IGS Task Force for the Format Standard of Product Combination Statistics

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Participants

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1. **Purpose**

   The meeting reviewed the current status of the YAML-based format standard for product combination statistics, introduced the six top-level sections and their blocks, and discussed open questions raised in the community feedback. The work is being finalized for submission of a formal proposal to the Governing Board in early December.

2. **Point of Discussion**

   Presentation on the status of action items by J. Geng:

   - 【Complete】Finalize the goals of the task force.
   - 【Complete】Discuss and compare the JSON, SINEX and YAML formats.
   - 【Complete】Discuss possible contents for product combination statistics.
   - 【Complete】Design preliminary combination statistics in YAML format.
   - 【Complete】Draft specification for the combination statistics file and accompanying YAML format. First and second round of community feedback collected.
   - 【In progress】Continue refining the draft specification and YAML format based on first and second round community feedback.
   - 【In progress】Improve the auxiliary plotting scripts for combination statistics file.

   Presentation on the discussion content by J. Geng:

- Six top-level sections.
  - The META section records the fundamental information needed to identify and trace the combination. It contains three blocks, namely COMBINATION, PRODUCTS and COMMENTS.
  - The ALIGNMENT section records the systematic differences removed from the AC products before combination, so that all inputs are referred to a common reference. It contains three blocks, namely ORBIT, CLOCK and BIAS.
  - The WEIGHT section quantifies the contribution of each AC to the combined product. The weights are expressed in percent and are reported for four blocks, namely ERP, ORBIT, CLOCK and BIAS. AC-specific, system-specific and satellite-specific weighting strategies are supported.
  - The CONSISTENCY section is the central part used to assess the agreement between each AC product and the combined product. It reports the RMS statistics of the residuals after alignment and contains four blocks, namely ERP, ORBIT, CLOCK and BIAS.
  - The BOUNDARY section describes the discontinuity between consecutive daily products at the day boundary. It contains two blocks, namely ORBIT and CLOCK. A missing record indicates that the 24:00 epochs are not all available, and no extrapolation is performed.
  - The OUTLIER section records the epochs eliminated by outlier detection during combination. It contains three blocks, namely ORBIT, CLOCK and BIAS, and station clocks are also allowed in the CLOCK block. The start and end epochs and the number of outliers are reported. This information helps AC operators and PPP users distinguish usable epochs from those that are unavailable.
- Floating-point format.
  - The number of decimal places is determined by the physical resolution of each quantity, and the highest practical precision is retained.
  - One decimal place is used for millimeters (mm), microarcseconds (as),

picoseconds (μps), microseconds (μs) and percent (%). Two decimal places are used for the scale in parts per billion (ppb). Three decimal places are used for polar motion rates in μas/d, and four decimal places are used for clock drift in ps/d.

Discussions on the task force:

- **L. Massarweh**: 1) Whether the ERP weight is a single value or assigned per component. 2) The appendix formulas require angles to be converted to radians and the ppb term to be handled accordingly, since the file units should not be used directly inside formulas. Besides, the radial, along-track and cross-track components are defined in the ECEF rotating frame rather than an inertial frame and should be stated precisely.

  J. Geng: 1) A single scalar weight is applied uniformly across all ERP components, because ERP participates as a whole and cannot be split, similar to the three orbit directions. 2) The appendix and the text describing the algorithms and theoretical parts should be reviewed. The formulas would be checked so that angles are converted to radians and the ppb term is handled correctly instead of using the file units directly. All the relevant contents would be reviewed later to make the description more precise.

- **R. Dach**: 1) SVN and PRN in WEIGHT appear redundant. 2) The current IGS combination includes PPP validation and SLR validation, and they are useful, and should be an optional section in the format. 3) Full PPP validation is not meaningful for ultra-rapid products, as it would turn them into highly delayed combinations. 4) The legacy final uses more than ten stations for PPP validation. 5) SLR validation can be extended from this YAML file. 6) The a-priori transformations from Paul Rebischung should be reported for transparency, and the core station-combination parameters should eventually be included in the same file.

  T. Yates: PPP validation can be placed in a separate block and is not pressing, since adding a block is easier than removing one.

S. Loyer: 1) Whether the validation stations are commonly used by all centers or not used by any center. 2) Validation is performed only for finals. It would be tricky to require all future validations to be completed by the same person before delivery, since validation can be done only after the products are completed.

J. Geng: 1) SVN supports long time series because PRN does not persist, and satellite-specific weighting is accommodated. The combination team uses system-level weights but keeps the field for other software. 2) About ten fixed globally distributed stations are used for daily processing, the ambiguity fixing rate and comparison with the IGS weekly solution, without excluding stations used by ACs. The validation section would be deferred and kept optional, and it would not be included in the proposal to be presented to the Governing Board in December. 3) Paul's SINEX coordinate combination also uses seven parameters, which conflict with the orbit seven parameters. Tom Herring noted this at the second meeting, and unification was abandoned. The two are described separately. The combination team would discuss this again with Paul.

- **S. Banville**: 1) Phase-bias combination should be considered, since PPP-AR products are already provided and wide-lane agreement across ACs cannot be assessed. The BIAS block should be expanded to include Melbourne-Wubbena phase-bias consistency. An inconsistent ANTEX file would show up in the wide-lane biases, while the problem is harder to isolate after conversion to OSBs. 2) A metric on the number of fixed integer ambiguities, which helps diagnose ACs that fail to resolve integer offsets.

  R. Dach: Phase-bias combination statistics should be reported in the file.

  J. Geng: 1) Phase bias is combined with the integer clock to keep the format simple. Separating it would require additional observables, and a larger number of Melbourne-Wubbena combinations could be formed when five or six frequencies are available. But the BIAS block would be expanded to include Melbourne–Wubbena phase-bias consistency. The required change to the observable fields would be implemented to accommodate this addition. 2) No

separate integer flag is added, because the integer property is already implied by the phase-bias information.

3. Action Items

The following new action items were agreed and should be addressed before the next task force meeting:

- Add the Melbourne-Wubbena phase-bias consistency in the BIAS block and adjust the number of observables (the only structural addition agreed).
- Continue to improve the specification in Google Docs.
- Collect and respond to community feedback on the YAML format.
- Develop auxiliary Python tools to visualize the YAML format.
- Prepare the formal proposal for the Governing Board in early December.