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Global Products for GPS Point Positioning Approaching Real-Time

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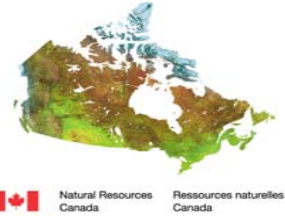
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Outline

- **Precise Point Positioning (PPP) Using Precise Orbit/Clock Products**
 - **Advantages and Challenges**
- **Review Current GPS Products Enabling PPP**
- **Global Point Positioning Possibilities**
 - **What's available to users now**
- **Correction Precision: The Network Difference**
- **Real-Time User Application Testing**
- **Recommendations**



Precise Point Positioning (PPP) Using Precise Orbit/Clock Products

Advantages

- Processes undifferenced code and carrier observations
- Estimates epoch position, clock, and tropospheric delay
- Supports users operating in static and kinematic modes
- Applies globally
- Connects directly to the satellite reference frame
- cm ~ dm accuracy without the need for base stations
- Increases flexibility for field operations, reduces labor and equipment cost, simplifies operational logistics

Challenges

- Availability of timely accurate satellite orbits and clocks
- Faster phase bias convergence algorithms (wrt local RTK)



GPS Products Enabling PPP



POST-MISSION

Source	Accuracy	Latency	Update	Interval	Format	Access
	Orbit Clock (cm) (ns)			Orbit clock	Orbit clock	

Final	2	0.05	13 days	Weekly	15 min 5 min	SP3 RNX	FTP
Rapid	3	0.1	17 hours	Daily	15 min 5 min	SP3 RNX	FTP
UltraEST	5	0.2	3 hours	12 hr	15 min 15 min	SP3 SP3	FTP

REAL-TIME

IGDG (Global)	10	0.2	4.5 sec	1 sec	29 sec 1 sec	JPL Design	UDP
GPSC (Regional)	10	0.5	3-5 sec	2 sec	20 sec 2 sec	MRTCA	Radio UDP



Point Positioning Options

POST-MISSION/
PUBLIC
REAL-TIME/
COMMERCIAL

Service	Model	User Data	Correction Products	User Dynamics	Processed Frequency	Access
SCOUT	DD	RNX	Orbit/Network	Static	Dual	Internet
OPUS	DD	RNX	Orbit/Network	Static	Dual	Internet
AUSPOS	DD	RNX	Orbit/Network	Static	Dual	Internet
Auto-Gipsy	PPP	RNX	Orbit/Clock	Static	Dual	E-mail
CSRS-PPP	PPP	RNX	Orbit/Clock/GIM	Static/ Kinematic	Dual/ Single	Internet
SkyFix	PPP	Proprietary	Proprietary	Static/ Kinematic	Dual	SatCom
StarFire	PPP	Proprietary	JPL IGDG	Static/ Kinematic	Dual	SatCom



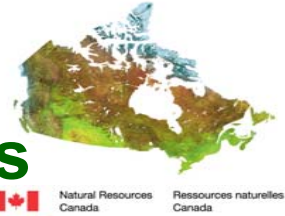
Correction Precision: The Network Difference

GPS*C Application Input					User PPP RMS (February 1-7, 2004)		
Network	Data Availability	Data Source	Orbit	Satellite Clock Estimates	LAT (cm)	LON (cm)	HGT (cm)
Regional (code)	Real-Time	RT-CACS	Ultra	Code (Carrier filtered)	29	26	38
Regional (carrier)	Real-Time	RT-CACS	Ultra	Code & Carrier	11	12	22
Global (carrier)	15 minutes	IGS-LEO RT-IGS	Ultra	Code & Carrier	5	6	10
Global (combined)	Daily	IGS	IGR	Code & Carrier	3	4	9



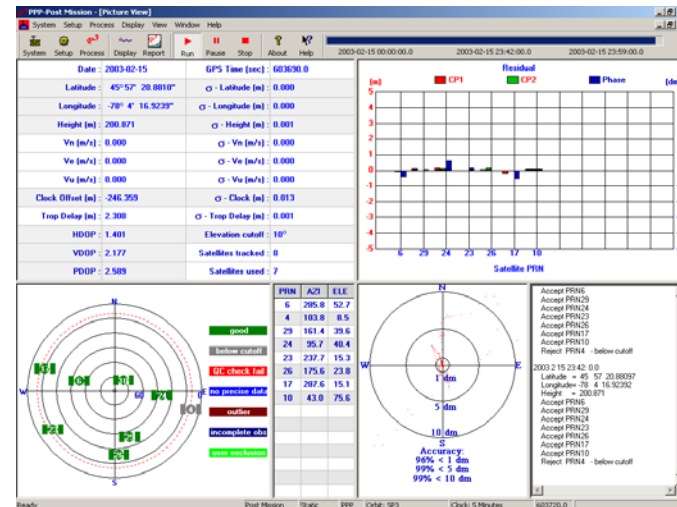
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P³ – A Software Package for PPP Users



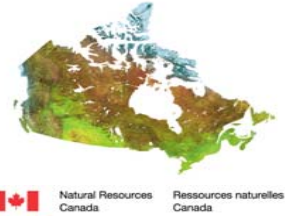
Features

- Undifferenced code/carrier processing
- Different observation model implementations
- Precise tropospheric delay and receiver clock estimation
- Static and kinematic positioning
- Forward and backward data processing
- Post-mission PPP using IGS Precise ephemeris and clock products
- Real-time PPP using JPL and NRCAN real-time precise orbit/clock products
- Easy-to-use interface
- On-line view of processing results
- Various utilities

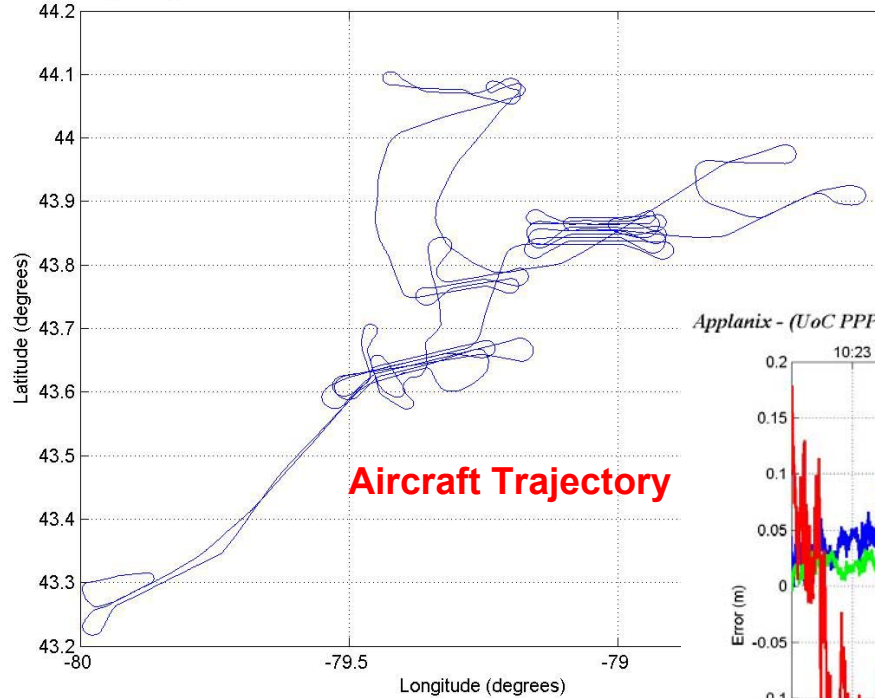




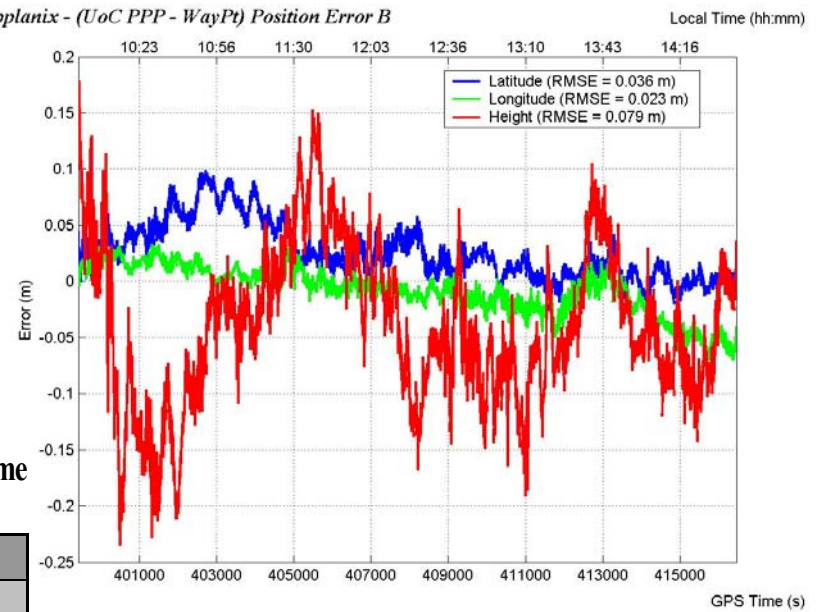
Real-Time User Application Testing



Applanix - Trajectory



Applanix - (UoC PPP - WayPt) Position Error B



P³™ Backward Pass Position Error Statistics Using JPL Real-Time Corrections

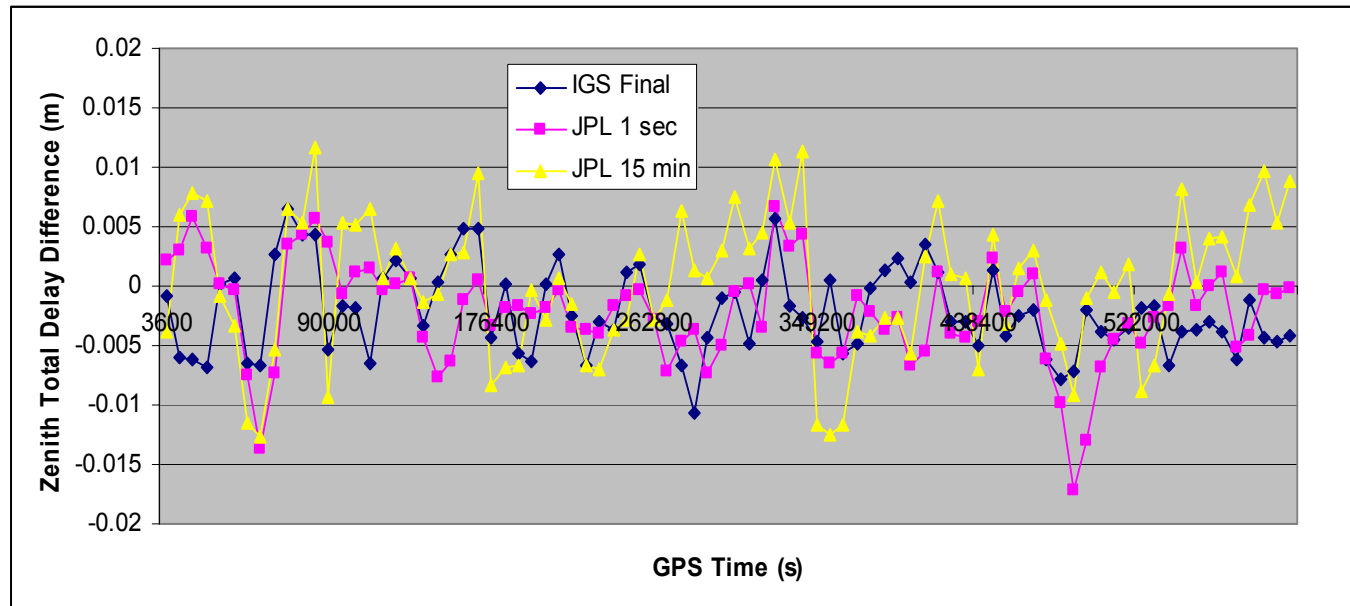
	Position Errors		
	Latitude (cm)	Longitude (cm)	Height (cm)
Mean	2.6	-0.8	-3.9
Std. Dev.	2.5	2.1	6.9
RMSE	3.6	2.3	7.9



Real-Time User Application Testing



Zenith Total Delay Differences wrt IGS Final Tropospheric Products (GPS Week 1251)



Precise Products	RMS (m)	Mean (m)
IGS Final	0.0041	-0.0020
JPL RT 1 sec	0.0052	-0.0022
JPL RT 15 min	0.0059	0.0001



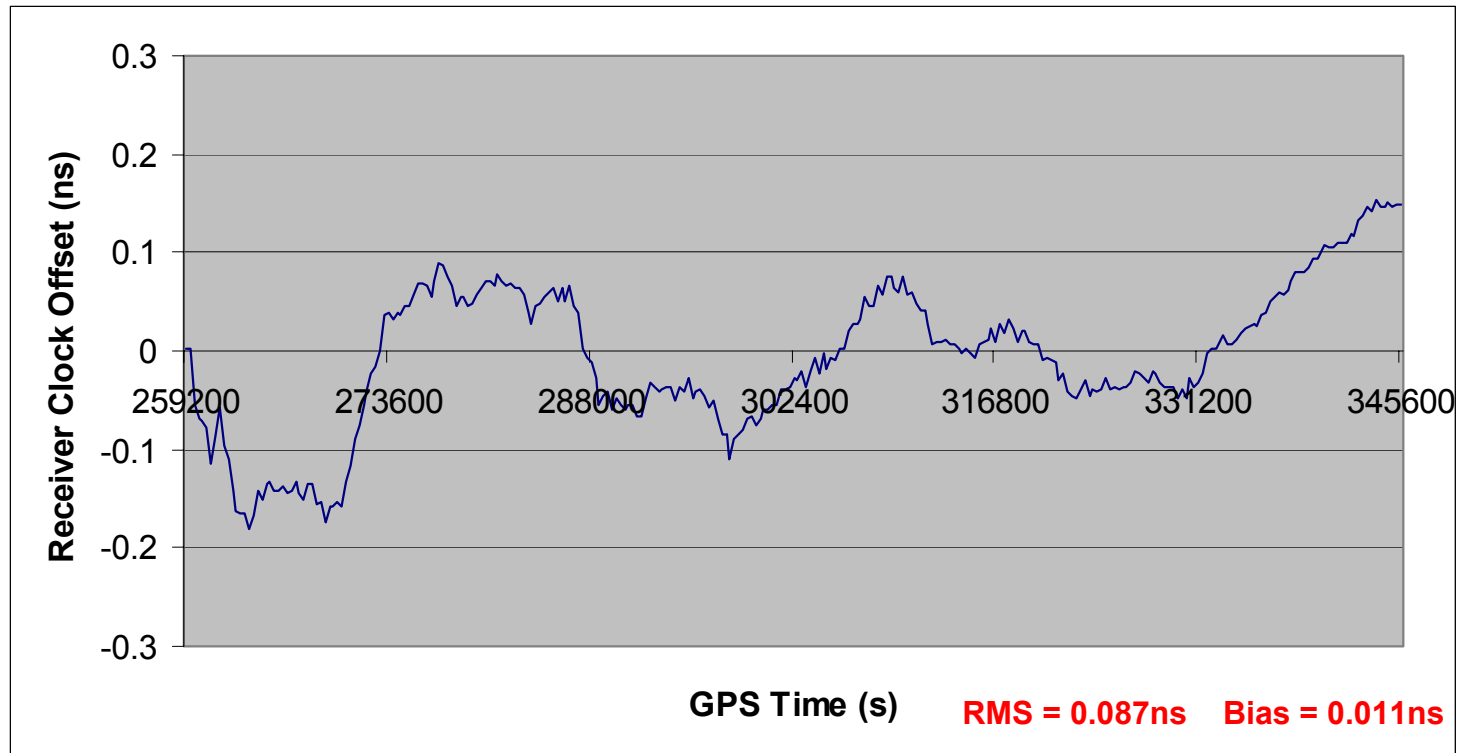
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Real-Time User Application Testing

**IGS Station AMC2 Clock Estimation Using JPL RT 15 min
Orbit/Clock Corrections (Dec 31, 2003)**





RECOMMENDATIONS

Global GPS Network

- Real-Time access to tracking station data

Global GPS Products

- Ultra clocks at 5-minute interval to allow more timely post-mission PPP using high-rate GPS data.
- Standard correction format for real-time orbit/clock corrections
- Standard protocol for Internet distribution

PPP Users

- Fast phase bias convergence algorithms for undifferenced processing (IAG SC4.5 "Next Generation RTK")
- Receiver independent real-time PPP applications
- Standard serial format for orbit/clock correction input to GPS receiver.



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