AOCSim: a Tool for Rapid Analysis of Satellite Attitude Dynamics During the Early Phases of a Project

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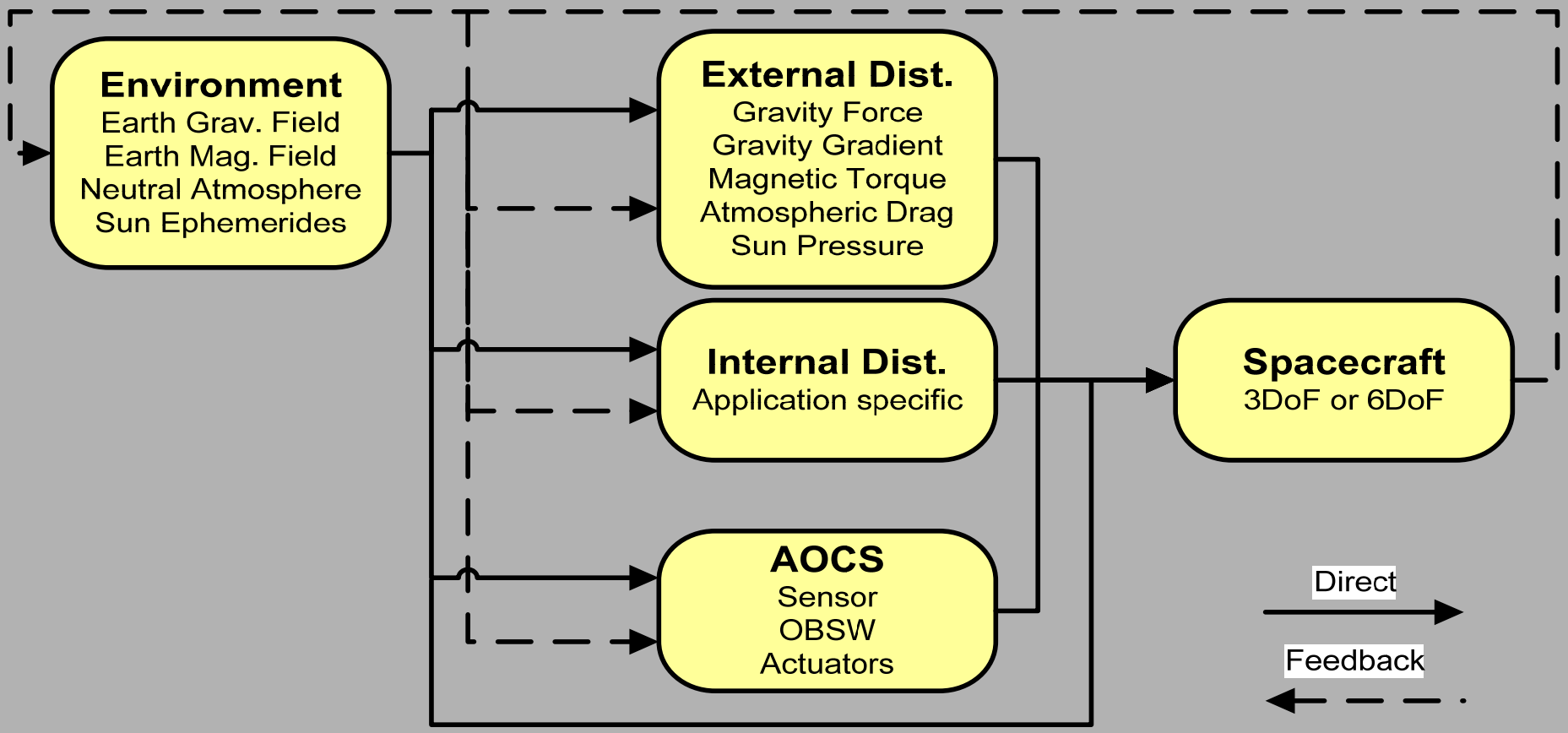
Introduction

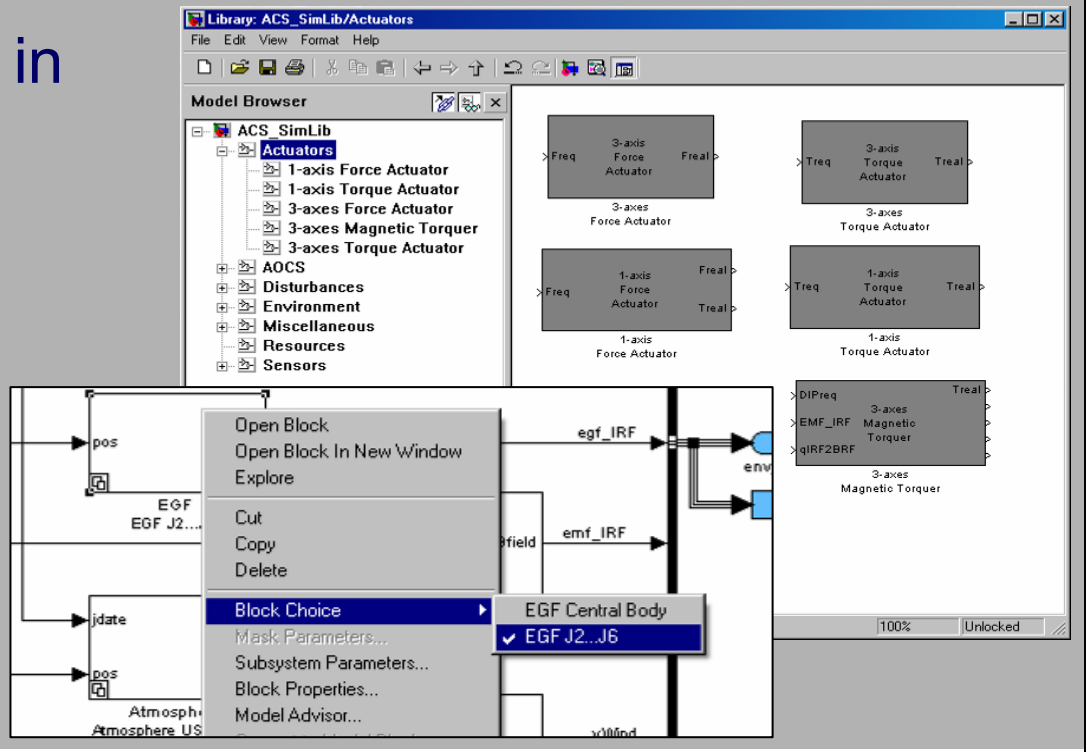
- The **AOCSim** is a tool for rapid analysis on satellite dynamics during the early phases of a project.
- The **AOCSim** aims to become an effective element of the system and mission analysis tools for the Future program Section in the Earth Observation division in ESTEC.
- **Main Features**
  - Allows a quick adaptation to models, missions and system requirements;
  - The level of detail for the simulator fits the available information;
  - Easy to use;
  - Based on Matlab/Simulink.

AOCSim architecture



Basic applications

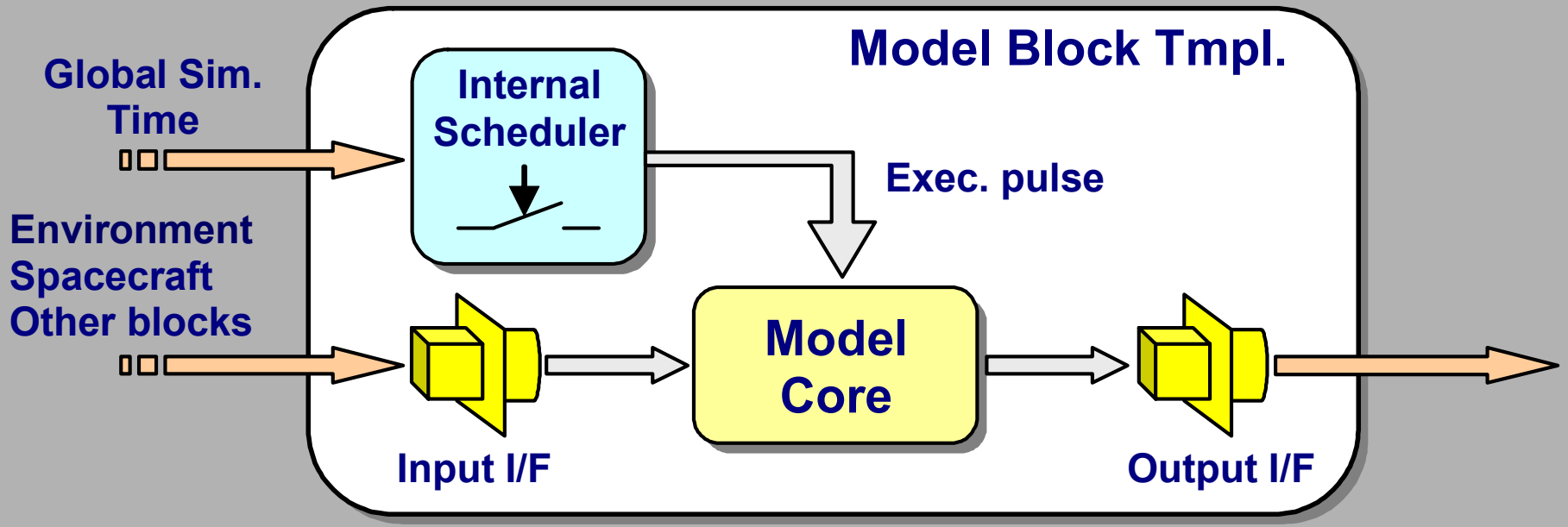
- The basic application for **AOCSim** is the analysis of some given AOCS configuration during the early phases of a mission study.
- The user tasks consist mainly in
  - Select the models
  - Tune the parameters
  - Collect and analyse the data
- Basic knowledge of Matlab/Simulink is required



Advanced applications

- The **AOCSim** can be turned into a design tool.
- Programming skills are required to define attitude control laws and to create new models.
- Pieces of code written in Matlab, C/C++, FORTRAN and ADA can be integrated in the **AOCSim**.
  - It is possible to take advantage of existing models and functions
  - A model block template is available to speed up the implementation of external code and reduce the modification on the original
  - This template has been extensively used to build up the **AOCSim** libraries

Advanced applications (*cont.*)



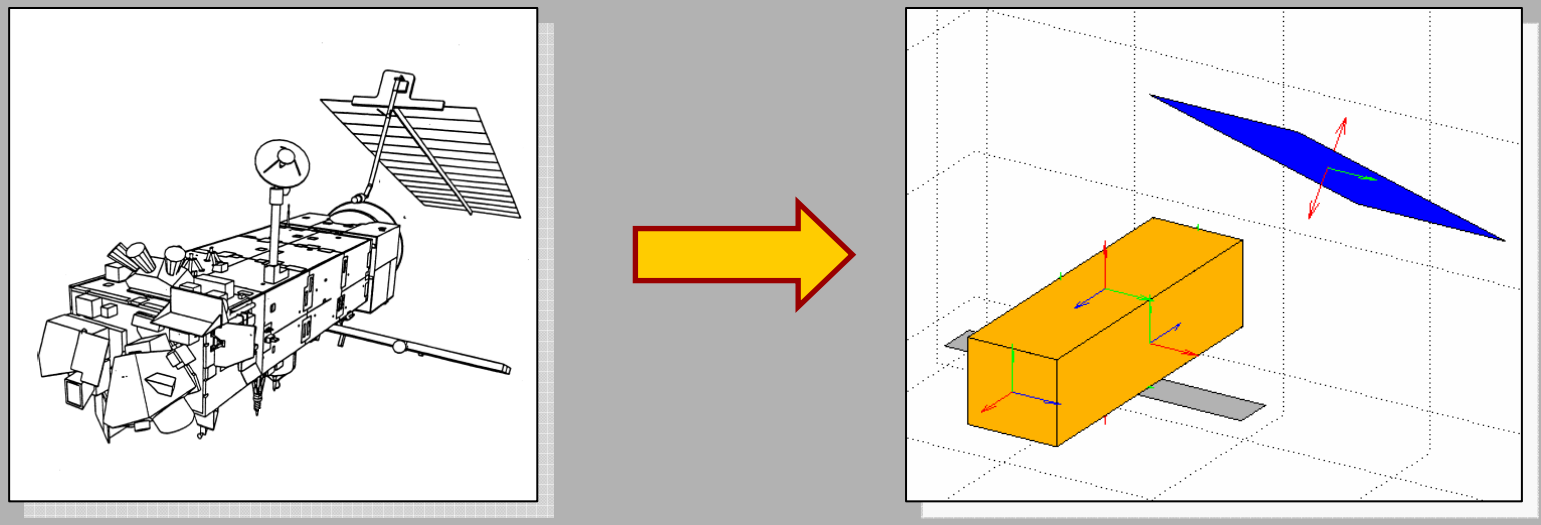
ENVISAT test case

The objective of this test case is to validate the concept of the simulator against a real mission.

- ENVISAT is an Earth-observing satellite launched on 1st of March 2002 aboard with Arianne 5 into a Sun synchronous polar orbit at a height of 790 km.
  - Relevant features for positive match:
    Fine pointing (Star Sensor + Gyro)
    AME = 0.03deg 3σ;
    APE = 0.02deg RMS;
    Actuation range ±0.1Nm x-, z-axes
    ±0.05Nm y-axis
    Orbit decay ≈100m/day

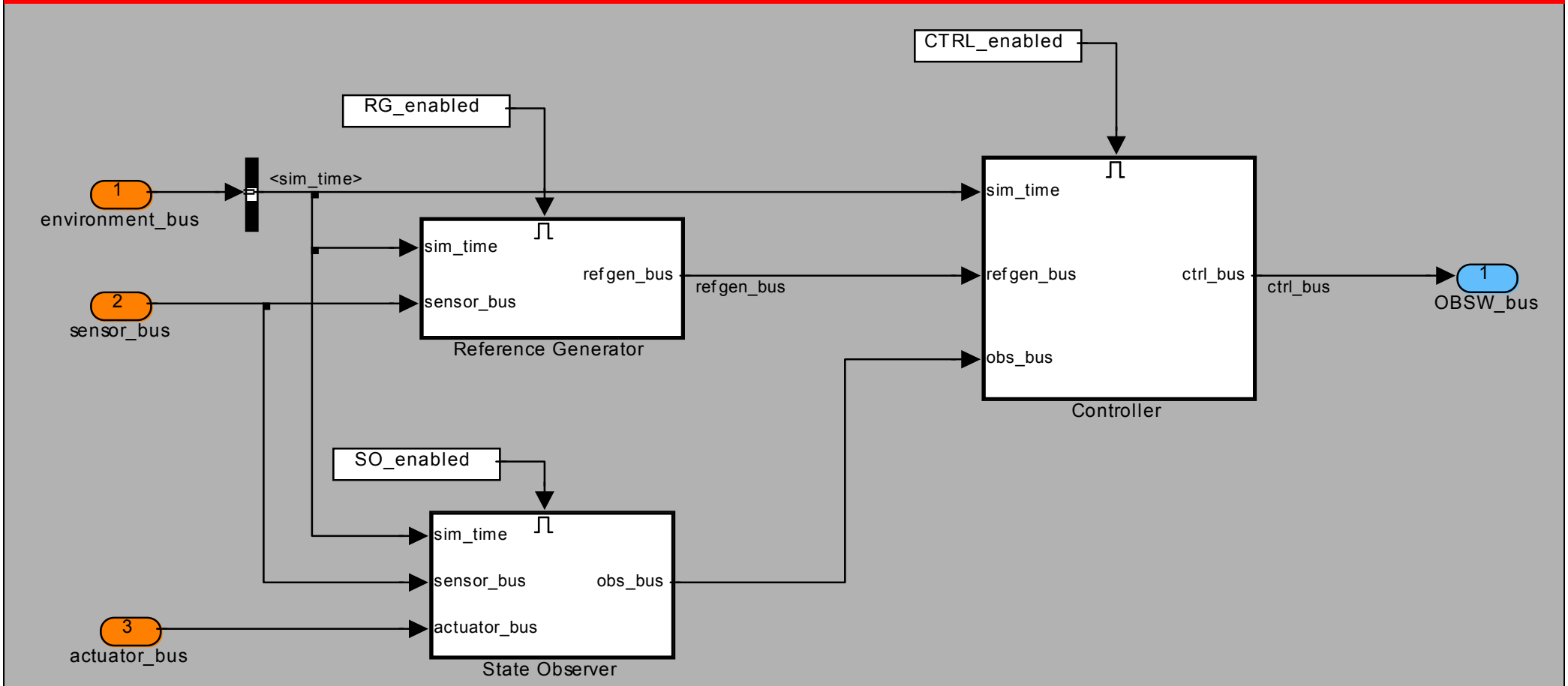
ENVISAT test case (*cont.*)

- **Aerodynamic model**
  - Body(6surf.) + Sar(2surf.) +Solar array(2surf.) = 10 surfaces total



- **Internal Disturbances**
  - Rotating Solar Array (ASAR)
  - Vibrations caused by Reaction Wheels Assembly (RWA)

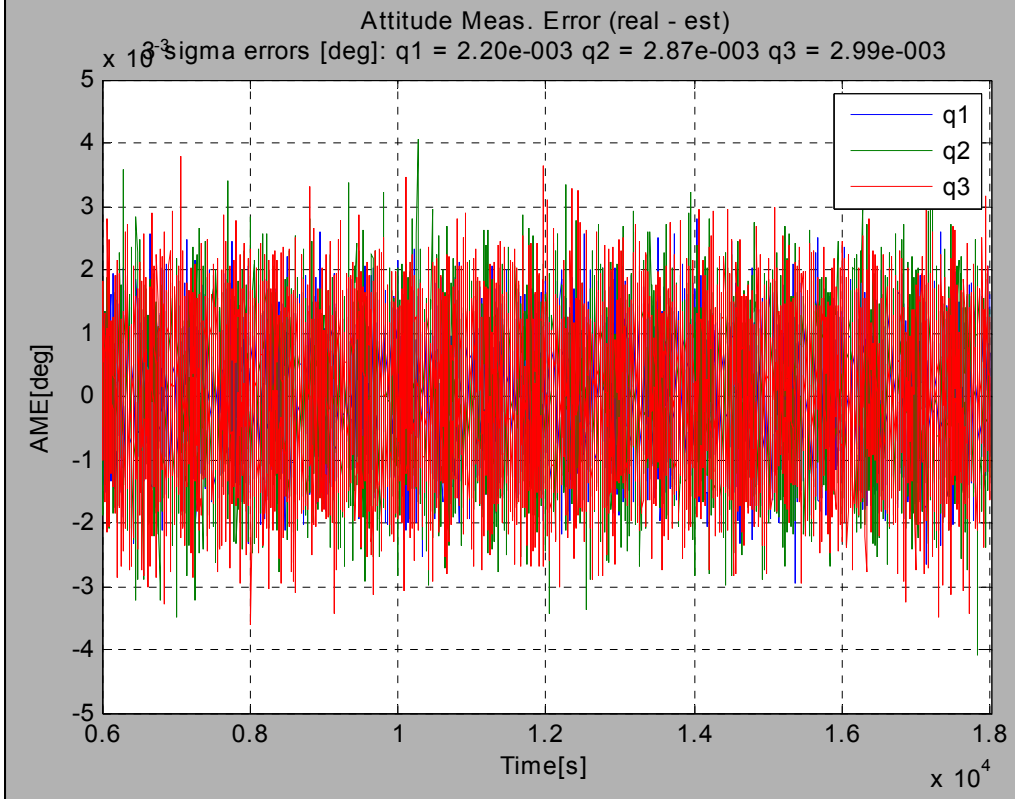
ENVISAT test case (*cont.*)

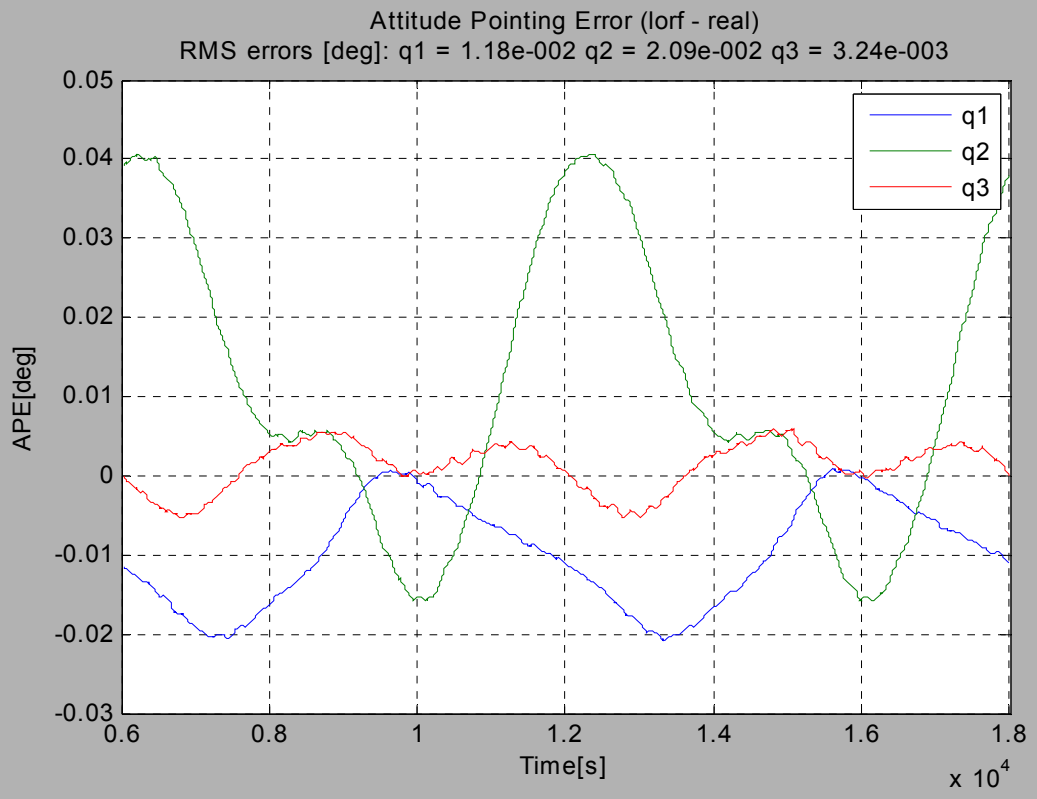


ENVISAT test case (*cont.*)

- **State Observer**
  - EKF (STR, STR+GYRO)
  - Navigation Sensor
  - Ext. Dist. Model
- **Reference Generator**
  - Orbital propagator
  - Trajectory generator
- **Controller**
  - Globally and asymptotically stable control law
  - Command handling/dispatching
  - Saturation management

ENVISAT test case (*cont.*)





ENVISAT test case (*cont.*)

- The simulated ENVISAT performs slightly better than the real one in terms of the AME.
  - *It is a consequence of some favourable assumptions about the State Observer*
- The controller operates within the prescribed limits
  - *The requested torques (not shown) appear quite "nervous". More time should have been spent in tuning the gains*
- The orbit decay is slower than the real one
  - *Solar array influence would need to be re-assessed. The US standard atmosphere model (USSA2000) proved to be conservative at low altitudes but not for orbits as high as ENVISAT's*

Future Activities

- **Allocated Resources**
  - Maintain and update libraries
  - Improve configurability
  - The user-friendliness of the tool must be improved
- **Applications**
  - MTG (Phase A)
  - Geo-Oculus (Feasibility study)
- **Search for other potential users**

Questions & Answers

End of the presentation

Thank you for your attention

For comment or information, please contact:

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