Integrity Monitoring of IGS Products

March 2004

James F Zumberge
Tracking Systems and Applications Section
Jet Propulsion Laboratory, California Institute of Technology

Hans-Peter Plag
Geodetic Institute
Norwegian Mapping Authority

Overview

- Integrity Monitoring: theory
- Application to IGS Products
- User Survey
- IGS Ultra Rapid Orbit

What is in this Session?

- Integrity Monitoring of IGS Products *Zumberge, Plag*
- GNSS Integrity Concept *Lobert*
- Products Produced Under Direction of AC Coordinator: Processes, Accuracies, Quality Control *Gendt*
- The Use and Integrity Monitoring of IGS Products at Geoscience Australia *Govind et al.*
- Discussion

What is in this Session (posters)?

- Ultra Rapid Satellite Clocks – Modelling and Comparisons
  Broderbauer, Weber
- On the Use of Zero Difference Residuals for the Quality Assessment of GPS Permanent Stations *van der Marel, Gundlich*
- First Measurements of Kazerun Fault GPS Network
  Nankali, Walpersdorf, Hatzfeld
- Routinely GPS Data Quality Check at GFZ-Potsdam *Ramatschi, Galas*

STATENS KARTVERK

How Does This Fit in With IGS's Strategic Plan?

- Strategy 1: Ensure delivery of "world-standard" GPS (and other GNSS) data and products, providing the standards and specifications globally.
  - Maintain and improve … data, products
  - Promote IGS … to current and potential users …
    - …
    - Devote attention to user needs…
    - …
  - …
- Strategy 2: Pursue new opportunities for growth to improve the services and serve a broader range of users.
  - …
  - Pursue and develop implementation plans related to real-time…
- Strategy 3: Continuously improve the effectiveness of the IGS organization.

Integrity Monitoring: theory

- Definitions:

Integrity is that quality which relates to the trust which can be placed in the correctness of the information supplied by the total system.

Integrity risk is the probability of an undetected failure of the specified accuracy.

Integrity includes the ability of a system to provide timely warnings to the user when the system should not be used for the intended operation.

Integrity Monitoring: theory, cont.

total system, intended operation: what is the application?

specified accuracy: what does this application require?

system monitoring: describe system performance with respect to specifications; normally a part of the system.

performance assessment: characterize system in terms of a relevant metric; characterization independent of the system.

Edit View Go Bookmarks Tools Window Help
http://igscb/components/prods.html Go Search
Mail Home Radio Netscape Search Bookmarks Instant Message WebMail Contact People Yellow Pages Download Channels Re
IGS Products

IGS Product Table [GPS Broadcast values included for comparison]

		Accuracy	Latency	Updates	Sample Interval	Archive locations
GPS Satellite Ephemerides/ Satellite & Station Clocks						
Broadcast	orbits	~200 cm	real time	--	daily	CDDIS(US-MD) SOPAC(US-CA) IGN(FR)
	Sat. clocks	~7 ns				
Ultra-Rapid (predicted half)	orbits	~10 cm	real time	twice daily	15 min	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	Sat. clocks	~5 ns				
Ultra-Rapid (observed half)	orbits	<5 cm	3 hours	twice daily	15 min	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	Sat. clocks	~0.2 ns				
Rapid	orbits	<5 cm	17 hours	daily	15 min	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	Sat. & Stn. clocks	0.1 ns			5 min	
Final	orbits	<5 cm	~13 days	weekly	15 min	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	Sat. & Stn. clocks	<0.1 ns			5 min	

Note 1: IGS accuracy limits, except for predicted orbits, based on comparisons with independent laser ranging results. The precision is better.
Note 2: The accuracy of all clocks is expressed relative to the IGS timescale, which is linearly aligned to GPS time in one-day segments.

Document: Done (0.451 secs)

Edit View Go Bookmarks Tools Window Help
http://igscb/components/prods.html Go Search
Mail Home Radio Netscape Search Bookmarks Instant Message WebMail Contact People Yellow Pages Download Channels Re
IGS Products

GLONASS Satellite Ephemerides						
Final		30 cm	~4 weeks	weekly	15 min	CDDIS(US-MD)
Geocentric Coordinates of IGS Tracking Stations (>130 sites)						
Final positions	horizontal	3 mm	12 days	weekly	weekly	CDDIS(US-MD) SOPAC(US-CA) IGN(FR)
	vertical	6 mm				
Final velocities	horizontal	2 mm/yr	12 days	weekly	weekly	CDDIS(US-MD) SOPAC(US-CA) IGN(FR)
	vertical	3 mm/yr				
Earth Rotation Parameters: Polar Motion (PM) Polar Motion Rates (PM rate) Length-of-day (LOD)						
Ultra-Rapid (predicted half)	PM	0.3 mas	real time	twice daily	twice daily (00 & 12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	0.5 mas/day				
	LOD	0.06 ms				
Ultra-Rapid (observed half)	PM	0.1 mas	3 hours	twice daily	twice daily (00 & 12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	0.3 mas/day				
	LOD	0.03 ms				
Rapid	PM	<0.1 mas	17 hours	daily	daily (12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	<0.2 mas/day				
	LOD	0.03 ms				

Document: Done (0.451 secs)

Edit View Go Bookmarks Tools Window Help
http://igscb/components/prods.html
Go Search
Mail Home Radio Netscape Search Bookmarks Instant Message WebMail Contact People Yellow Pages Download Channels Re
IGS Products

Earth Rotation Parameters: Polar Motion (PM) Polar Motion Rates (PM rate) Length-of-day (LOD)						
Ultra-Rapid (predicted half)	PM	0.3 mas	real time	twice daily	twice daily (00 & 12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	0.5 mas/day				
	LOD	0.06 ms				
Ultra-Rapid (observed half)	PM	0.1 mas	3 hours	twice daily	twice daily (00 & 12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	0.3 mas/day				
	LOD	0.03 ms				
Rapid	PM	<0.1 mas	17 hours	daily	daily (12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	<0.2 mas/day				
	LOD	0.03 ms				
Final	PM	0.05 mas	~13 days	weekly	daily (12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	<0.2 mas/day				
	LOD	0.02 ms				
Note: The IGS uses VLBI results from IERS Bulletin A to calibrate for long-term LOD biases.						
Atmospheric Parameters						
Final tropospheric zenith path delay		4 mm	< 4 weeks	weekly	2 hours	CDDIS(US-MD) SOPAC(US-CA) IGN(FR)

Document: Done (0.451 secs)

	LOD	0.03 ms				IGS CB(US-CA)
Final	PM	0.05 mas	~13 days	weekly	daily (12 UTC)	CDDIS(US-MD) SOPAC(US-CA) IGN(FR) IGS CB(US-CA)
	PM rate	<0.2 mas/day				
	LOD	0.02 ms				
Note: The IGS uses VLBI results from IERS Bulletin A to calibrate for long-term LOD biases.						
Atmospheric Parameters						
Final tropospheric zenith path delay		4 mm	< 4 weeks	weekly	2 hours	CDDIS(US-MD) SOPAC(US-CA) IGN(FR)
Ultra-Rapid tropospheric zenith path delay		6 mm	2-3 hours	every 3 hours	1 hour	CDDIS(US-MD)
Ionospheric TEC grid		2-8 TECU	~11 days	weekly	2 hours; 5 deg (lon) x 2.5 deg (lat)	CDDIS(US-MD) IGN(FR)
Rapid ionosphere products		(under development)				

View all current products on the product availability page, or view the traditional product summaries for the CB and the Global Data Centers: CDDIS, IGN and SIO.

This page last updated: **21 Nov 2003**
Please send comments about this website to: IGS Central Bureau.

Which products require Integrity Monitoring?

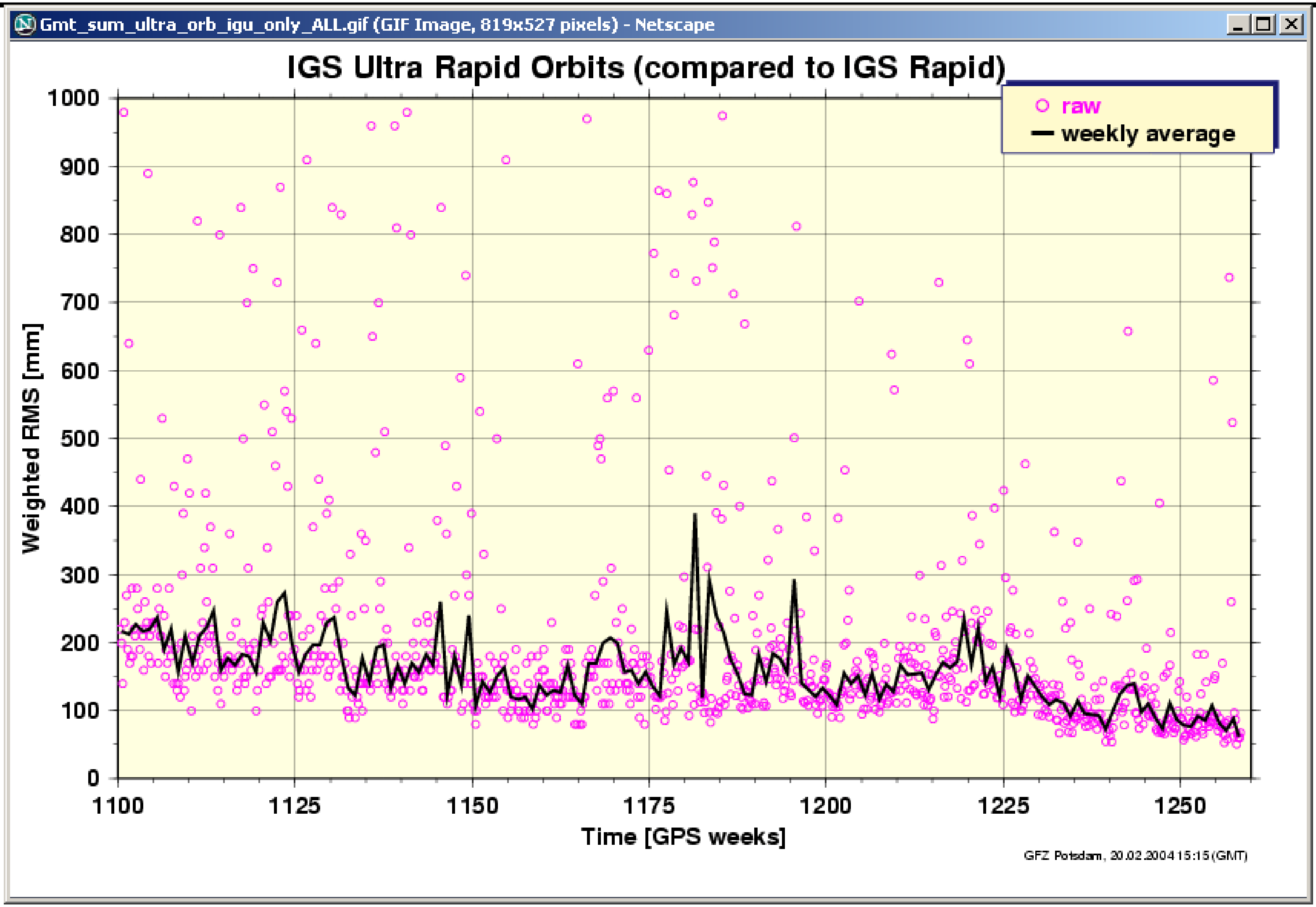
- All IGS products are subject to quality control
- What is difference between QC and IM?
  - IM generally implies a real-time application
- From the PP: *Even if the system is unable to provide timely warnings to the user when the system should not be used for the intended operation, it may be that the integrity risk, as defined in Section 2, is low. That is, even without integrity monitoring the system works well enough often enough. Or, the consequences of an undetected failure at a certain rate are acceptable. Thus assessing the value of integrity monitoring for a given product and application is important.*

User Survey (IGS mail 4756):

- particular IGS product(s) used (refer to http://igscb.jpl.nasa.gov/components/prods.html if you like);
- quality control measures you have implemented (or indicate none if that is the case);
- how you use the IGS product(s) (optional);
- any comments you have based on your experience as a user.

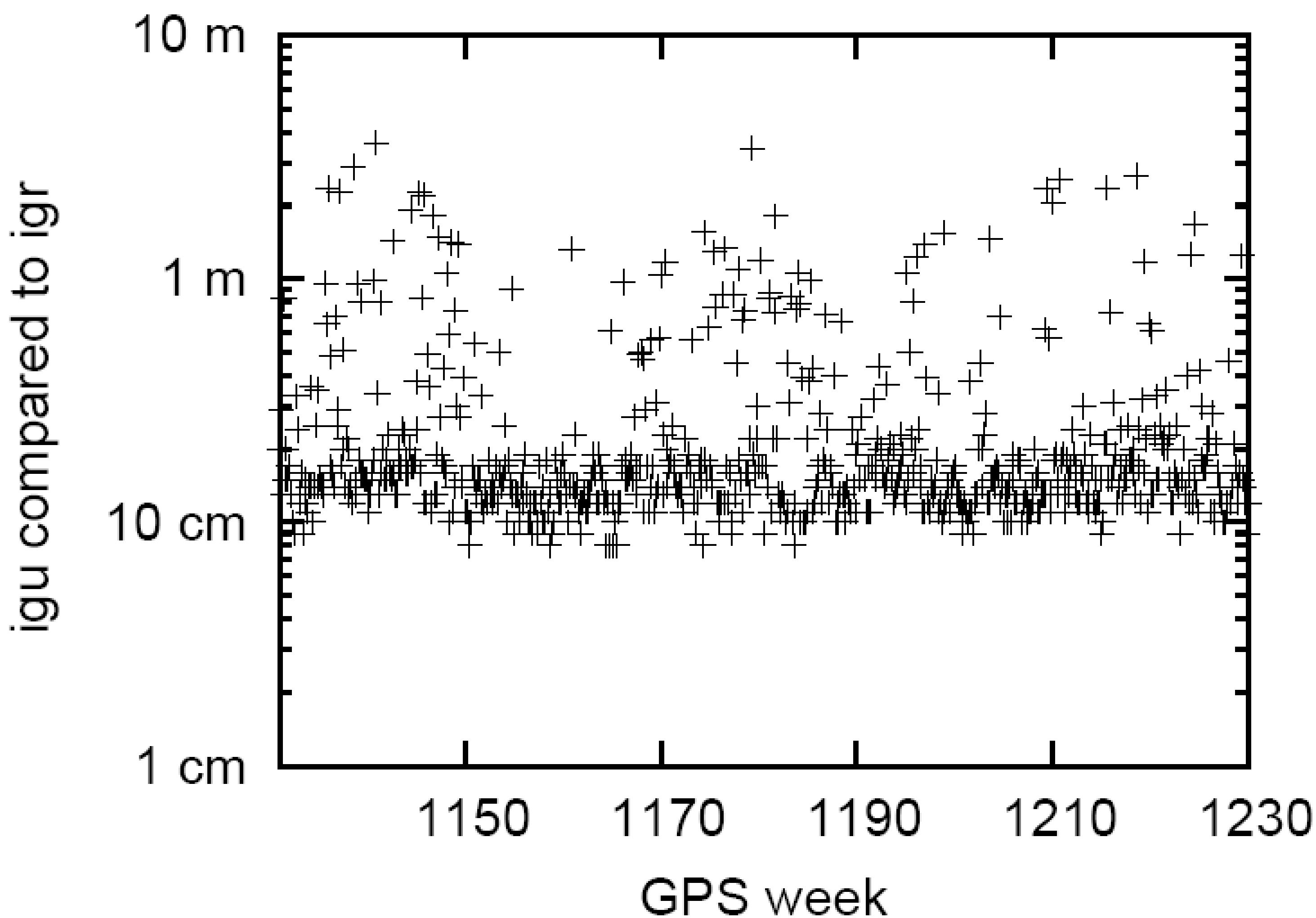
User Survey (IGS mail 4756):

- 26 responses, mix of products, applications, organizations
- Lots of praise; e.g. “I pray for their continued availability”;
- Some user-implemented QC/IM, maybe 50%
- Comments on ultra rapid: need more satellites and better quality flags
- ION GNSS Meeting, Sep 2004, Long Beach, CA: IGS User Forum


Gmt_sum_ultra_orb_igu_only_ALL.gif (GIF Image, 819x527 pixels) - Netscape
IGS Ultra Rapid Orbits (compared to IGS Rapid)
raw
weekly average
Weighted RMS [mm]
1000
900
800
700
600
500
400
300
200
100
0
1100
1125
1150
1175
1200
1225
1250
Time [GPS weeks]
GFZ Potsdam, 20.02.2004 15:15 (GMT)

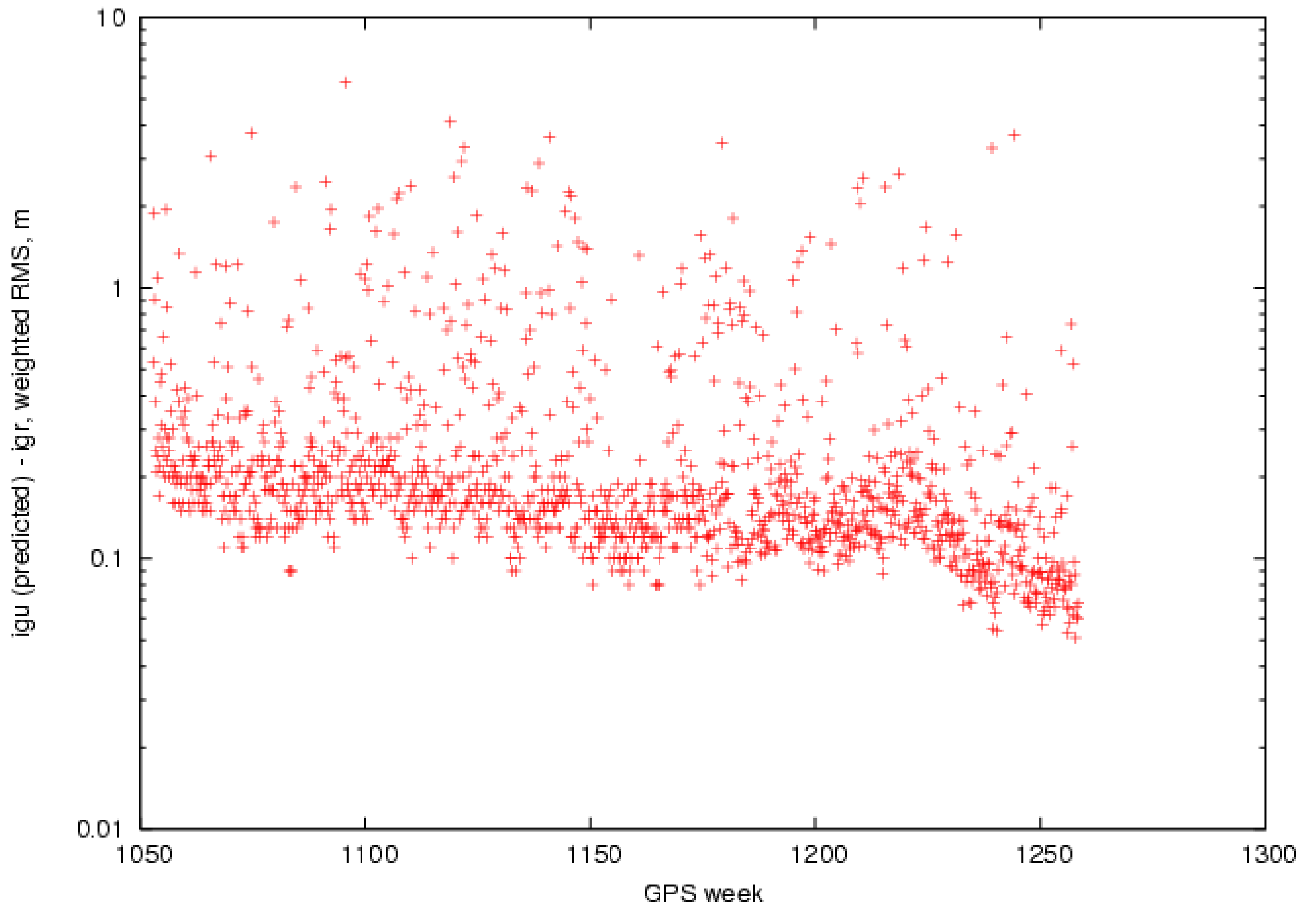
le Edit View Document Tools Advanced Window Help
Open Save Print Email Search Create PDF Review & Comment Secure Sign
Select Text 100%
How To..?

ure 1: Daily RMS differences – over satellites and the day – between Ultra rapid and rapid orbits
ess the outliers are flagged with appropriate codes in the sp3c file, points with large differences ar
lematic and would benefit from integrity monitoring.



11 x 8.5 in
5 of 8

STATENS KARTVERK



Questions:

- Integrity monitoring of IGS products inextricably tied to the application
- For a given IGS product, are users' applications sufficiently similarly to warrant integrity monitoring by IGS?
- Should integrity monitoring or additional QC be left up to the user?
- What IGS products warrant implementation of integrity monitoring?