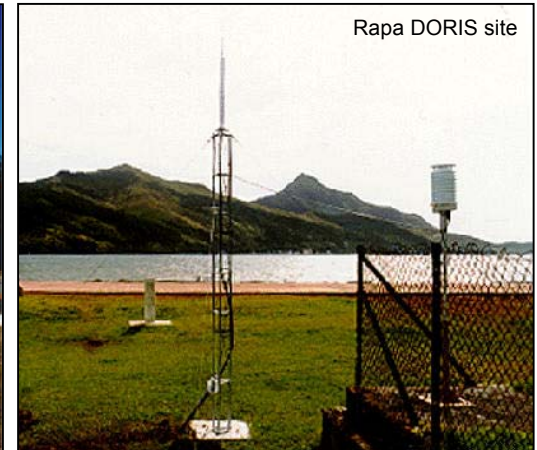


GAMBLE WP4 (theme 3):

Orbit determination and satellite tracking

GAMBLE mid-term review

SOC, Southampton, 17 January 2003



Eelco Doornbos

*Delft Institute for Earth-Oriented Space Research
Delft University of Technology*



Workshop: Delft, November 8, 2002

Summary of requirements

- **Pierre-Yves Le Traon** (CLS): Sea-height
- **David Cotton** (SOS): Sea-state

Tracking systems

- **Ron Noomen** (DEOS): SLR
- **Patrick Vincent** (CNES): DORIS
- **Drazen Svehla** (TUM): GPS, cm-level POD
- **Max Meerman** (SSTL): GPS, SSTL receivers

Precise orbit determination

- **Phil Moore** (Univ. Newcastle): Aspects of POD
- **C.K. Shum** (OSU): Orbit choices and kinematic approach
- **Pieter Visser** (DEOS): Gravity
- **Eelco Doornbos** (DEOS): Non-gravitational forces

Discussion

Precision Orbit Determination (POD)

Goals of orbit determination

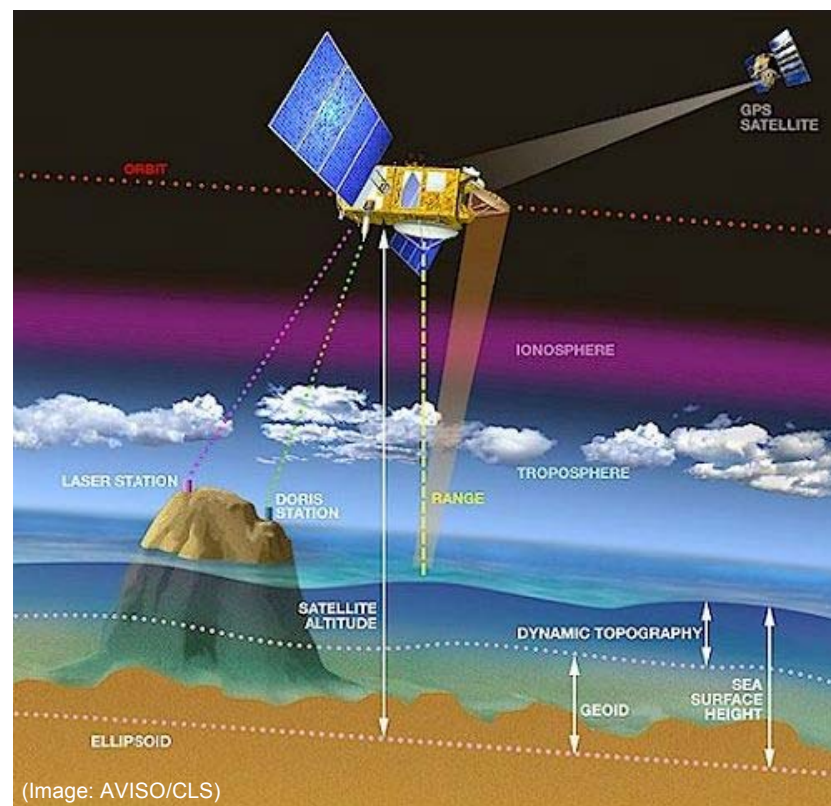
- Knowledge of the position of the satellite at a certain time
- Required for communication, planning, etc.

Precision orbit determination

- Relates the altimeter range to a terrestrial reference

Requires:

- Accurate tracking
- Accurate force models



POD strategies

Dynamic POD

- Use of force models (gravity, drag, radiation pressure, etc.) to integrate orbit from initial state.

Reduced dynamic POD

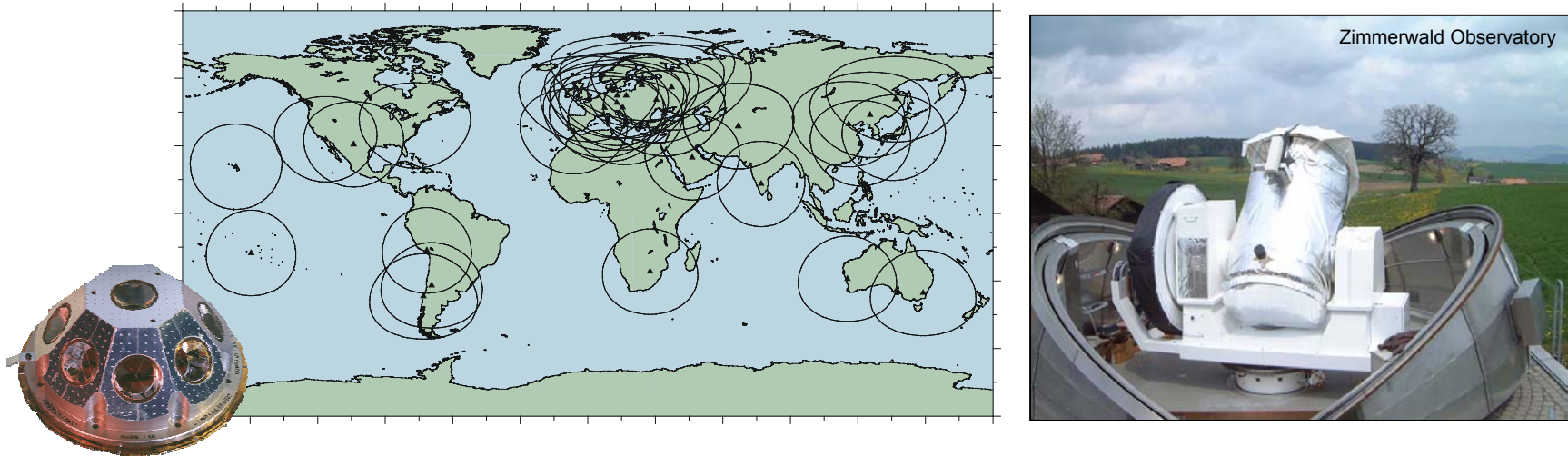
- Adjust force model parameters to obtain a better fit with the tracking data.

Kinematic POD

- Geometrical approach. Orbit follows tracking data closely, force models become irrelevant.

Precision satellite tracking systems 1

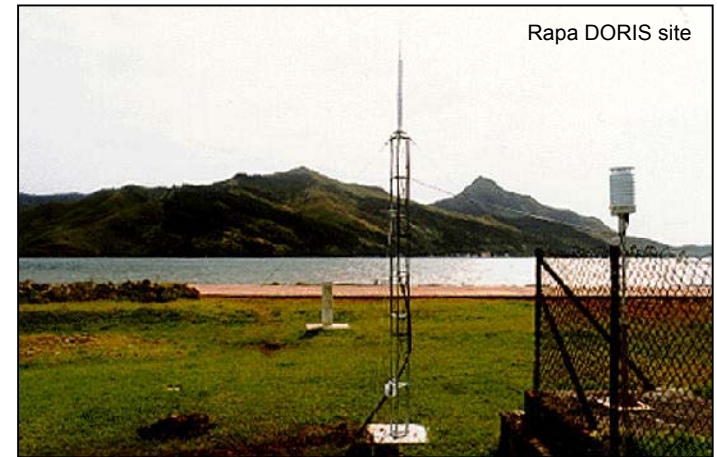
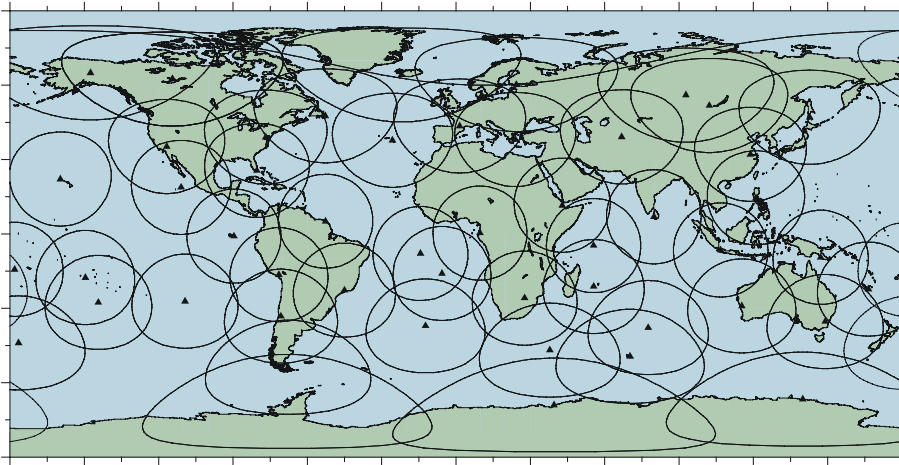
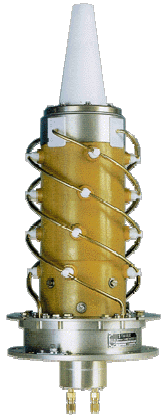
SLR: Satellite Laser Ranging



- Two-way ground-to-satellite optical (laser) system
- Approximately 30 stations operational
- Most stations are in Europe
- Limited by local weather and station scheduling

Precision satellite tracking systems 2

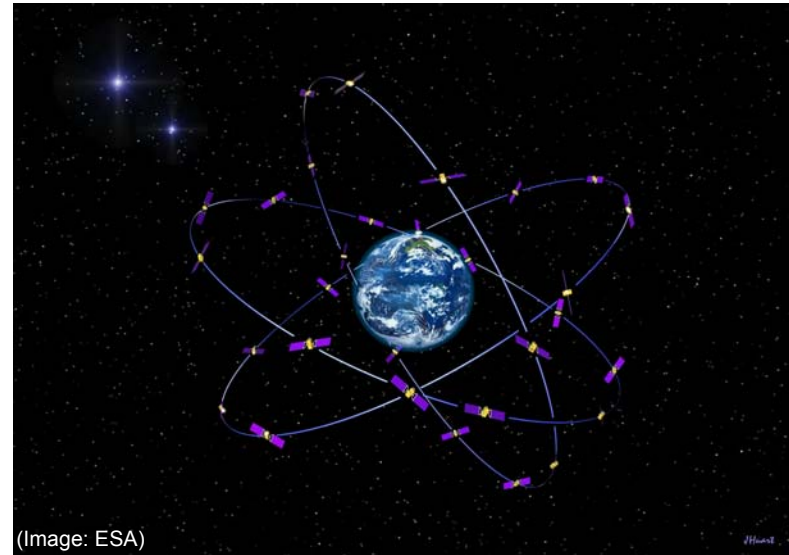
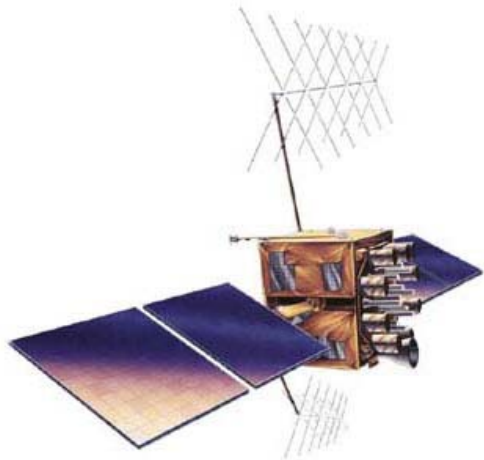
DORIS: Doppler Orbitography and Radiopositioning Integrated by Satellite



- One-way ground-to-satellite Doppler system
- Approximately 60 ground beacons
- Excellent global coverage
- DORIS/DIODE Navigator provides real-time orbits with 30-cm precision

Precision satellite tracking systems 3

GPS (and Galileo/Glonass)



- At least 24 satellites in 6 orbital planes at 20200 km altitude.
- Pseudo-range measurements are used for orbit determination of many (micro-)satellites at appr. 15 m accuracy.
- Advanced receivers on altimetry satellites can use carrier-phase measurements for cm-level POD.

Use of altimetry data in POD

Currently in use for ERS-2 and GFO

Measurement types

- Altimeter crossover differences.
- Altimeter range measurements, corrected and referenced to mean sea surface model.

Pros

- Supplies crucial information for high-accuracy orbits when radiometric tracking is absent and SLR data is sparse.

Cons

- Danger of absorbing ocean signals in orbits.

Tracking requirements from WP2/3

Sea-state altimeter missions (GANDER, SWIMSAT):

- No high-accuracy tracking system required.

Sea-height altimeter missions (Jason-2, AltiKa):

- High-accuracy tracking and precise orbit determination required.

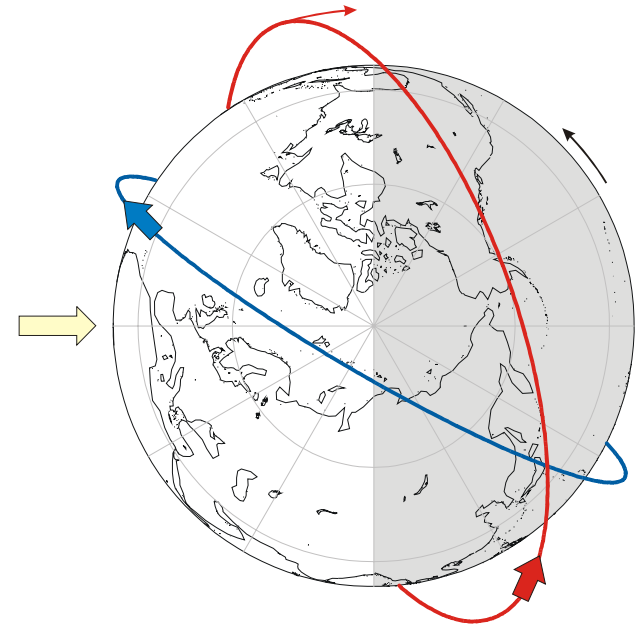
GANDER modified for sea-height measurements

- High-accuracy tracking not necessarily required.
- Orbits might be adjusted using crossovers with reference missions such as Jason-2, in addition to sparse or low-accuracy tracking.

Orbit choice

Final recommendations will be made as part of WP8 (Constellation Optimization)

- High altitude orbits are favourable for POD and orbit maintenance;
- Continuation of the ERS/TP and Envisat/Jason configuration is highly recommended;
- Tidal aliasing issues need to be taken into account (see WP2).



Force model issues

Atmospheric drag will be the only remaining major force model error source.

Possible solutions:

- Reduced dynamic or kinematic POD approach.
- High altitude orbits.
- High mass, low area satellite design.
- Include accelerometer on satellite.

Tracking systems

High-accuracy sea-height altimeter missions:

- Either a GPS/Galileo or DORIS receiver
 - High-accuracy, near-continuous tracking
 - DORIS navigator for real-time orbits
- Laser retroreflector
 - Additional high-accuracy tracking
 - Validation of radiometric tracking
 - Calibration of altimetric range
 - Fail-safe backup tracking

GANDER specific issues:

- Only consider SLR/DORIS/GPS if the altimeter is upgraded with sea-height measuring capabilities.
- In that case, also consider use of crossovers with reference class mission, such as Jason-2, for POD.

Status of interim/final WP report

Interim report (November 2002):

- Contains summary of workshop presentations and discussions.

Intentions for final report (due April 2003):

- Engage WP4 partners for further (written) contributions and discussions.
- Possibly take the mission scenarios identified at the mid-term review into account.

- Input: WP2/3 requirements
- Output: recommendations for WP7/8