Time bias analysis and prediction: a prototype service

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• Summary
Prediction quality and time bias

- Satellite position prediction quality affects the tracking performance of stations and with that of the network.
- Mostly only effects low flyers (e.g. Swarm, Grace, Hy2a, etc.)
- Range biases (RBs) are continuously monitored and distributed via various reports but Time Biases (TBs) are not.
- Effect of large TBs
  - Acquisition time increases or satellite cannot be found at all
  - In particular in combination with clouds and other parameters that have to be optimized (Tx beam and Rx telescope pointing, beam divergence, etc.)

- Currently no reports or monitoring service for the TB of predictions and no requirements for prediction providers.
Time bias analysis

- Our own passes are of course available (FR CRD), but only few
- Concurrent estimation of RB and TB from passes

TB values estimated from passes collected from POT3 station.
Time bias analysis

- Our own passes are of course available (FR CRD), but only few
- Concurrent estimation of RB and TB from passes
- EDC database holds passes from stations world wide (NPT CRD)
- Issues: sometimes short passes with a low number of NPs, reduced data rate (FR vs. NPs) and uncombined segments

TB values estimated from passes collected from stations world wide.
Time bias analysis

- Typically linear or parabolic trends over time depending on the satellite and the prediction provider
- These fits can be used to predict the TB in real time and to evaluate the quality of the predictions
- Predicted TB values can be used as a priori value during tracking

TB values estimated from passes collected from stations world wide. Fits (1st and 2nd order) are added to the trend of TB values of two predictions.
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TB values estimated from passes collected from stations world wide. Fits (1\textsuperscript{st} and 2\textsuperscript{nd} order) are added to the trend of TB values of two predictions.
Time bias prediction

- Fits applied to TB values stepwise from 2/3 ... to all
- Interpolation to the time of the next pass for prediction
- Residual = observed – predicted time bias value
- Check on the prediction performance
Time bias prediction

- **Results:**
  - With more passes and over time the residuals become smaller with outliers

- **But:**
  - Time of a pass ≠ pass submission time to EDC (after shift vs. after calibration)

- **Performance improvement:**
  - Reducing pass submission times if possible (e.g. after calibration and not after shift)

Differences between predicted and actual TB values for Hy2a using a 1st order fit. TB values covering the first 100 days of 2017 were used for this analysis.
Prototype service

- **Enhanced fitting**
  - $< 4$ TB values -> last TB value is shown
  - $< 5$ TB values -> first order (linear) fit
  - $\geq 5$ TB values -> second order (parabola) fit

- **Currently provided in text format via internal URL which shows**
  - the satellites (Swarm, Grace, Cryosat 2, Jason 2&3, Envisat, Topex, Kompsat 5, ...)
  - the prediction (various providers)
  - the number of passes currently available for fitting
  - overall RMS of the former values to the fit

Screenshot of the current status of the TB prediction service.
Prototype service

• Even with outliers in the prediction of the TB values the information about the sign (+/-) and/or the magnitude helped because
  - Faster and easier acquisition of targets
  - More passes with more data/NPs
• Required for autonomous operation in particular with multiple parameters that have to be optimized
• In future a graphical representation shall be included in the service
  - Better evaluation of the data distribution
  - Better evaluation of the fit quality
  - Better evaluation of the potential quality of the predicted value
Summary

- Satellite position prediction quality affects station and network performance in particular for low flying satellites
- Range biases are monitored & reported, time biases are not
- Passes from stations world wide retrieved via the EDC database Api allow to monitor the time bias trend of predictions
- Time biases can be predicted continuously and in real time
- Currently a text based prototype service that improved POT3 performance which could be made publically available
- Prediction becomes better with time and more passes
- Stations interested in using this service could help improving the performance by quickly submitting relevant passes to EDC
- Monitoring prediction quality, improving the network productivity and maybe deriving requirements for providers
Thank you for your attention!