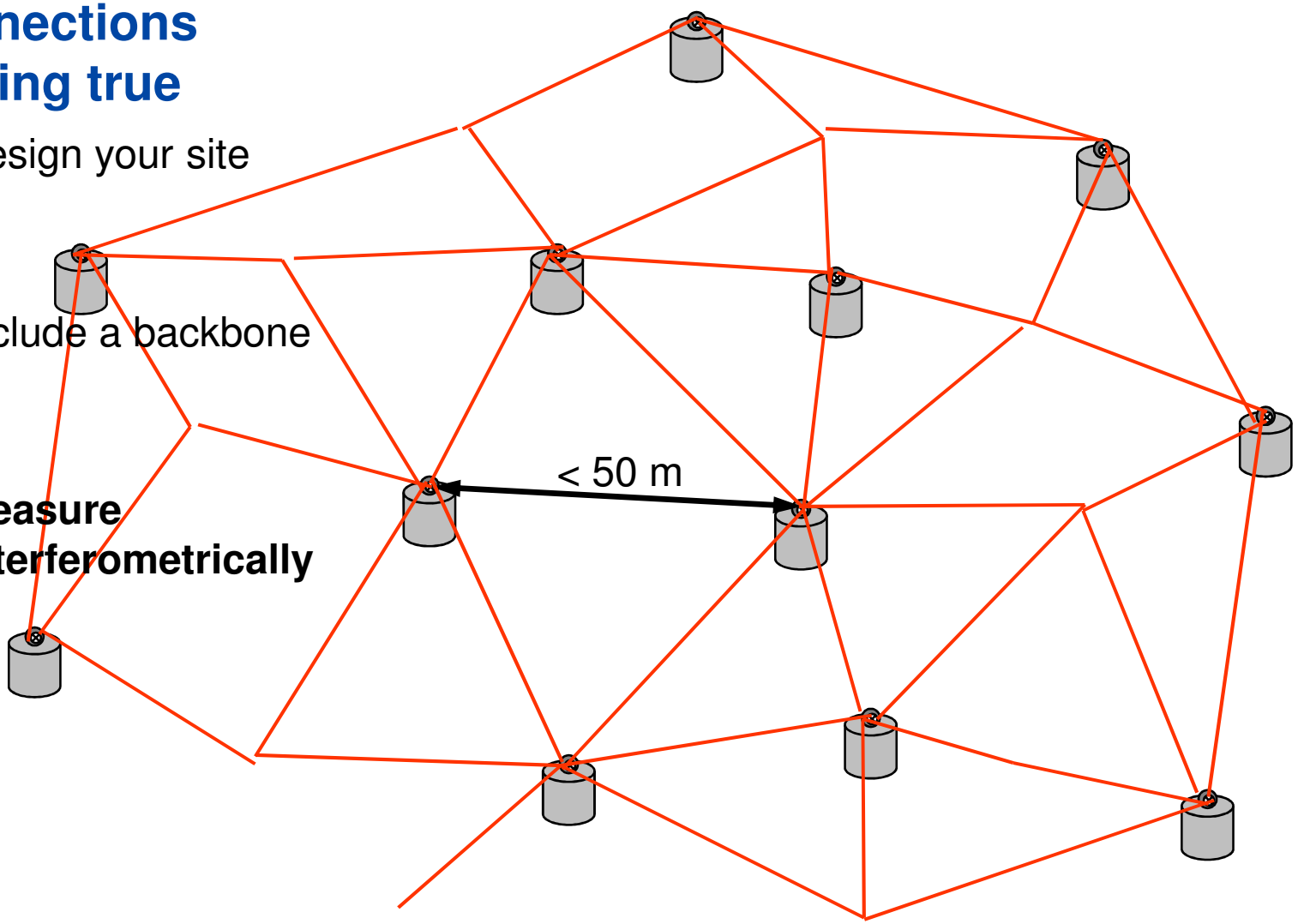
Continuous Cartesian Connections coming true

1. Design your site
2. **Include a backbone**



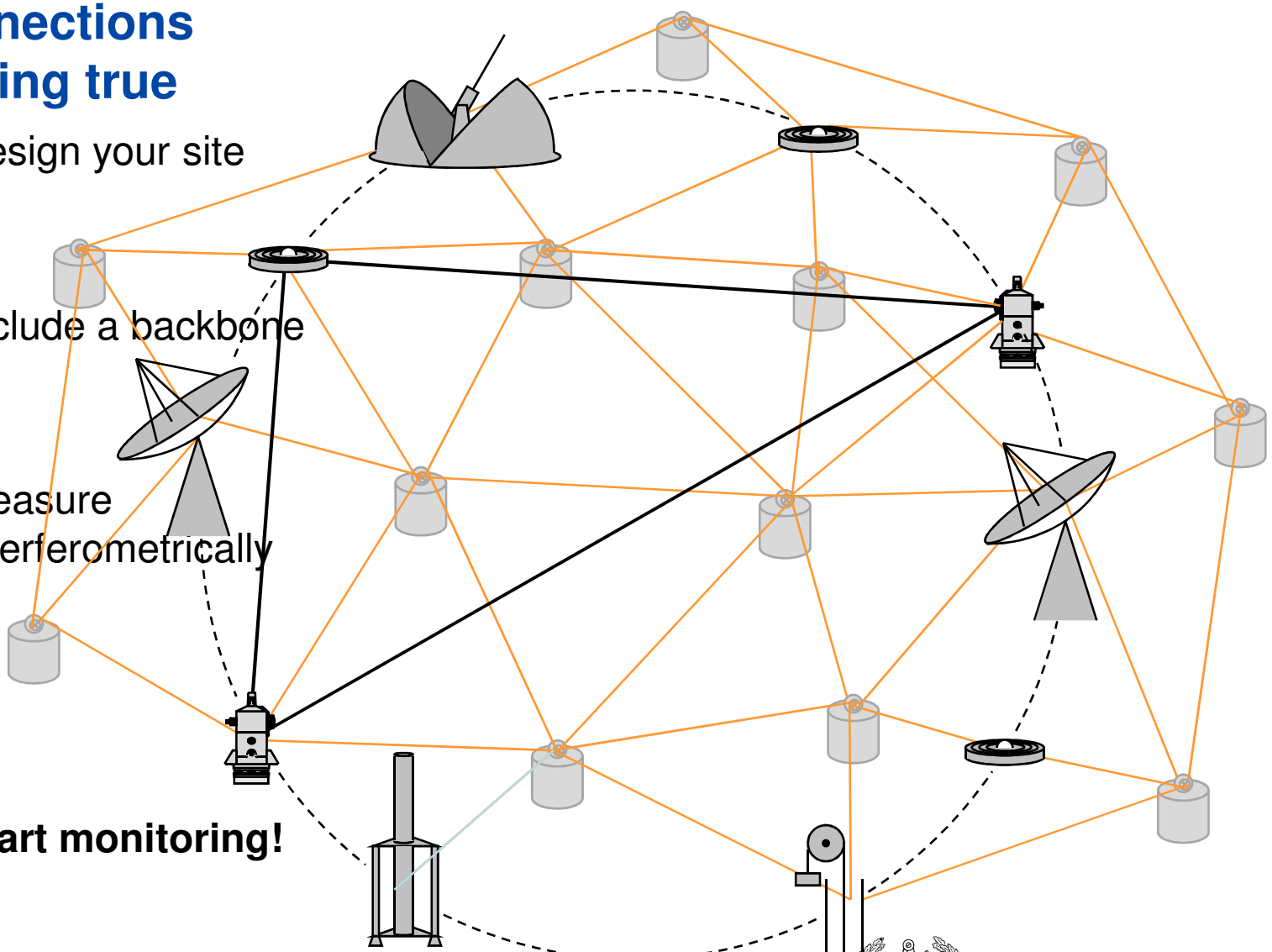
Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. **Measure interferometrically**



Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. Measure interferometrically
4. **Start monitoring!**

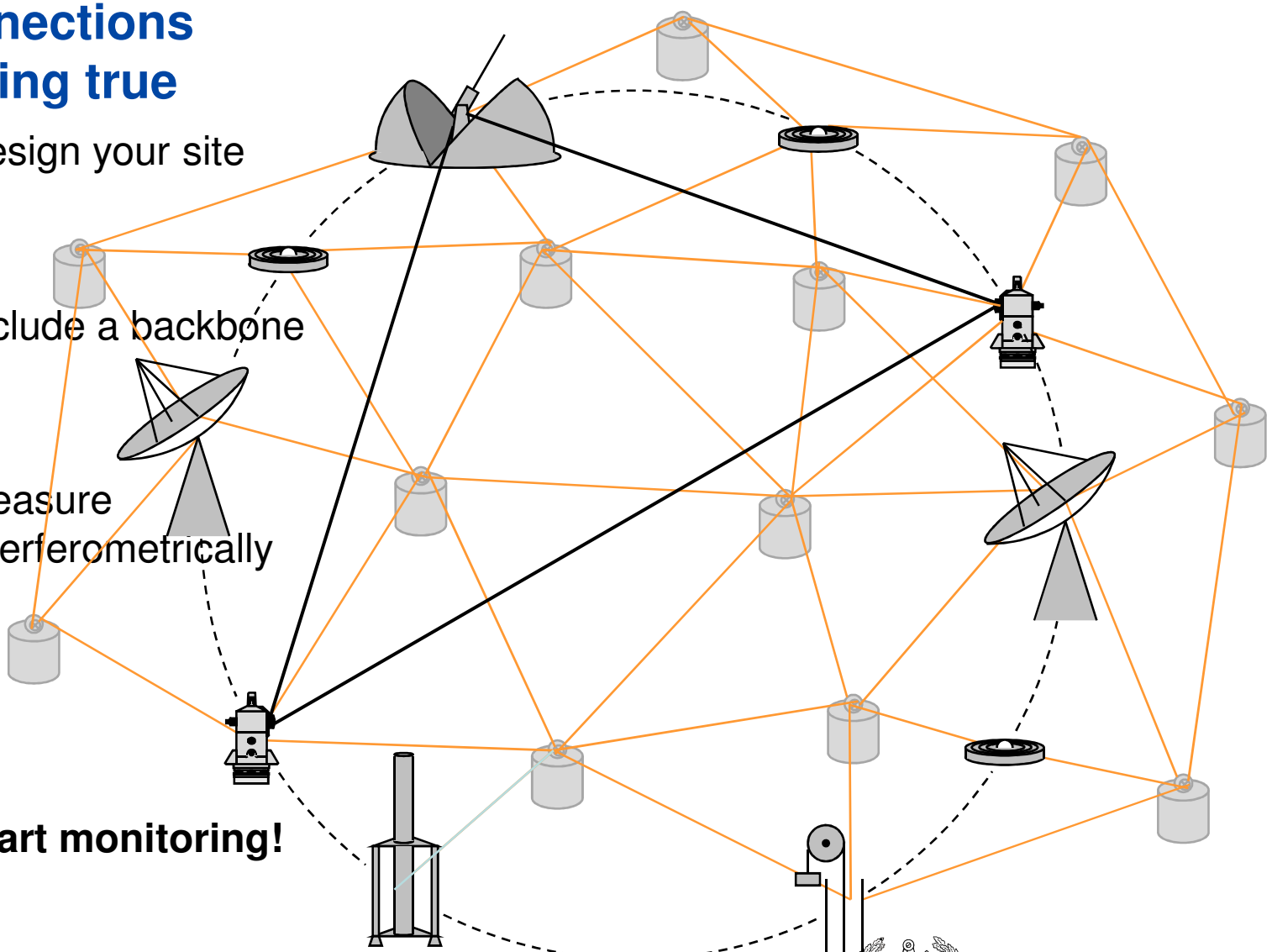


SP Technical Research Institute of Sweden

CHALMERS

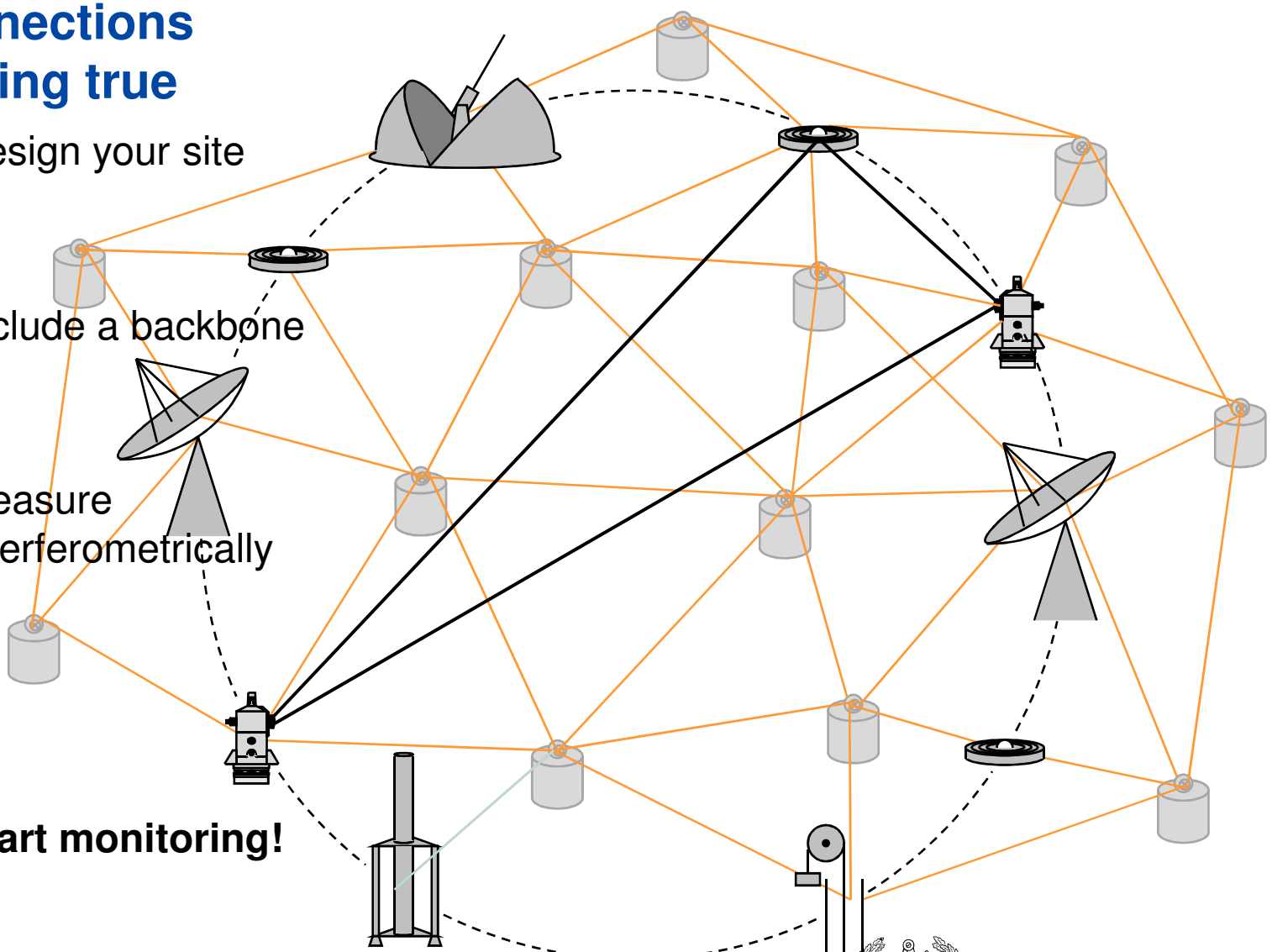
Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. Measure interferometrically
4. **Start monitoring!**



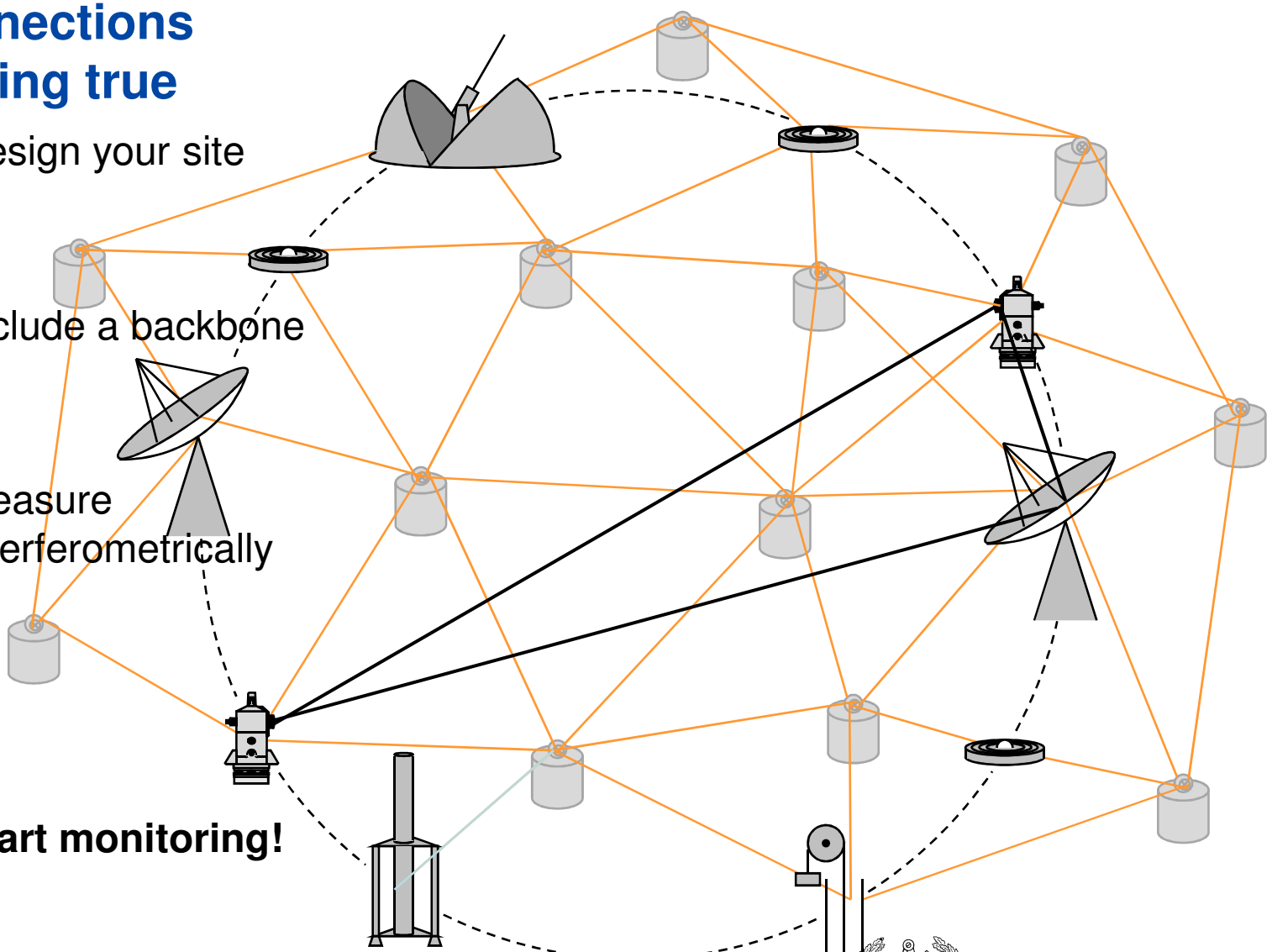
Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. Measure interferometrically
4. **Start monitoring!**



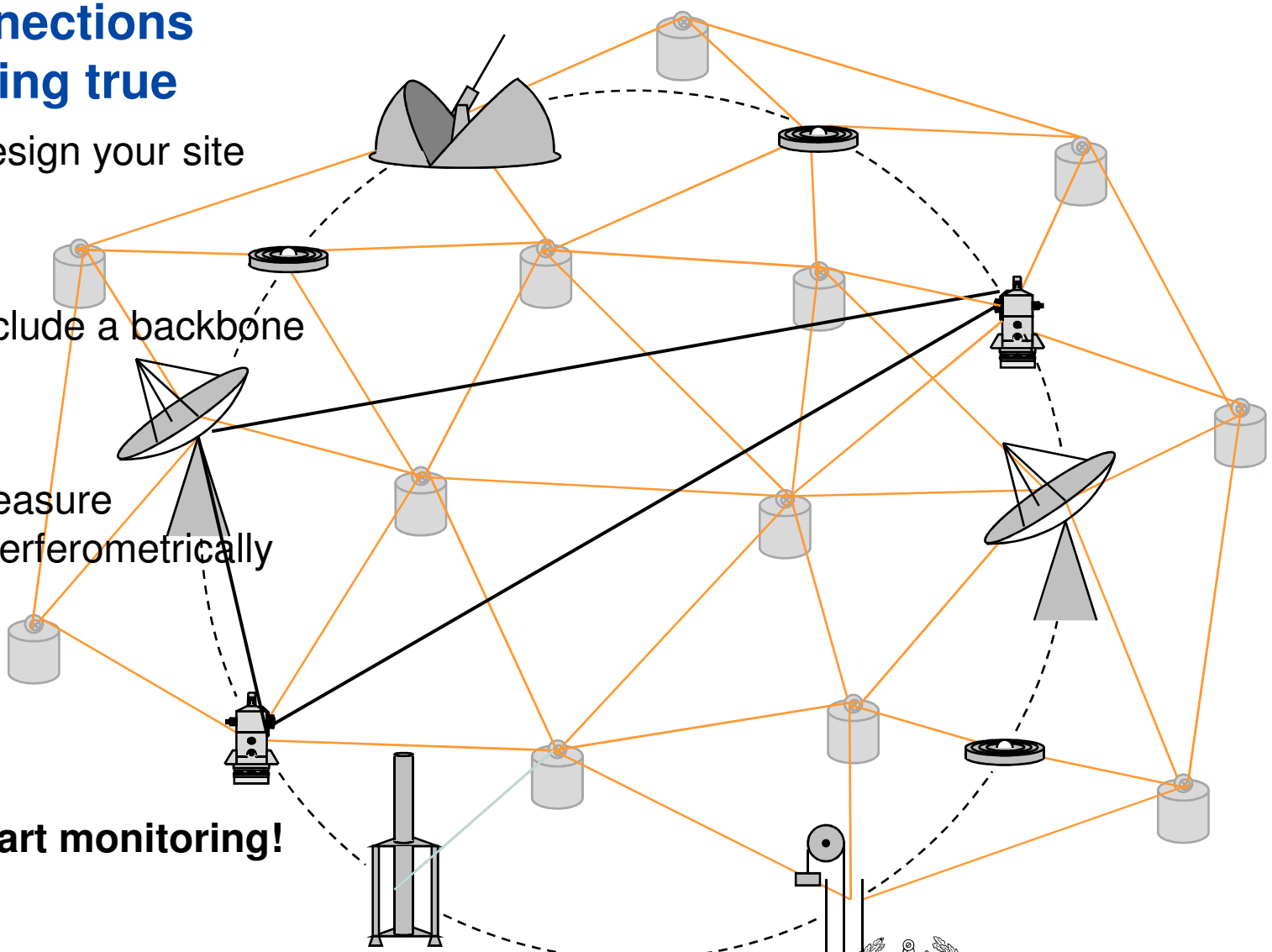
Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. Measure interferometrically
4. **Start monitoring!**



Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. Measure interferometrically
4. **Start monitoring!**

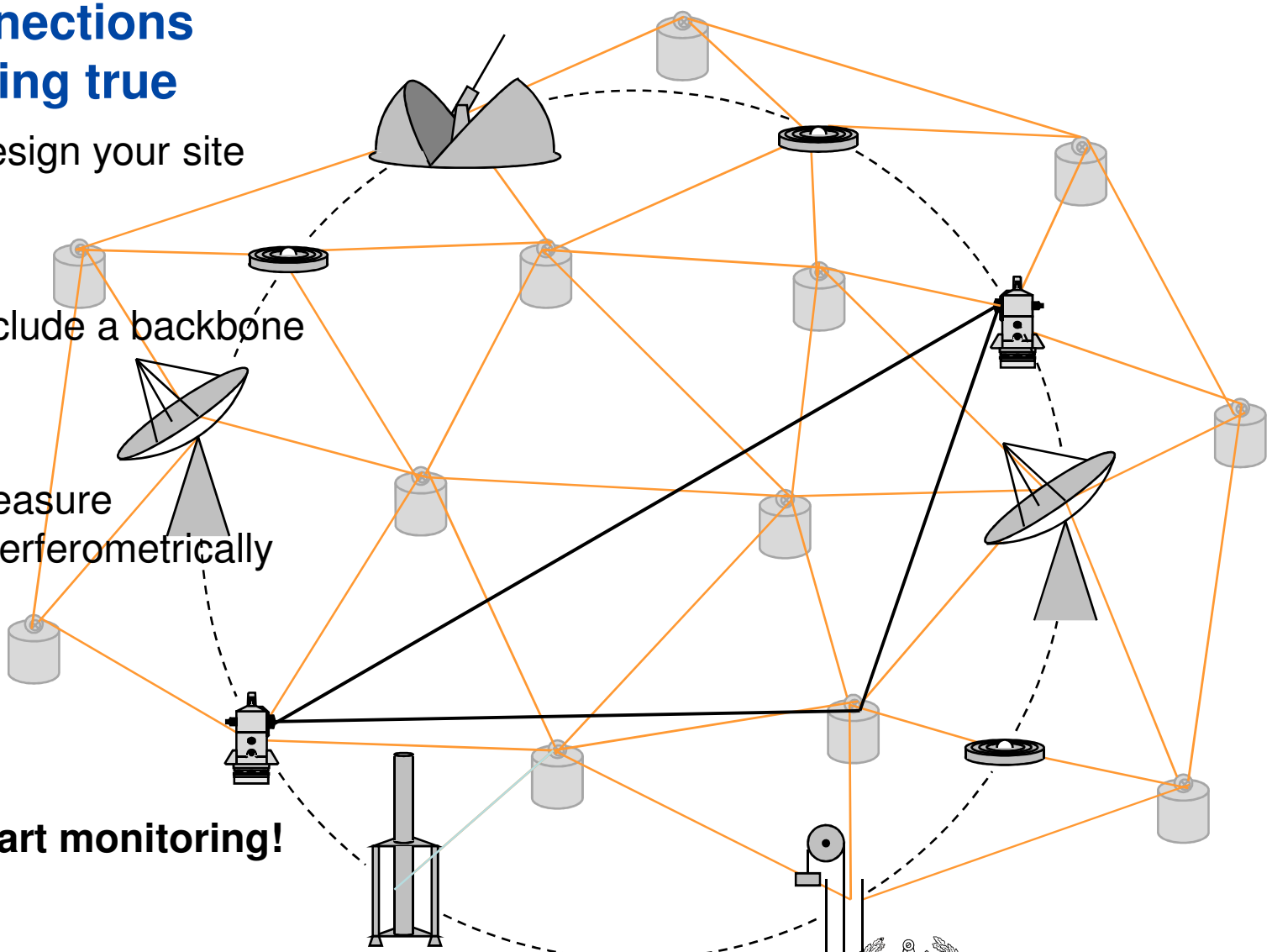


SP Technical Research Institute of Sweden

CHALMERS

Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. Measure interferometrically
4. **Start monitoring!**

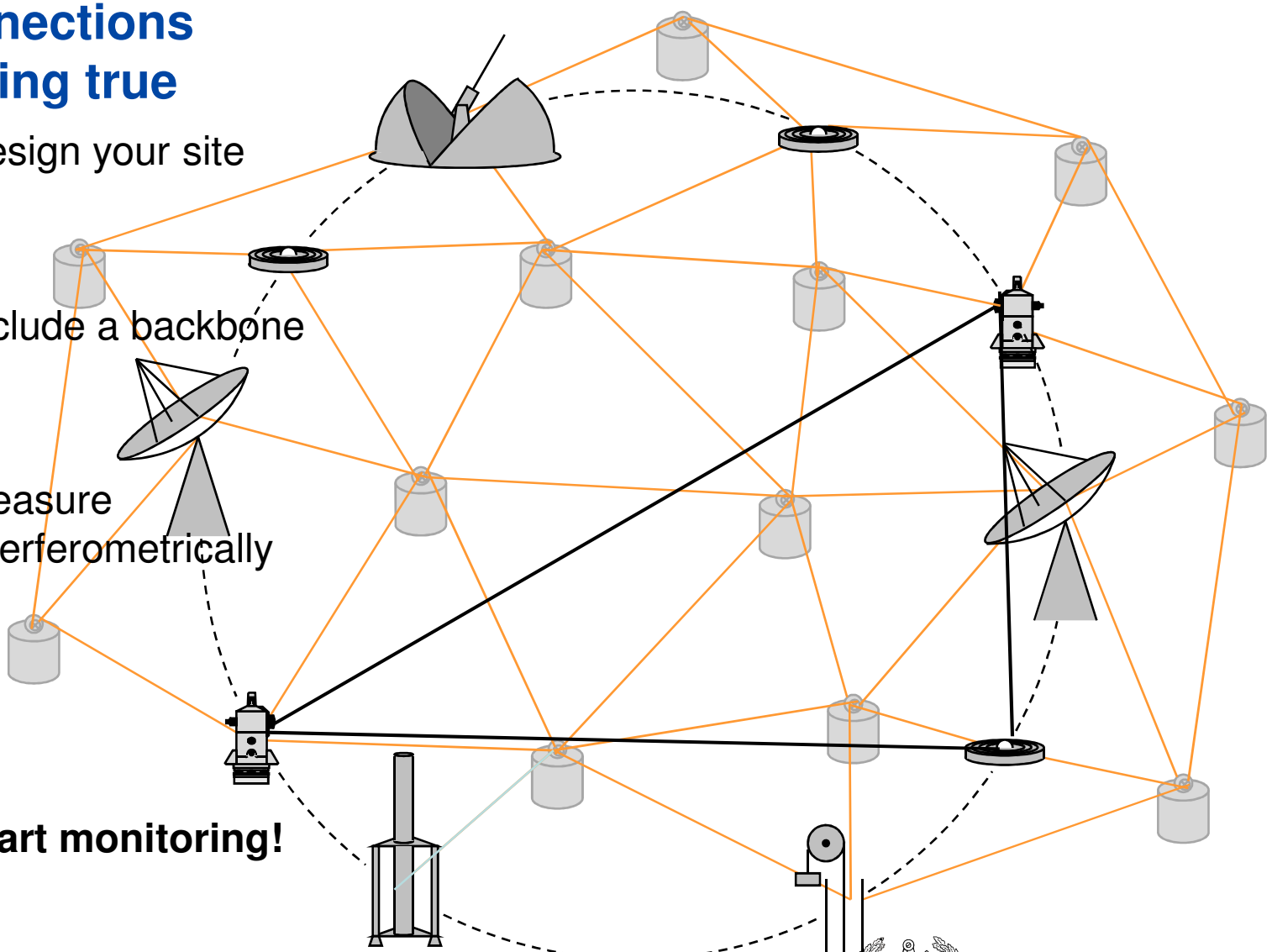


SP Technical Research Institute of Sweden

CHALMERS

Continuous Cartesian Connections coming true

1. Design your site
2. Include a backbone
3. Measure interferometrically
4. **Start monitoring!**



GGOS is striving for sub-mm accuracy and local ties must not be a limiting factor.

Can Continuous Cartesian Connections realize local ties at 0.1 mm level?

Still no…

How good can local ties get?

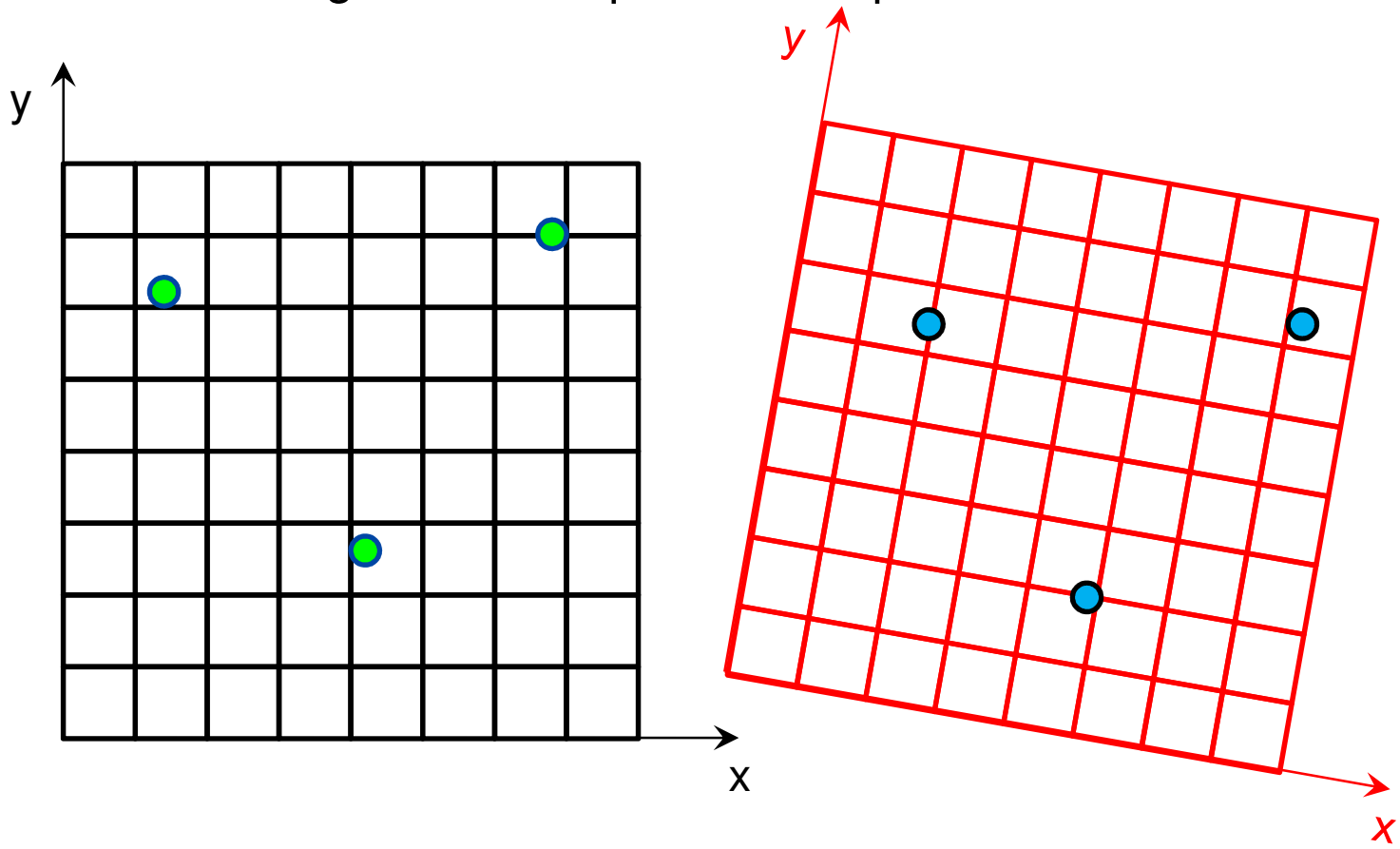
Utilizing the CCC concept:

Probably below 0.5 mm

SP Technical Research Institute of Sweden

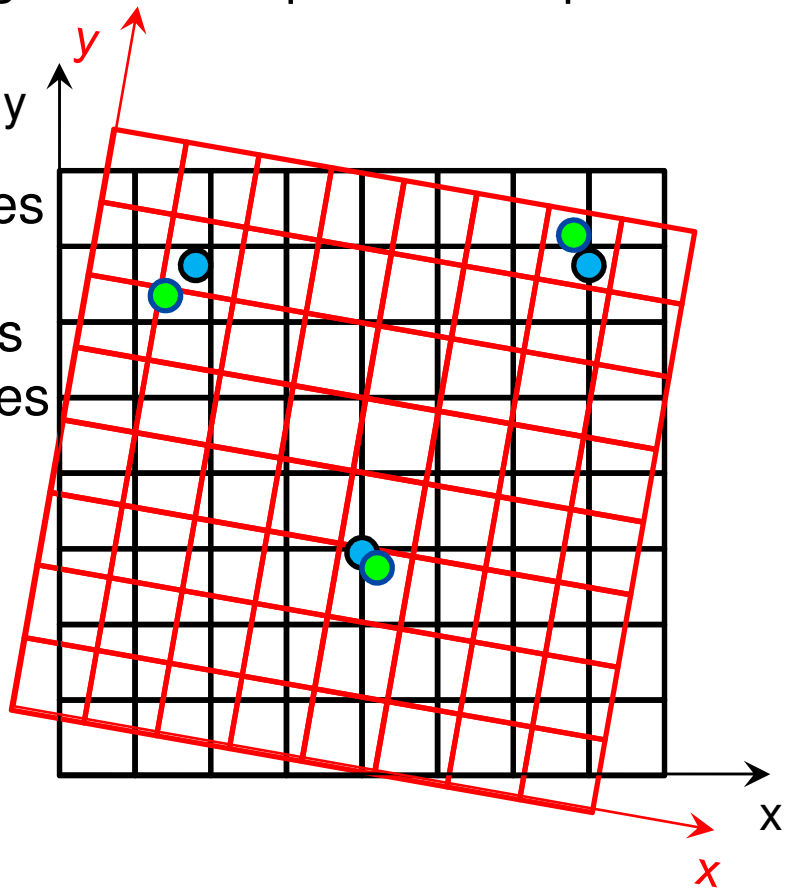
Why do we need local ties?

- We want to integrate techniques with separate reference frames



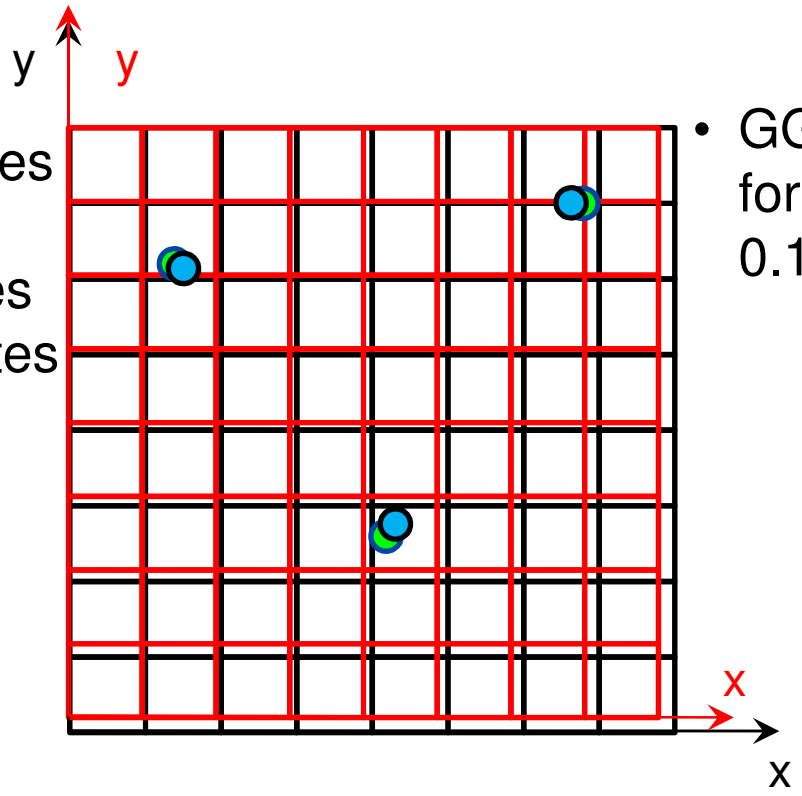
Why do we need local ties?

- We want to integrate techniques with separate reference frames
- Reference frames are connected through local ties at co-located sites
- ITRF task to combine



Why do we need local ties?

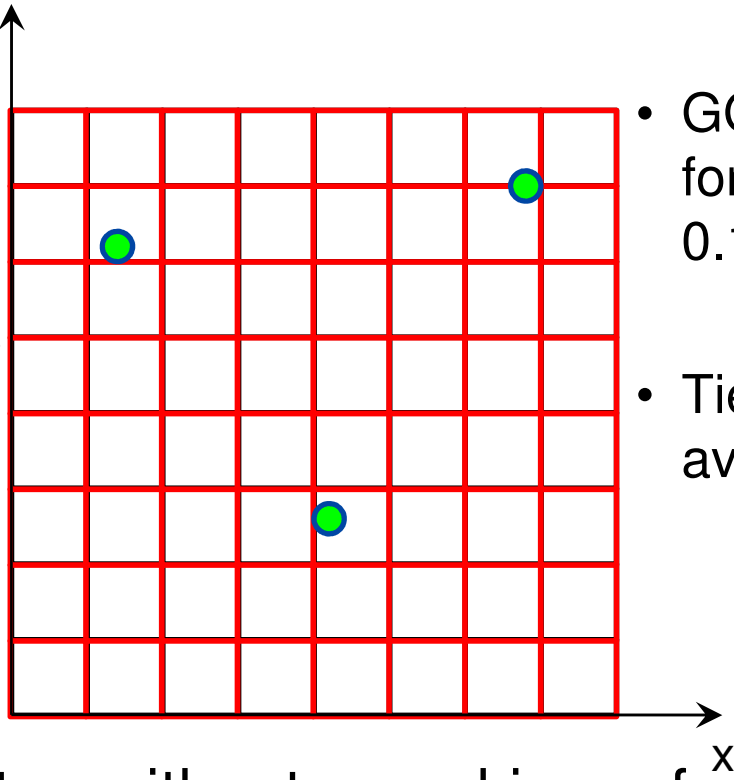
- We want to integrate techniques with separate reference frames



- Reference frames are connected through local ties at co-located sites
- ITRF task to combine
- GGOS 2020 aims for local ties at 0.1 mm level

Why do we need local ties?

- We want to integrate techniques with separate reference frames



- Reference frames are connected through local ties at co-located sites
- ITRF task to combine
- GGOS 2020 aims for local ties at 0.1 mm level
- Ties of that order not available

The world will stop without a working reference frame!