NORWEGIAN MAPPING AUTHORITY

DETERMINATION OF THE GRAVITY FIELD OVER NORWEGIAN TERRITORIES

POSITIONING DATA – FOR SOCIETY'S BENEFIT

Determination of the GRAVity field over NORwegian territories using GOCE data and space geodesy software ☐GEOSAT

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SPACE GEODESY SOFTWARE GEOSAT

- 25 years at Norwegian Defence Research Establishment☐
- GPS, VLBI, SLR simultaneously at observation level
  - Inter technique calibration
- Stochastic parameter evolution between days (arcs)
  - Utilization of parameter statistics
- Accelerometry: GOCE

GOCE (Gravity and Ocean Circulation Explorer)□

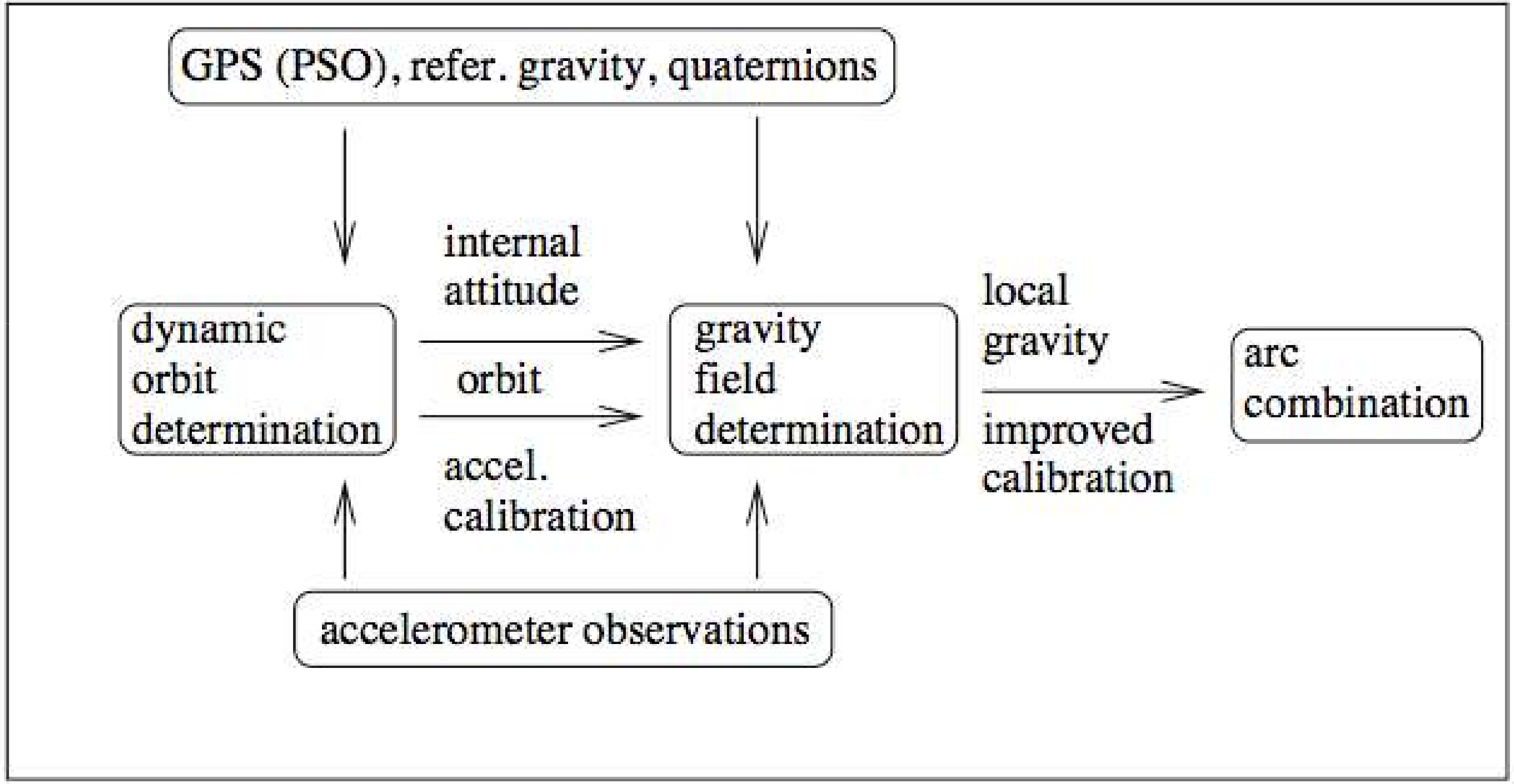
- Altitude: 250 km
- 6 accelerometers on board
- Not placed in Center of Mass: Gravity signal
- Frequency range of accelerometers: 5-100 mHz
- Ground track spatial resolution: 100-1500 km

DETERMINATION OF LOCAL GRAVITY (NORWAY)

- Norwegian Mapping Authority (NMA):
  - Contribute to the determination of climate parameters
  - Determine the cm geoid
  - Transfer of GEOSAT competence from NDRE to NMA

- Why local analysis?
  - ESA -> SH expansion: truncation issues (40,000 parameters)
  - May still be information left in accelerometer signal
  - Norway gravitationally “rough”

STRATEGY


GPS (PSO), refer. gravity, quaternions
dynamic orbit determination
internal attitude
orbit
accel. calibration
gravity field determination
local gravity
improved calibration
arc combination
accelerometer observations

SINGLE ACCELEROMETER OBSERVATIONS

- Benefits:
  - Less susceptible to accelerometer failure
  - Algorithms applicable to other missions like GRACE

- Disadvantage:
  - Non-gravitational force has to be modeled as part of gravity field determination

ACCELEROMETER OBSERVATION EQUATION

Output of accelerometer j:

$$A_j = M_j a_j + Q_j(\bar{A}_j)^2 + B_j + \dot{B}_j \Delta t + (Fourier)_j$$

$$\bar{A}_j \equiv M_j^{-1}\left[\tilde{A}_j - B_j - \dot{B}_j \Delta t - (Fourier)_j\right]$$

True acceleration:

$$a_j = \left(R - \Omega^{\mathrm{t}} T \nabla^2 V T^{\mathrm{t}} \Omega\right)(L_j + O) + \Omega^{\mathrm{t}} D + \ddot{O}$$

ATTITUDE CORRECTIONS

GRF 2 CRF rotation matrix☐:

$$\Omega(q) = R_3(\phi_3)R_2(\phi_2)R_1(\phi_1)\Omega(\tilde{q})$$

$$\phi_i = B_\phi(i) + C_\phi(i)\cos u + S_\phi(i)\sin u$$

Indirect effect on true acceleration☐:

$$R(\vec{\omega}, \dot{\vec{\omega}}) \qquad \omega_{x_i} = \frac{1}{2}\sum_{j,k=1}^{3} \varepsilon_{ijk}\dot{\Omega}_{lj}\Omega_{lk}$$

DYNAMIC ORBIT DETERMINATION/CALIBRATION

Computation of orbit:

$$\ddot{\vec{r}} = T\nabla V + \hat{D} + \Delta$$

$$\vec{r} = \vec{r}\left[\vec{r}_0, \hat{D}(M_i, B_i, \phi_i, ...), ...\right]$$

Accelerometer orbit-□GPS orbit=instrument imperfections□

Expression for non-gravitational force D dependent instrument imperfections?

Estimate of D for Dynamic Orbit Determination

LSQ applied to accelerometer observations with D as only unknown:

$$\hat{D} = \Omega \left(\sum_{i=1}^{6} M_i^{\mathrm{t}} W_i M_i \right)^{-1} \times \sum_{j=1}^{6} M_j^{\mathrm{t}} W_j \left[\tilde{A}_j - A_j(D \equiv 0) \right]$$

CALIBRATION BY DOD

- Issue☐:

  Along-track scale factor not well determined from DOD alone due to along-track DFC (Visser, 2009)

- Solution?:

  Simultaneous determination of orbit and local gravity field

PARALLELL AND FUTURE

- Altimetry: Sea level & ocean currents
- IVS Analysis Centre
- GRACE
- COMMENTS ☐?