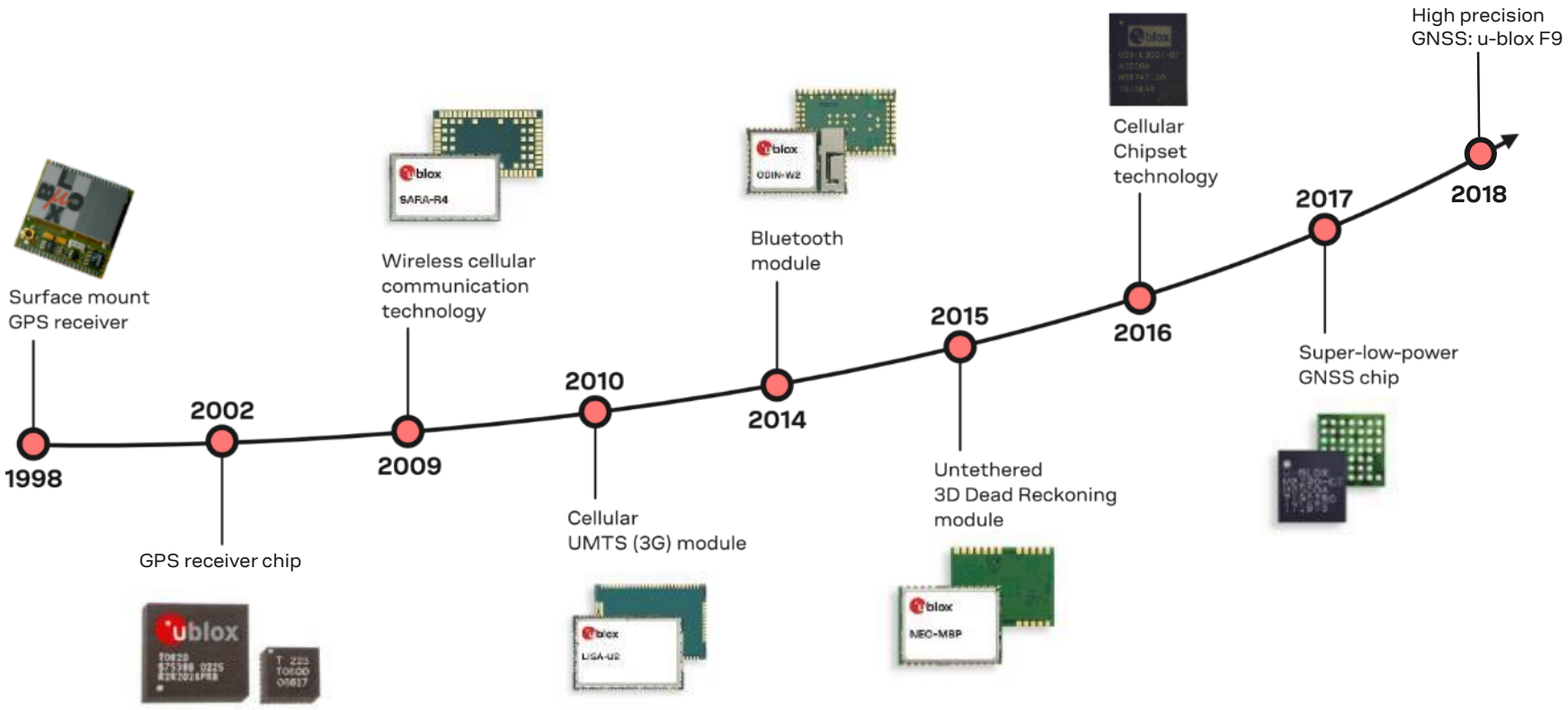
u-blox F9

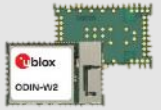
High precision GNSS for the mass market
April 2018

Innovation is our lifeblood

Strong innovations lead to the future



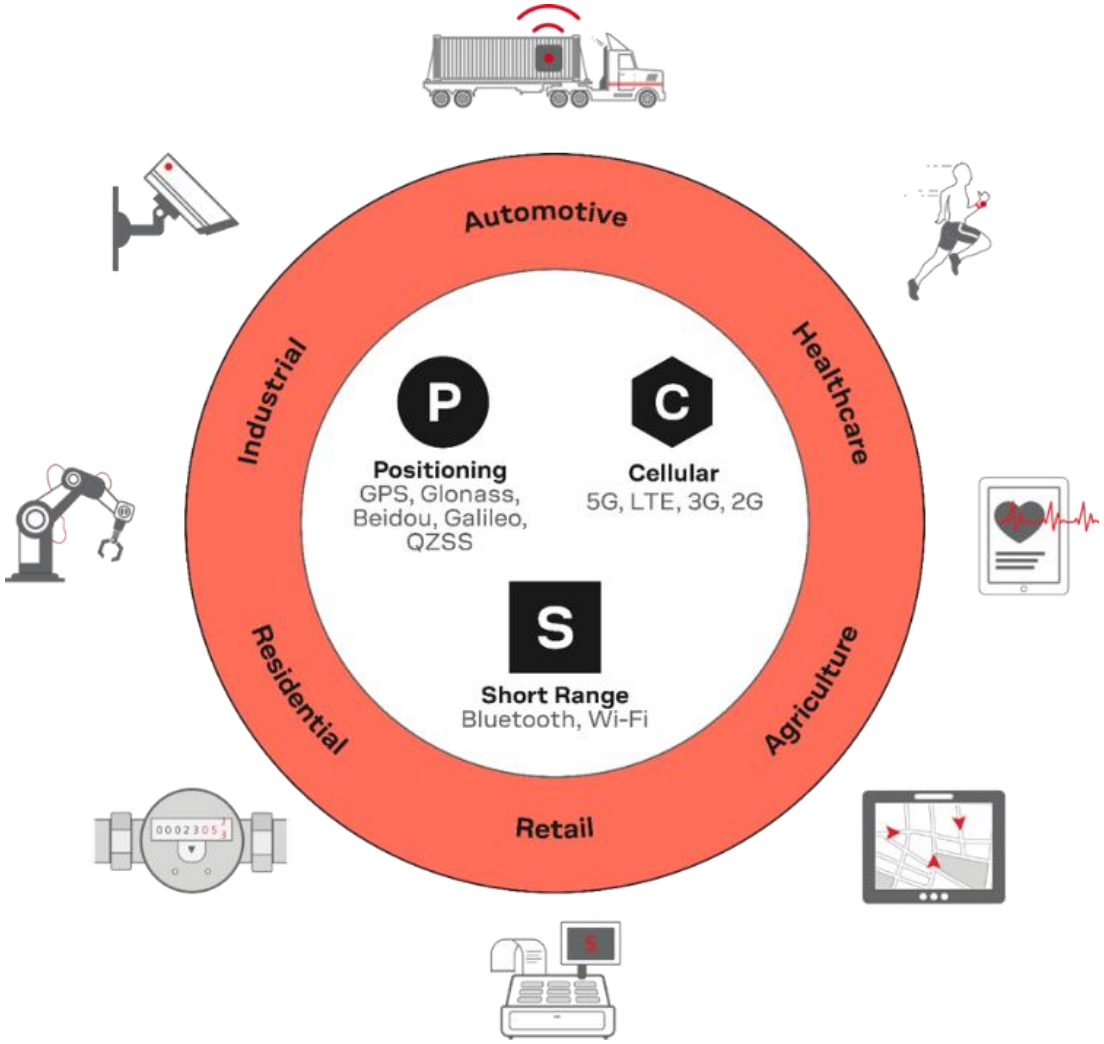
Unique combination of technology and product offerings

	Positioning *	Cellular Communication	Short Range Communication
Integrated Circuits			
Modules			
Services and Solutions	CellLocate® (modem based positioning) AssistNow™ (world wide GNSS assistance service) GNSS Correction Data (for high precision)* FOTA (Firmware over the air) Lifetime Security		

*through Sapcorda, a JV with industry partners

The combination of our three core technologies offered in the form of chips and modules provides essential benefits to our customers.

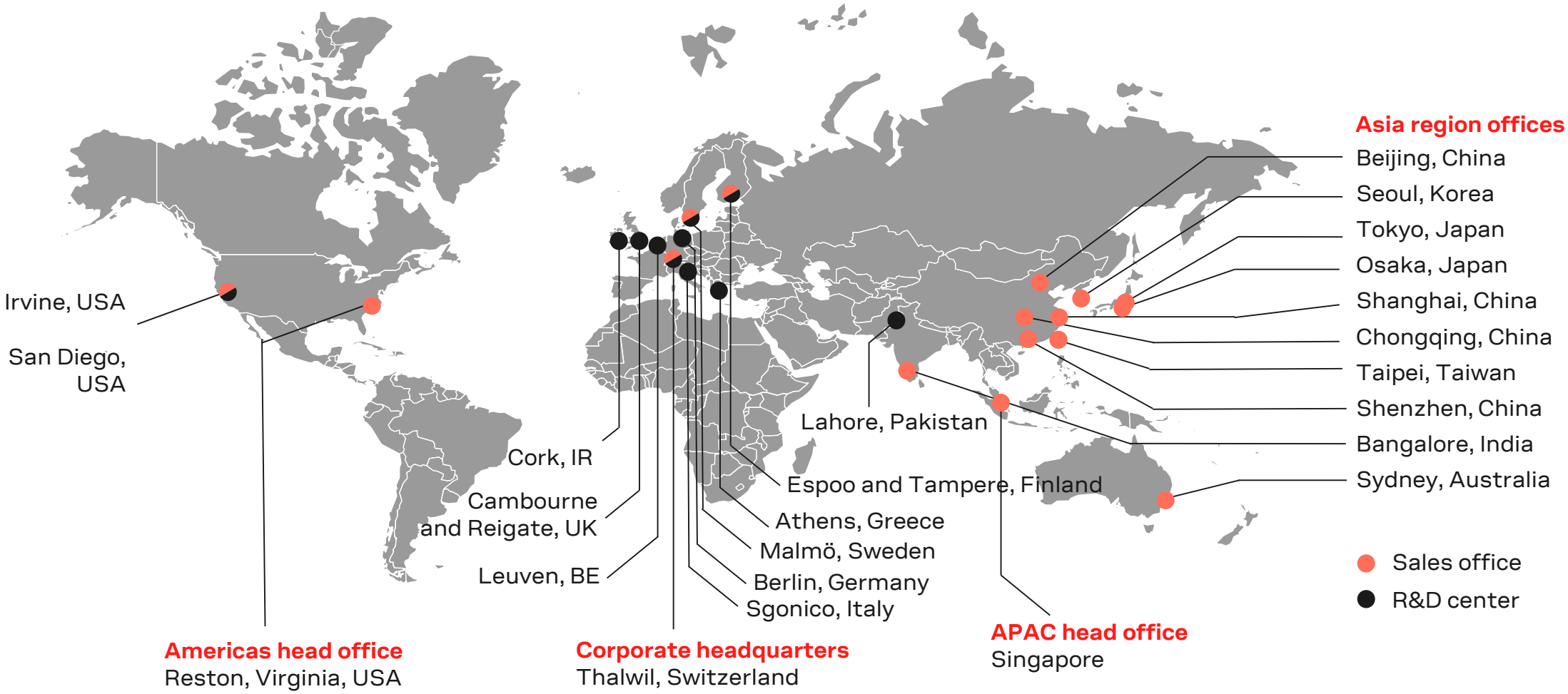
Enabling the Internet of Things (IoT)
u-blox at the core



Our three technologies – Positioning, Cellular, and Short Range – transform a wide range of products and devices into the Things of the IoT.

Global presence
25 locations

R&D centers in Espoo and Tampere



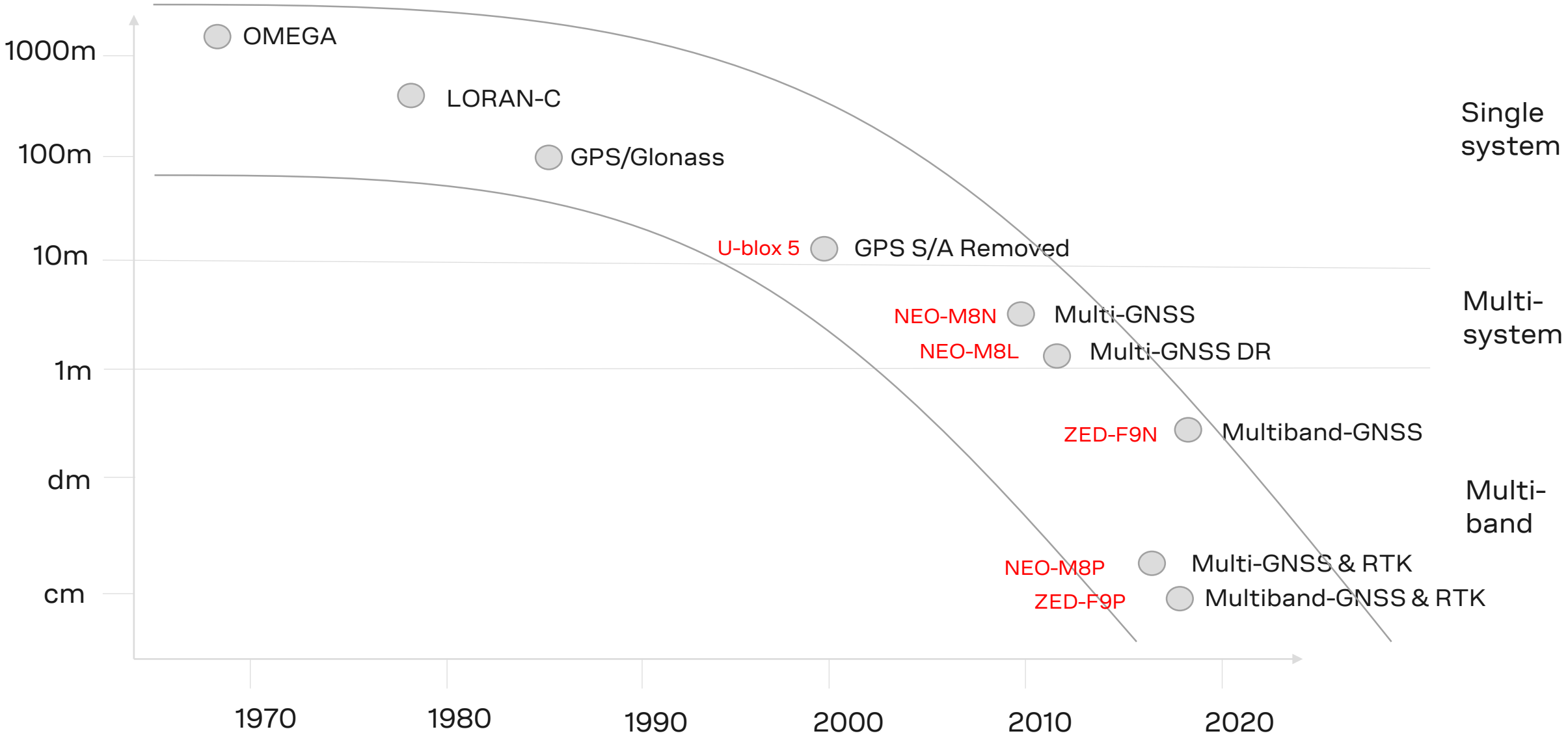
Americas head office
Reston, Virginia, USA

Corporate headquarters
Thalwil, Switzerland

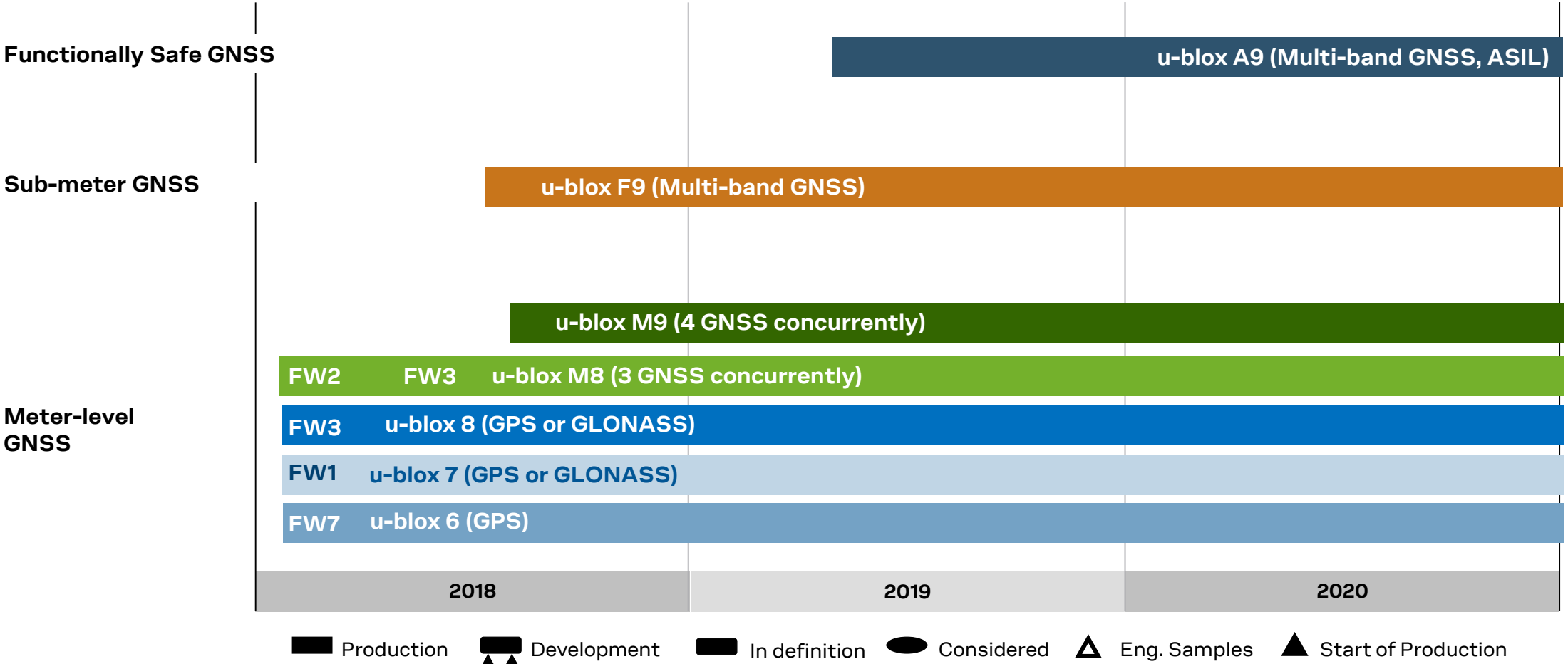
APAC head office
Singapore

High Precision GNSS

Position accuracy vs time (1:10 per decade)



Platform roadmap – Positioning products



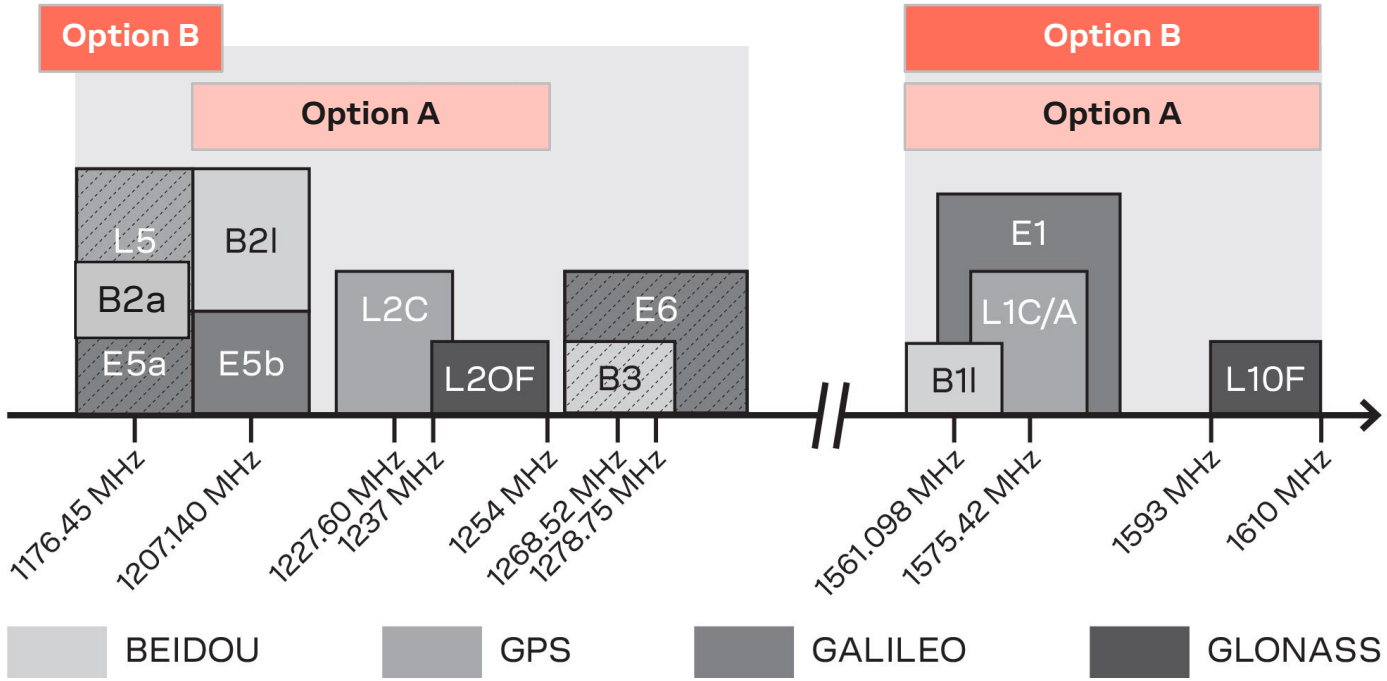
u-blox GNSS platforms

	u-blox M9	u-blox F9	u-blox A9
Target application	Wide range of Standard Precision in consumer, industrial and automotive	High Precision Navigation, V2X/automotive, augmented reality, UAV, etc.	Highly automated driving
Accuracy	<2.0m (CEP68) <1.5m (CEP68) w/ SBAS	<1.5m (CEP68) <1.0m (CEP68) w/ SBAS <0.2m (CEP68) w/ SSR <0.03m (CEP68) w/ RTCM 3.x	<0.2m (CEP68) w/services
Bands supported	Single-band (L1)	Multi-band (L1, L2, L5)	Multi-band (L1, L2, L5)
Corrections	SBAS, QZSS SLAS	SBAS, SSR, OSR	SSR (Mandatory)
Variants	Timing, Dead Reckoning, Wearables	Timing, Dead Reckoning	Dead Reckoning (built in)
Safety features	No	No	Yes (ISO 26262) • Guaranteed integrity • Protection level
Security features	Yes	Yes	Yes

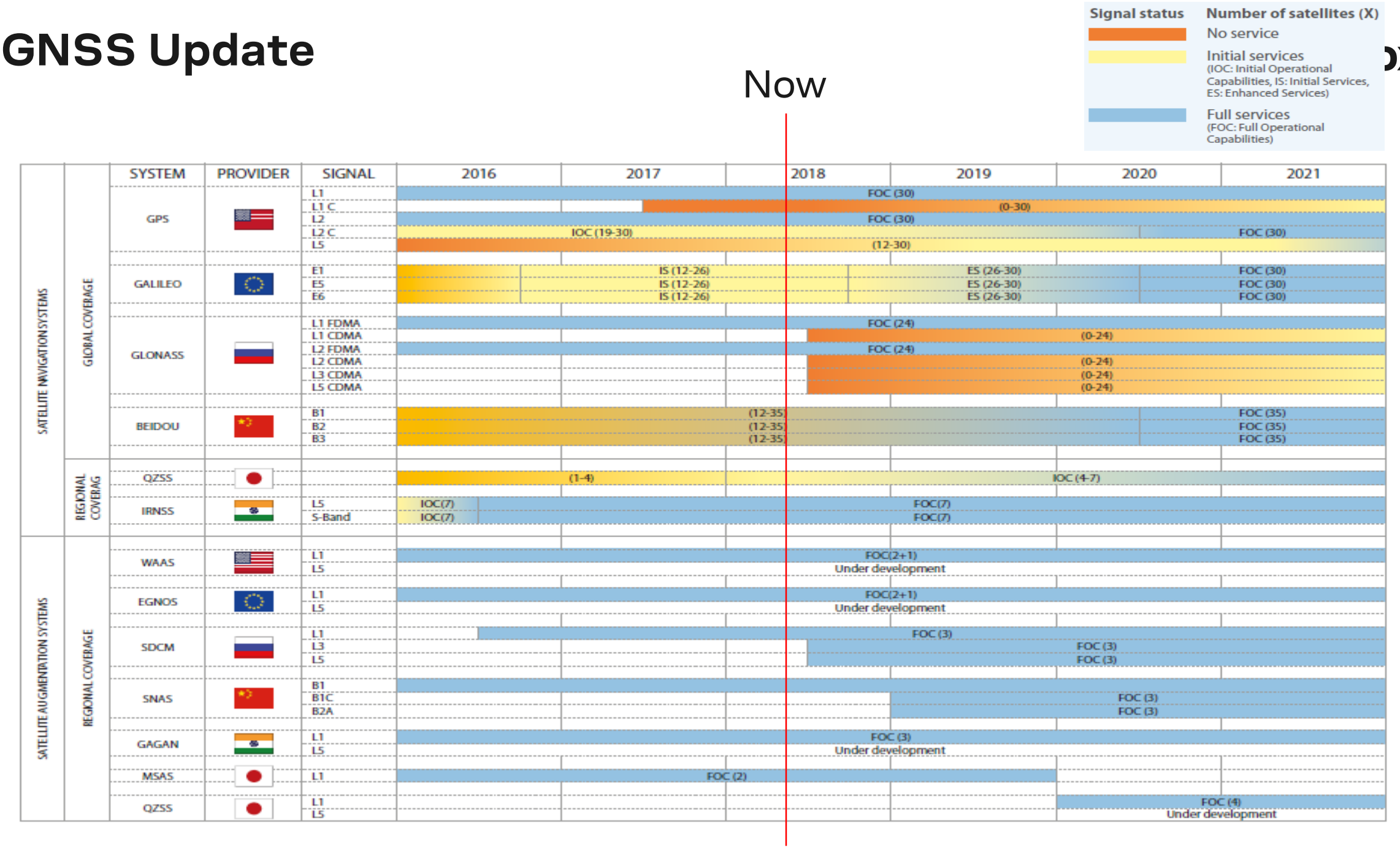
u-blox F9

Multi-band, Multi-constellation capabilities

- u-blox F9 capable of tracking all civil GNSS signal bands
- Multi-band enables fast time to first fix and robust performance by mitigating ionosphere errors
- Multi-constellation enables receiver to track a high number of GNSS observations

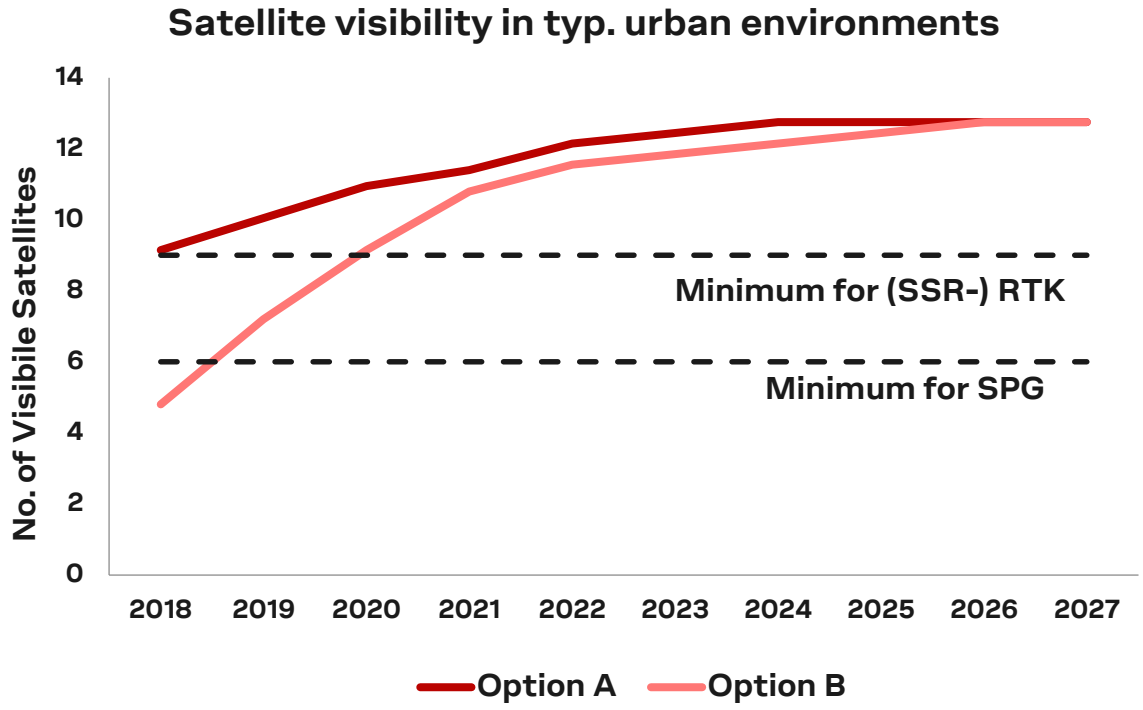


GNSS Update


Signal status
Number of satellites (X)
No service
Initial services
(IOC: Initial Operational Capabilities, IS: Initial Services, ES: Enhanced Services)
Full services
(FOC: Full Operational Capabilities)
Now
SATELLITE NAVIGATION SYSTEMS
GLOBAL COVERAGE
REGIONAL COVERAG
SATELLITE AUGMENTATION SYSTEMS
REGIONAL COVERAGE
SYSTEM
PROVIDER
SIGNAL
2016
2017
2018
2019
2020
2021
GPS
L1
L1 C
L2
L2 C
L5
FOC (30)
(0-30)
FOC (30)
IOC (19-30)
FOC (30)
(12-30)
GALILEO
E1
E5
E6
IS (12-26)
IS (12-26)
IS (12-26)
ES (26-30)
ES (26-30)
ES (26-30)
FOC (30)
FOC (30)
FOC (30)
GLONASS
L1 FDMA
L1 CDMA
L2 FDMA
L2 CDMA
L3 CDMA
L5 CDMA
FOC (24)
(0-24)
FOC (24)
(0-24)
(0-24)
(0-24)
BEIDOU
B1
B2
B3
(12-35)
(12-35)
(12-35)
FOC (35)
FOC (35)
FOC (35)
QZSS
(1-4)
IOC (4-7)
IRNSS
L5
S-Band
IOC(7)
IOC(7)
FOC(7)
FOC(7)
WAAS
L1
L5
FOC(2+1)
Under development
EGNOS
L1
L5
FOC(2+1)
Under development
SDCM
L1
L3
L5
FOC (3)
FOC (3)
FOC (3)
SNAS
B1
B1C
B2A
FOC (3)
FOC (3)
GAGAN
L1
L5
FOC (3)
Under development
MSAS
L1
FOC (2)
QZSS
L1
L5
FOC (4)
Under development

Importance of Maximizing Number of Signals in Urban Areas

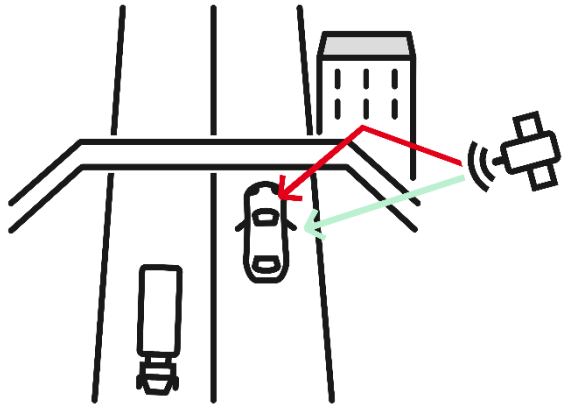
- Multi-constellation, multiband RTK / SSR-RTK is crucial for decimeter-level performance
- Option A maximizes satellite visibility for RTK / SSR-RTK
  - GPS & GLONASS: readily available in L2C/L2OC
  - Galileo: full E5b constellation by ~2020
  - BeiDou: B2I available until migration to B2a
- Option B maximizes satellite visibility for Standalone GNSS
  - Dependent on BeiDou migration to B2a
  - Does not become useful for RTK / SSR-RTK until 2021



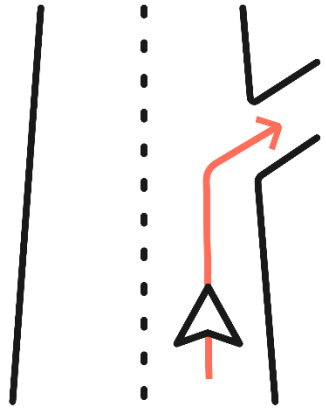
u-blox F9 platform maximizes satellite visibility in urban environments for both High Precision and Standalone GNSS use cases

Challenges for high-accuracy GNSS

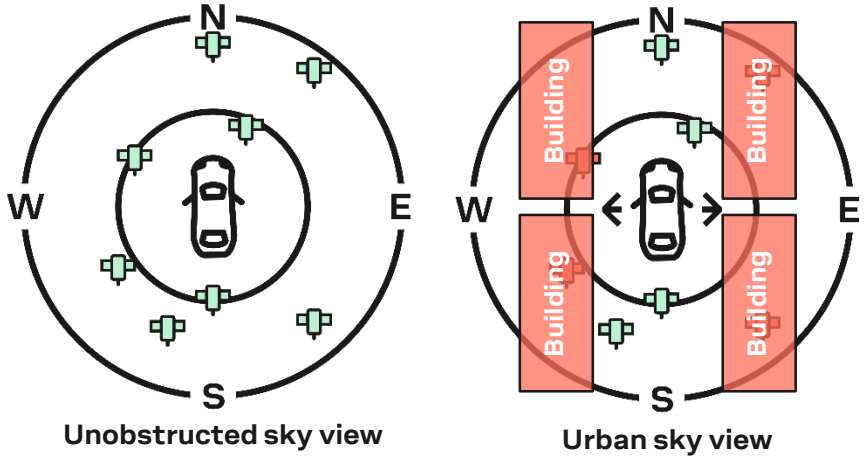
- Next generation mass market navigation applications require more automation & control
- Higher accuracy, more affordable, more versatile & globally deployable than existing solutions
- Performance of existing navigation applications in multipath & limited sky view environments



Multipath



Lane Level Navigation

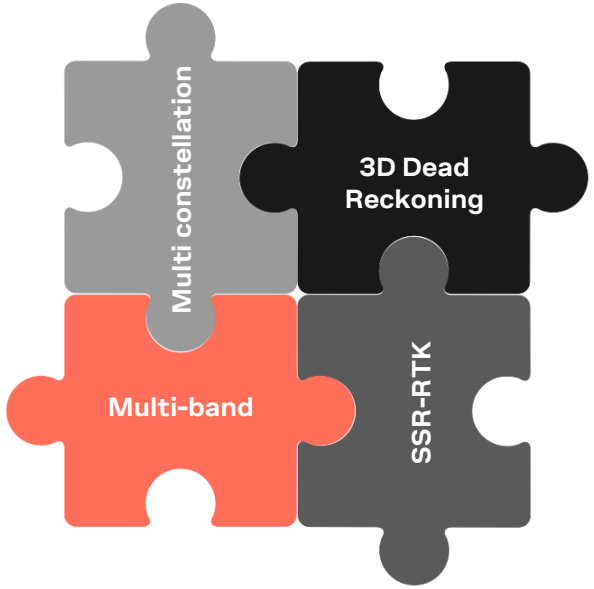


Limited Sky View

u-blox F9 technology

- There is no single technology capable of providing the required position accuracy in all environments
- u-blox F9 uses a tight combination of core GNSS technologies:

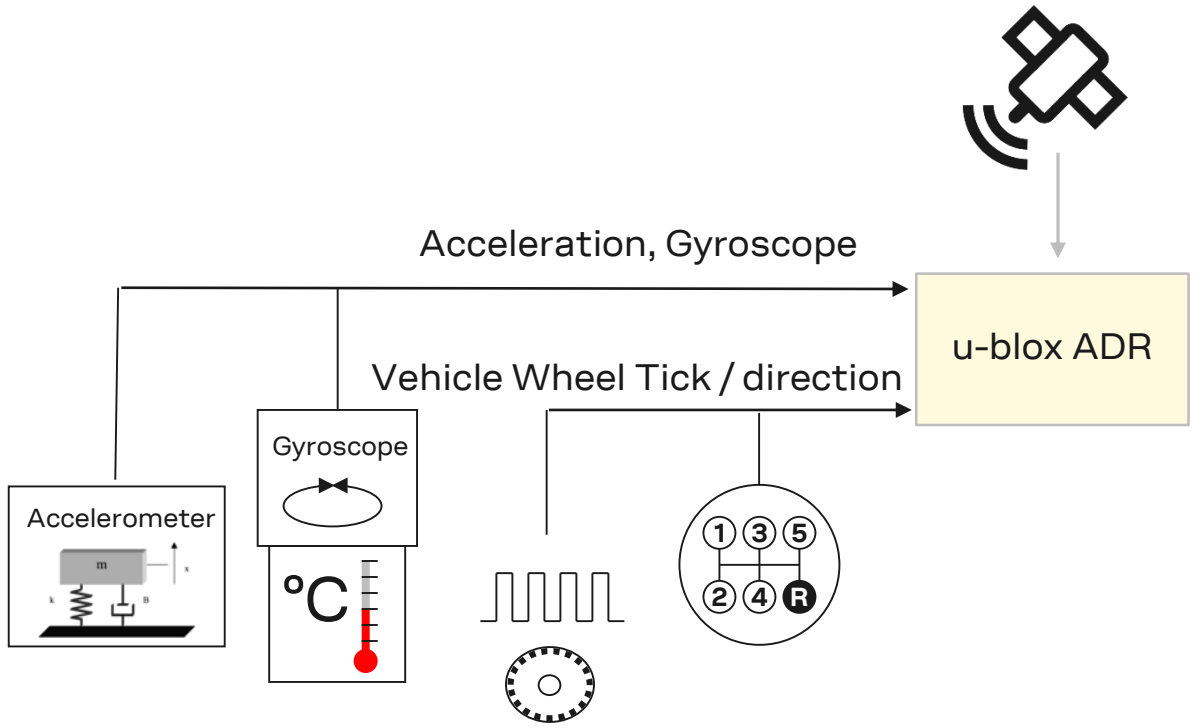
- for a large number of direct line-of-sight measurements
- for fast convergence & re-convergence of high precision positions

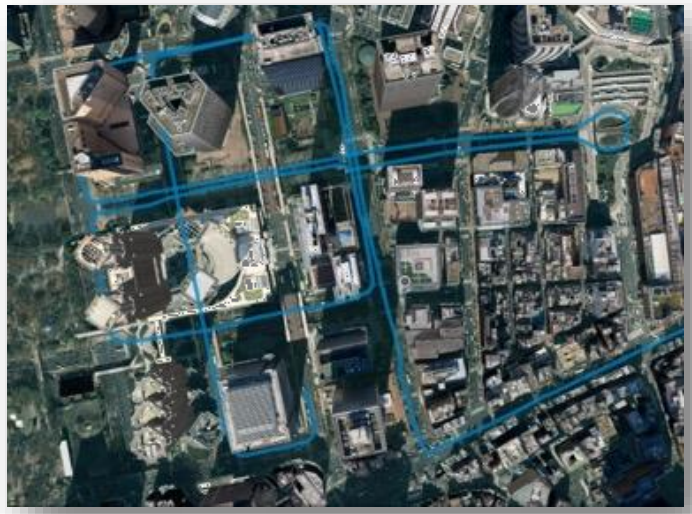


- to smooth multipath effects, bridge obstructions
- maintain positioning in tunnels & parking garages in automotive navigation
- delivering down to centimeter-level accuracies

u-blox F9 - dead reckoning

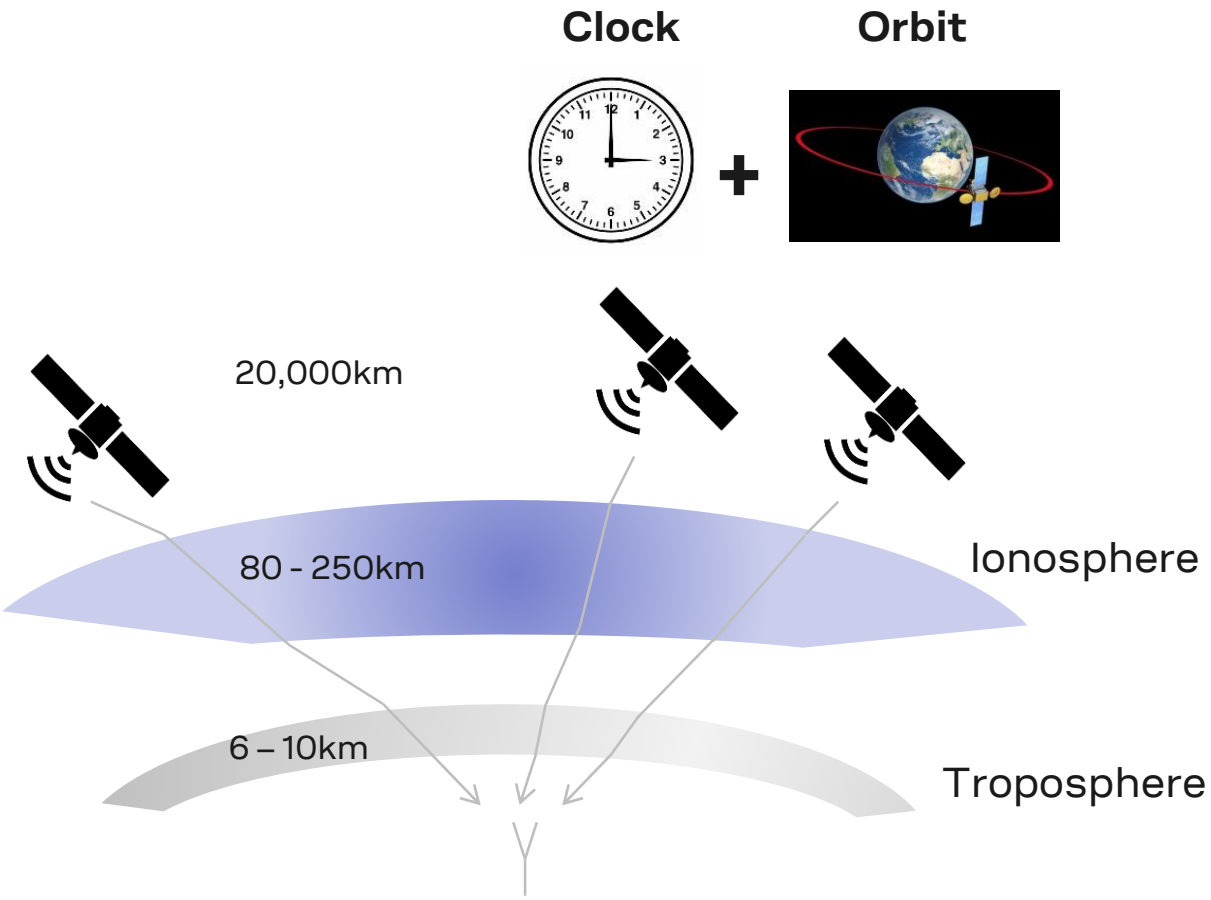
- Dead reckoning calculates position with sensor inputs and GNSS, even if GNSS signal is lost or degraded
- Combined with high precision GNSS we get down to centimeter-level accuracies, also in urban environments



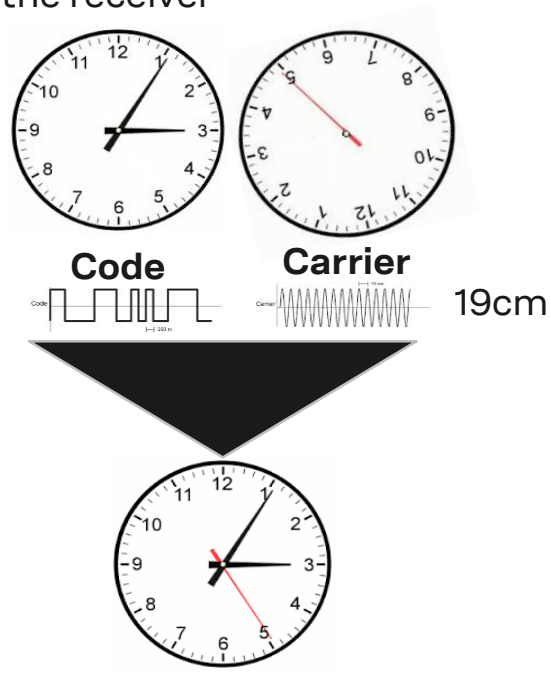


GNSS error sources and RTK technology

We need to eliminate the error sources:
Clock, orbit, Ionosphere and troposhere

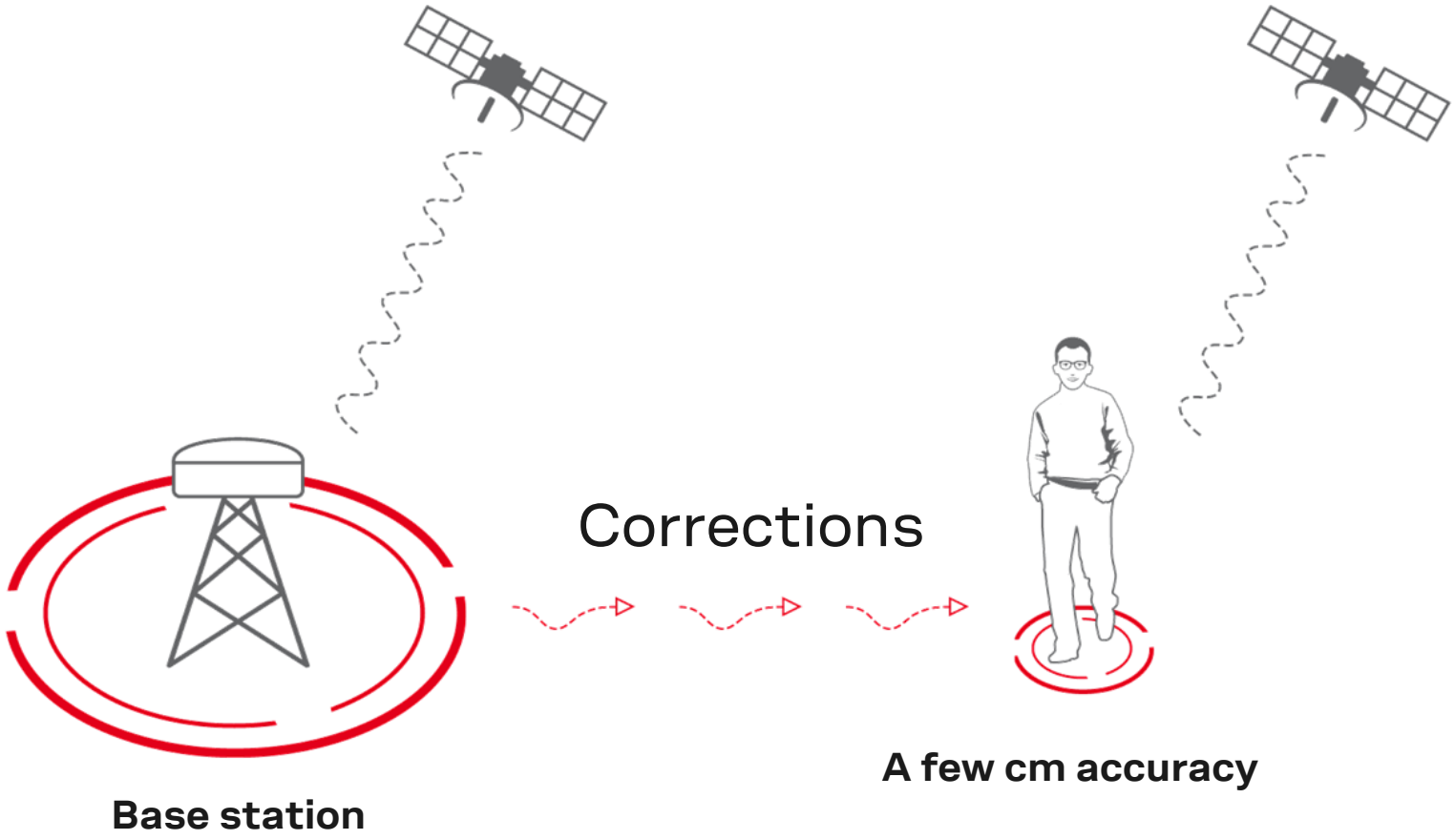


RTK = Real Time Kinematic
We need to solve how many carrier cycles there are between the satellite and the receiver



Carrier phase ambiguities fixed

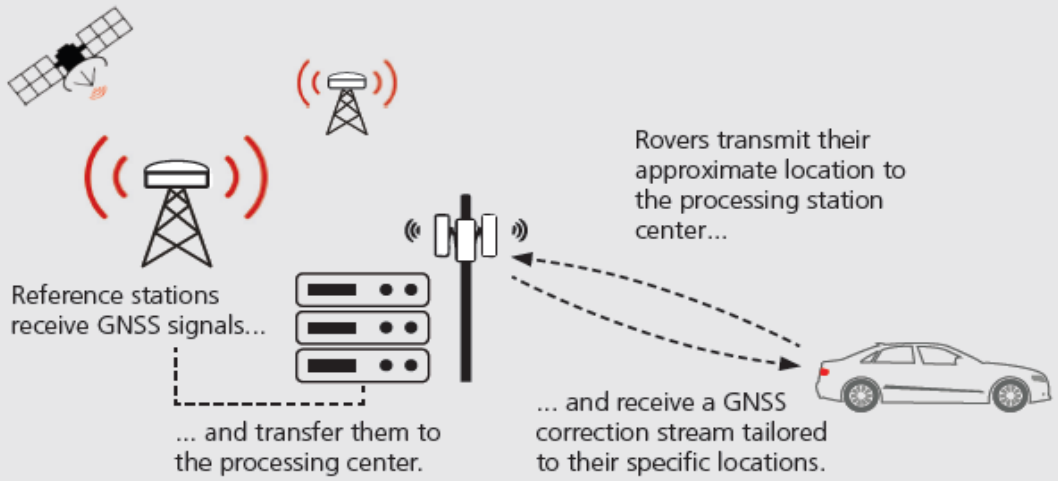
RTK - Centimeter-level precise positioning



u-blox F9 - GNSS correction services

Global coverage and versatility

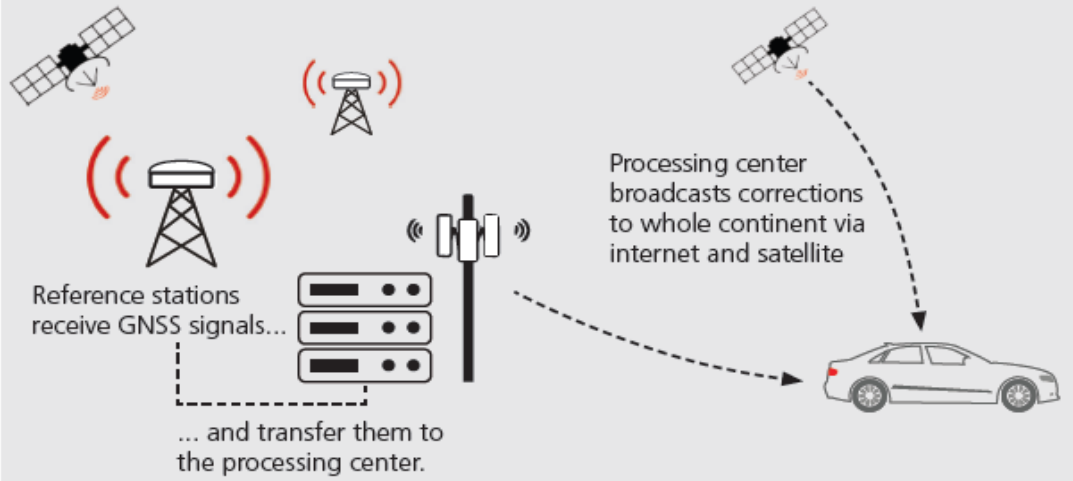
Observation State Representation (OSR)



+	centimeter-level accuracy
−	local coverage
−	high bandwidth
−	correction data tailored to a single location
−	two-way communication

e.g. RTCM v 3.x Single Baseline or Network RTK (VRS)

State Space Representation (SSR)



centimeter-level accuracy	+
global coverage	+
low bandwidth	+
correction data valid over the entire serviced area	+
one-way communication	+

e.g. Sapcorda services

Summary

Multi-band GNSS will come to mass market, main hurdles so far

- Cost (several 100$ - several k$)
- Size (40 x 60mm)
- Power consumption (~1W)

u-blox multi-band GNSS receivers will change that

- cm-level accuracy in tiny form factor and affordable price points.

Visit our booth for further discussions:

- Check also open positions @ www.u-blox.com