IGMA-IGS Joint Trial Project Status Update

Tim Springer (ESA/ESOC) on behalf of the IGS
IGS-IGMA Main Aims
(from terms of reference)

• Make use of the IGS infrastructure and products
  – High quality precise orbit and clocks to be used as reference product for GNSS monitoring
  – Large high quality global tracking station network

• Compute using well defined and documented principles:
  – Orbit and clock differences
    • Allows to easily compute SISRE
  – Signal in space UTC offset error (UTCOE)
  – PDOP and availability
  – Signal in space user range error (SISURE)
    • Using data from the global tracking network
IGS-IGMA joint trial project

- In 2017 12 groups responded to the IGS call for participation
- A smaller subset has been active in this project:
  - DLR, ESOC(lead), GMV, GOP, ICGC, SHAO, UNESP, WHU
- Main Activities
  - 2017-2019 Initial orbit and clock test with vastly different results
    - Resolved this with a number of simpler tests
  - 2019 performed a detailed 1 day test and a 3 month comparison (February to April 2019)
    - Four groups participated in that
  - ICG-IGMA comparisons only at “in person” meetings
    - So COVID hindered progress since 2020.....
    - Mainly monthly teleconfs on ICG-IGMA level
Orbit and Clock Comparison 2019

- The next slides show a couple of results
  - Very controlled experiment
  - All IGS MACs used:
    - Same MGNSS reference orbit
    - Same broadcast orbit file
- Still got significant differences
  - Mostly resolved as being caused by different time intervals used for the different GNSS systems
    - Issues like validity time, start time, end time.
- For the clock comparisons different approaches were used
  - Still discussions needed there
  - Also one approach relies on bias product(s) being available.
GLONASS Differences in very controlled experiment
GPS Differences
(driven by validity time differences)
Different Reference Points

• Broadcast orbits and clocks refer to the **antenna phase center** \((\text{APC}_{\text{brd}})\)
• IGS Precise orbits refer to the **center of mass** \((\text{CoM})\) of the satellite
• IGS Precise clocks refer to **antenna phase center** \((\text{APC}_{\text{igs}})\)
  - \(\text{APC}_{\text{brd}}\) hardly ever the same as \(\text{APC}_{\text{igs}}\)
• Values \((\text{APC}_{\text{brd}})\) have been consolidated
Open Point: Satellite Attitude

- The IGS precise positions have to be transformed
  - From the CoM to the APC\textsubscript{brd} or visa versa
- The IGS precise satellite clocks have to be transformed
  - From APC\textsubscript{igs} to APC\textsubscript{brd} or visa versa or both to CoM
- The X- and Y-offsets (“horizontal”) have a limited effect on the clock differences so just accounting for the Z-offset (radial direction) may be sufficient
- Eclipse phases of the GNSS satellites
  - In those phases the satellite rotations are very significant
  - GNSS attitude law for eclipses not known for all systems
  - Not even predictable for some (e.g. switch from Yaw to ON and visa versa)?
IGS-IGMA needs

• IGS-IGMA needs information/activities from IGS:
  – Official IGS combined GNSS orbits and clocks
    • Biases for alignment of clocks for signal differences between precise and broadcast clocks
  – Improved broadcast navigation messages
    • Sometimes get “garbage” in broadcast
    • Or a dedicated product for monitoring purposes
    • Possibly an enhancement of the RINEX Navigation file format (or a new dedicated format)
  – Possibly IGS timescale for UTCOE

• IGS-IGMA needs information/activities from ICG-IGMA:
  – the attitude law of the satellites, in particular during eclipse, that is used for the broadcast ephemerides
Summary

- Orbit differences have converged
- PDOP discussions ongoing in ICG-IGMA
  - does IGS-IGMA want to contribute to that?
- UTCOE to follow after orbit and clock comparison is resolved
- SISURE follows later
  - Computed from network of receivers
- ICG in person meeting October 2022
  - Possibility to compare results
    - A full year of comparisons is planned
    - Time for some renewed activities of IGS-IGMA
PDOP and Availability

- BDS GRID_ELL
- BDS GRID_EAL
- BDS GRID_IB
Next Steps

• Update and review workplan of IGS-IGMA
  – To be done ASAP
• Broadcast Clock monitoring approach
  – Different approaches used, needs some discussion
• Test the reference point conversions
  – So far PCO offsets (both IGS and BRC) were ignored
• Does IGS-IGMA want to contribute to PDOP computations?
• Initial thought on UTC offset error computations
  – Possibility to use IGS Timescale for that?
The End