Geospatial Technique for Validating the Accuracy of Location Service with Links to Modern Transport

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GNSS overview: global

GPS (USA)

MEO (24)

L1 L2 L5

GLONASS (Russia)

MEO (24)

L1 L2 L3

BeiDou (China)

MEO (27), IGSO (3), GEO (5)

B1 B2 B3

Galileo (Europe)

MEO (30)

E1 E5a E5b E6

GNSS overview: regional

QZSS (Japan)

IGSO (3), GEO (1)
L1 L2 L5 E6

NaVic (India)

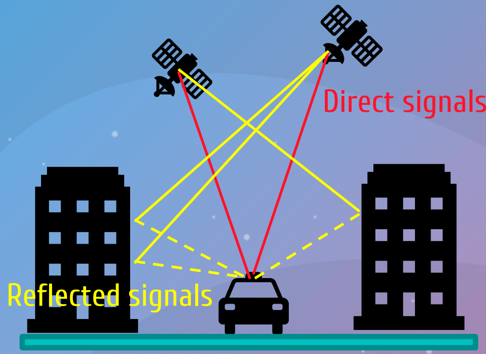
IGSO (4), GEO (3)
L5 S

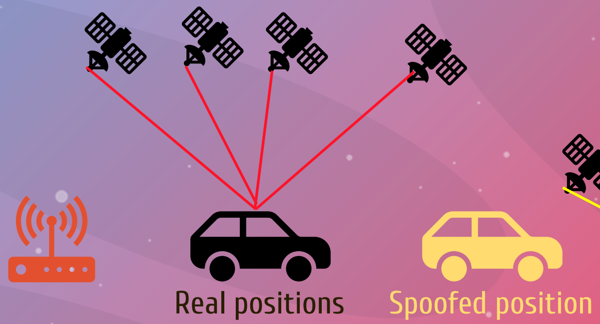
KPS (South Korea)

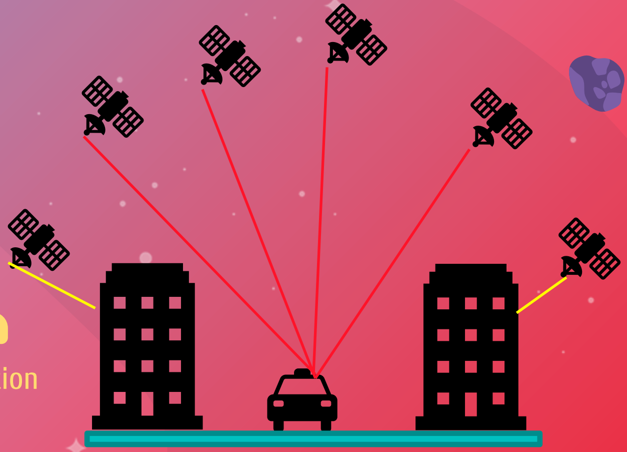
IGSO (4), GEO (3)

More to come ....

GNSS errors







Signal multipath

Several metres
10 m or greater

Signal interference

Jamming
Spoofing

Signal blocking

Urban canyon
Tunnel
multi-level roads

GNSS receivers for vehicle guidance

Small and low-cost

Receiver: ZED-F9R, ZED-F9P, ZED-F9T

Patch Antenna

Processing programme: RTKLib

Power-efficient

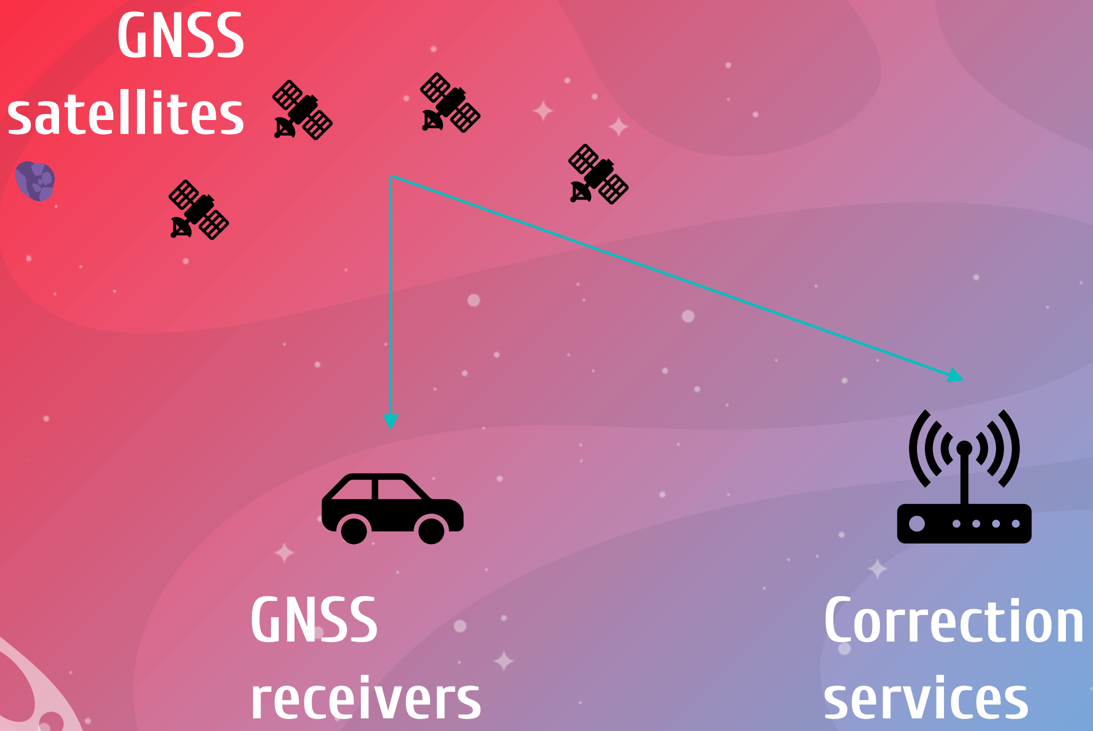
Drift-less properties of GNSS attitude sensor

Wheel speed, Gyroscope, accelerometer

Indoor tracking

No GNSS signals

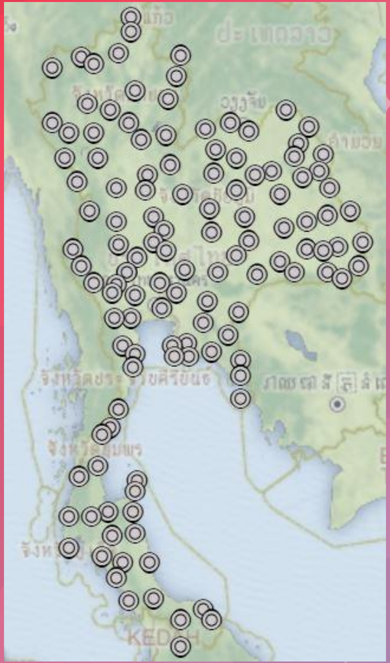
High-precision GNSS services



- Network Real-Time Kinematic positioning technique (multi-permanent stations
- National Continuously Operating Reference Station (CORS) network
- Integrated GNSS observations amongst Thai government and academic institutes

https://ncdc.in.th/portal/apps/sites/#/ncdc

High-precision GNSS services



- Contain 228 stations
- Homogenously distributed nationwide
- Provide real-time positioning, GNSS observation achieves and online data post-processing

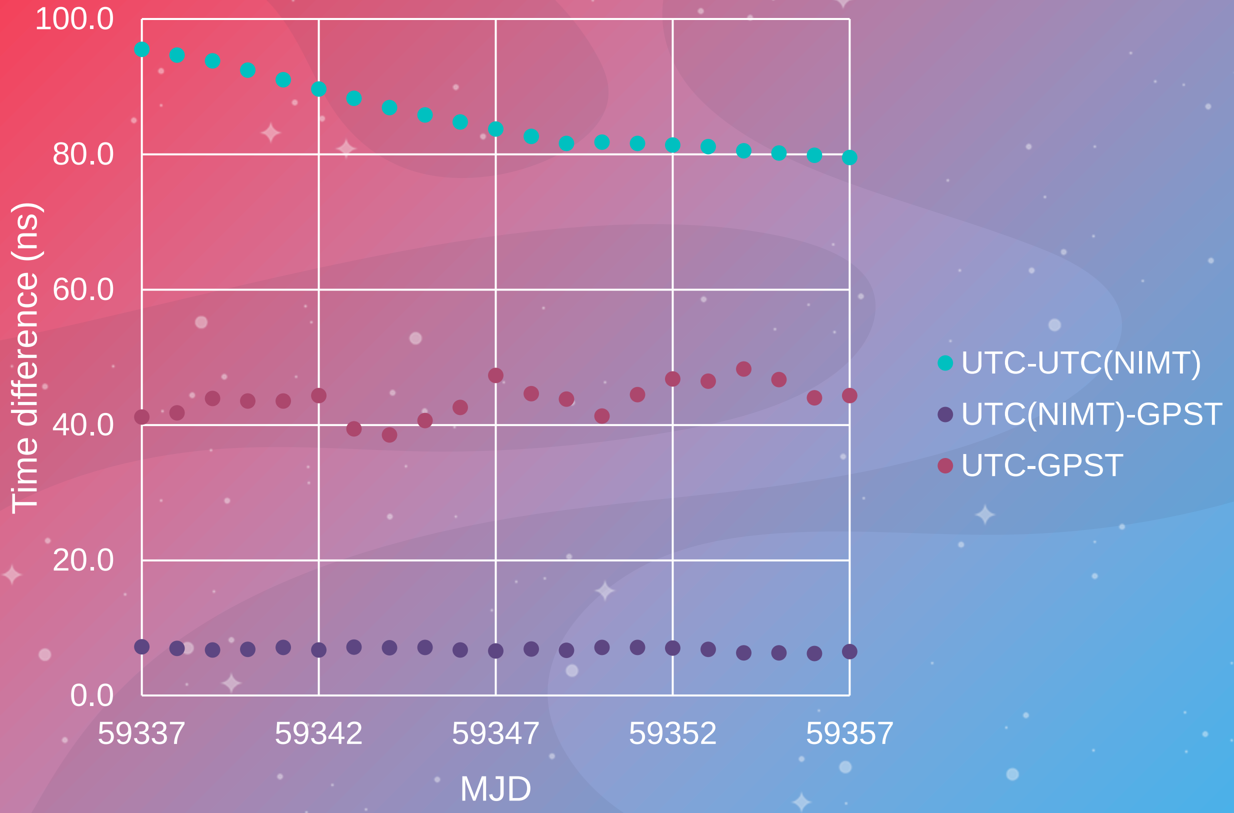
GNSS positioning infrastructure

https://ncdc.in.th/portal/apps/sites/#/ncdc

UTC(NIMT)

https://mx.nimt.or.th/?p=14153

UTC(NIMT)


100.0
80.0
60.0
40.0
20.0
0.0
Time difference (ns)
59337
59342
59347
59352
59357
MJD
UTC-UTC(NIMT)
UTC(NIMT)-GPST
UTC-GPST

GNSS receivers for attitude information

- GNSS observations need to be integrated with Inertial Measurement Units (IMU)
- GNSS attitude information is a valuable input for georeferencing, that is, post processing of data acquired
- The use of a GNSS multi-antenna system provides attitude information that remains unaffected by drift and magnetic variations; determining heading, roll and pitch angles to derive slip angle measurements

Heading determinations

- Portable digital heading gauge implemented on a tablet, which can be fed by low-cost GNSS antennas mounted on a vehicle rooftop
- Low-cost GNSS-based digital heading gage and tracking system developed for automotive applications, ANavS

https://anavs.com/

Lidar mobile mapping systems

GNSS land surveying with LIDAR mms

LIDAR mobile mapping vehicle, Trimble MX9

- GNSS
- INS
- DMI

Trajectory positions

- Real-time broadcast ephemeris
- IGS precise satellite orbit and clock offset solutions
- Position and Orientation System Post-processing Package Mobile Mapping Suite version 8 (POSPac MMS 8)
- Trimble Business Centre (TBC) version 5.40

https://www.sciencedirect.com/science/article/pii/S2665917421000416

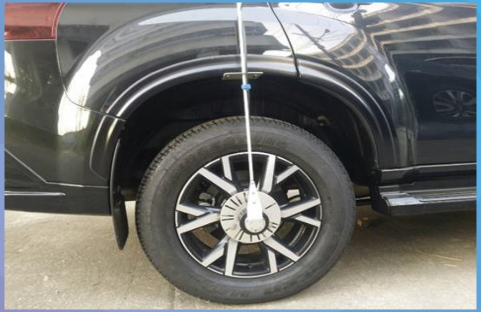
Lidar mobile mapping systems

Integrated GNSS and INS

GNSS | LIDAR | INS | DMI

Navigation performances

Accuracy | Integrity | Continuity | Availability



Distance measurement instrument

Lidar mobile mapping systems

Height determinations

- Local gravity model: Thai Geoid Model 2017 (TGM2017) is applied
- Local gravity is instantaneously measured with the up-down accelerometer

Velocity determinations

- Measured accelerations
- Corrected for known gravity
- Computed Coriolis and centrifugal accelerations
- Integrated to correct the velocities

Lidar mobile mapping systems

Mapping route

- 106 km
- Underneath highways
- Central Bangkok

Positioning determinations

- NRTK surveys
  - Actual observations (SBKK)
  - Virtual observations
- Ground control points
  - Prior determined and assigned as checking points
  - 25 positions along surveyed passage

Lidar mobile mapping systems

Applied IGS orbit products	Vehicle during cruising (cm)				Vehicle during parking (cm)				Combined accuracy (cm)	
	Maximum positioning shifting		Averaged RMSE		Maximum positioning shifting		Averaged RMSE		RMSE	
	H17	V	H	V	H	V	H	V	H	V
Broadcast	35.8	22.8	2.0	1.8	30.6	20.7	2.3	2.5	2.1	2.2
Ultra-rapid	10.0	10.4	0.6	0.6	2.8	1.9	0.3	0.3	0.5	0.5
Rapid	10.0	10.4	0.5	0.5	2.8	1.9	0.3	0.3	0.4	0.4

Lidar mobile mapping systems

Applied IGS orbit products	Maximum positioning shifting (cm)		Averaged RMSE (cm)	
	H	V	H	V
Broadcast orbit	13.6	28.5	7.4	12.6
Ultra-rapid orbit	16.2	26.8	7.3	12.5
Rapid orbit	16.2	27.2	7.2	12.5
Final orbit	13.6	27.3	6.9	12.3

Conclusions

- GNSS challenges for vehicle positioning are due to signal mitigations in urban canyon
- Real-time kinematic services from national positioning infrastructure could provide decimetre-level accuracy
- Time synchronisation could be achieve through UTC(NIMT)
- GNSS, INS and DMI integration provides centimetre-level accuracy through post-processing and ground control points along the vehicle passage

Thanks!