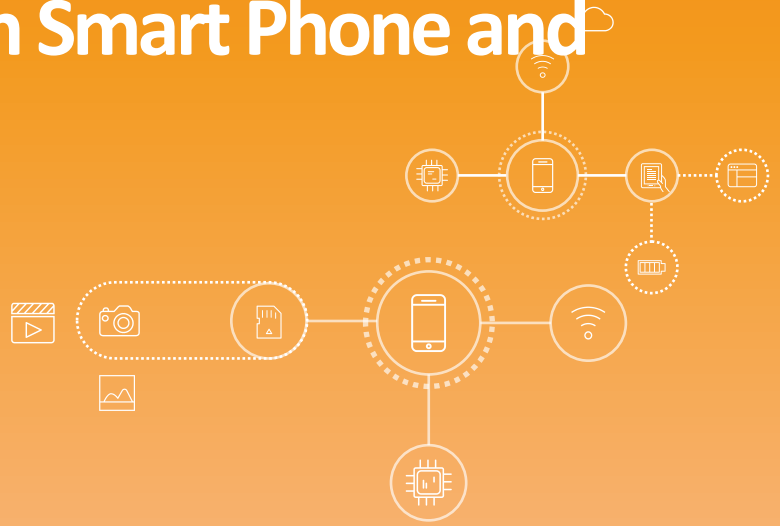
Performance of GNSS+INS on Smart Phone and Telematics of Vehicle

Tsung-Yu Chiou Feb 23 2023



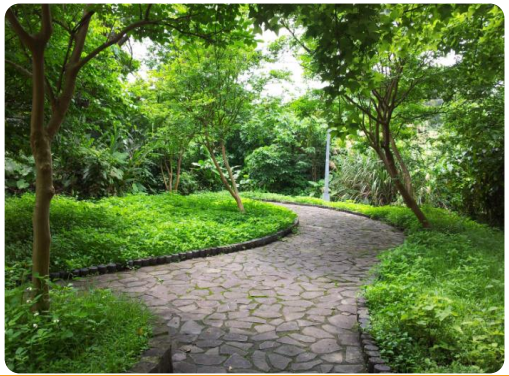
Goal: Provide Positioning in Various Conditions with Cost Effective Receiver and Sensors for billions of users

Open Sky

Signal Blocked

Urban Canyon

Under Trees



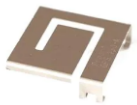
Tunnel

Parking Tower

Challenges

- Antenna efficiency limited by form factor of the device
  - Smart phone received CNR in car and open sky: 28~33 dB-Hz
- Weak signal environments
  - Most of signal CNR < 30 dB-Hz
- Crystal clock noise worse than TCXO
  - Clock dynamics of a crystal can be 2~6.5 times worse than a TCXO
  - Cause longer TTFF due to worse data decoding performance
- Multipath
- Low-cost inertial sensors

PIFA Antenna



L1: 30x30 mm^2

MEMS sensors

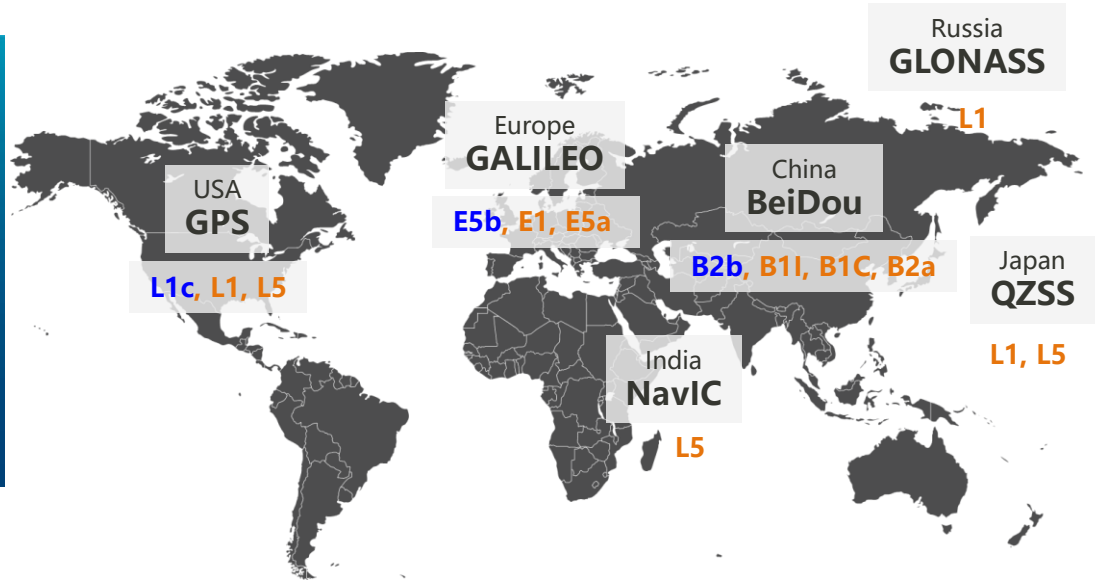
LGA-14L
(2.5 x 3.0 x 0.83 mm) typ.

Signal Power		CNR (dB-Hz)
Input signal	-130dBm	44dBHz
EVB lost	-3.5dB	40.5dBHz
In car	-2dB	38.5dBHz
Antenna efficiency 30% (Very good L1 phone antenna)	-5dB	33.5dBHz
Antenna efficiency 20% (Typical L1 phone antenna)	-7dB	31.5dBHz
Antenna efficiency 10% (Typical L5 phone antenna)	-10dB	28.5dBHz

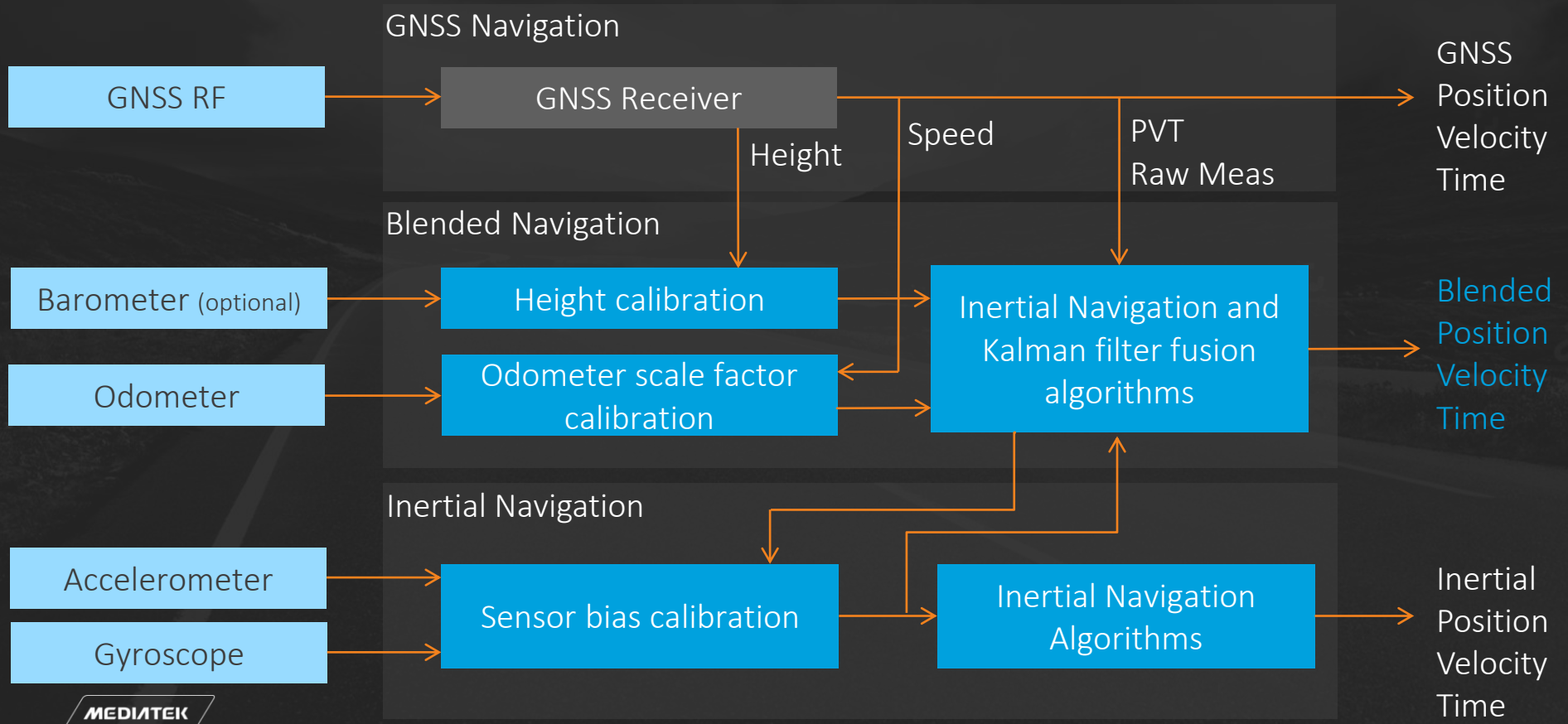
Item	Smart phone	Novatel
Antenna (compare with Novatel GNSS 850)		
Design	PIFA antenna (GNSS+modem+wifi)	Patch antenna (GNSS dedicated)
Antenna Gain at Zenith (90°)	L1 maximum: -3 dBi L5 maximum: -5 dBi	L1 minimum: +5 dBi L5 minimum: +3 dBi
Sensor (compare with Epson G370N IMU)		
Gyro bias instability	5°/s (22727 times larger)	0.00022°/s
Angular Random Walk	0.005°/√s (312 times larger)	0.000016°/√s

Seamless Navigation with Most Comprehensive GNSS Signals

- With China BeiDou B2b, USA GPS L1c, Europe Galileo E5b
- Support the most satellite systems and provide better accuracy



Method: Loosely + Tightly Coupled GNSS + INS



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Results: UDR in Weak Signal Conditions

MediaTek Dimensity 1000

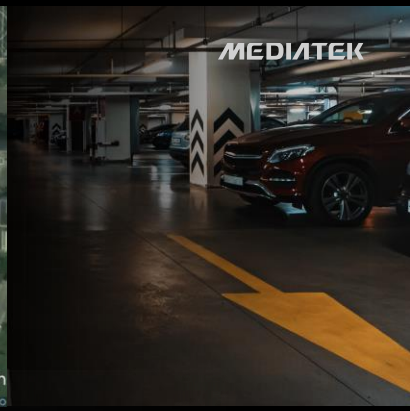
Accurate Positioning, No Break Points.

Results: UDR in Dead Reckoning

MediaTek Dimensity 1000

Best Seamless Positioning Experience

Even when entering underground carpark, we can still deliver accurate positioning



Results: UDR in Tunnel

MediaTek Dimensity 1000

Best Seamless Positioning Experience

Continuous and longer navigation even in tunnel

Results: PDR in Urban Canyon (L1 + INS)

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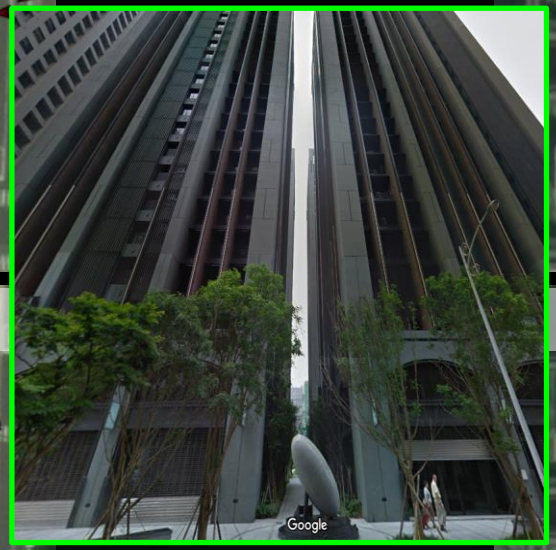
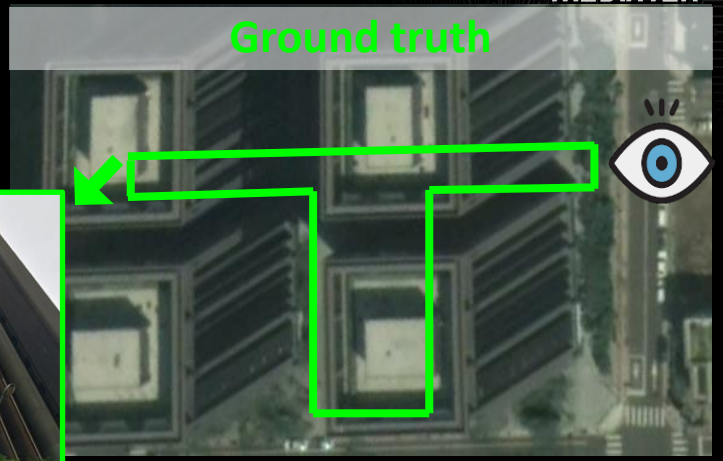
Competitor: init 38m, PDR ready: 15m

Top4 CNR: 32 dB-Hz

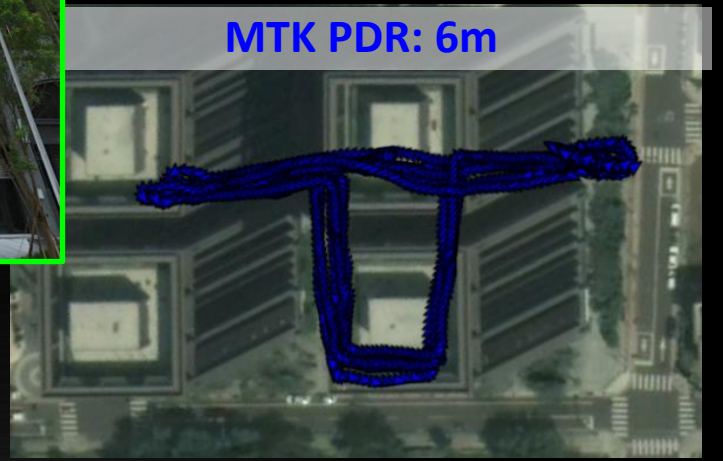


Ground truth



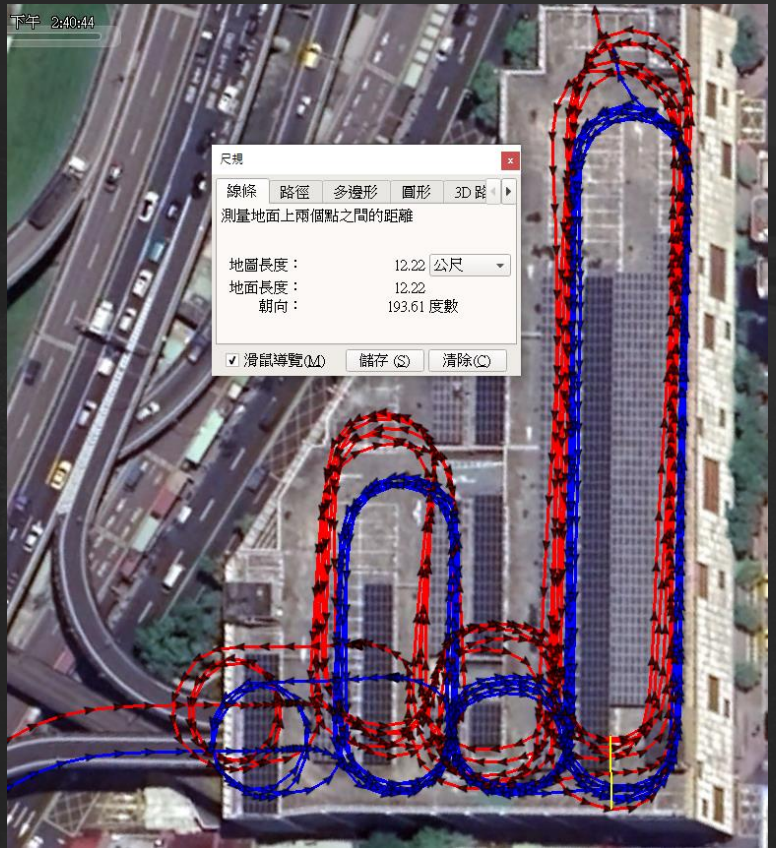
MTK GNSS only: 30m

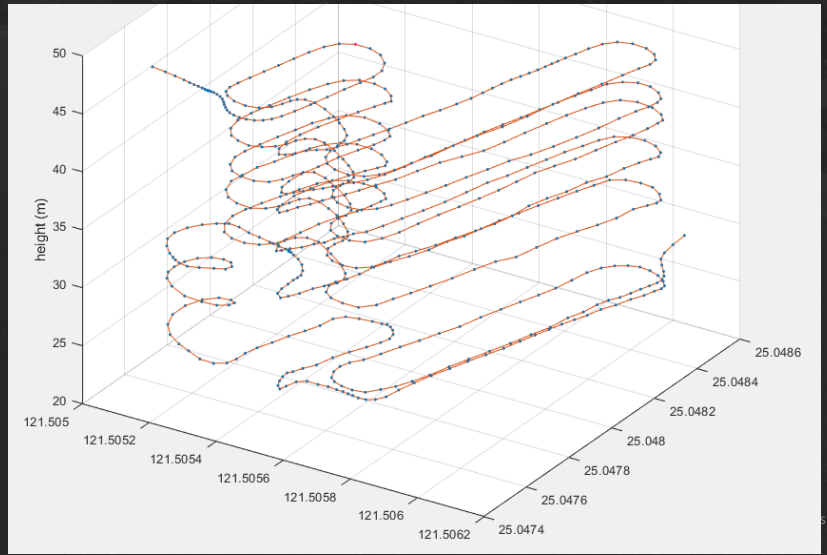
MTK PDR: 6m



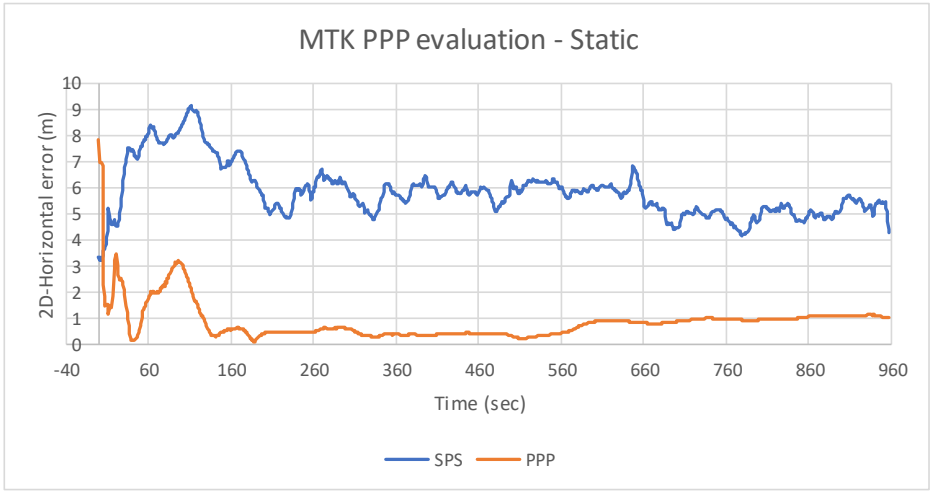
Blue: MTK, Red: Competitor

Results: ADR in Multi-Level Parking Lots





Results: PPP Performance – Open Sky, Static Scenario

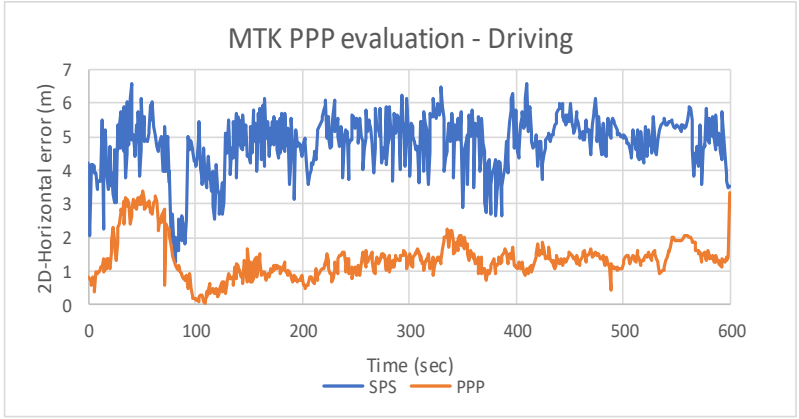


2D-Horizontal err	RMS (m)	CEP68 (m)	CEP95 (m)
SPS	6.45	6.05	7.78
PPP	1.42	0.94	2.25
Improvement	77.98%	84.46%	71.08%

SPS: Standard Positioning Service
PPP: Precise Point Positioning

Results: PPP Performance – Open Sky, Driving Scenario

Ground True: Green, SPS: Blue, PPP: Red



2D-horizontal err	RMS (m)	CEP68 (m)	CEP95 (m)
SPS	4.85	5.25	5.88
PPP	1.47	1.45	2.75
Improvement	69.69%	72.38%	53.23%

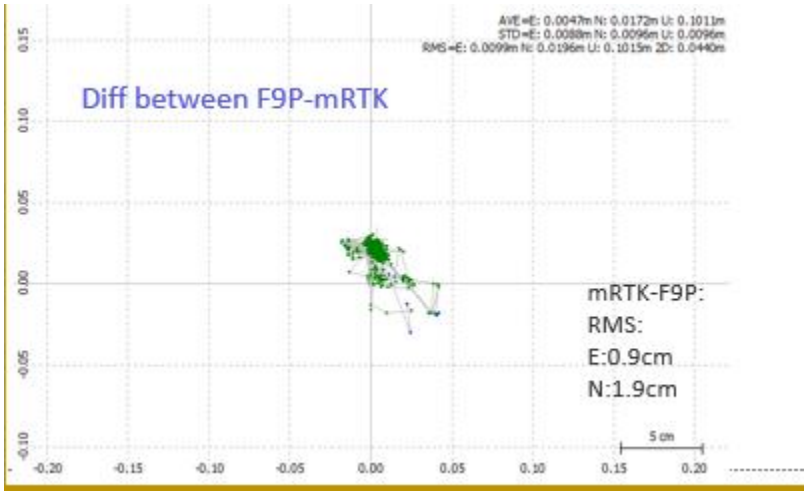
Cross-track err	RMS (m)	CEP68 (m)	CEP95 (m)
PPP	0.57	0.37	1.16

SPS: Standard Positioning Service
PPP: Precise Point Positioning

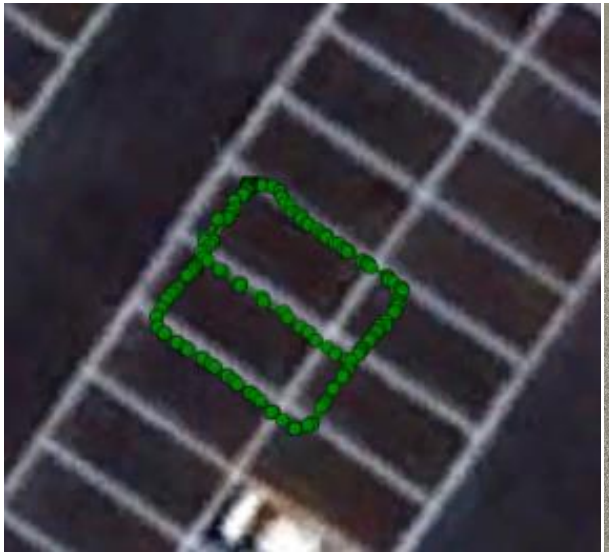
Results: RTK (patch antenna + EVB)

- Demonstration of RTK on a low-cost platform
  - Open sky, Co-patch antenna with uBlox F9P
  - Results: RMS error < 2 cm of difference

- Static receiving



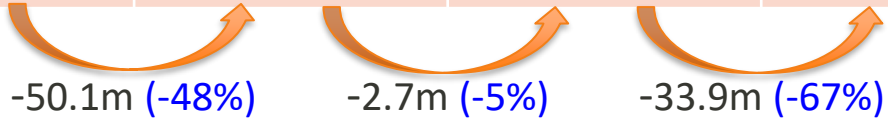
- Dynamic receiving



Conclusions

- User experience has been improved a lot from L1 only to L1+L5+INS, 84% improvement in accuracy, (89 deep urban logs, 94 hours of driving)

Deep Urban	L1	L1 + L5	L1 + INS	L1 + L5 + INS
max error (m)	103.5	53.4	50.7	16.9



- High accuracy positioning is feasible in low-cost chips, as compared to high end instruments
  - Submeter accuracy demonstrated

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