ACES MWL data analysis center at SYRTE

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ACES Mission components

[Diagram showing the components of the ACES mission, including ACES payload, ISS, ELT signal, MWL signal, MWL GT network, ELT Data Centre, ACES USOC, ISS NASA CC, Columbus CC, and TM/TC with Space-X Falcon 9 and Dragon Free Flier.]
ACES Ground segment

[Diagram showing the ACES Ground segment with various elements like ISS, TDRS, ISS NASA CC, USOC, Col-CC (ESOC), PHARAO-CC (USOC), PL-CC (USOC), ODC (GSOC), Archive (USOC), ELT-DC (TUM), DPC - 1 (LNE-SYRTE), DPC - 2, and networks of local clocks.]

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ACES microwave link setup


Two-way measurement cancels range + tropospheric delay at 1st order

General case
one measurement each 80 ms on ground and in space

Λ configuration (interpolated)
minimizes effects due to orbit determination and troposphere model errors
### Processing software

- Early developments \( \approx 10 \) years ago
- First lines of this code written in 2011
- Now \( \approx 6300 \) lines of Python
- Takes raw data as input and returns desynchronisation (+ TEC, pseudo-range...) between ground terminal and flight segment.

### Simulation software

- Parallel development (different developer, different language)
- \( \approx 1500 \) lines of Matlab
- Highly flexible
- Mimics what is expected to be L1 data (best guess sometimes !)
A typical pass

- Top: input desynchronisation (drift = GR)
- Bottom: residuals (theoretical - calculated desynchronisation)
- Noise = counter quantization (= noise floor)
Simulated passes with desynchronisation (1 ms offset + RG drift), code residuals mean values change within ± 10 ps as expected, but carrier residuals mean values stay stable at the sub-ps level.
Major milestone since last Moriond: Carrier disambiguation

10 days (∼50 passes) during a “quiet” period (no ISS boosts).
Simulation uses real ISS orbit data.
Using the software for interesting things (before having actual data)

**Produce test data for Ground Segment developers**
- General Debugging
- Special cases scenarios
- Validation data

**Prepare for future data analysis**
- Check sensitivity to GR deviations
- Get ready to deal with expected perturbations

**Experiment!**
- Influence of the uncertainty on ISS position
- ...
Simulation of ISS orbitography uncertainty

Starting point: difference between SIGI orbitography and more precise GNSS orbitography, data provided by O. Montenbruck from 2006 ISS orbitography archive.

Difference vector is projected on Radial, Transverse and Normal unitary vectors.

Order of magnitude: a few meters (smaller on R).

We chose a quiet period (no ISS boost).

Simulation is generated using precise orbitography (POD data).

Then we generate « fake » orbitography as input for data processing (base data + k × error).
Evolution of desync. recovery as a function of ISS orbitography uncertainty

10 days, 57 passes with exact knowledge of ISS position
Evolution of desync. recovery as a function of ISS orbitography uncertainty

10 days, 57 passes with expected error on knowledge of ISS position (few m)
Evolution of desync. recovery as a function of ISS orbitography uncertainty

10 days, 57 passes with $\times 10$ worse error on knowledge of ISS position ($\sim 100$ m)
Evolution of desync. recovery as a function of ISS orbitography uncertainty

10 days, 57 passes with $\times 100$ times worse error on knowledge of ISS position ($\simeq 1$ km)
Evolution of TDEVs as a function of ISS orbitography uncertainty

10 days, 57 passes with exact knowledge of ISS position
Evolution of TDEVs as a function of ISS orbitography uncertainty

10 days, 57 passes with expected error on knowledge of ISS position (few m)

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Evolution of TDEVs as a function of ISS orbitography uncertainty

10 days, 57 passes with $\times 10$ times worse error on knowledge of ISS position ($\sim 100$ m)
Evolution of TDEVs as a function of ISS orbitography uncertainty

10 days, 57 passes with $\times 100$ worse error on knowledge of ISS position ($\approx 1$ km)
**Conclusions**

**On ISS position uncertainty impact**

Should be well within specifications as far as per-pass desynchronisation is concerned.
Next step: more thorough study on impact on integrated gravity potential modelisation.

**On Data Analysis Center readiness**

Our software is already able to process large chunks of data (parallelisation) in a semi-automated way.
Definition of the interface with the CADMOS Data Center is ongoing.
We accumulate experience on data handling, visualisation and validation.
Eagerly waiting for real data!