Status Report of the IGS Clock Products

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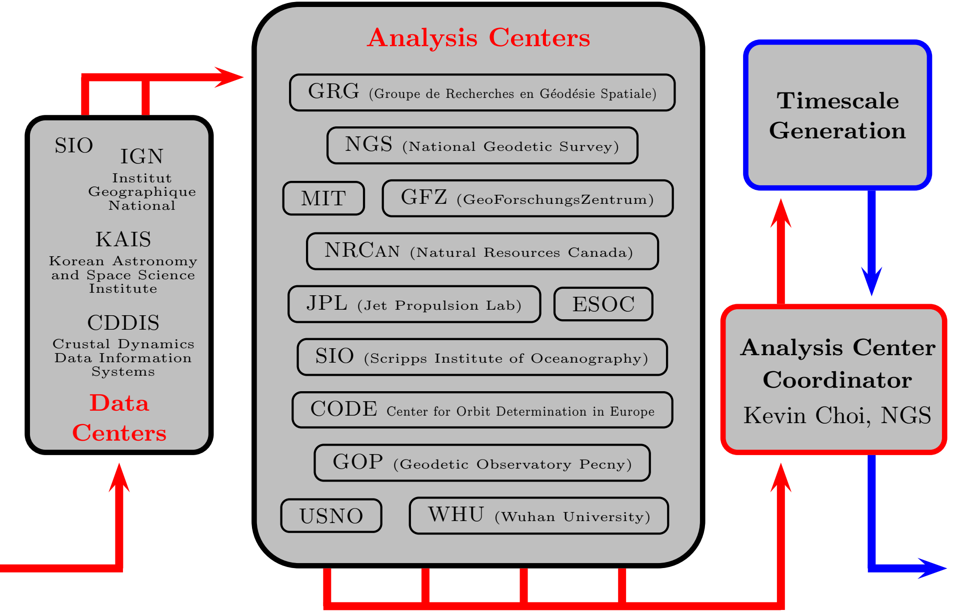
Existing IGS Core Products

SERIES	Product	Interval	Accuracy	Issue Time	Latency
Ultra Rapid (IGU)	GPS orbits	15 min	~ 3.0 cm	Daily at 03:00 09:00 15:00 21:00 UTC	3 – 9 Hours
	GPS clocks *	15 min	~ 150 ps		
	polar motion	6 hrs	~ 40 μas		
	length of day	6 hrs	~ 10 μs		
Rapid (IGR)	GPS orbits	15 min	~ 2.5 cm	Daily at 17:00 UTC	17 – 41 Hours
	GPS clocks †	5 min	~ 75 ps (RMS)		
	polar motion	1 day	~ 40 μas		
	length of day	1 day	~ 10 μs		
Final (IGS)	GPS orbits	15 min	~ 2.5 cm	Weekly on Wednesday or Thursday	11 – 17 Days
	GLONASS orbits	15 min	~ 5.0 cm		
	GPS clocks †	5 min	~ 75 ps (RMS)		
	polar motion	1 day	~ 30 μas		
	length of day	1 day	~ 10 μs		

* Only satellite clocks are reduced in the Ultra Rapid products.

† Both satellite and station clocks are reduced but **not** all IGS network station clocks.

Production Line



IGS Time

The current IGS timescale is formed for both the IGS rapid and final products and is derived using a standard Kalman Filter approach.

Kalman Filter was introduced in IGS2.0 version. This second version was implemented in 2011 with repreocessing computed from 2010.

Specifications for IGST

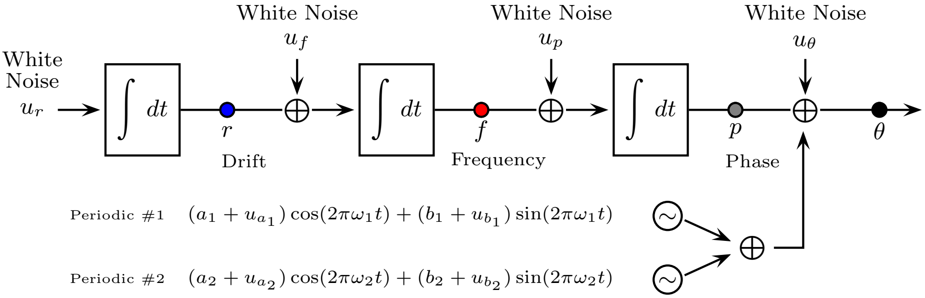
- Consists of an average of 50 – 60 positively weighted member clocks.
- Timescale is generated and exchanged with the IGS data clock reference for the Rapid and Final products.
- Stability performance as low as `E-16` for longer averaging intervals.
- Steers to UTC via `AMC2` or `USNO`. Goal is towards `UTC(USNO)`.

Timescale Features

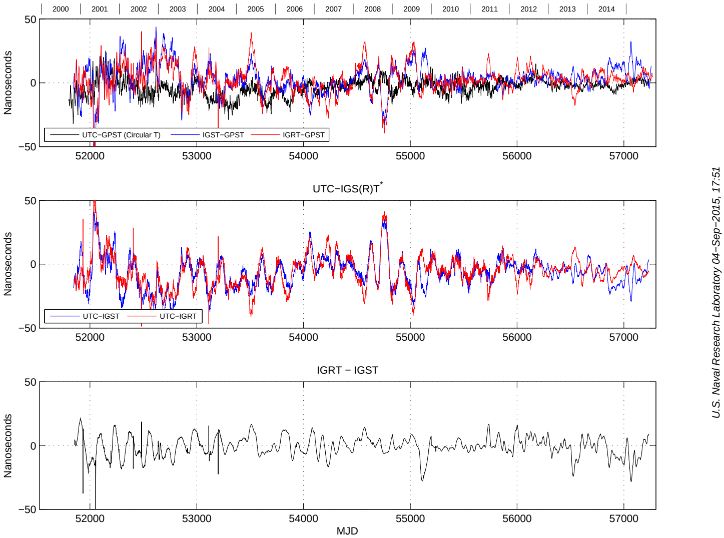
- Institutes a harmonic component into model for all satellite clocks.
- Automated break detection responds to phase and frequency breaks in clock data as well as day–by–day boundaries.
- Steering achieved using Linear Quadratic Gaussian Steering Algorithm.

General IGS Clock Model

- Filter uses a four state clock model for all station clocks. The total phase state incorporates additional white noise process.
- For satellite clocks, two fixed period harmonics are estimated and added to the total phase state. Hence, some clocks have 8 states.

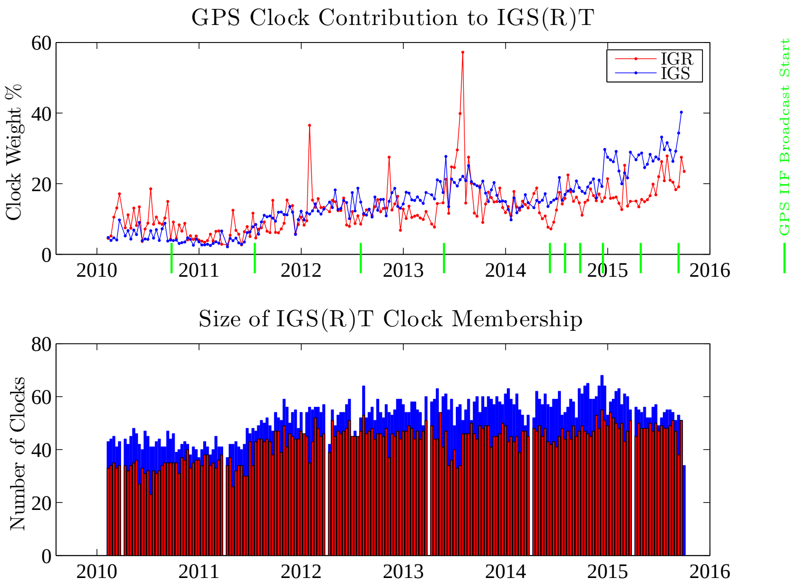


IGS(R)T Offset from UTC



* Assumes that GPS Time via Circular T is equivalent to GPST

GPS Clock Frequency Weight Contribution



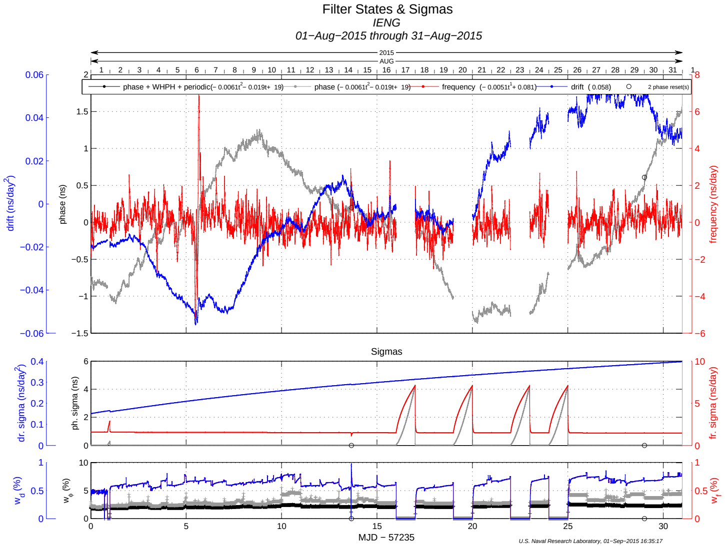
Ground Stations Reduced in Combinations

These tables show some common stations that are weighted in the timescale over the first 257 days of year 2015.

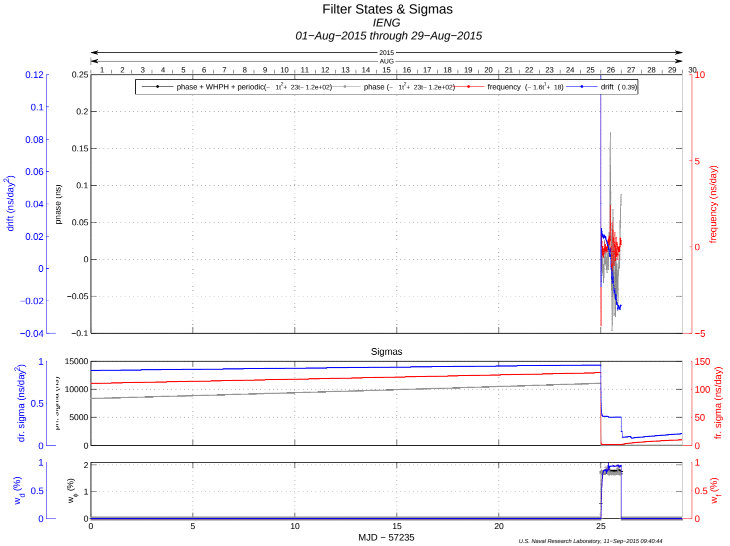
Stations with IGS & UTC (Partial List)

Station			IGST			IGRT		
IGS	UTC	Location	Days	w_p	w_f	Days	w_p	w_f
BJNM	NIM	Beijing CHINA	59	4.31	4.30	0	--	--
IENG	IT	Torino ITALY	38	2.31	0.89	239	3.77	3.85
NIST	NIST	Boulder CO USA	0	--	--	212	4.80	4.80
OPMT	OP	Paris FRANCE	223	4.37	4.38	1	4.86	4.96
PTBB	PTB	Braunschweig GERMANY	233	4.44	4.44	249	4.85	4.84
SFER	ROA	San Fernando SPAIN	225	4.36	2.21	6	5.16	3.53
SPTO	SP	Boras SWEDEN	130	3.69	3.68	194	4.66	4.66
TWTF	TL	Chung-Li TAIWAN	119	4.32	4.31	113	5.07	5.07
USNO	USNO	Washington DC USA	73	3.58	1.09	58	4.37	4.36
WAB2	CH	Bern SWITZERLAND	231	1.64	1.97	238	2.13	0.11

Data is mostly present for the rapid product.



Data is largely absent for the final product.



Proposed Improvements

UTC(k) Laboratory Inclusion

- UTC labs occasionally fall from IGS(R)T due to Analysis Center computation changes and/or drop outs. This is especially more prominent in IGR.
- Request that Analysis Centers utilize some collection of UTC(k) labs to allow improved IGS(R)T stability and UTC steering (as best possible / if possible). Request at next Governing Board Meeting in [December 2015 @ AGU]
- Goal via steering to these references is to maintain

$$\left|\text{UTC} - \text{IGS(R)T}\right| < 10 \text{ ns}$$

Satellite Clock Models

- Improvements to the initialization of clock states and covariances are being timescale filter. This will assist with false starts for GPS clocks and/or resets.
- Increase the contribution of GNSS clocks in IGS(R)T; in particular, include from Galileo, Glonass and Beidou as data becomes available after MGEX project complete. [Longer term timeline]
- GPS (in future, GNSS) clocks are nearly always part of the IGS combinations.

IGS Information / Contact

For more information on the IGS core products, experiments and working groups:

`www.igs.org`

For suggestions or requests for the Clock Products:

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