Products produced under direction of AC Coordinator:
Processes, accuracies and quality control

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Contents

1. Overview about combination processes for Orbits, Clocks, ERPs (background for discussion on IGS integrity)
2. Summary on accuracy and consistency
3. Discussion on existing and possible quality control

Bern, March 2004
Combination -- Overview

AC products

SNX COMBI

Weekly rotation (SNX-AC to IGS00)

Daily x-y-rotations (ERP-AC to IGS-ERP)

Correction for radial orb-diff. AC to IGS

weights

ONLY FINAL

COMB ERP

ERP

SP3

CLK

GPS Time

Clock Product Center

IGS time scale loosely steered to GPS Time In

(Ultra)Rapid: IGS00 RF fixed by ACs
Comparison of AC Final orbits & clocks to IGS Final

Orbits

Last 60 weeks

Clocks

SA off

New CLK combi
Ultra Rapid Predictions

AC Ultra orbit predictions compared to IGS Rapid

(smothed)

No. PRNs
- all
- <30 cm
- <20 cm
- <12 cm
- <= 8 cm
- <= 4 cm
- <= 2 cm

Missing PRNs

N missing

IGU Quality histogram

23-Mar-04
X&Y Pole and LOD Residuals Time Series

Comparison of AC ERP to IGS Combination

Final                  Rapid                  Ultra

AC Final X-Pole (0.1 mas = 3 mm)

AC Rapid X-Pole

AC Ultra X-Pole

AC Final Y-Pole

AC Rapid Y-Pole

AC Ultra Y-Pole

AC Final LOD (10 us = 5 mm)

AC Rapid LOD

AC Ultra LOD

23-Mar-04
Consistency between the various products is a first measure for quality and integrity.

- Consistency
  - between same products of all ACs (Reports)
  - between the product lines (Final, Rapid, Ultra)
  - between diff. products, e.g. orbits and ERPs
Consistency / Rapid Orbit to ERP
Consistency / Ultra Orbit to ERP
Consistency / Summary

Orbits to ERPs
(Diff: \([\text{ORB}_{AC} - \text{ORB}_{COMB}] - [\text{ERP}_{AC} - \text{ERP}_{COMB}]\))

Orbits and Station coordinates (Finals)
(Helmert transformations)
(Diff: \([\text{ORB}_{AC} \text{ to } \text{ORB}_{COMB}] - [\text{SNX}_{AC} \text{ to } \text{SNX}_{COMB}]\))
SNX_{COMB} is CoM corrected
Quality, Reliability, Integrity

Basis:
- Quality of the stations in IGS network (stable RF)
- Quality of AC products (best and consistent models)

1. Avoiding single point of failure
   - Assurance of RINEX data availability
     - Redundant GDC & redundant data submissions to GDC
   - Assurance of AC product availability at Combi Center
     - Submission to 2 different servers (ACC, GDC)
   - Back-up Combi Center

2. Assurance of combined product generation
   - Account for all possibilities of corrupted inputs, formats, data, ...

3. Assurance of product consistency and quality
   - btw. all AC submission within one product line (Final, Rapid, Ultra)
   - between the product lines
     (consistencies down to mm-level may be important)

4. Assurance of the long-term stability and the alignment to ITRF
3. Assurance of product consistency and quality

"On-line quality check": Checks during combination

1. Tracking the consistency between AC submissions
   - detect and remove bad contributions (fit, rotations)
   - feed-back to ACs; avoid "jumps" by changing number of ACs

   e.g. Orbit Combination:

   - Remove max. (AC/SAT) outlier
   - Remove max. (AC) outlier
   - Remove max. (AC) outlier

   COMB SP3

   SAT outlier?

   AC transformations

   AC RMS outlier?

   Min Number of ACs

   Only for Ultra (3ACs); "single AC-sol" flagged 0

   Error codes for all products (flagged if no check possible)

2. Precise Navigation: Check of orbits&clocks for 3 stations (not in Ultra)

3. Finals only: - Long-arc orbit check
   - Cross-check of ERP_{SNX} to EPR_{ORB}
"On-line quality check" : Checks during combination (continued)

4. (Planned)
PrecisePointPositioning (PPP) with IGS SP3 and IGS Clocks
- Repeatability of station solutions (quality of orbit & clocks)
  (for clock quality only differences; not Time and Frequency)
- Realization of RefFrame (ITRF, IGS00) by IGS customers
- Monitoring of PPP results (Helmert transform., bias in East !)

Remark:
CoM : Center of Mass
PPP in Rapid : Orbit(CoM) & Clocks (ITRF) ➔ Stations (ITRF)
PPP in Final : Orbit(CoM) & Clocks (CoM) ➔ Stations (CoM)
3. Assurance of product consistency and quality (continued)

"Off-line quality check":

- Tracking the consistency between product lines
  - Rapid to Final (after 2 weeks)
  - Ultra to Rapid (after 1 day)

**ERP - Comparison of IGS Rapid to IGS Final**
Quality assurance and integrity

Assurance of product consistency and quality (continued)

"Off-line quality check":
- Ultra predictions to Rapid

Comparison of all single PRN cases to IGS Rapid

- Special Problems for Ultras:
  - Maneuvers (are unpredictable) or bad behaving satellites (rely on NANUs to flag orbits in SP3c?!) → Real-time monitoring
IGS Products
- Quality of cm (orbits, clocks) & mm level (ERPs, Sta)
- Checks of consistency & integrity have to be performed for that level

Of basic and growing importance is the quality in the long-term realization of the ITRF (mm-accuracy). Here some efforts are needed.

IGS Products are already checked for internal consistency
- during its generation, and
- with some delay between different products lines.
This has to be improved, and more checks should lead to automated warnings and feed-backs.

The growing importance of the ultra rapid predictions requires better integrity checks,
- which can only partly be fulfilled in the existing framework,
- here a combination with real-time procedures have to be developed.
Combination of Final Products - Overview

Combination of Final Products

IGS Core Products

MIT NCL

GNAAC

SNX

SNX weekly

SNX accum

ITRF

Bull A

StaLog

Aux. Input Steering

IERS LOD

SNX

SNX weekly

Geoc.

ERP

SNX accum (veloc)

igs00P02.erp

igs95P02.erp

ERP

SP3

CLK

TRO

ION

Iono Comb

Trop Comb

igswwwwd.sp3
igswwwwd.clk
igswww7.erp

igswww7.snx

( : IGS core products )

23-Mar-04
Comparison of AC Rapid orbits to combined IGS Rapid

Last 60 weeks
Consistency / Final Orbit-ERP

- ITRF97
- IGS00
- Differences to IGS Final Combination

Rotations [mas]

Time [GPS weeks]

1100 1110 1120 1130 1140 1150 1160 1170 1180 1190 1200 1210 1220 1230 1240 1250 1260

ERPE RP x

ORB y

cod
emr
esa
gfz
jpl
ngs
sio
igr
Integrity:
- Assurance of the existence of the product
- and the quality, reliability of the product

- Consistency between the various products is a first measure for quality and integrity
- Consistency
  - between same products of all ACs (Reports)
  - between the product lines (Final, Rapid, Ultra)
  - between diff. products, e.g. orbits and ERPs
RF realization using IGS (e. PPP)

4. (Planned)
PrecisePointPositioning (PPP) with IGS SP3 and IGS Clocks
- Repeatability of station solutions (quality of orbit & clocks)
  (for clock quality only differences; not Time and Frequency)
- Realization of RefFrame (ITRF, IGS00) by IGS customers

- Monitoring of PPP results (Helmert transformation, bias in East !)

SP3 are given in Center of Mass (CoM),
CoM moves with a few cm wrt to RefFrame Center (CoN) (is monitored).