

Satellite Orbit Determination using GENSO

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Presentation



- How I got involved in all this....
- GENSO in a nutshell
- Orbit Determination project idea
- Non-ideal system
- How to make Orbit Determination possible
- Simulations GENSO and Orbit Determination
- Questions

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Project startup



- Searching for a MSc project
 - Computer Science - Open University NL
- AMSAT-UK Colloquium made the first contacts with GENSO possible
- Nice combination of study, hobby (and work).
- Preparation phase finished,
Orbit Determination project just started

GENSO in a nutshell



- Global Educational Network for Satellite Operations
- Large number of receiving stations
 - Distributed around the world
 - Connected by the Internet
 - Centrally co-ordinated
- Ground Stations are mainly amateur radio stations

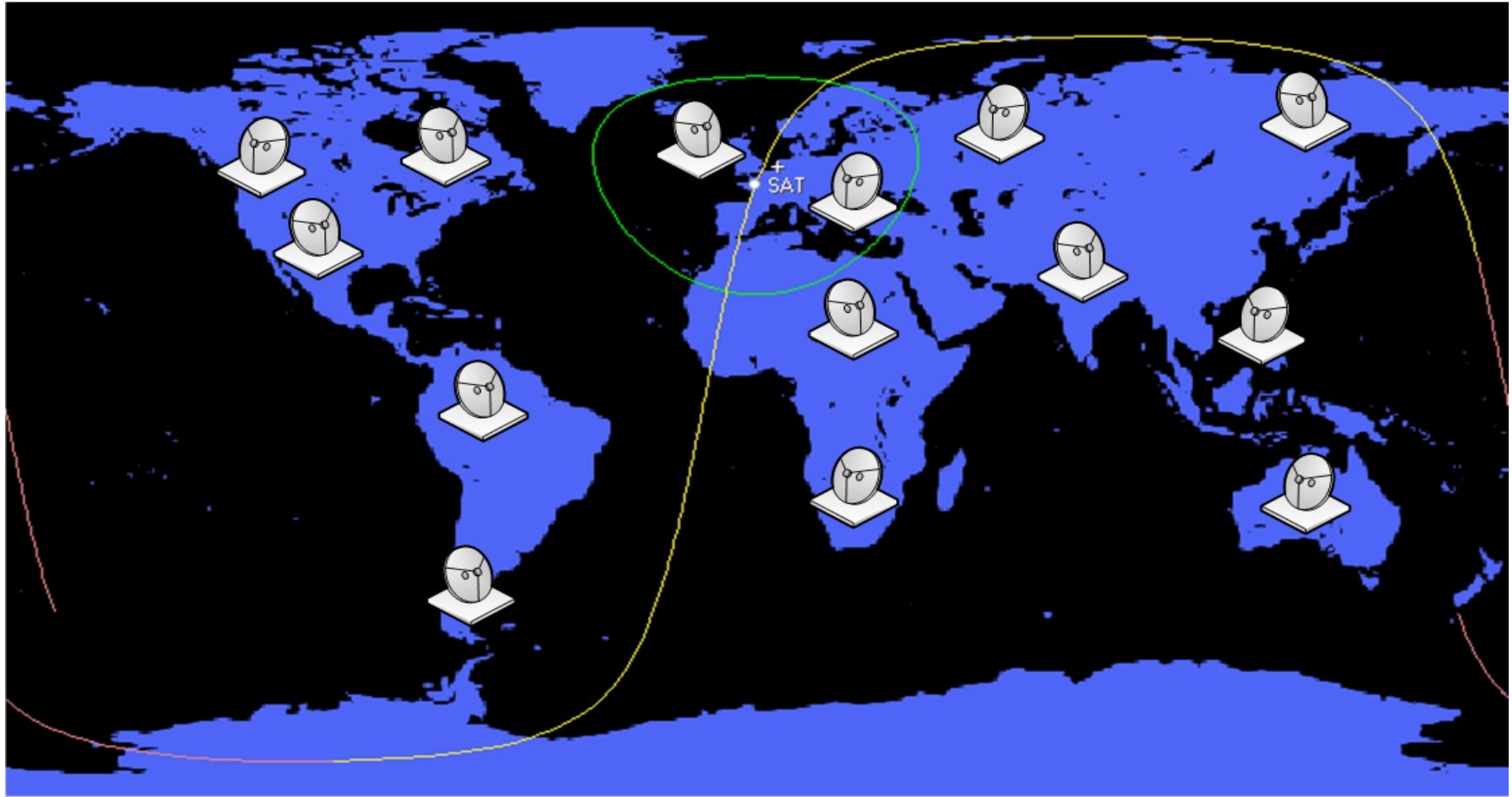
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Project idea (1)



- Orbital data (TLEs) provided by NORAD
 - Free today, not certain for the future
- Use the GENSO observation capabilities for the orbit determination of satellites
- Fast orbital data available during LEOP
- Focus on LEO satellites
- Can we do without NORAD ;-) ?

Project idea (2)



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GENSO characteristics



GENSO characteristics from the point of view of Orbit Determination:

- Global Educational Network for Satellite *Observations*
- Makes use of SGP4 algorithm and TLEs for satellite predictions
- Centrally co-ordinated
- Designed for communication, not detection
- Large amount of low-resolution stations

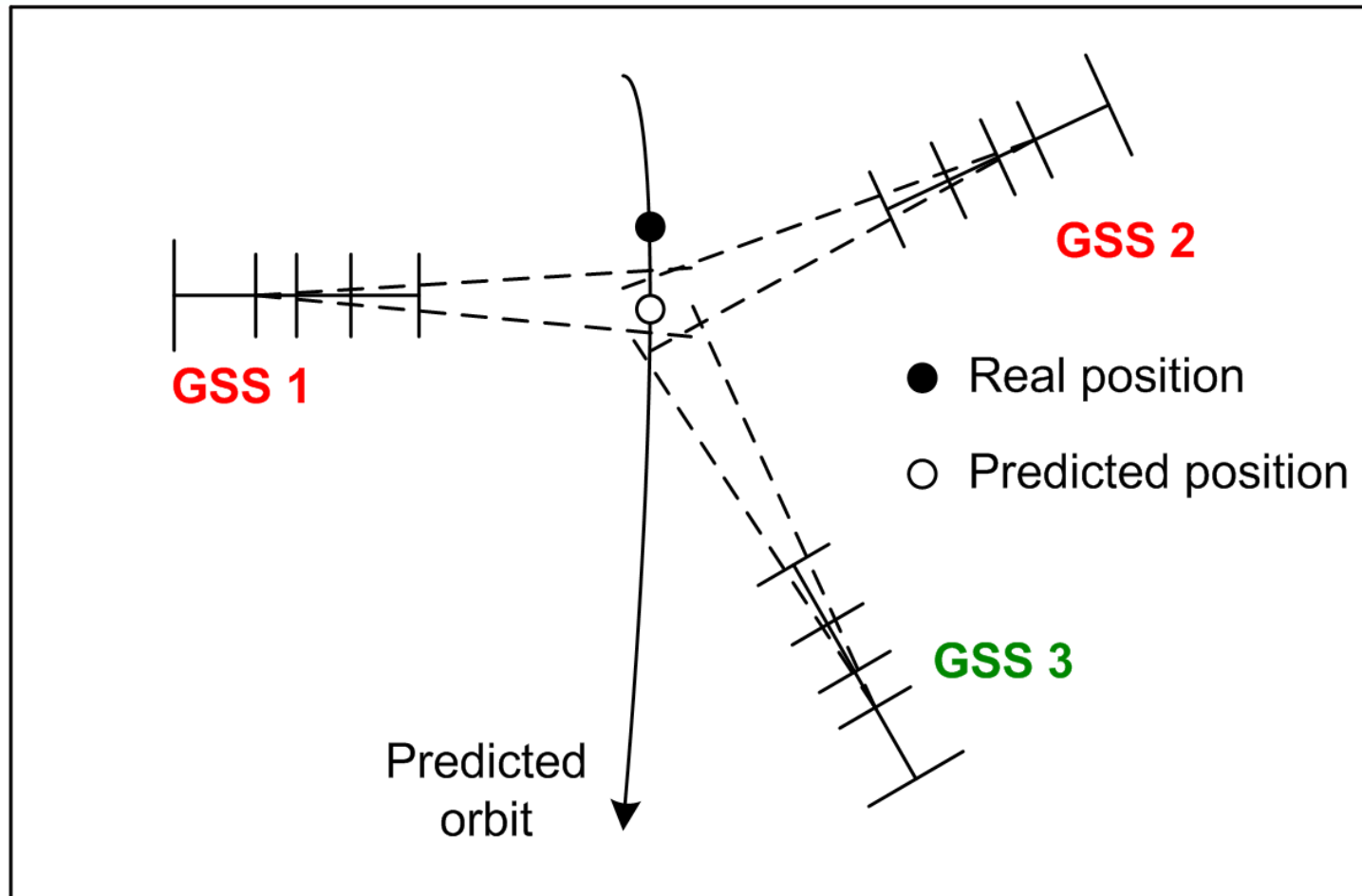
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GENSO observations



- Relatively imprecise for orbit determination
 - Relatively large beam widths of antennas
 - Relatively low accuracy of rotators
- No measured distance/range information
- Antenna points to predicted satellite position
 - Active tracking not implemented / possible

Drifting satellite problem



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Project approach

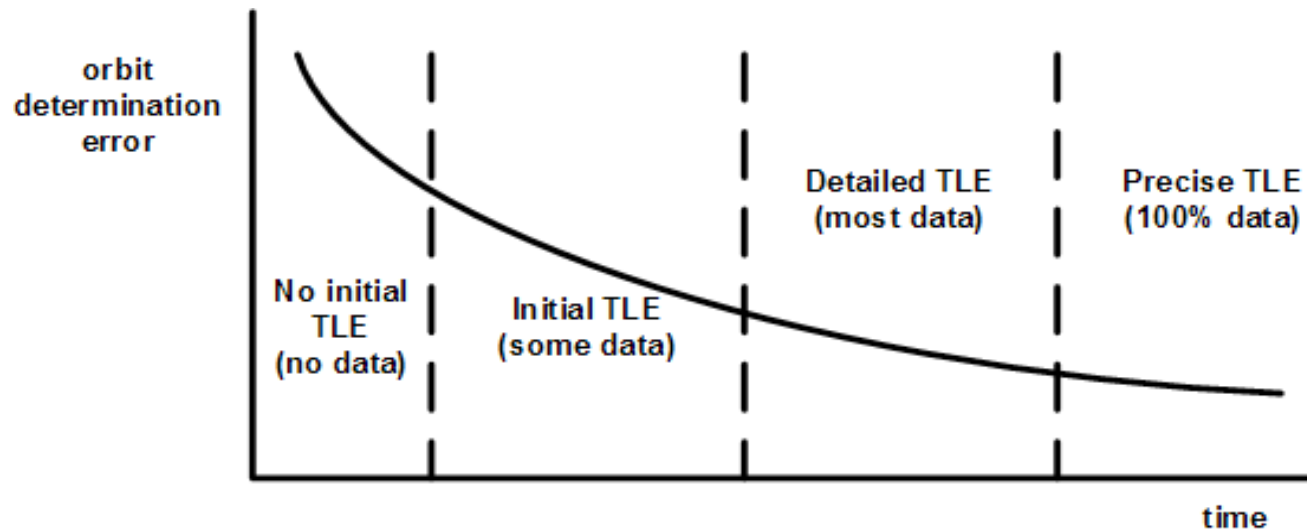


- Analysis of possible techniques to perform orbit determination in GENSO
- Comparison of the different techniques will result in a recommendation to GENSO
- Approach:
 - theoretical analysis
 - Simulation
 - Prototype testing

Determination phases



- Different orbit determination phases:
 - No initial information about the orbit
 - Initial information available
 - Some data received
 - Optimal orbit determined, keep it updated



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Determination techniques (1)



- Calculations (e.g. orbital period, geometry)
- Deviating TLEs (other parameters)
 - Trial-and-error learning
 - Choose smart deviations, depending on phase
 - Make use of known orbit perturbation
- Two or three types of TLEs:
 - GENSO optimal TLEs
 - GENSO deviated TLEs
 - (NORAD TLEs)

Determination techniques (2)



- Test with circular orbits
 - LEO orbits are near-circular
 - Four instead of six orbital parameters
- For initial stage of orbit determination:
 - omni-directional antennas
 - fixed position directional antennas
- Choose the correct ground stations for the correct task

Simulation model (1)



- Use SGP4 algorithm two times per satellite
 - Calculate the 'real' positions
 - Calculate the estimated positions
- Generate reception data
 - Signal strength at ground station
 - Frequency at ground station (Doppler)

Simulation model (2)

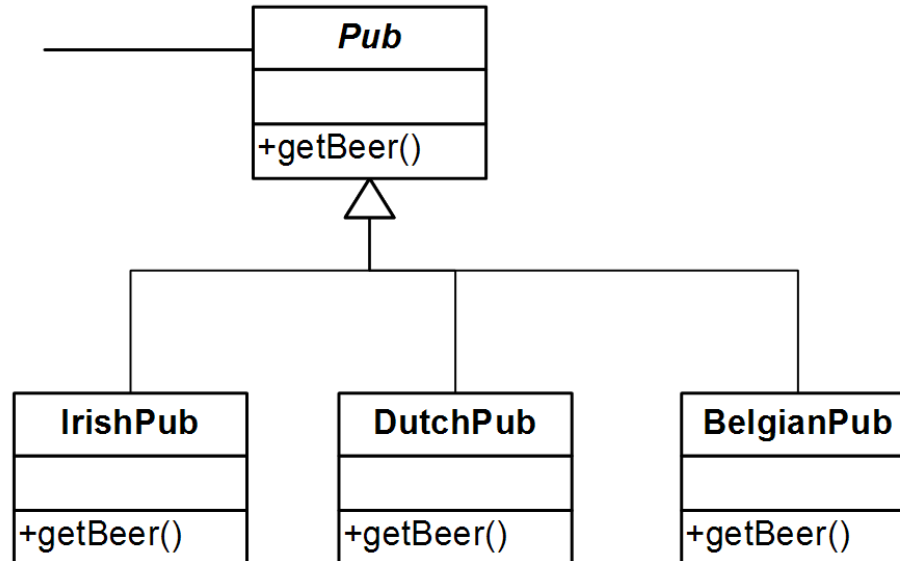


- Three basic elements:
 - Satellites
 - Radio links
 - Ground stations
- Reception data used as input to the orbit determination process

Simulation model (3)



- Flexible and modular
 - Changing parts of the model possible
 - Start simple, add complexity later



Correctness of Orbit



- How to determine correctness of the estimated orbit?
 - Doppler analysis (TCA, curve fitness)
 - Signal strength analysis
 - AOS, LOS time measurements
- Use ground station 'statistics' to make relative measurements globally useful

Define the Correct Orbit



Possible success indicators in simulation:

- Percentage of data received by 'GENSO', compared to the maximum amount of data.
- Minimum deviation of 'GENSO' orbit compared to NORAD's TLE orbit.
- Time frame in which GENSO is able to obtain the orbit with a certain accuracy.

Discussion



Implementing Orbit Determination:

- Who wants to track a satellite using a potentially wrong TLE?
- Impact on scheduling, a part of GENSO will be assigned to Orbit Determination
- Is AMSAT also able to do something similar, or do we need a system like GENSO for this?
- Does AMSAT need GENSO when no TLEs are provided anymore?

Acknowledgements



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- *Open University*: Schil and Pieter
- *Other*: Alberto, and Linda

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Questions,
suggestions,
remarks?

(or later during the Colloquium,
good ideas deserve a beer...)