

International Federation of Surveyors (FIG)

GNSS Precise Point Positioning (PPP)

From Users' Perspective

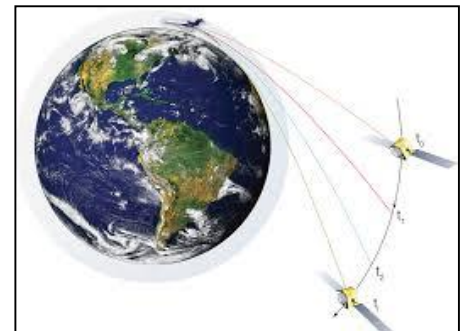
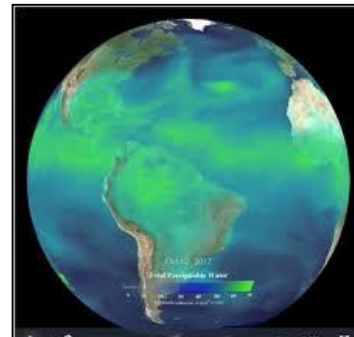
**UNOOSA ICG
Xi'an, China, November 2018**

Suelynn Choy – Chair, Working Group 5.4 on GNSS, FIG

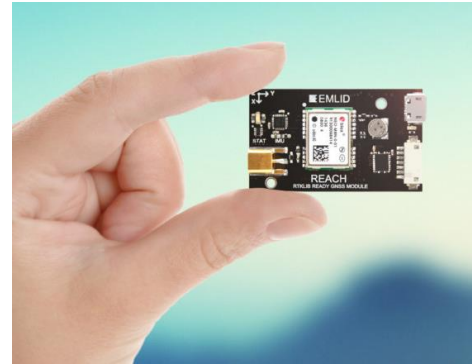
Mikael Lilje – Vice President, FIG

Matt Higgins – Honorary Member, FIG

GNSS precise positioning enables a diverse array of applications



Mass-market users and innovative applications



Welcome to Xiaomi MI 8,
the world's first dual-frequency GNSS smartphone.



European
Global Navigation
Satellite Systems
Agency

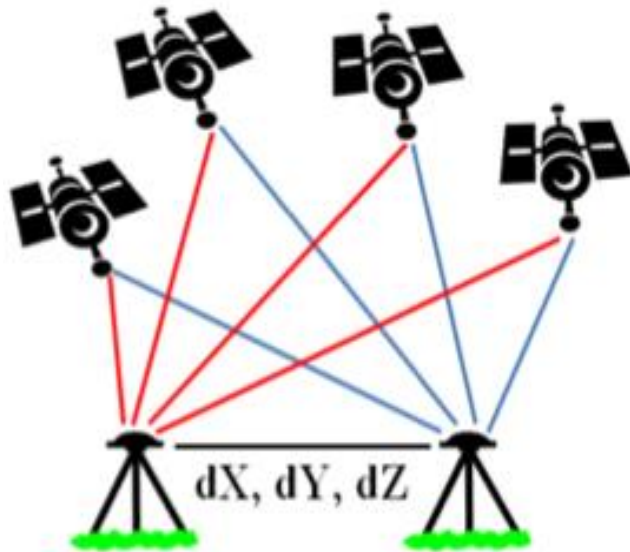


NAVIGATION
SOLUTIONS
POWERED BY
EUROPE

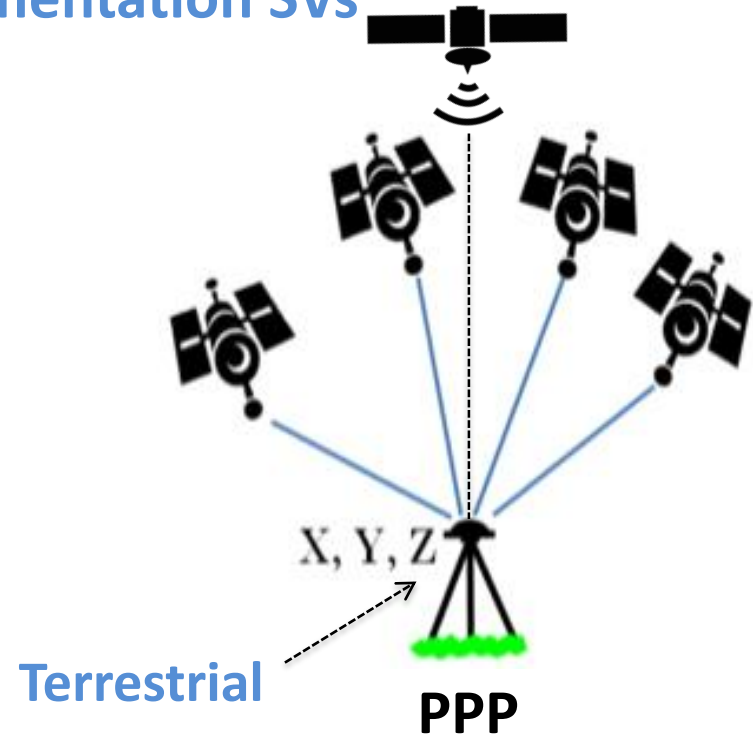


Precise Point Positioning (PPP)

“Augmentation SVs”

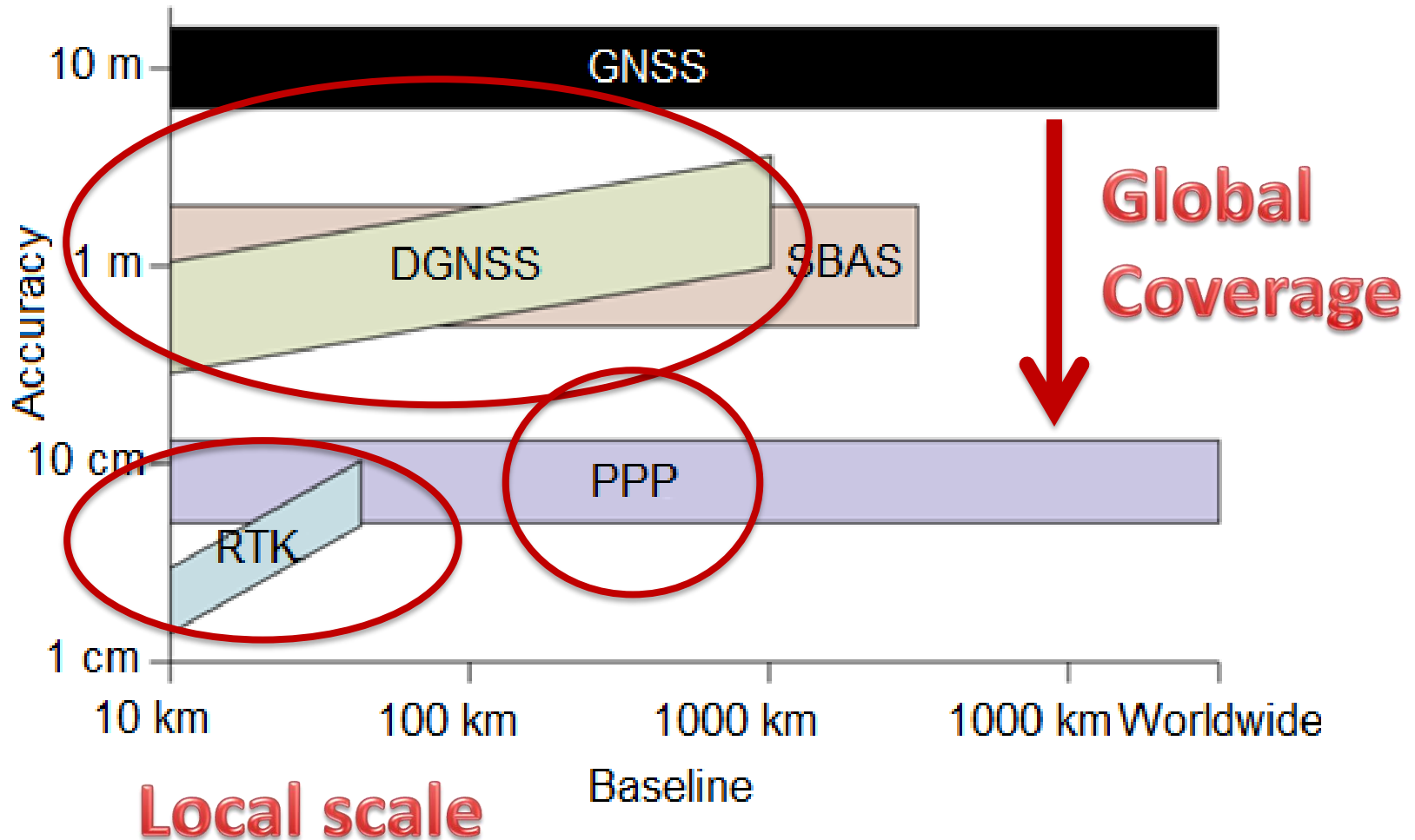


Differential



PPP uses **state space representation (SSR) correction** products such as **precise satellite orbits, clocks** and **code/phase biases** from either (1) *commercial or/and public providers* that are delivered to the user via (2) *satellite and/or terrestrial comms*.

Pushing the boundary of precise positioning



Use and Applications

- Commercial PPP Services, e.g.,
 - Trimble CentrePoint™ RTX™
 - NavCom Global StarFire™ Service
 - Fugro's Precise (Point) Positioning Service
 - Veripos Ultra (Ultra²) and APEX (APEX²) Service
 - TerraStar Correction Services



PPP is **feasible** for positioning and navigation in **remote areas** or regions of **low GNSS reference stations**

PPP Service:

Compatibility and Interoperability

PPP Augmentation Signals by GNSS and RNSS

System	SV Orbit	Augmentation Signal for PPP	Frequency (MHz)	Bandwidth (bps)
Galileo/ EGNOS	MEO	E6b	1278.75	500
	GEO	E5b	1207.14	250
GLONASS/ SDCM	MEO	?	?	?
	GEO	?	?	
BeiDou-3	GEO	B2b	1207.14	1000
QZSS	IGSO and GEO	L6D, L6E	1278.75	2000
Australia	GEO	L1	1575.42	250
		L5	1176.45	250

GNSS and RNSS PPP Service Characteristics

System	Coverage	Format	Supported GNSS/RNSS	Supported Service
Galileo/ EGNOS	Global	Open	?	?
GLONASS/ SDCM	Global	Commercial	?	?
BeiDou-3	Regional	Open ?	?	?
QZSS	Regional	Open	GPS, QZSS, GLO, GAL, BDS(TBD)	PPP/PPP-AR (AO) SSR-RTK (JAP)
Australia	Regional	Open	GPS & GAL	PPP

* PPP: Standard float ambiguity PPP
 PPP-AR: Ambiguity resolved PPP
 SSR-RTK: RTK based on state space representation method

* AO: Asia Oceania
 JAP: Japan

Which PPP Service ?

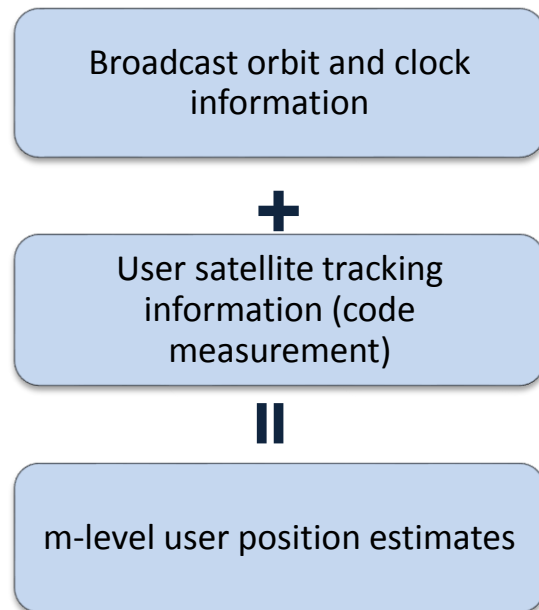
	PPP	PPP-AR	SSR-RTK*
Satellite orbits	✓	✓	✓
Satellite clocks	✓	✓	✓
Code biases	x	✓	✓
Phase biases	x	✓	✓
Ionospheric delay	x	x	✓
Tropospheric delay	x	x	✓

*Hybrid system of PPP and RTK, i.e. SSR-RTK/PPP-RTK/RTK-PPP

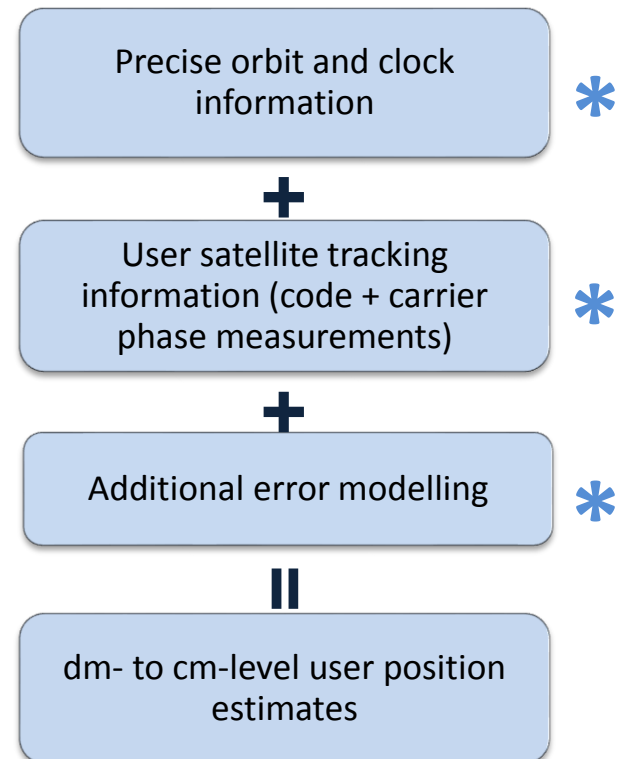
Precise Point Positioning (PPP)

Precise Point Positioning (PPP) allows a single GNSS receiver user to determine position at the decimetre / centimetre error level in kinematic / static mode using precise satellite orbits and clocks.

Standard Positioning Service



Precise Point Positioning



User Algorithm and Service Characteristics

System	Precise Orbits Reference Frame	Precise Clocks Reference	Definition of Phase Biases	Performance*
Galileo/ EGNOS				Accuracy: 20 cm
GLONASS/ SDCM				Accuracy: 10 cm
BeiDou-3				Accuracy: cm-dm
QZSS	IGS05 (CLAS-D) ITRF? (CLAS-E)			Accuracy: cm-dm
Australia	ITRF 2014	Hydrogen-maser; C1P2 reference	--	Accuracy: cm-dm

* PPP performance characteristics: Accuracy, Convergence Time, Availability and Integrity

Next Steps ?

- High precision GNSS in the future
 - Is it a commodity? Or high-tech?
- Ensure compatibility and interoperability to maximize benefit to all GNSS users
- Outcomes from WG-D meeting in Melbourne on 24 October 2018:
 - Briefing document / “PPP template” (circulated)
 - Coordination with other WGs, i.e., WGs D, S & B joint discussion on Wednesday 7 November, 11:15-12:00
 - Possible joint meeting mid 2019