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Precise GNSS Positioning for Mass-Market Applications

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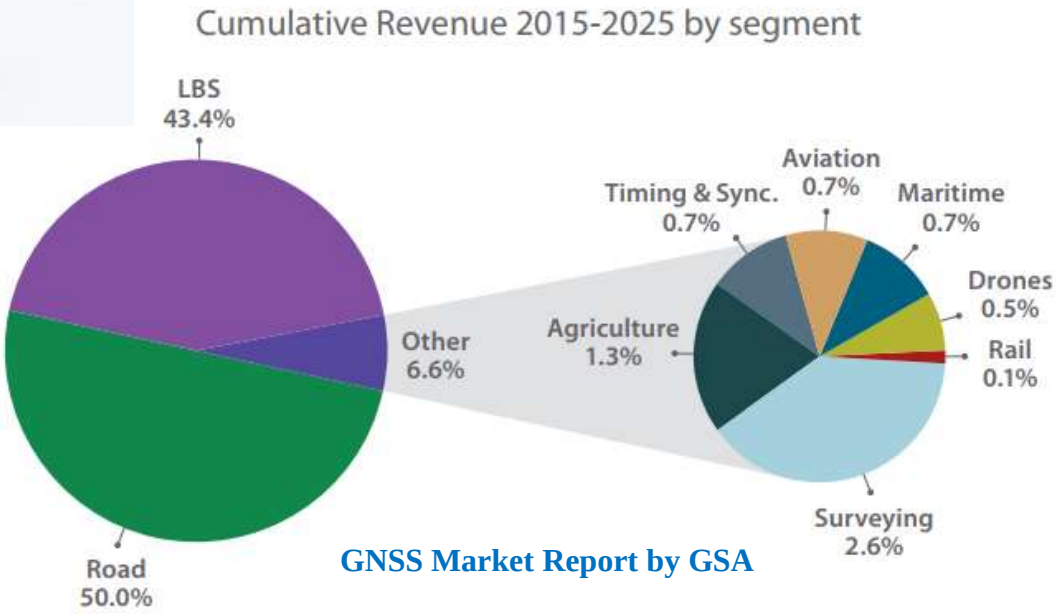
- **Why "Precise GNSS Positioning" for mass-market applications?**
- **Current "Precise GNSS Positioning" techniques**
- **Mass-market application requirements and challenges**
- **Innovation areas and some recent efforts**
- **Summary**

Why "Precise GNSS Positioning" for mass-market applications?

- Self-driving cars: require up to cm accuracy for driving assistance/automation
- UAV: requires precise location info to fly in challenging environments
- LBS: precision increases values of services
- .....



GNSS Market Report by GSA

Current "Precise GNSS Positioning" techniques

RTK

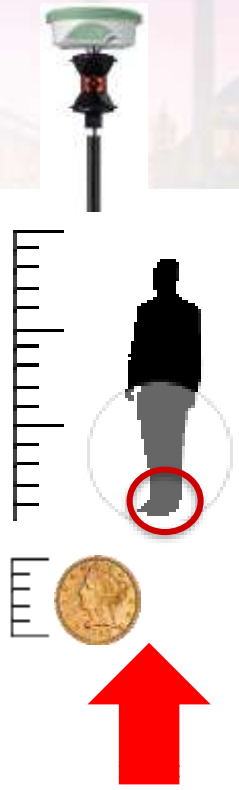
Network RTK

SBAS

PPP

Augmentation Msg

- Orbit corrections
- Clock corrections
- Atmospheric corrections
- Phase bias corrections
- …



Able to provide real-time sub-m to cm accuracy!

Mass-market application requireemnts and challenges

Small, light and low-cost system, continuous and valid positioning solution...

Challenges

- **Equipment:** they are using low-cost receivers: higher noise level, sensitive to dynamics, frequent cycle slips, biases in mesurmeents
- **Environment:** they are operating in challenging signal environments: poor visibility, multipath, loss of corrections
- **Positioning Technology:** RTK is limited by coverage/cost and PPP suffers slow convergence for mass-market applications
- **Correction Service:** high update rate of corrections and cost are obstacles for mass-market applications

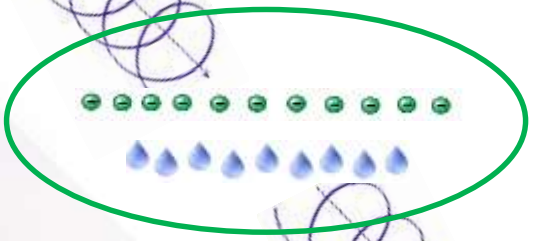
Innovation areas and some recent efforts

GNSS

New NAV Msg

New Augmentation Msg

New atmospheric augmentation



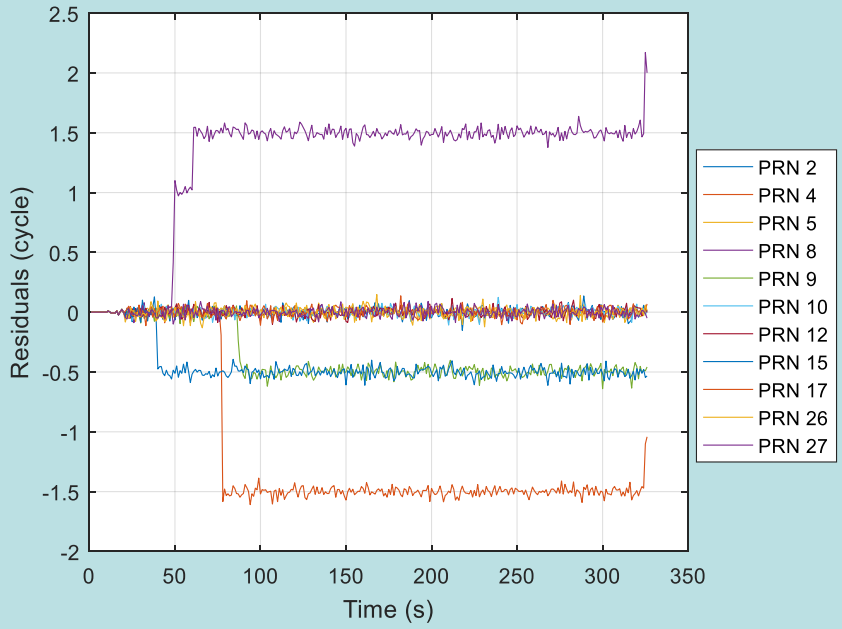
New positioning algorithms, low-cost receiver design

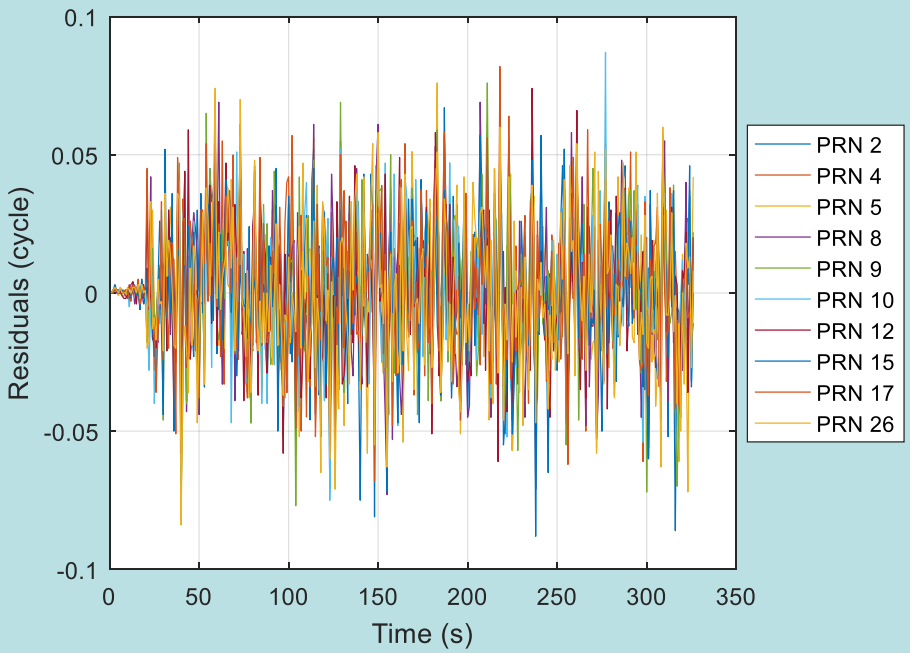
Augmentation Msg

New low-cost receiver signal tracking architecture

- Carrier phase measurements are limited by antenna, oscillator quality and tracking algorithms, resulting in higher noise level, more cycle slips, high sensitivity to dynamics.
- An adaptive joint vector architecture is proposed to improve tracking performance with low-cost oscillators and high dynamics.

Scalar PLL v.s. Joint VPLL

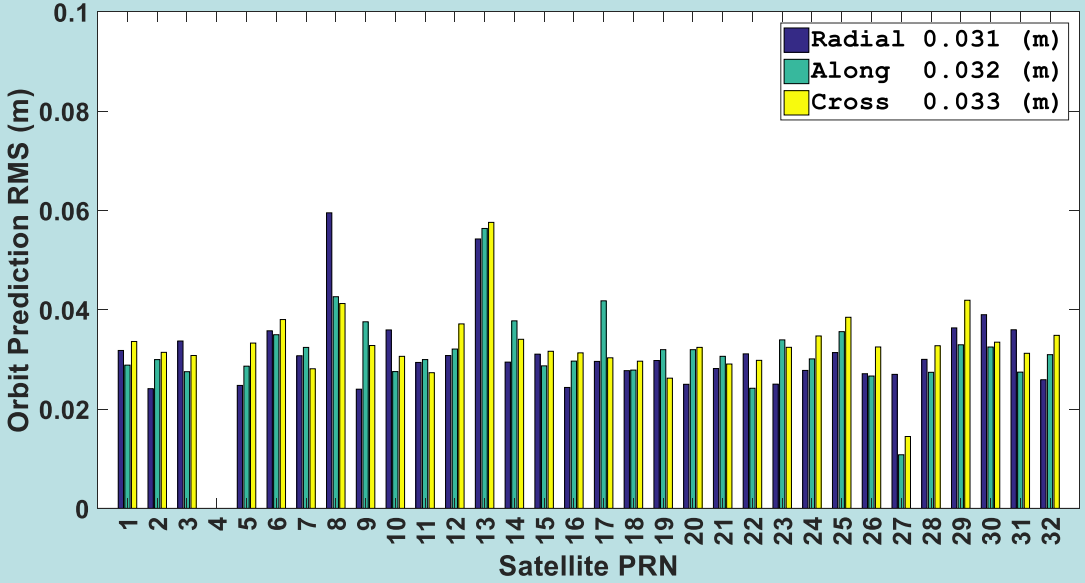




Scalable update rate for correction service

- Reducing the updata rate of corrections
- Transmission of Initial Parameters to allow scalable update rate of correction srvice
- Mitigating loss of corrections, reducing correction service cost, increasing availability, enhancing system robustness

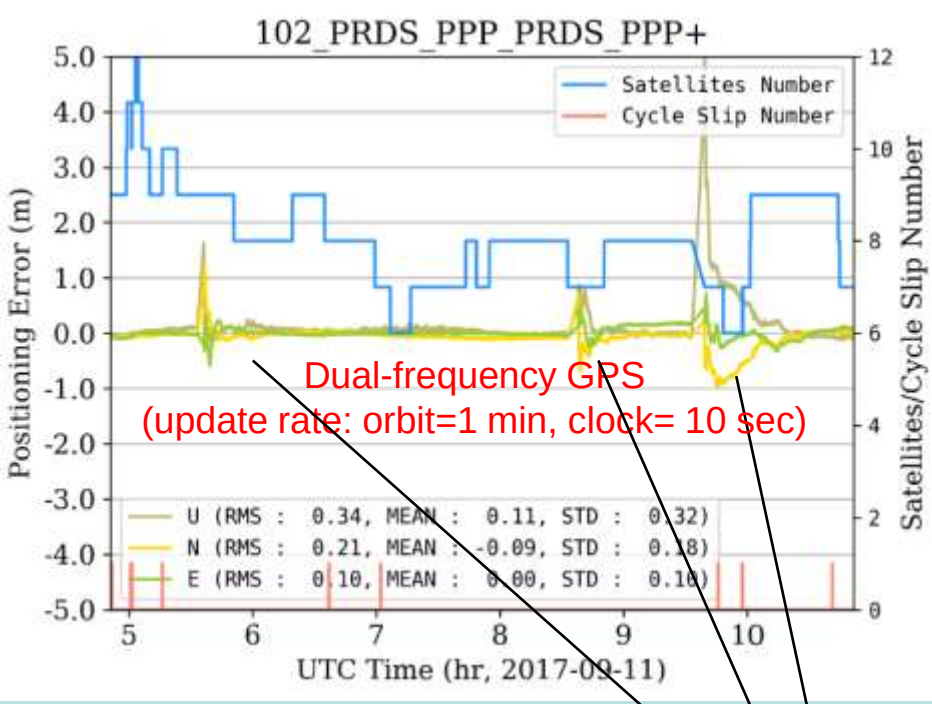
Satellite orbit correction RMS (m)

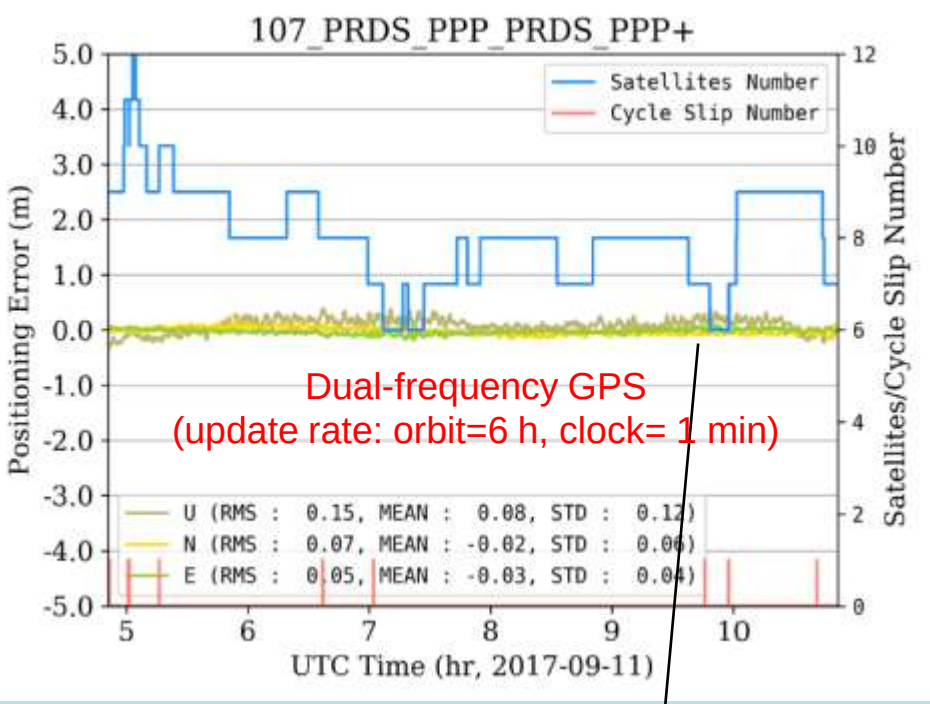


Satellite clock correction RMS (ns)

	1 hour	3 hours	6 hours
IIR/Rb	0.41	0.47	0.62
IIR-M/Rb	0.35	0.42	0.61
IIF/Rb	0.24	0.39	0.60
IIF/Cs	1.12	1.25	1.83

Scalable update rate for correction service





Dual-frequency GPS
(update rate: orbit=1 min, clock= 10 sec)

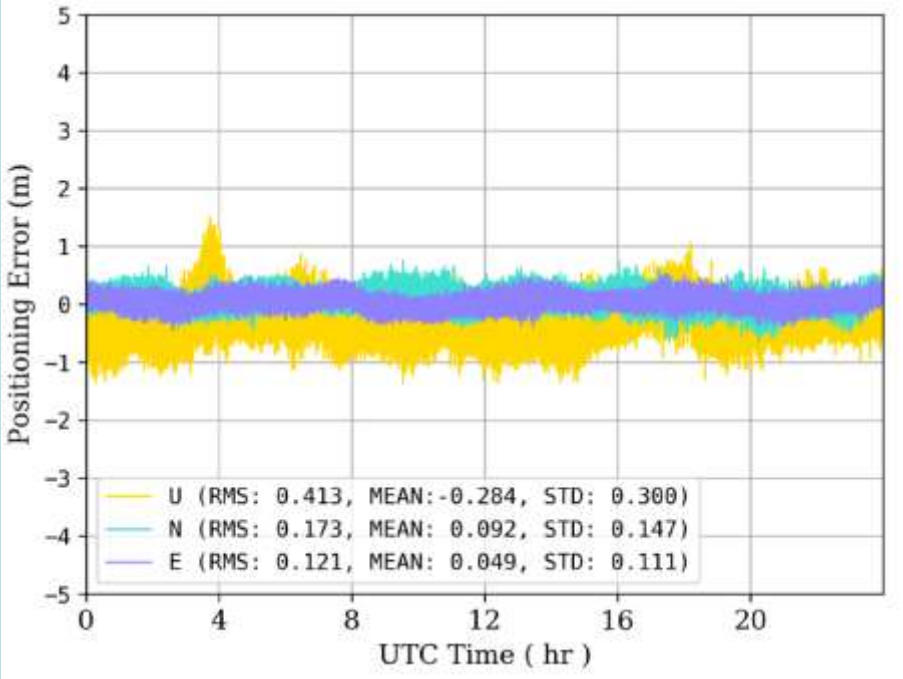
Dual-frequency GPS
(update rate: orbit=6 h, clock= 1 min)

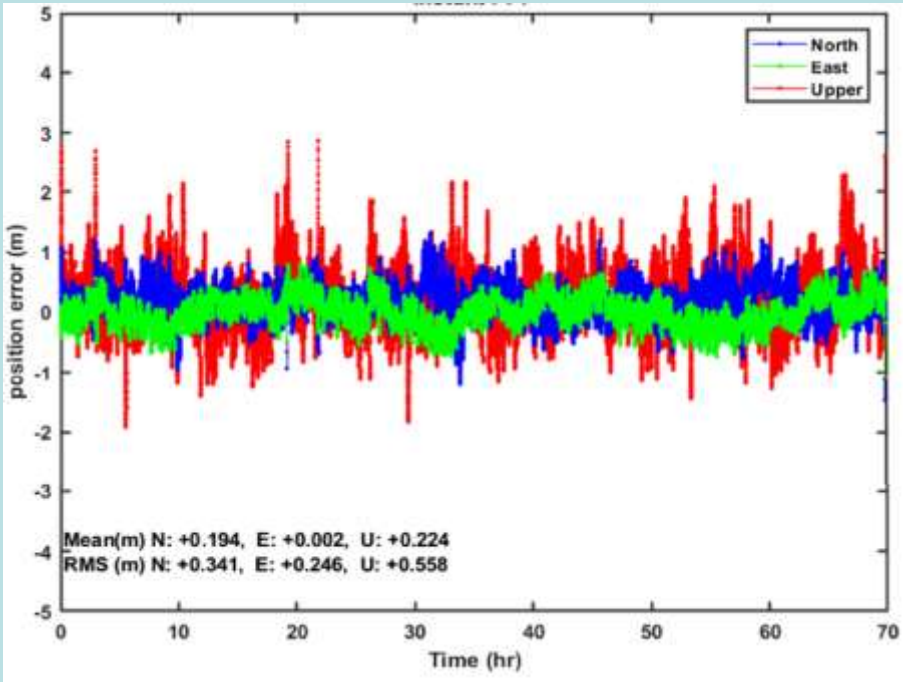
Re-convergence
use of high update rate corrections

Use of low update rate initial parameters

Fast PPP (no-convergence)

- New positioning algorithm development
- Fast precision availability with no convergence time
- Maximizing precision to meet mass-market application requirements





Summary

- There are significant demands for "precise GNSS positioning technology" to support mass-market applications
- All receivers including chipsets will output phase measurements, soon as an industry norm, which will affect future precision GNSS products and applications
- Mass-market applications require "precision" obtainable with low-cost receivers, low-cost correction services, and high availability/robustness
- Some solutions are proposed which require further studies towards product development