IGS Real Time Pilot Project Analysis Results: Achievements and Challenges

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RTPP Key Objectives

- Manage and maintain a global IGS real-time GNSS tracking network
- Generate real-time products
- Investigate standards and formats for real-time data collection, data dissemination and delivery of derived products
- Monitor the integrity of IGU predicted orbits and GNSS status

Service Targets

- **Dissemination of real-time clock and orbit correction information through IP channels**
  - **Clock accuracies of 0.3 ns**
  - **Orbit accuracies of 5-6 cm**
  - **Latency better than 10 sec**

RTPP Infrastructure

- **Participation from 34 organisations**
  - 10 participating Analysis Centres
  - ESOC is the AC Coordinator, performing the combination
- **Data Infrastructure**
  - RTIGS infrastructure from NRCan
  - NTRIP infrastructure from BKG
  - Station operators contribute > 100 RT streams
- **Development of standards and formats for RT**
  - IGS has joined the Radio Technical Commission for Maritime Services (RTCM)
    - Data formats to satisfy RINEX 3 requirements
    - Product dissemination via new SSR formats
    - RTCM formats included in the receivers by manufacturers

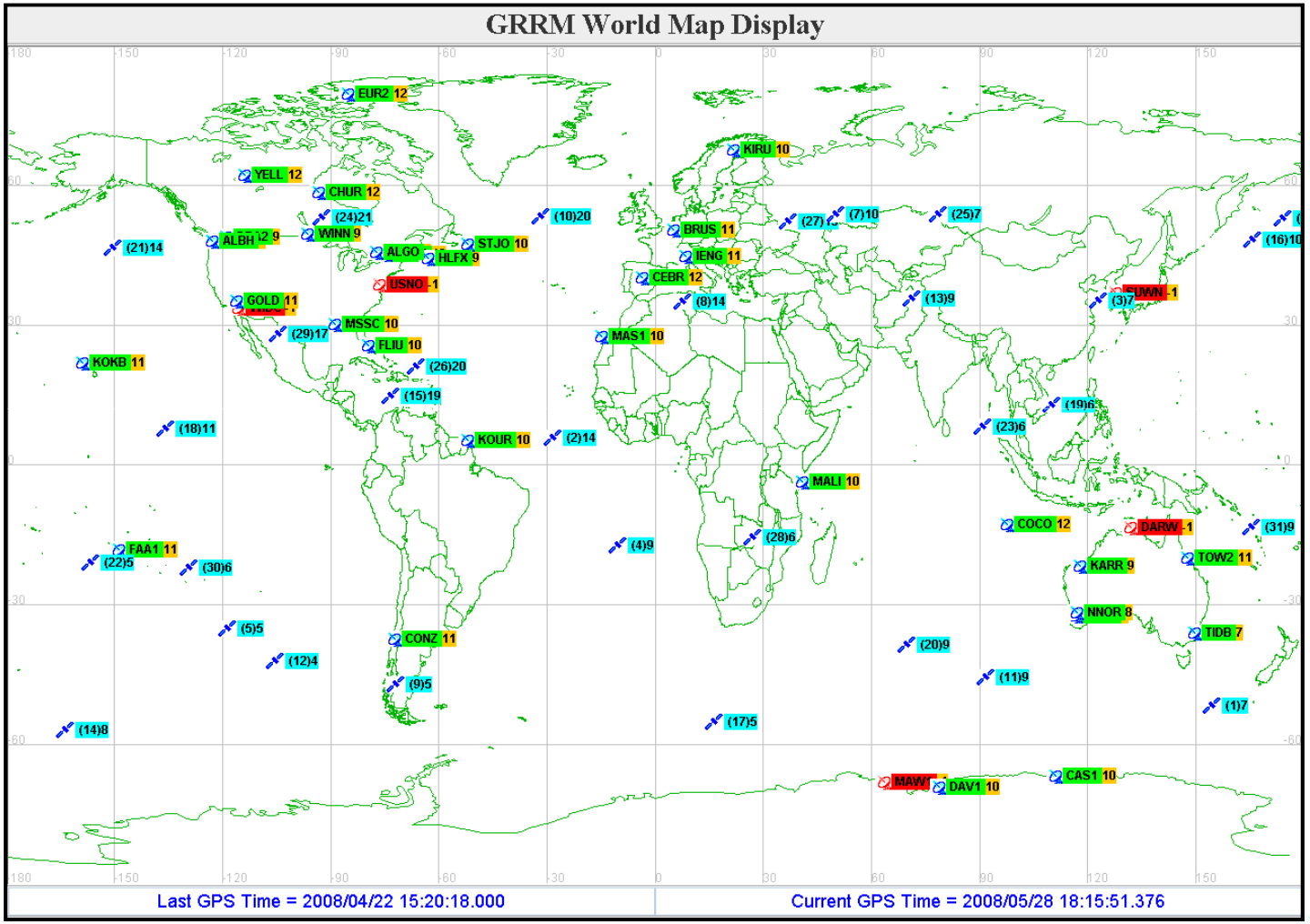
Analysis Centre Status (1/2)

Centre	Status	RT Product
ESOC	RT Clocks and TZD using NRT Orbits (every 2 hours) from batch process.	Available
NRCan	RT Clocks and TZD using NRT Orbits (every hour) from batch process. Currently distributing RT products via satellite.	Imminent
BKG with TU Prague	GPS and GPS + GLONASS RT clocks using IGS ultra-rapid orbits.	Available
DLR	RT clocks using IGS ultra-rapid orbits.	Available
IGG (TU Wien)	RT Clocks based on IGU orbits. Currently generates online comparisons with IGU clocks. IGU orbit residuals in near future	Near future

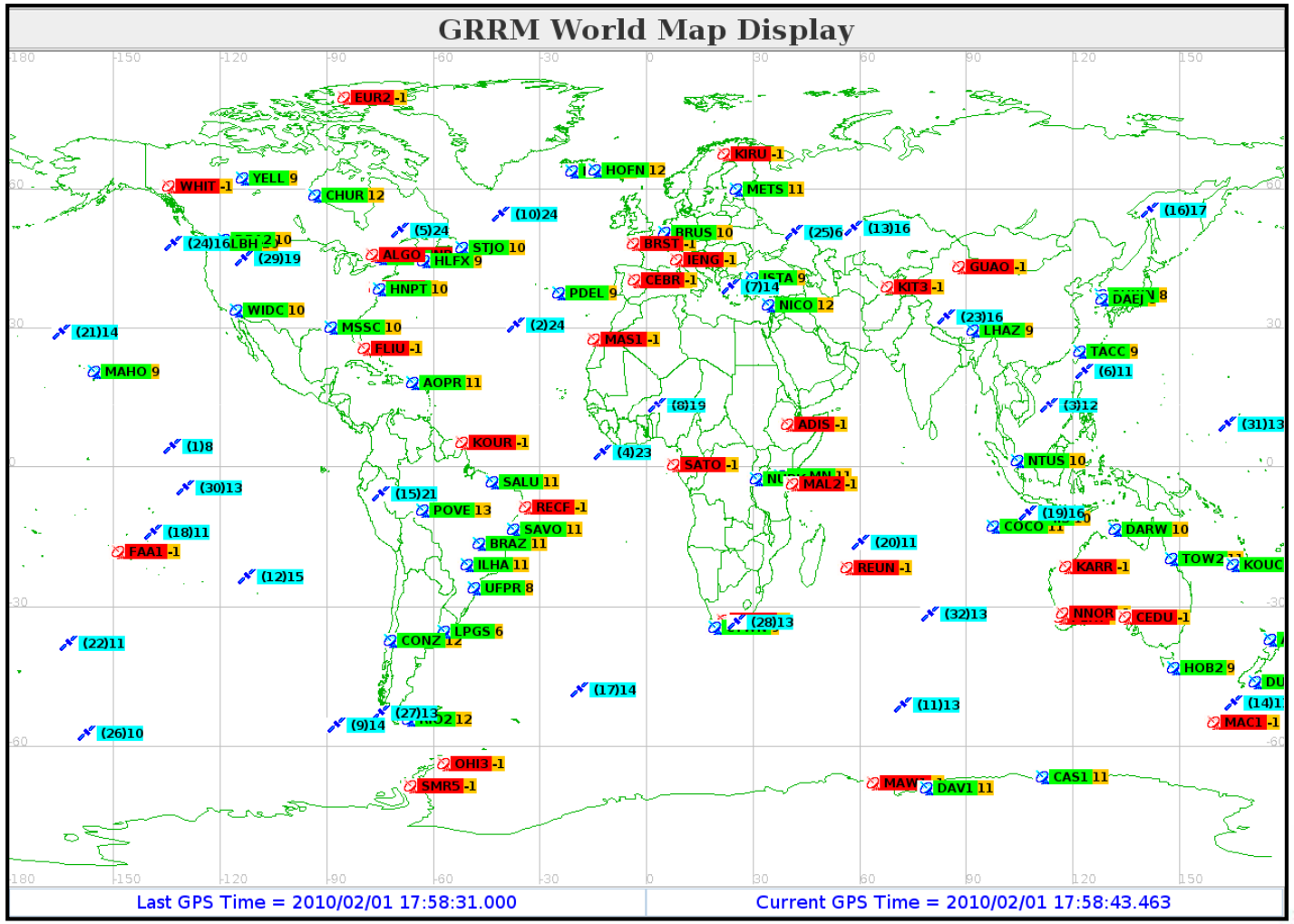
Analysis Centre Status (2/2)

Centre	Status	RT Product
GMV	Predicted SP3 and clock RINEX files every hour (with current capabilities). RT system under testing.	Imminent
University of Newcastle	RT obits and clocks. Clocks determined with smoothed pseudo ranges.	TBC
TU Catalonia	AC for RT Ionospheric Products.	TBC
Chalmers	Emphasis is on a Tropospheric product for weather forecasting. Intend to participate as a RT Analysis Centre using own software for estimation of orbits and clocks.	TBC
Geo++	RT streams currently available but not yet submitted to the PP.	Near future

Tracking Network 2008



Tracking Network 2010



Performance 2009

Example of Daily Comparison Statistics – Feb 2009

AC	nSats	Orbit RMS (mm)	Samples	Satellite Clock RMS (ns)	Satellite Clock Sigma (ns)
Comb.	**31**	**-**	**8874**	**0.29**	**0.21**
BKG*	**48**	**67.8**	**3206**	**8.36**	**5.85**
DLR	**31**	**43.8**	**8909**	**0.45**	**0.19**
ESOC	**31**	**57.8**	**8870**	**0.43**	**0.37**
ESOC2	**31**	**40.7**	**8928**	**0.35**	**0.27**
NRC**	**31**	**31.5**	**7862**	**0.92**	**0.88**
GMV***	**31**	**47.5**	**8928**	**1.72**	**1.71**

*BKG is a double difference solution and does not lend itself to absolute clock comparisons
**NRC performance currently suffering from poor network coverage
***The GMV solution is a 1-2 hour prediction

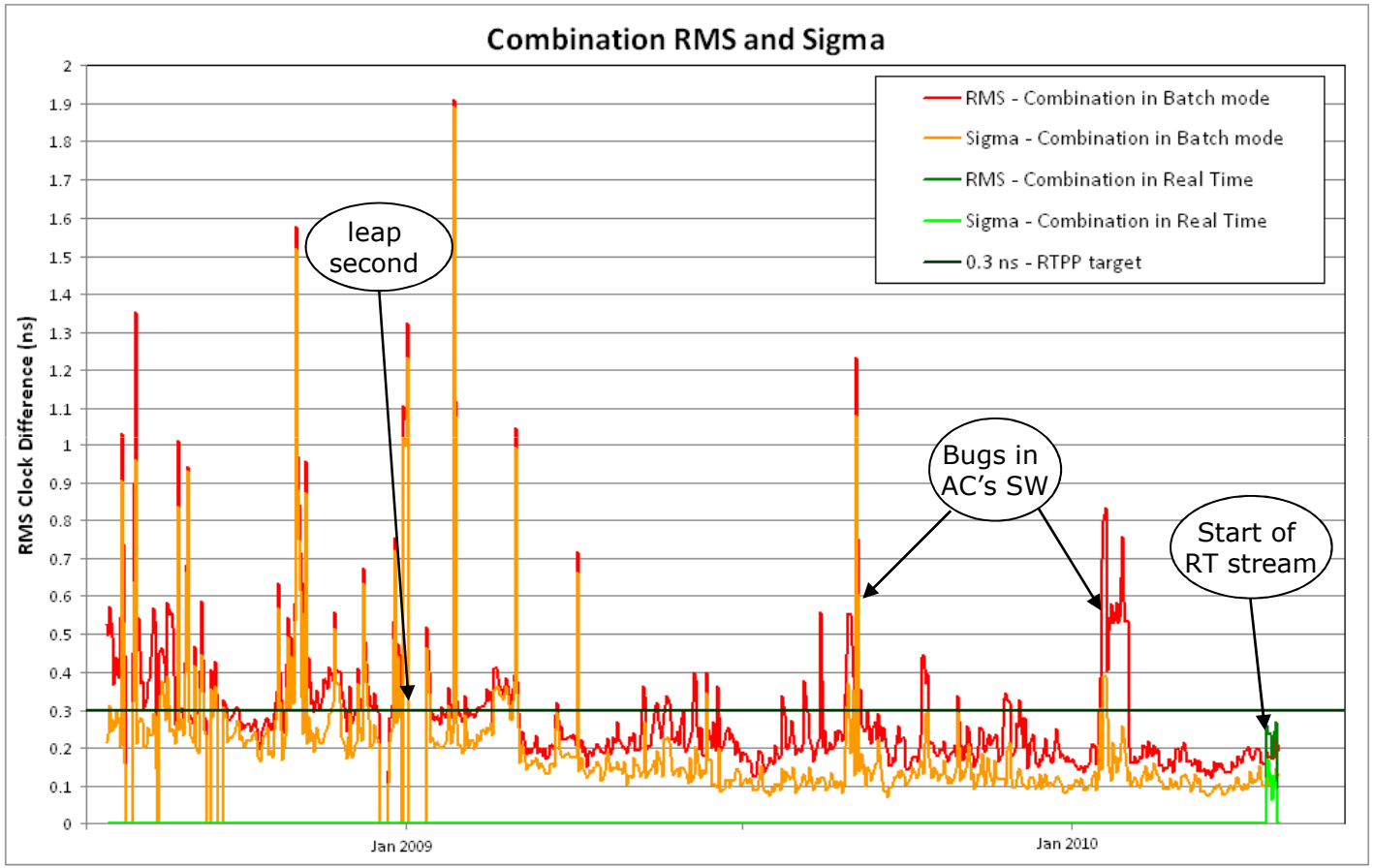
Performance 2010

Example of Daily Comparison Statistics – May 2010

AC	nSats	Orbit RMS (mm)	Samples	Satellite Clock RMS (ns)	Satellite Clock Sigma (ns)
Comb.	**30**	**-**	**8352**	**0.15**	**0.08**
RT Comb.	**30**	**46.8**	**7864**	**0.18**	**0.10**
BKG	**29**	**47.5**	**8061**	**0.23**	**0.09**
DLR	**30**	**49.1**	**8352**	**0.19**	**0.12**
DLR2	**30**	**45.6**	**8352**	**0.27**	**0.11**
ESOC	**30**	**21.9**	**8335**	**0.21**	**0.13**
ESOC2	**30**	**45.6**	**8310**	**0.22**	**0.10**
NRC	**30**	**35.3**	**8351**	**0.27**	**0.10**
TUW	**30**	**423.9**	**6770**	**0.92**	**0.82**

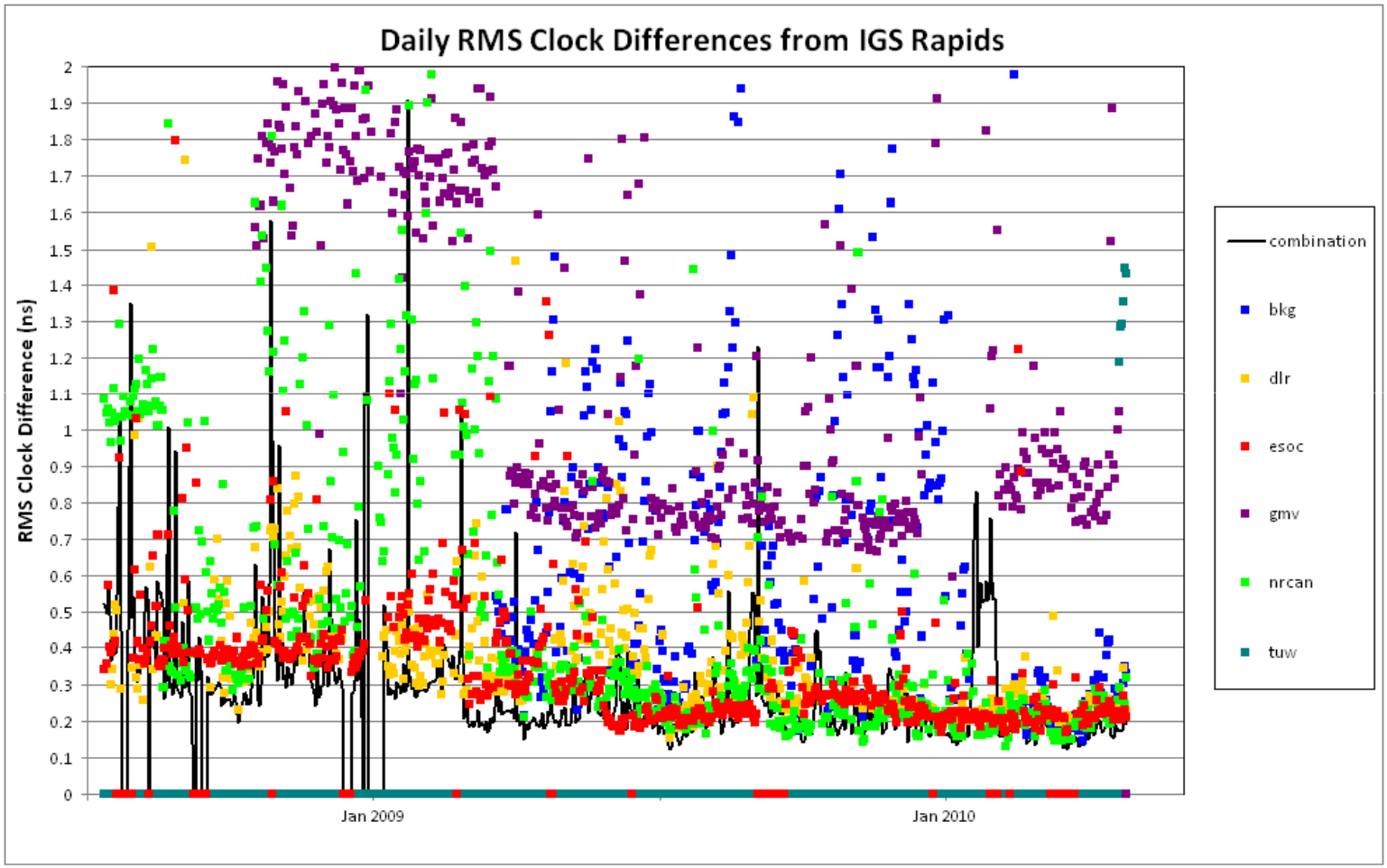
Data from 1st May 2010

Combination Solution

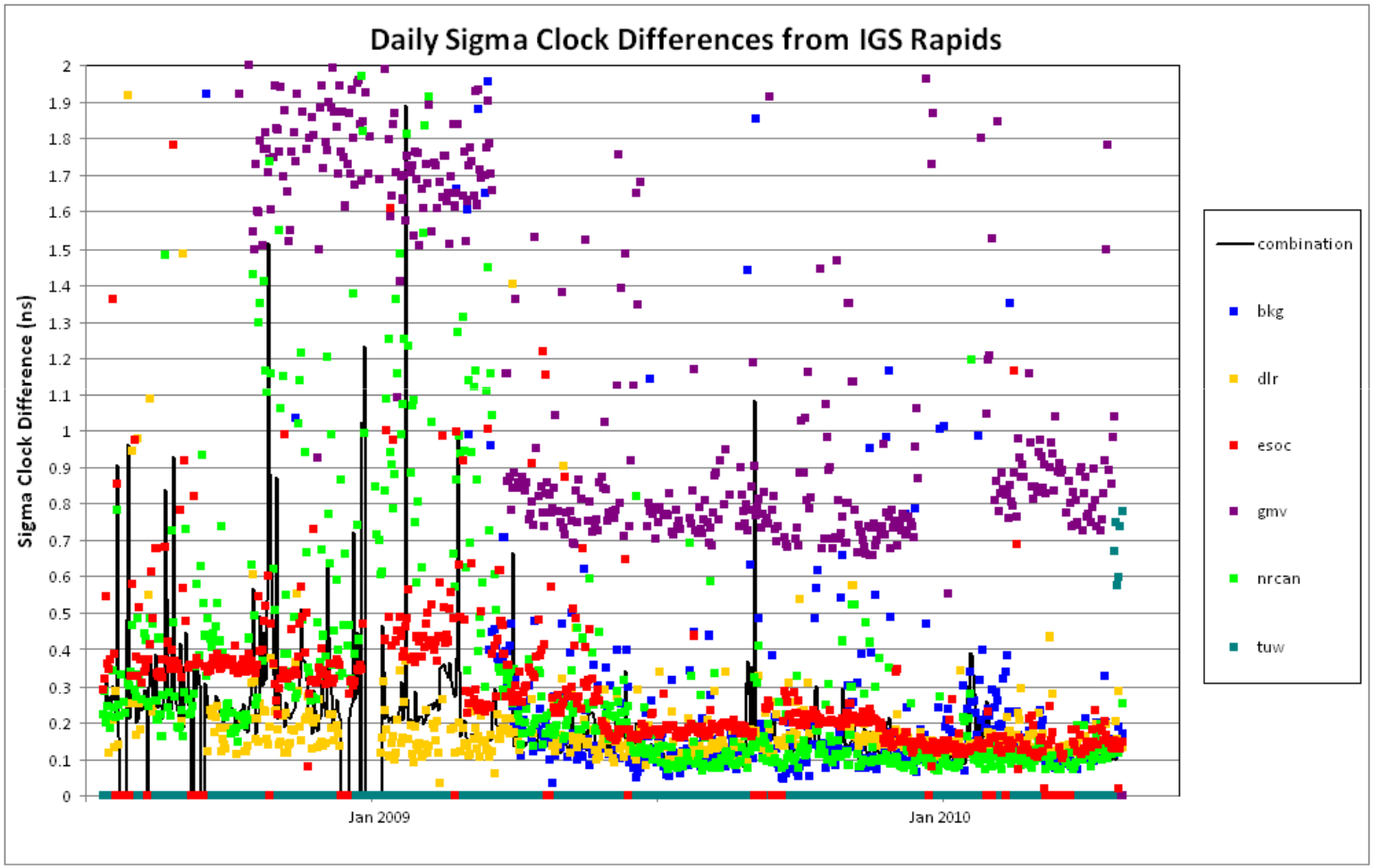


- History shows continuous improvements
- Daily results and comparison plots are available at http://www.rtigs.net/pilot/products.php

RMS of individual solutions



SIGMA of individual solutions



Performance Summary

- Accuracy (compared to IGS Rapids)
  - **Orbit: 5-6 cm 1-D RMS**
  - **Clock RMS: 0.2 ns**
  - **Clock Sigma: 0.1 ns**

- Latency
  - **Latency of Individual Solutions: 7-15 sec**
  - **Latency of Combination: 20 – 30 sec**

RTPP achievements

- **IGS has become active within RTCM Special Committee 104 through the RTPP's efforts**
- **RTPP combination solution now available using RTCM state space representation on NTRIP:**

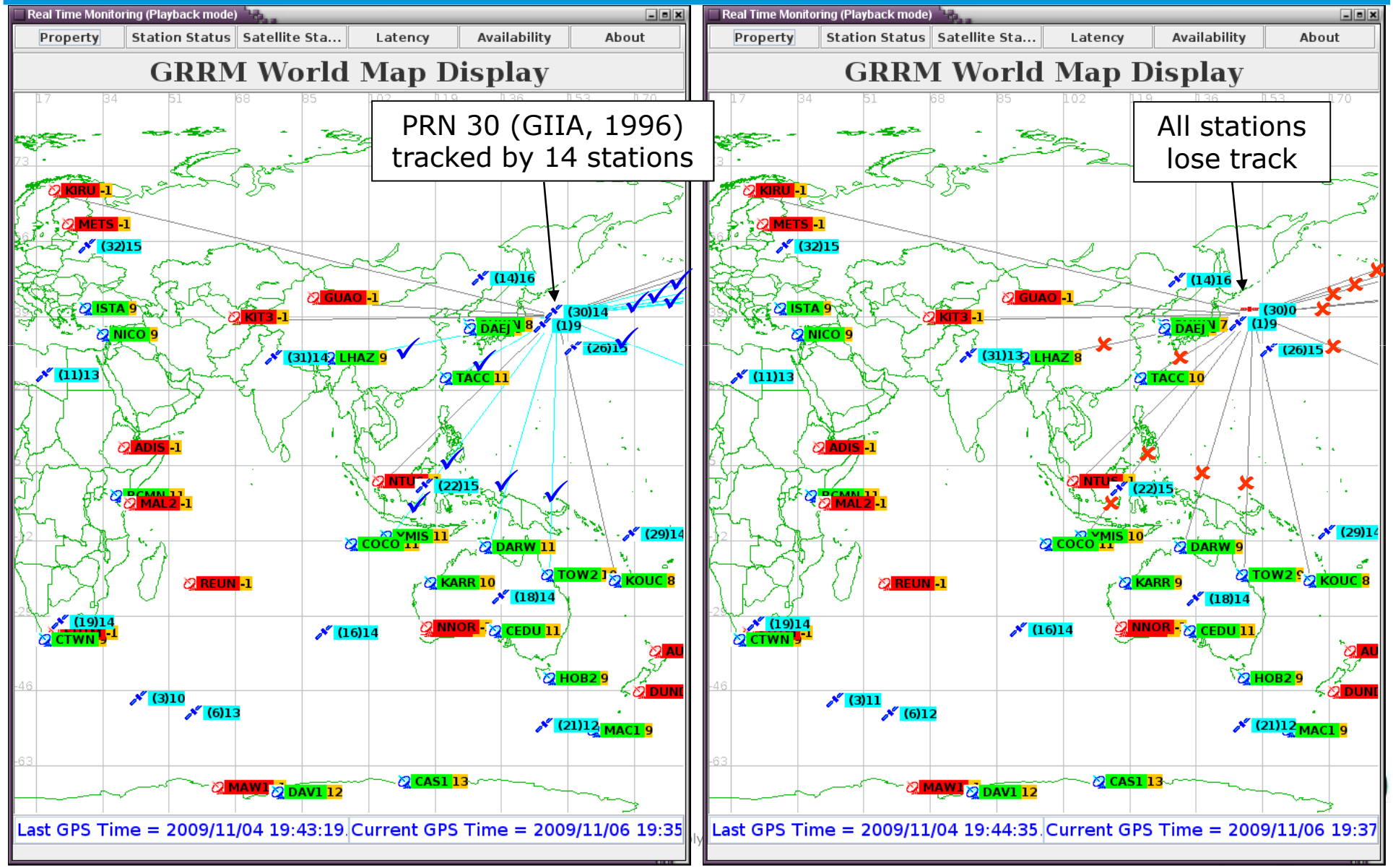
Caster:	**www.igs-ip.net**
Mountpoint1:	**CLK30**
Mountpoint2:	**CLK31**

- **Real Time series from 3 individual ACs are also available in www.igs-ip.net**
- **Interest in Real Time products and services is increasing**
  - Prominent role in GGOS (Global Geodetic Observing System)
  - Main topic at next IGS workshop

Challenges

- **Multi-constellation capabilities**
  - Handling of DCBs and Inter-System biases
  - Multiplication of frequencies and signal types
- **Reduction in latencies**
  - SSR format improvements
  - Processing improvements
- **Increasing problems with ageing GPS satellites**
  - Block IIA satellites exhibit signal glitches (a few events per week)
  - RT and Batch solutions usually exhibit clock jumps after these events

Block IIA signal glitch



Conclusion

- **RT combination solution provides advantages in terms of improved accuracy and stability**
  - Errors were due to lack of coordination (e.g. movement of receiver antennas), the introduction of the leap second on 1 January 2009, unexpected satellite events like manoeuvres that are not communicated in advance, software changes introducing bugs in one of the solutions
- **Accuracy targets achieved and surpassed**
- **Latency issues need to be addressed**
- **IGS cooperation with RTCM has led to significant advances in the standardisation of RT formats**