USING LOCAL GRAVITY OBSERVATIONS FOR NETWORK CALCULATIONS IN SPATIAL ANALIZER

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Introduction

A new method for measurement and calculation of geodetical network has been developed by SAM (Survey, Alignment and Metrology) team at ESS. The strategy is to use gravity vector observations from laser tracker (AT960, AT403) built-in inclinometer for network calculation in Spatial Analyzer (SA). The aim is to achieve network solution that takes into account shape of the geoid without a need for data from leveling campaign. The site at ESS is getting vastly occupied with instrumentation and equipment to such extent that carying out full-scale leveling campaign is not possible anymore in experimental halls.

The implementation of geodetic considerations and representation of geoid in SA will be presented, along with the method to calculate network using established reference spheres. We will conclude with an evaluation of results against the capacity of AT403.

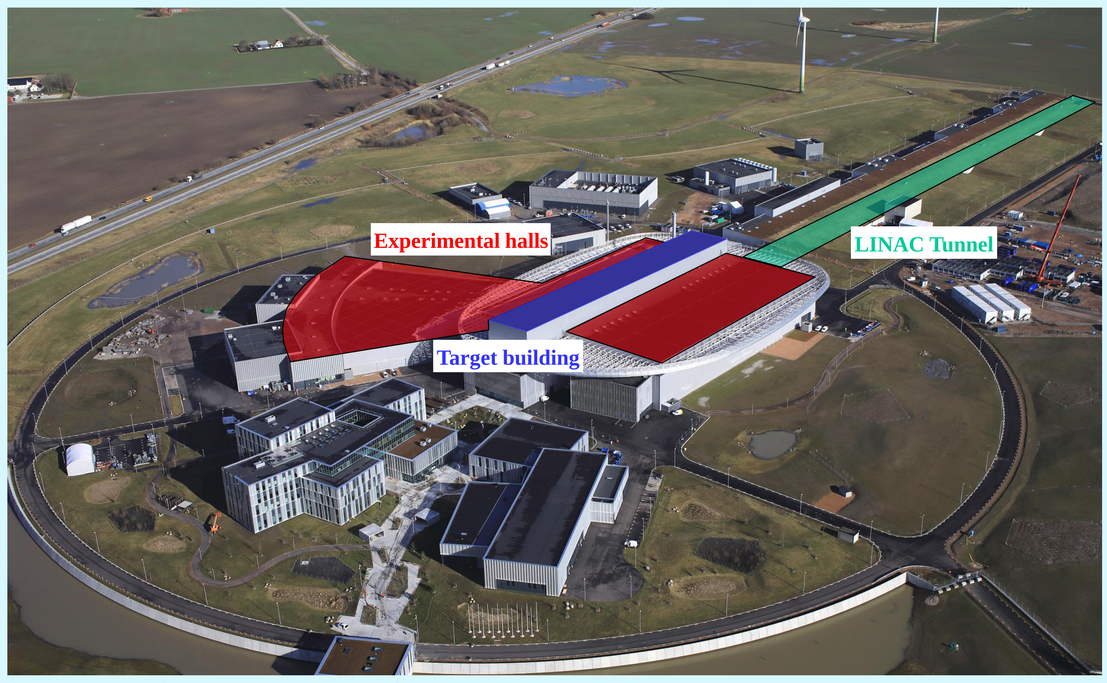

Fig.1 Aerial view of ESS facility

Geoid implementation (Fig.2)

- ESS project origin in SWEREF 99-13-30: E= 134180,000m
  N= 6179019,000m
- Transformatin to elipsoid GRS 80: φ= 55,7344°
  λ= 13,2482°
- From elipsoid to reference sphere with radius $\boldsymbol{R_m} = \sqrt{\rho\nu} = 6385950{,}433\text{m}$

Where: $\rho = \frac{a(1-e^2)}{\sqrt{(1-e^2 * sin^2(\phi))^3}}$ (meridian direction)

$\nu = \frac{a}{\sqrt{1-e^2 * sin^2(\phi)}}$ (parallel direction)

- Geoid height *N* (35,958m) without statisticaly significant deviation across ESS site => can be substituted with reference sphere with radius $\boldsymbol{R_g} = 6385986{,}391\text{m}$
- Elevation of the project from geoid *H* (81,4m) => sphere $\boldsymbol{R_{TCS}} *= 6386067{,}791\text{m}$

**TCS – Target Coordinate System (main coordinate system at ESS)*

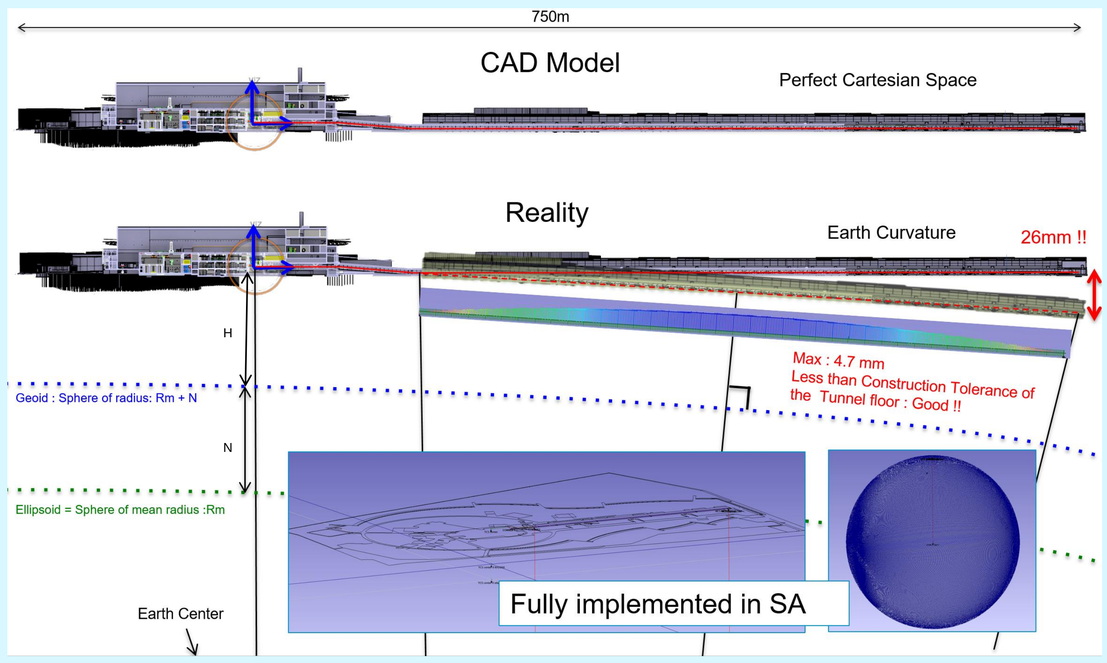

Fig.2 Scheme – mean radius sphere and geoid implemented in SA at ESS facility (source: Fabien Rey, IWAA 2016, Grenoble)

Use in practice (Fig.3)

- 52 stations covering target building and experimental halls
- Last possibility to directly connect both sides of target monotith
- Extending existing network in target building and connecting new network in E02
- Each station is pre-localize and oriented normal to geoid reference sphere using measured inclination frame
  - Correction for AT960 (inclination frame ≠ instrument frame) => fabricated measurements with new instrument => **leveled data expressed in instrument frame**
- Solving free USMN
  - Instrument frame; nRx, nRy constraining perpendicularity to local geoid
  - 2 stations closest to origin fixed
- All stations remain perpendicular to reference sphere
- Localization within the network
  - Inclination frame to “G-frame“ – grid of frames normal to geoid
  - 4DoF (nRx, nRy) best-fit

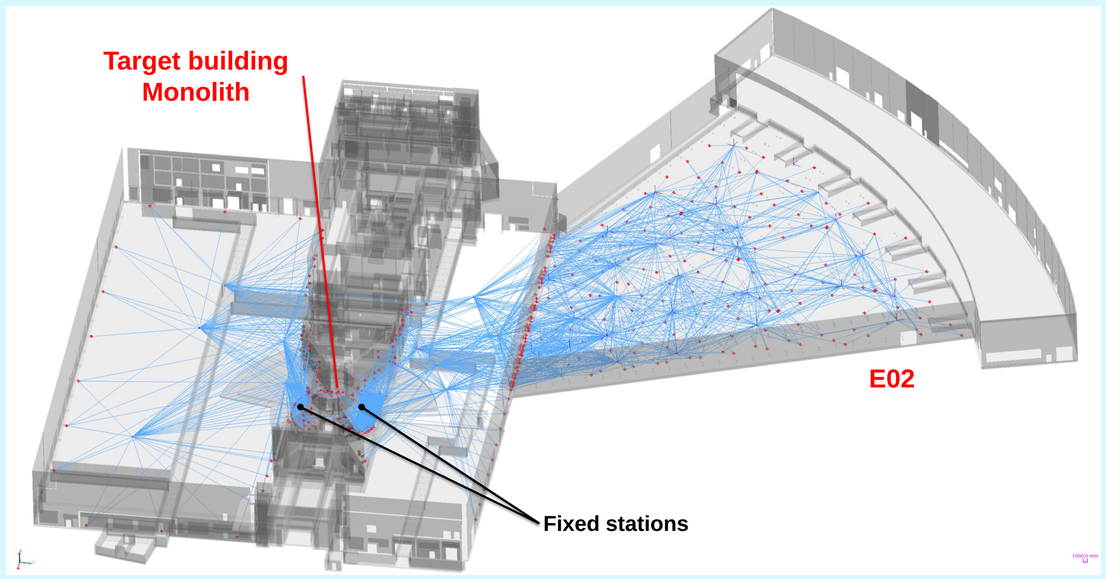

Fig.3 Network setup in target building and experimental halls

Testing the network against AT403 (Fig.4)

- Difference in height from network is espressed in local G-frame
- Measured difference come from leveled AT403 station

Where: $\Delta = \Delta_{Network} - \Delta_{AT403}$

Average $\Delta/\text{m} = 3\mu\text{m}$

Δ/m	E02F-40	E02F-41	E02F-53	E02F-54	E02F-65	E02F-215	E02F-309	E02F-314	E02F-315	E02F-325	E02F-327	E02F-328	E02F-335	E02W-30
E02F-40	0	0,065	0,066	0,088	0,080	0,076	0,029	0,091	0,030	0,094	0,077	0,083	0,037	0,014
E02F-41	0,012	0	0,001	0,023	0,015	0,011	0,036	0,156	0,095	0,028	0,011	0,017	0,102	0,051
E02F-53	0,002	0,000	0	0,022	0,014	0,010	0,037	0,157	0,096	0,028	0,011	0,017	0,103	0,052
E02F-54	0,004	0,001	0,002	0	0,008	0,012	0,059	0,179	0,118	0,006	0,011	0,006	0,125	0,074
E02F-65	0,003	0,001	0,001	0,001	0	0,004	0,051	0,171	0,110	0,014	0,003	0,003	0,117	0,066
E02F-215	0,002	0,000	0,002	0,001	0,000	0	0,047	0,167	0,106	0,018	0,001	0,007	0,113	0,062
E02F-309	0,001	0,001	0,001	0,002	0,001	0,002	0	0,120	0,059	0,065	0,048	0,054	0,066	0,015
E02F-314	0,002	0,003	0,009	0,007	0,005	0,013	0,005	0	0,061	0,185	0,168	0,174	0,054	0,105
E02F-315	0,001	0,002	0,004	0,003	0,003	0,005	0,002	0,007	0	0,124	0,107	0,113	0,007	0,044
E02F-325	0,002	0,001	0,001	0,000	0,000	0,001	0,006	0,006	0,004	0	0,017	0,011	0,131	0,080
E02F-327	0,002	0,000	0,000	0,000	0,000	0,000	0,009	0,006	0,004	0,002	0	0,006	0,114	0,063
E02F-328	0,002	0,000	0,000	0,000	0,000	0,000	0,005	0,007	0,005	0,001	0,001	0	0,120	0,069
E02F-335	0,001	0,002	0,003	0,003	0,002	0,004	0,002	0,003	0,001	0,003	0,004	0,004	0	0,051
E02W-30	0,000	0,001	0,001	0,002	0,001	0,001	0,001	0,002	0,001	0,007	0,003	0,003	0,001	0

Fig.4 comparison of height difference between points from calculated network and AT403 measurements above diagonal - Δ; bellow diagonal - Δ/m

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