USNO Analysis Strategy Summary

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Background:

- **Orbit Models:**
  - Gravity Field: JGM3 12x12
  - Solar radiation pressure: GSPM_EPS (Bar-Sever, 1997)
  - Numerical integration: variable order Adams predictor-corrector
- **Reference Frame:**
  - Generally ~68% of sites constrained to the IGS realization of ITRF00 (IGb00)
- **Software Used:**
  - (TOS) GIPSY/OASIS-II (v. 2.5.2-y2k) developed by JPL
  - (CHAN) GIPSY/OASIS-II (v. 2.6.1) developed by JPL
- **Hardware Used:**
  - (TOS) HP J5600 running UNIX version 10.20
  - (CHAN) HP J6700 running UNIX version 11.11
- **Measurement Models:**
  - Arc length: 3+24 hours
  - Elevation cut-off: 15 degrees
  - Sample rate: 5 minutes
  - Observables: Carrier phase and pseudorange

Background (cont.):

- **Estimated Parameters:**
  - Station coordinates: fiducial sites constrained to IGb00 sigmas
  - Satellite and receiver clocks: stochastic (white noise)
  - Orbital:
    - Deterministic positions, velocities, y-bias, solar radiation pressure scale, stochastic accelerations in across-track and along-track (Gauss-Markov)
  - Attitude parameters: yaw rate for eclipsing satellites only (white noise)
  - Troposphere: stochastic wet zenith delay (random walk)
  - ERP: x and y pole and rate, and LOD

  R. Ray (1996) sub-daily EOP model applied
- **Products:**
  - Ultra-rapid orbits, ERPs, and clocks (0245 UT and 1445 UT)
  - Rapid orbits, ERPs, and clocks (1600 UT)
  - Zenith tropospheric delay (every three hours)
  - UTGPS predictions

Rapid Procedure:

Two solutions are run in parallel on separate computers. For one solution the orbits are constrained to the preceding IGU orbits using the accuracy codes.

- (TOS) Step 1:
  - Select 34 sites
  - Execute a maximum of 2 passes through filter/smoother
  - Execute a maximum of 4 passes through outlier deletion/smoother
  - Resolve phase ambiguities
  - Execution time ~4.3 hours
- (TOS) Step 2:
  - Select 34 sites
  - Assign satellite weights based on the results of step 1 as compared with the latest IGU combined orbits
  - Execute a maximum of 2 passes through filter/smoother
  - Execute a maximum of 4 passes through outlier deletion/smoother
  - Resolve phase ambiguities
  - Execution time ~4.5 hours

Rapid Procedure: (cont.)

- (CHAN) Step 1:
  - Select 34 sites
  - Execute a maximum of 2 passes through filter/smoother
  - Execute a maximum of 4 passes through outlier deletion/smoother
  - Resolve phase ambiguities
  - Execution time ~1.2 hours
- (CHAN) Step 2:
  - Select 42 sites
  - Assign satellite weights based on the results of step 1 as compared with the latest IGU combined orbits
  - Execute a maximum of 2 passes through filter/smoother
  - Execute a maximum of 4 passes through outlier deletion/smoother
  - Resolve phase ambiguities
  - Execution time ~4.1 hours
- (CHAN) Step 3:
  - Form a combination of the orbits and ERPs from the two parallel solutions
- (CHAN) Step 4:
  - Compute additional clock solutions using precise-point-positioning with orbits and ERPs held fixed
  - Submit results

Ultra-Rapid Procedure:

Two estimation solutions are run in parallel on separate computers (TOS and CHAN). The solutions are formed every three hours. The TOS solution uses multiple data arc processing. The CHAN solution follows the basic procedure of the first Rapid solution.

Step 1:

(TOS)

- Select 34 sites
- Reinitialize the process at 0600 and 1800 with forward parameter estimation for eight 3-hour data arcs
- Execute forward parameter estimation for a 3-hour data arc
- Back smooth parameter estimates for 9 3-hour data arcs

(CHAN)

- Select 40 sites
- Execute a maximum of 2 passes through filter/smoother
- Execute a maximum of 3 passes through outlier deletion/smoother

Ultra-Rapid Procedure: (cont.)

Step 2: (CHAN)

Form a combination of the orbits and ERPs from the two parallel solutions

(This step skipped at 0600 and 1800)

Step 3: (CHAN)

Predict clocks to complete 48-hour time span

Step 4: (CHAN)

Predict orbits to complete 48-hour time span

Step 5: (CHAN)

Compute the total tropospheric zenith delay

Step 6: (CHAN)

Submit results

Ultra-Rapid Prediction Procedure:

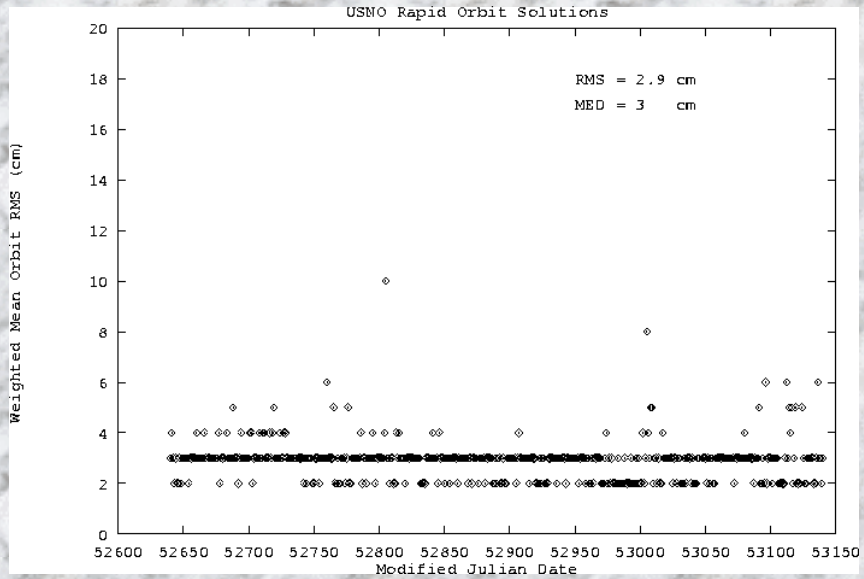
- Last 23 hours of determined orbit usually included in .SP3 file sent to IGS
- Predicted positions in file normally start at (Tpred-1 hr)
  - Tpred is the nominal prediction start time (midpoint of .SP3 file at 00h or 12h GPS)
- Fitted trajectory integrated forward to give predicted positions in .SP3 file
  - Correction added to initial predicted positions to remove determined orbit/predicted orbit discontinuity
  - Corrections are a cubic function of time
  - Coefficients are chosen:
    - to make predicted trajectory match last determined orbit point in position and velocity
    - to make correction value and its derivative zero two hours later

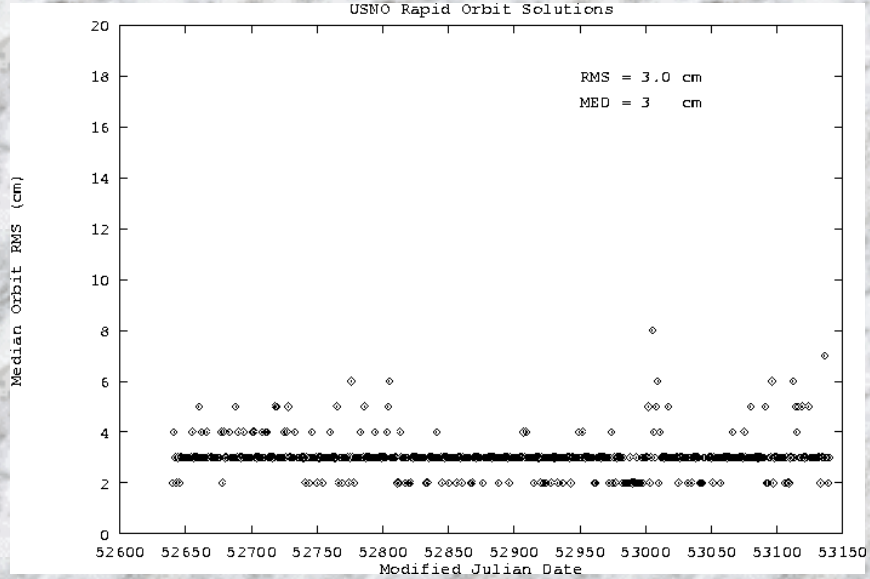
Ultra-Rapid Prediction Procedure (cont.) - Trajectory Fit:

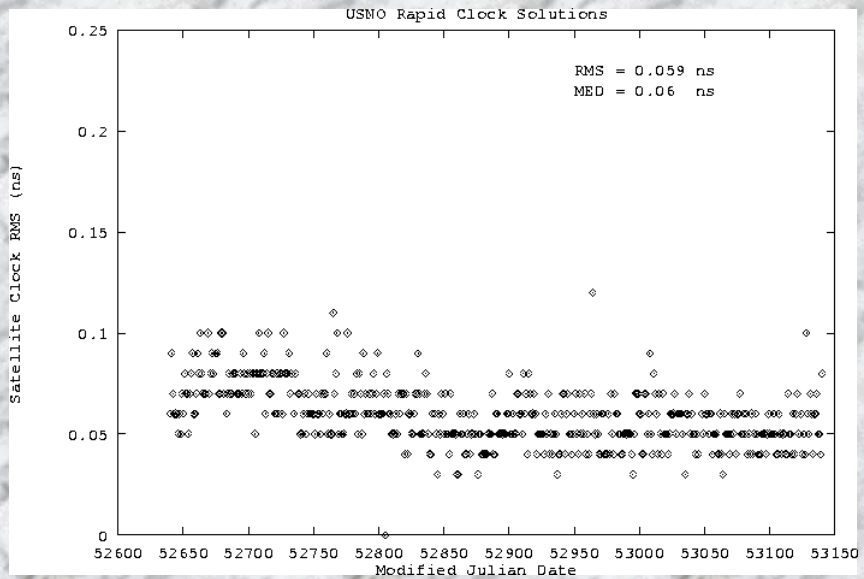
- Starting 2001 Sept 16, predictions based on Springer-type trajectory fit to a 3-day span of GPS orbit positions
  - Use standard gravity models, CODE 1998 radiation force model with VJS modifications (CODE/VJS-01 model)
  - Solve for 6 orbit parameters, Y-bias acceleration correction, scale factor applied to D axis (toward Sun) acceleration from CODE model
  - Predictions run at (Tpred -1 hour)

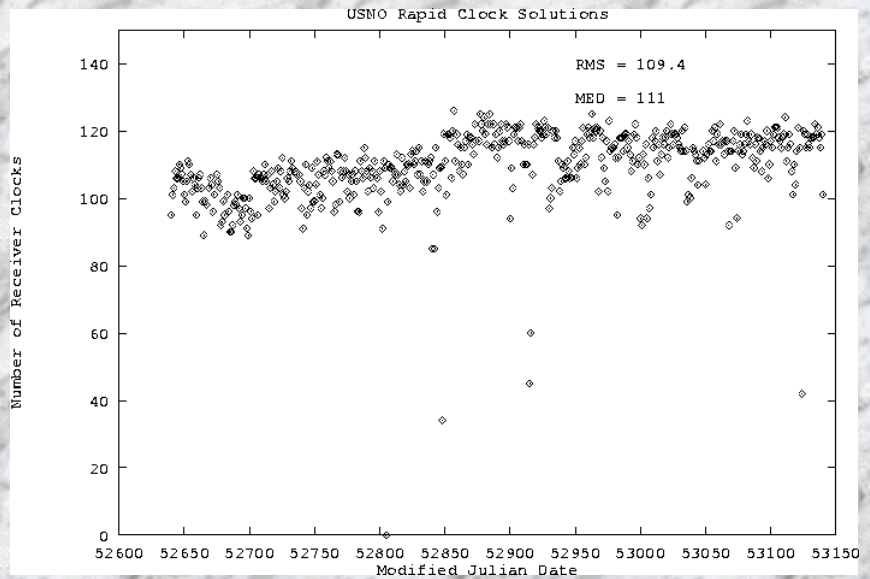
Ultra-Rapid Data Span Used:

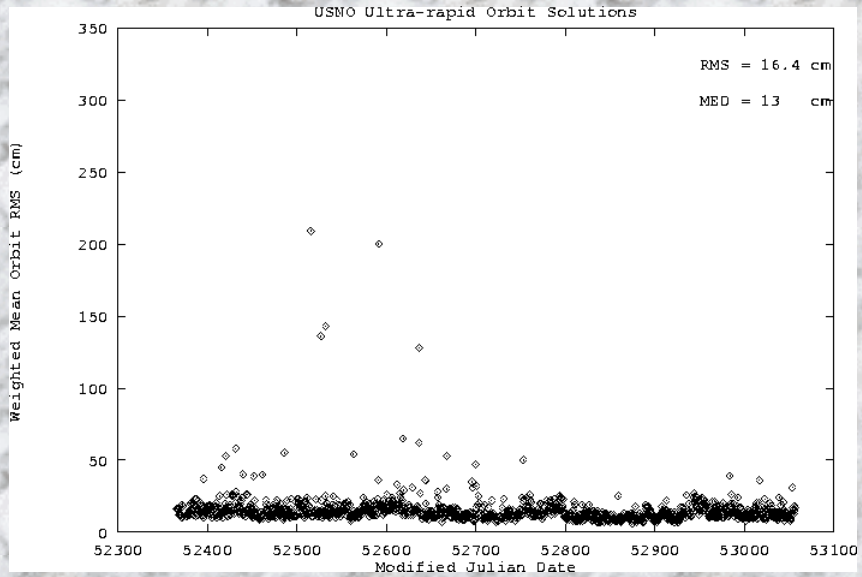
- Data span for fit extends from (Tpred - 3.5 day) to (Tpred - 0.5 day)
  - If thruster firing detected in interval, only use data after firing
  - IGS Rapid orbit data used for first part (2+ day) of fit; not available for last part at run time
  - USNO Rapid orbit data used for last day when available (Tpred at 12 h GPS), otherwise IGS Ultra-rapid combination (IGU) orbit used
  - USNO Ultra-rapid determined orbit included in Ultra-rapid file is only used to evaluate accuracy of extrapolated trajectory
    - Low weight (high accuracy code value) given to satellites showing large position differences
    - Low weight always given to problem satellites (PRN 15, 17, 21, 23, 29)

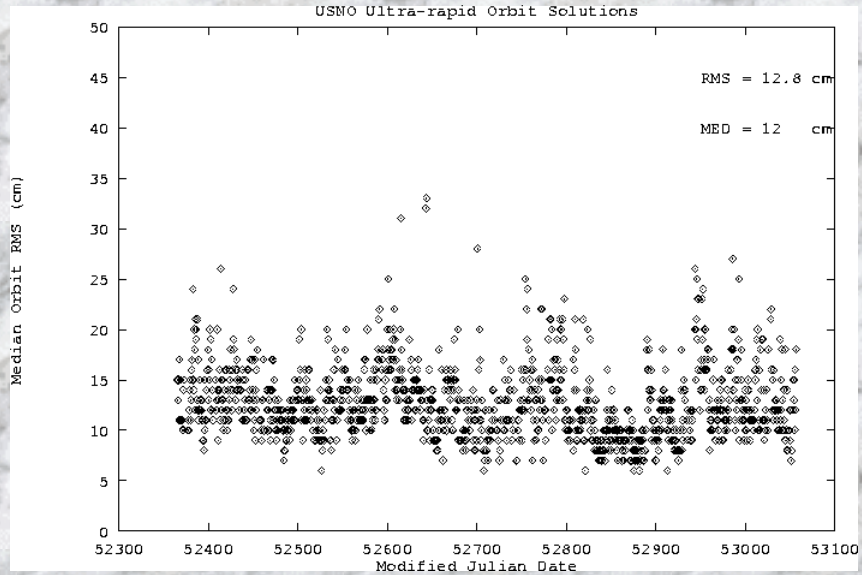

USNO Rapid Orbit Solutions
RMS = 2.9 cm
MED = 3 cm
Weighted Mean Orbit RMS (cm)
Modified Julian Date

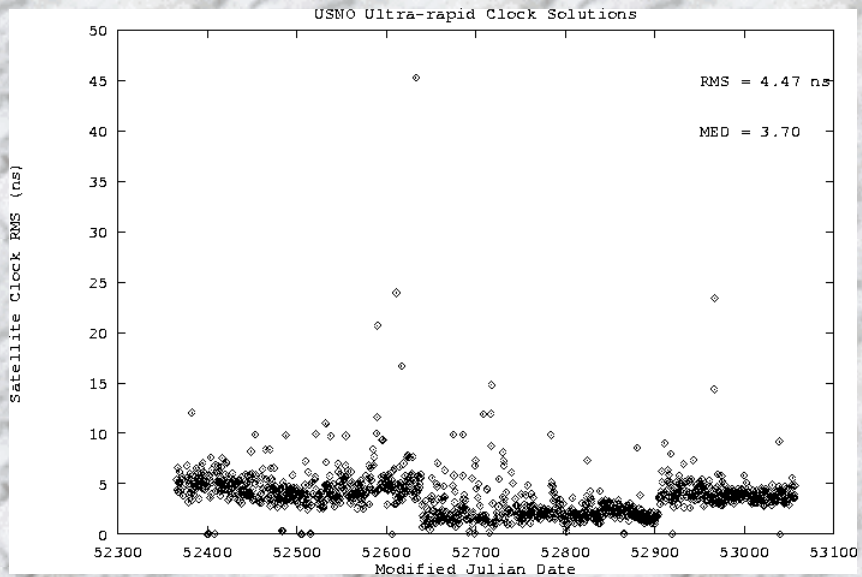

USNO Rapid Orbit Solutions
RMS = 3.0 cm
MED = 3 cm
Median Orbit RMS (cm)
Modified Julian Date


USNO Rapid Clock Solutions
RMS = 0.059 ns
MED = 0.06 ns
Satellite Clock RMS (ns)
Modified Julian Date


USNO Rapid Clock Solutions
RMS = 109.4
MED = 111
Number of Receiver Clocks
Modified Julian Date


USNO Ultra-rapid Orbit Solutions
RMS = 16.4 cm
MED = 13 cm
Weighted Mean Orbit RMS (cm)
Modified Julian Date
0
50
100
150
200
250
300
350
52300
52400
52500
52600
52700
52800
52900
53000
53100


USNO Ultra-rapid Orbit Solutions
RMS = 12.8 cm
MED = 12 cm
Median Orbit RMS (cm)
Modified Julian Date
0
5
10
15
20
25
30
35
40
45
50
52300
52400
52500
52600
52700
52800
52900
53000
53100


USNO Ultra-rapid Clock Solutions
RMS = 4.47 ns
MED = 3.70
Satellite Clock RMS (ns)
Modified Julian Date
0
5
10
15
20
25
30
35
40
45
50
52300
52400
52500
52600
52700
52800
52900
53000
53100