

Measurement Quality Monitoring for Low-Cost Small-Size Multi-Band Multi-System GNSS Receivers

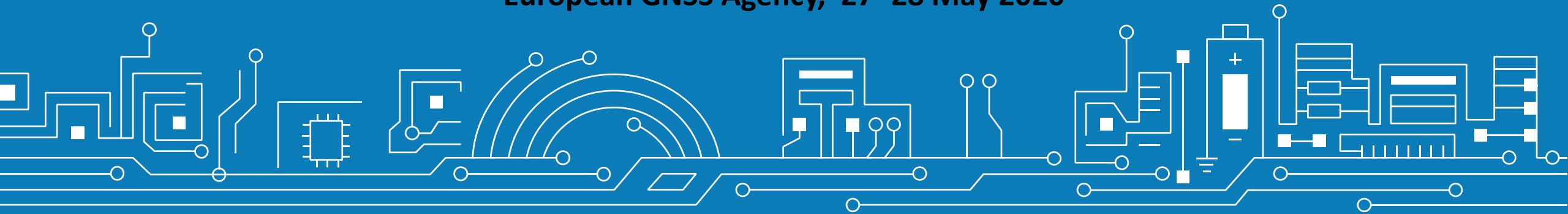
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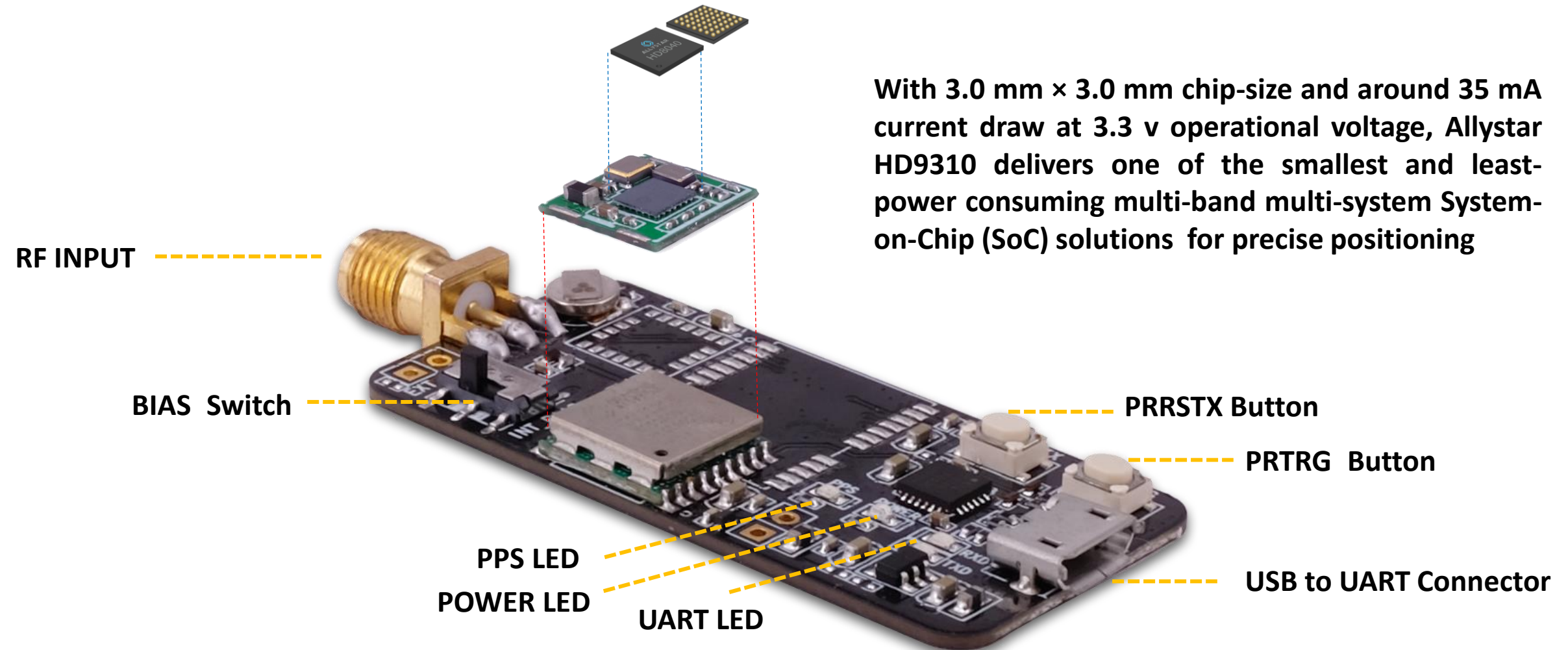
**4th Annual GNSS Raw Measurements Taskforce Workshop Online,
European GNSS Agency, 27- 28 May 2020**



- ❖ **Introduction:** Allystar Small-Size Low-Power Multi-Band Multi-System GNSS Solution
- ❖ **Allystar GNSS MQM (Measurement Quality Monitoring) Toolkit**
 - What is Allystar GNSS MQM Toolkit?
 - Raw Measurement Characterization
 - Noise & Multipath Monitoring and Smoothing
 - Cycle-Slip Detection & Validation
- ❖ **Summary and Future Work**

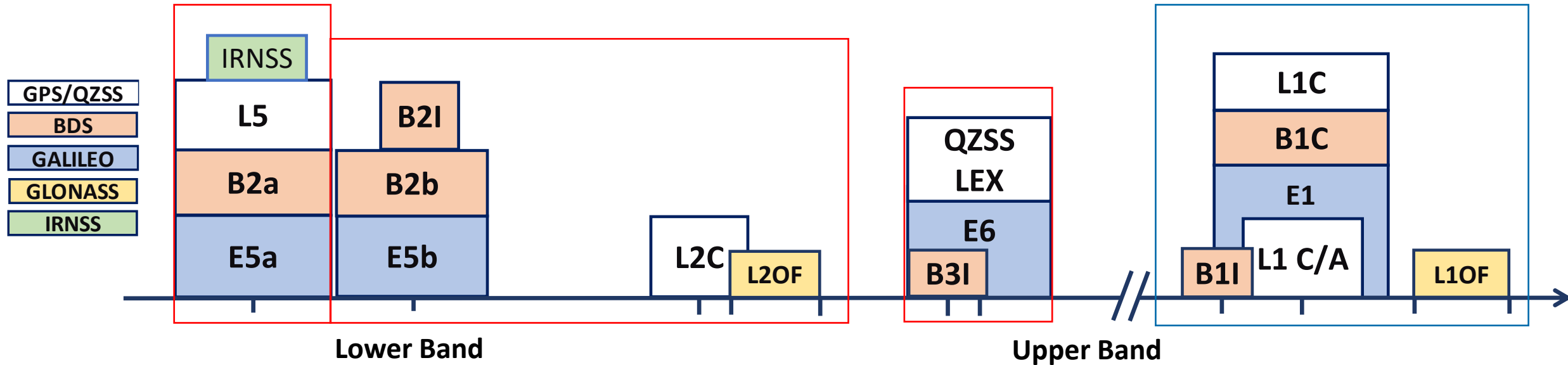
ALLYSTAR Multi-Band Multi-System Solution (1/2)

Evaluation Board



ALLYSTAR Multi-Band Multi-System Solution (2/2)

Dual band GNSS receiver to cover all constellations in all bands for different applications



[Option A] L5 band (standalone) : maximizes measurement accuracy and improve multipath mitigation

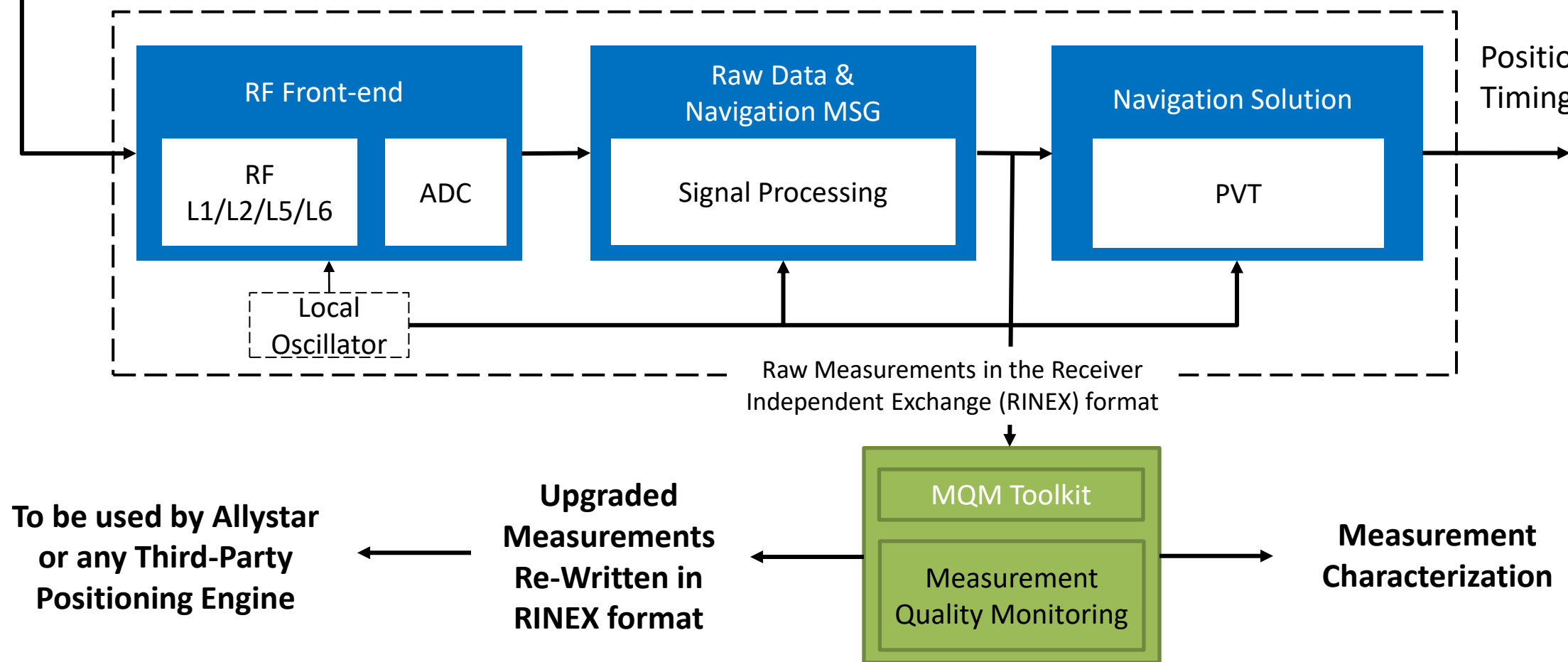
[Option B] L2 band (RTK) : Common Worldwide CORS supports GPS L1 / L2 & GLO L1 / L2

[Option C] L6 band (PPP) : SSR-type correction service

Receiver Antenna

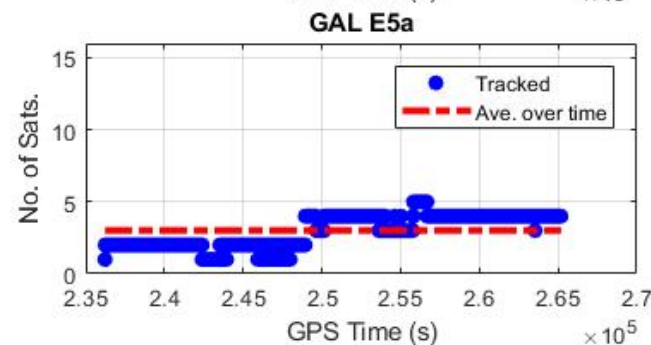
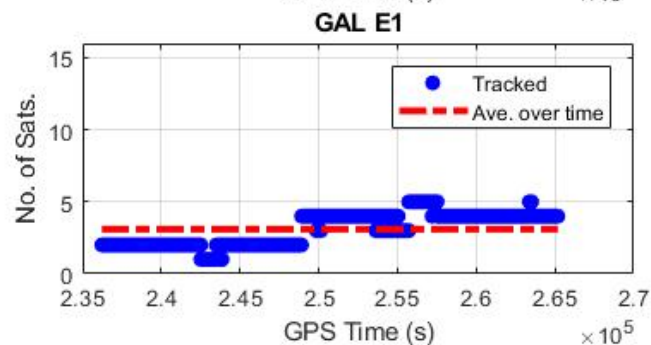
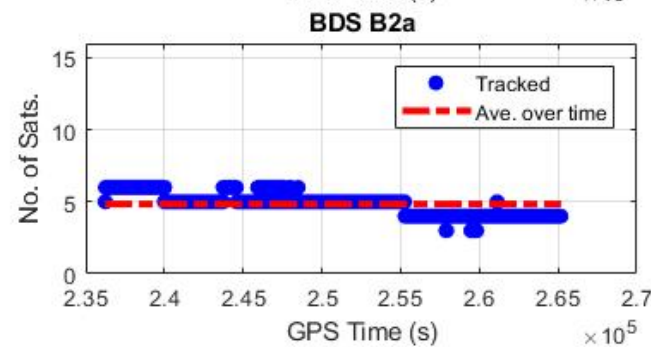
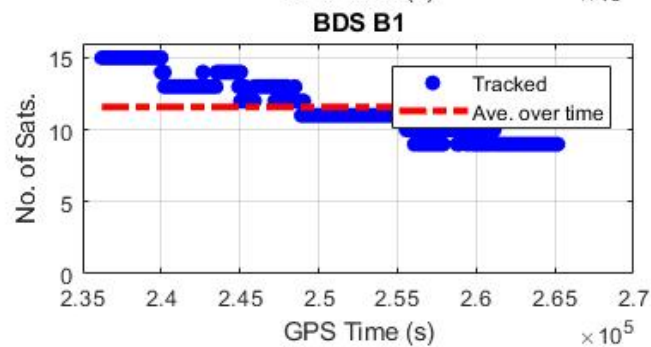
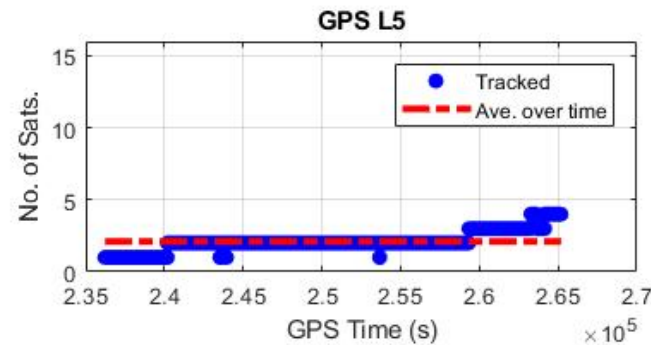
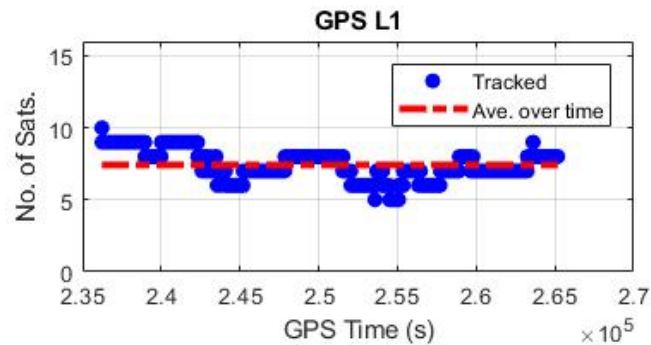
GNSS Receiver Architecture

Positioning & Timing Results



Raw Measurement Characterization (1/4)

Sample Results – No. of Satellites Tracked, Hong Kong - Static

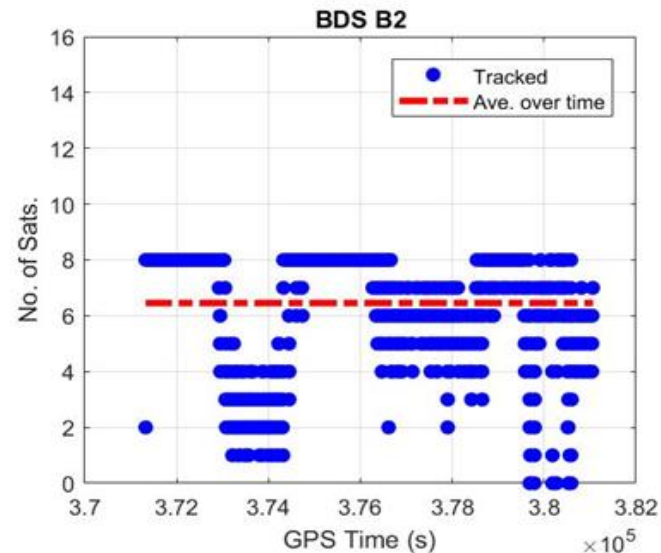
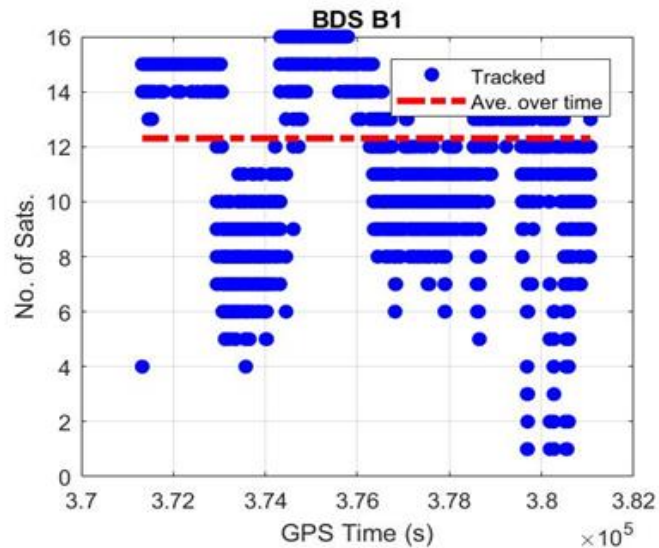
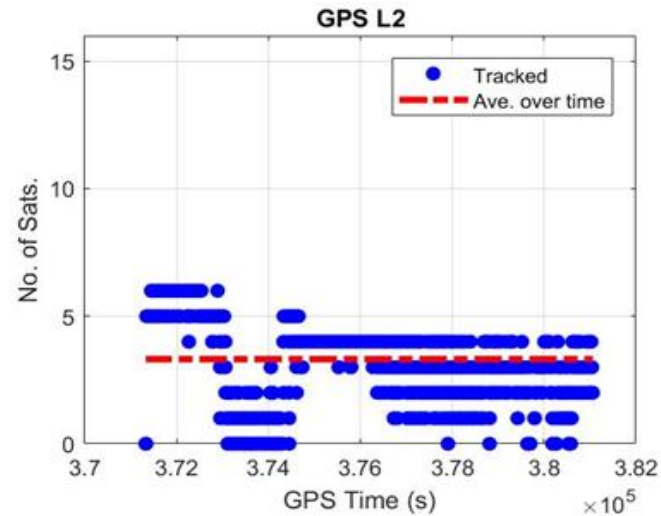
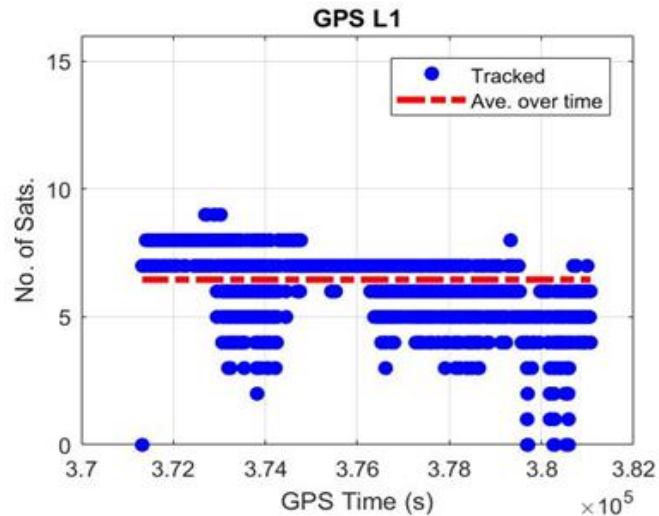


Number of Satellites Tracked			
SYS - FREQ	Mean Value*	SYS - FREQ	Mean Value*
GPS - L1	7.4	GPS - L5	2.1
BDS - B1	11.6	BDS - B2a	4.8
GAL - E1	3.1	GAL - E5a	3.0

*Averaged over time (all epochs)

Raw Measurement Characterization (2/4)

Sample Results – No. of Satellites Tracked, Beijing - Kinematic

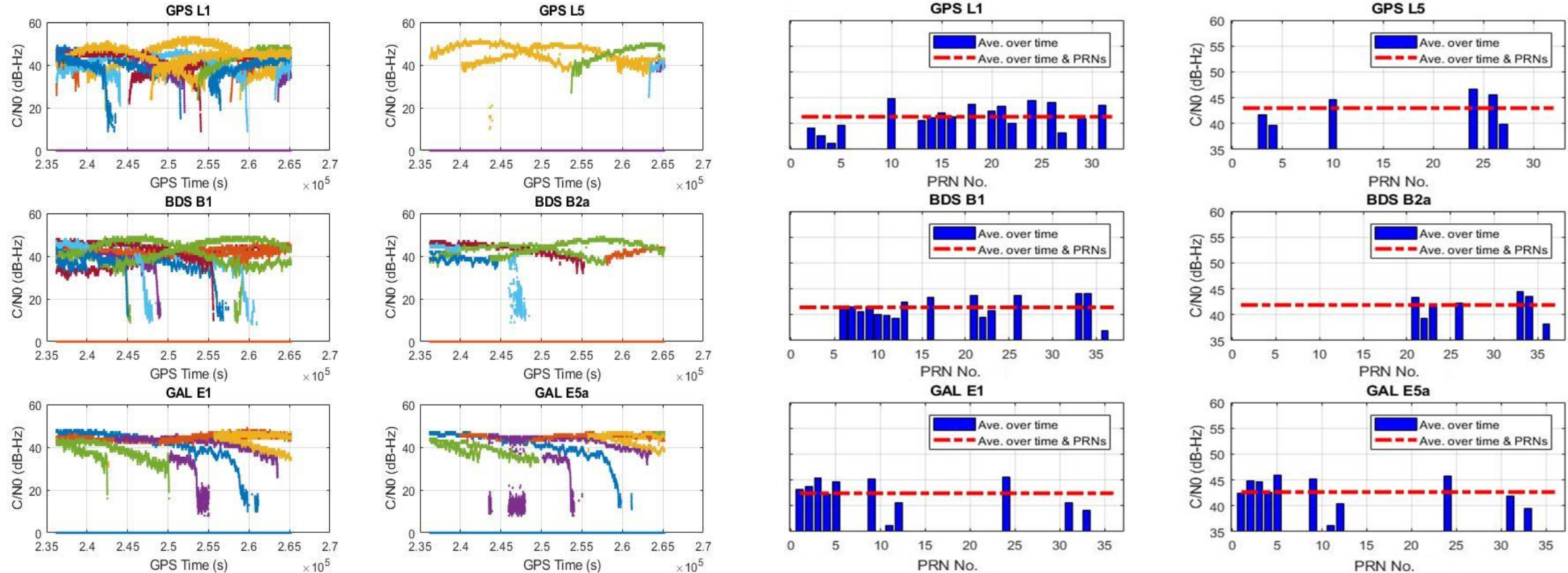


Number of Satellites Tracked			
SYS - FREQ	Mean Value*	SYS - FREQ	Mean Value*
GPS - L1	6.5	GPS - L2	3.3
BDS - B1	12.3	BDS - B2	6.5

*Averaged over time (all epochs)

Raw Measurement Characterization (3/4)

Sample Results – Signal Power, Hong Kong - Static Antenna

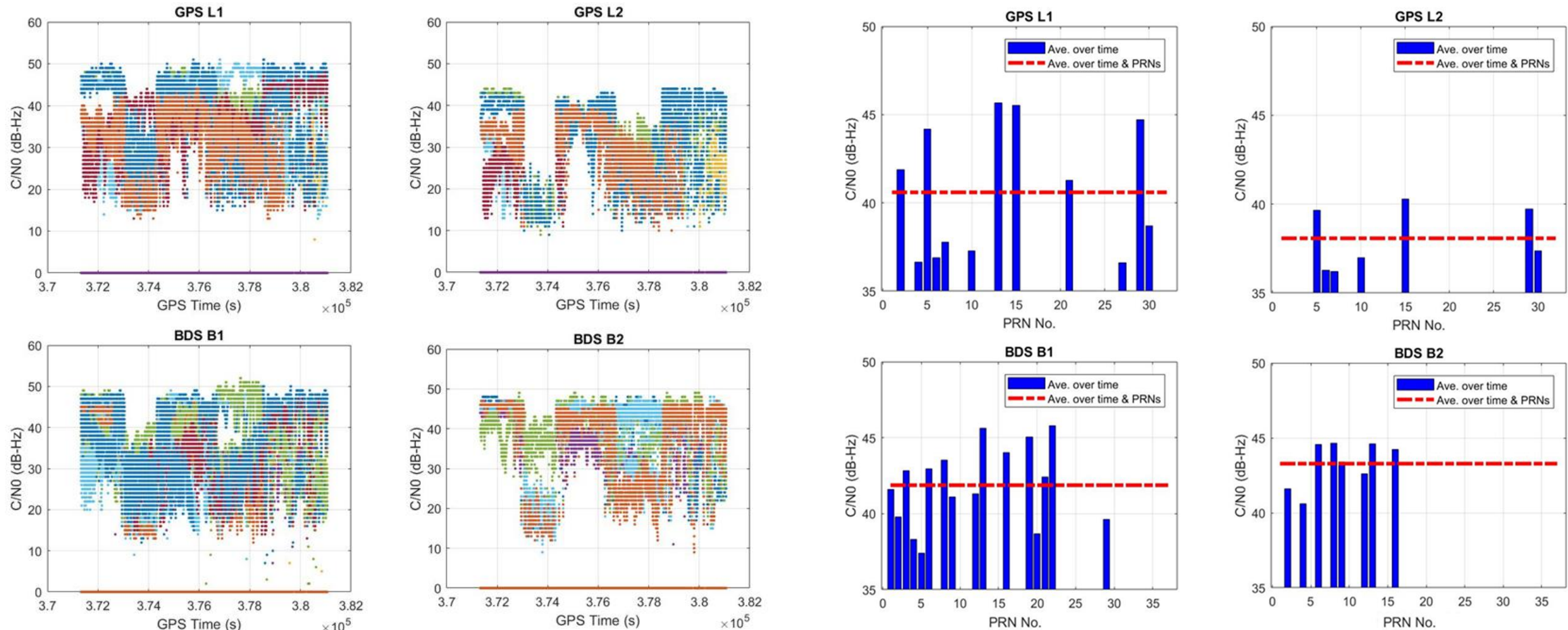


C/N0 (dB-Hz)			
SYS - FREQ	Ave. Value*	SYS - FREQ	Ave. Value*
GPS - L1	41.32	GPS - L5	43
BDS - B1	41.41	BDS - B2a	41.87
GAL - E1	42.42	GAL - E5a	42.66

*Averaged over time (all epochs) and all PRNs, for signal levels higher than 35 dB-Hz

Raw Measurement Characterization (4/4)

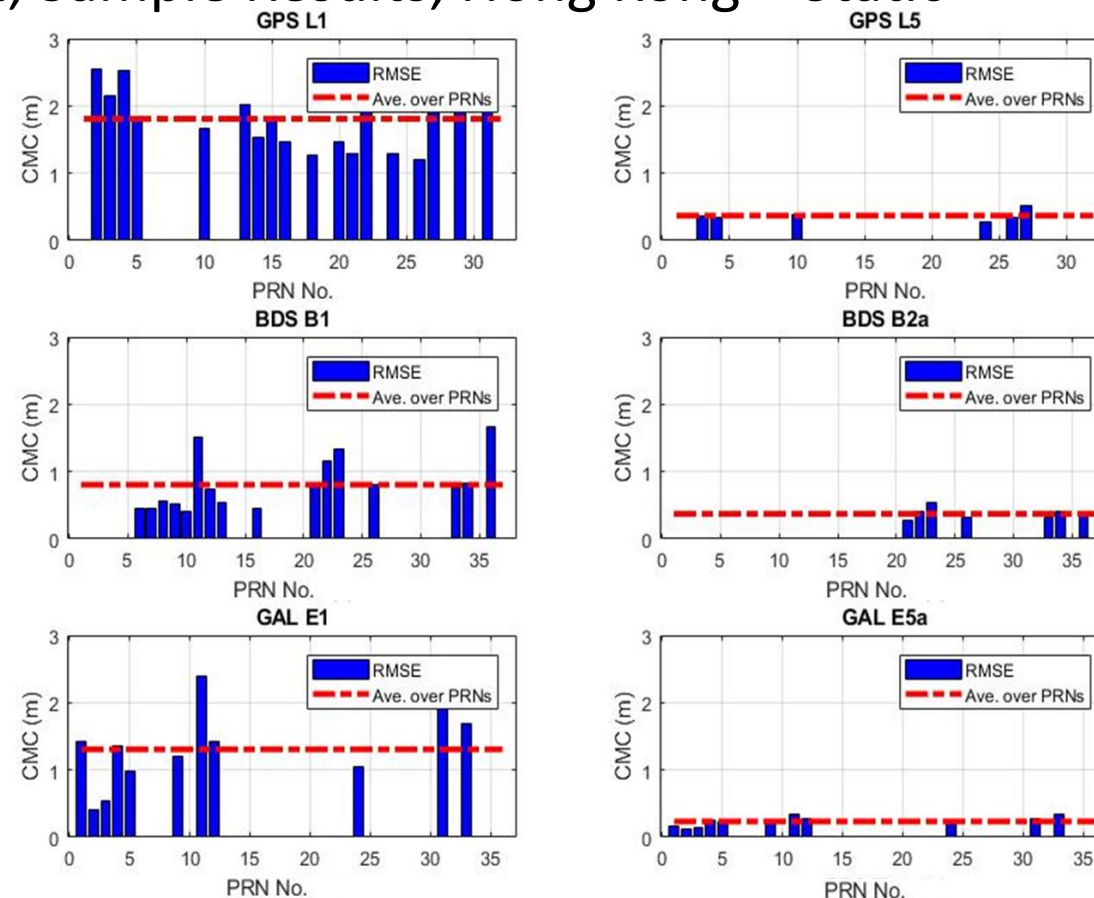
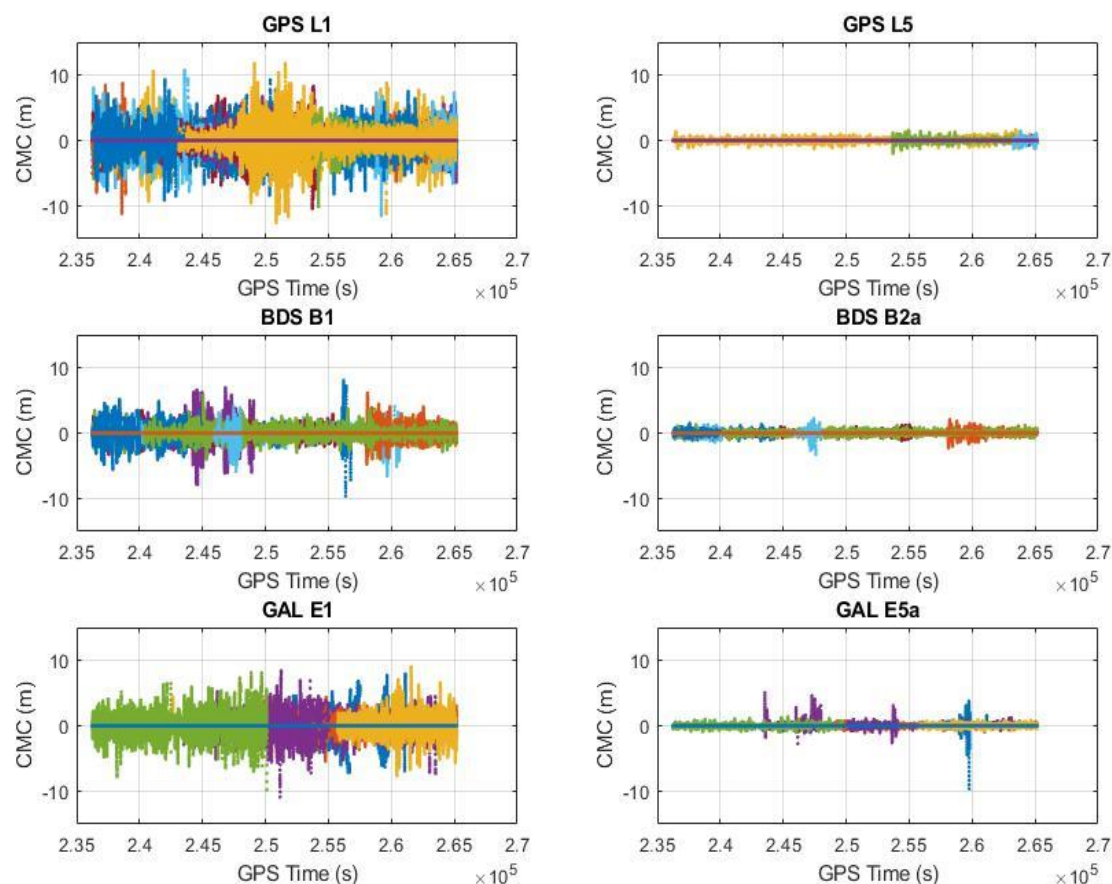
Sample Results – Signal Power, Beijing - Kinematic



*Averaged over time (all epochs) and all PRNs, for signal levels higher than 35 dB-Hz

Noise and Multipath Monitoring (1/2)

CMC: Code-Minus-Carrier phase measurement; Sample Results, Hong Kong – Static

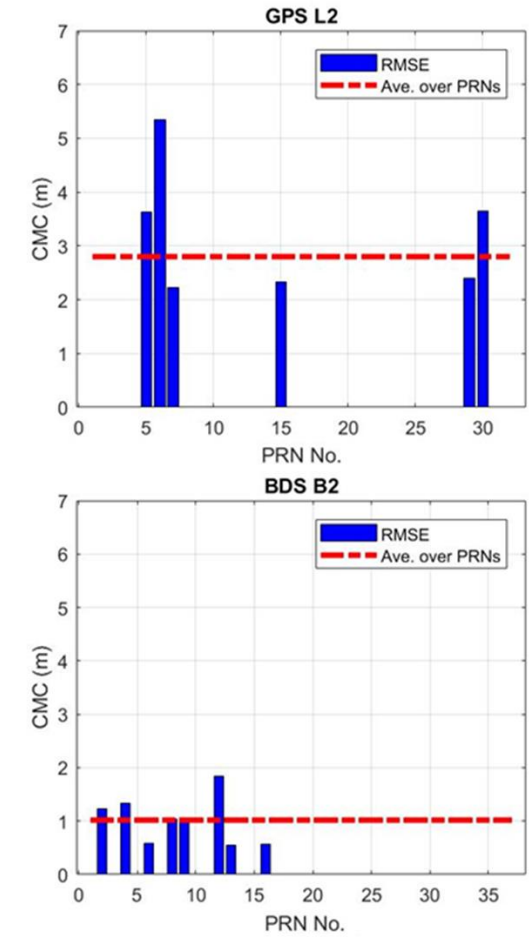
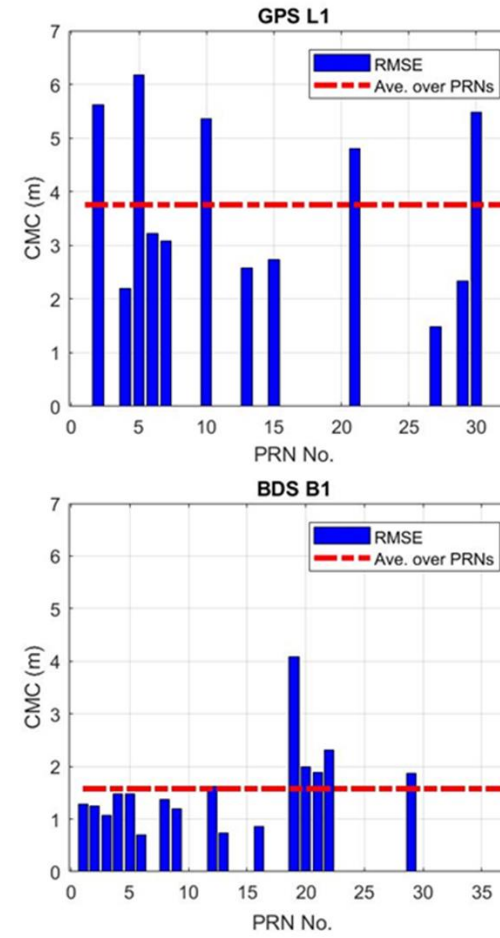
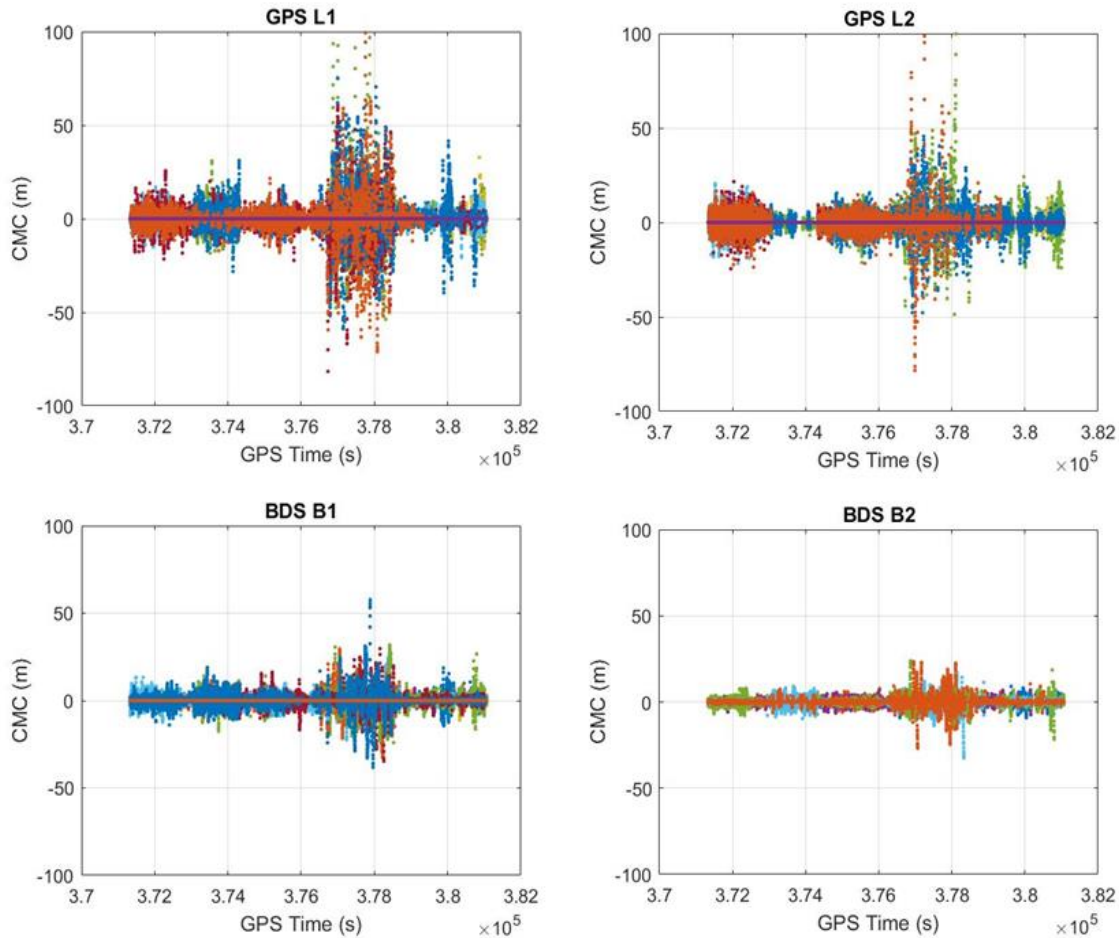


CMC RMSE (m)			
SYS - FREQ	Mean Value*	SYS - FREQ	Mean Value*
GPS - L1	1.81	GPS - L5	0.37
BDS - B1	0.81	BDS - B2a	0.37
GAL - E1	1.31	GAL - E5a	0.23

*Averaged over time (all epochs) and all PRNs, for signal levels higher than 35 dB-Hz

Noise and Multipath Monitoring (2/2)

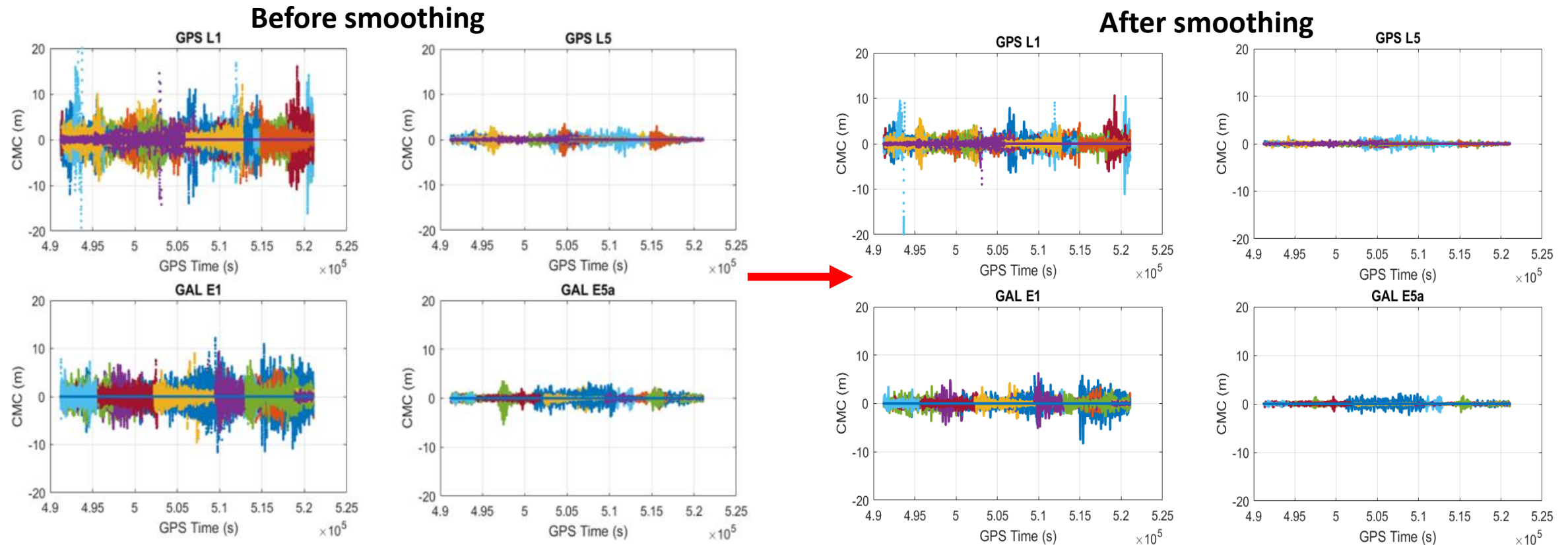
Sample Results, Beijing - Kinematic



CMC RMSE (m)			
SYS - FREQ	Mean Value*	SYS - FREQ	Mean Value*
GPS - L1	3.76	GPS - L2	2.80
BDS - B1	1.58	BDS - B2	1.02

*Averaged over time (all epochs) and all PRNs, for signal levels higher than 35 dB-Hz

Code-Minus Carrier Phase (CMC) Smoothing



Code-phase Noise & Multipath RMSE (m); Averaged over time (all epochs) and all PRNs, for signal levels higher than 35 dB-Hz

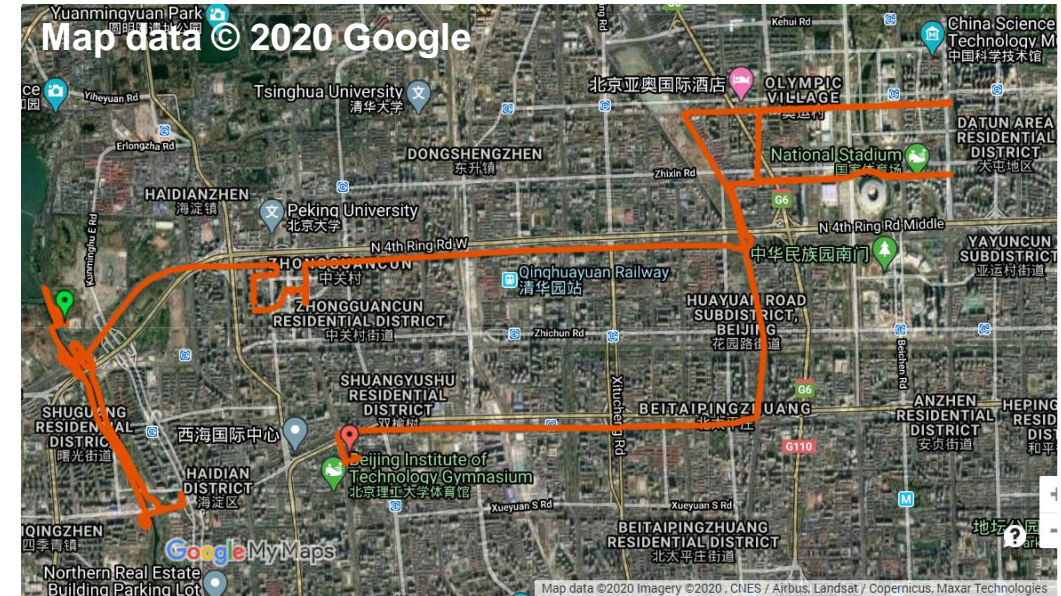
Signal	Before smoothing	After smoothing	Signal	Before smoothing	After smoothing
GPS L1	1.51	0.89	GPS L5	0.36	0.23
GAL E1	1.34	0.73	GAL E5a	0.39	0.24

**Sample Results,
Calgary Static**

Allystar HD9310 vs. u-blox F9P

Just a sample of results, Beijing - kinematic

- ✓ Allystar HD9310 shows competitive performance with higher portability and lower power consumption



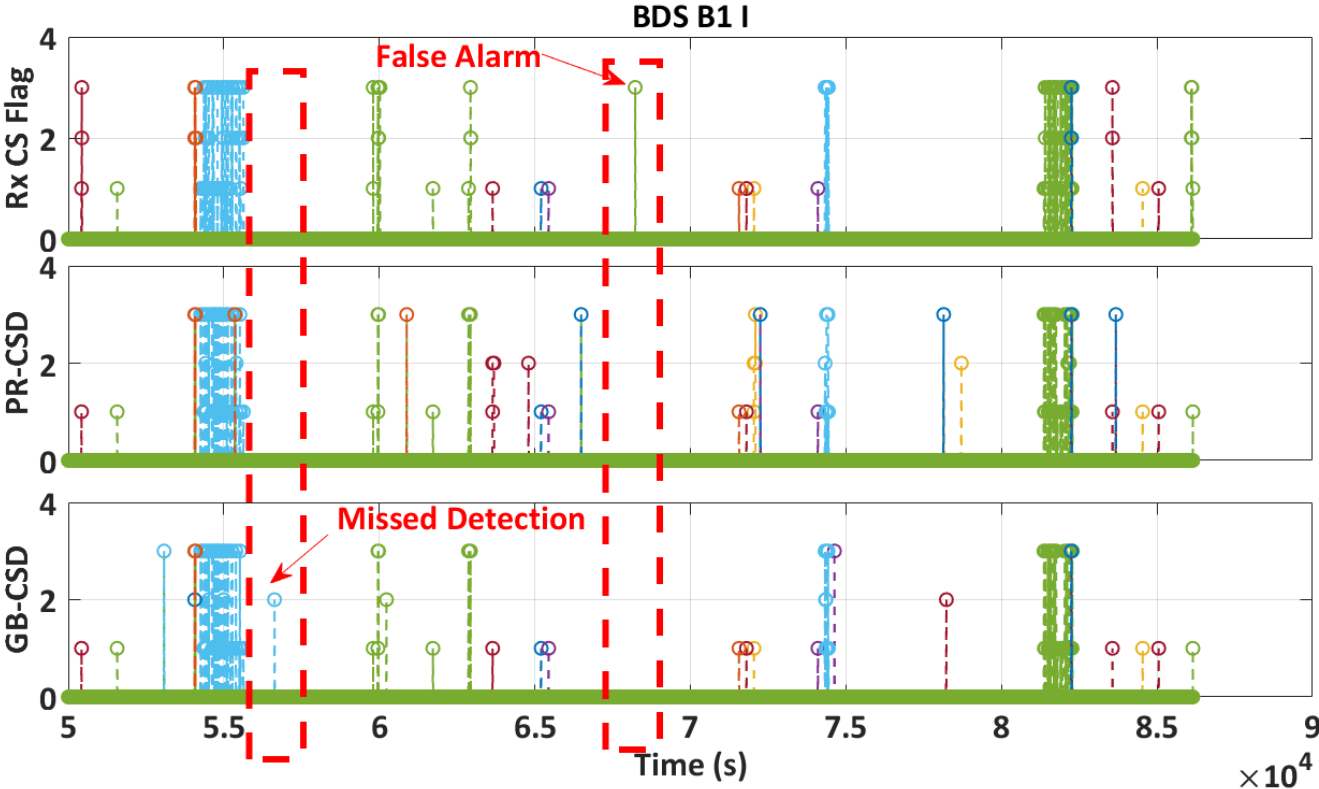
Kinematic (3h)	Signal	GPS Signals				BDS Signals			
	Receiver	Allystar HD9310		u-blox F9P		Allystar HD9310		u-blox F9P	
	Freq. Band	L1 C/A	L2C M	L1 C/A	L2C M	B1 I	B2 I	B1 I	B2 I
	No. of Satellites Tracked	6.42	3.27	6.41	<1	12.2	6.37	8.76	5.01
	Signal Power or C/N0* (dB-Hz)	40.63	38.01	41.34	N/A	41.87	43.28	43.13	45.22
	Code-phase Noise & Multipath RMSE* (m)	1.64	0.99	1.69	N/A	0.94	0.58	1.18	0.58

*Averaged over time (all epochs) and all PRNs, for signal levels higher than 35 dB-Hz

Cycle-Slip Detection

Sample Result - Calgary Static

- Rx CS Flag: Receiver Cycle-Slip Flag
- PR-CSD: Phase-Rate Cycle-Slip Detection
- GB-CSD: Geometry-based Cycle-Slip Detection



Averaged values for signal levels higher than 35 dB-Hz

Parameter		HD9310 - GPS		HD9310 - BDS	
		L1 C/A	L2C M	B1 I	B2 I
Static (24h)	No. of Satellites Tracked	10.94	6.74	6.81	2.37
	Signal Power or C/N0 (dB-Hz)	45.82	42.2	45.09	41.55
	Code-phase Noise & Multipath RMSE (m)	0.81	1.05	0.50	0.45
	Cycle-slip Detection	Correct Detection	97.06%	91.90%	82.72%
		False Alarm	0.04%	0.01%	0.02%

Summary & Future Work

- Allystar HD9310 delivers one of **the smallest and least-power consuming solution** for raw data collection
- **Promising measurement quality** with higher portability and much lower power consumption
- Relatively high measurement quality for modernized signals such **GPS L5, Galileo E5a, BDS B2a supported by HD9310**
- HD9310 supports **BDS Geosynchronous Equatorial Orbit (GEO) satellites**
- Allystar **single-chip dual-frequency RTK solution** is currently available for customers
- Working on GNSS/INS sensor fusion and dual-chip product for the **next generation of System-on-Chip (SoC) solutions**



THANK YOU

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