

Introduction

Centimeter-Level GNSS Precision for All Applications



Expanding Horizons – Why This Matters



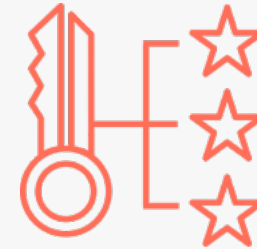
Ongoing Evolution

GNSS is **continuously expanding**, both in market adoption and applications growth.



The Big Shift

High-precision GNSS is transitioning from specialized sectors to **mass-market applications**.



Key Drivers

Increasing demand for **automation** from assisted navigation to **fully autonomous systems** across industries.

Key Enablers - Unlocking Unprecedented Possibilities

✓ New GNSS Signals & Services

- Galileo, BeiDou, and modernized GPS, as well as regional systems introduce new signals and new services.

✓ Receiver Advancements

- Multi- and all-band GNSS receivers are now **smaller, more efficient, and affordable**, accelerating mass adoption.

✓ Evolving Correction Services

- **Broader range of correction options** driving adoption.
- RTK & PPP-RTK mainstream adoption
- **Global PPP services** offer scalable high-precision solutions for OEMs(!).
- Free services complement a growing number of commercial solutions.

Key Enablers – Receiver evolution

2016

- Cm-level accuracy (RTK) in **small** form factor



(12.2 x 16 x 2.4 mm)

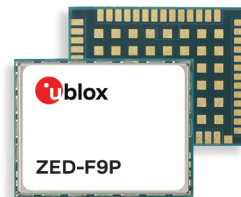
2021

- Support for continental **PPP-RTK** correction services in ZED-F9P



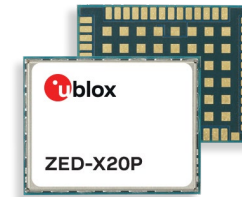
2019

- **Multi-band RTK** in small form factor
- Affordable multiband antennas

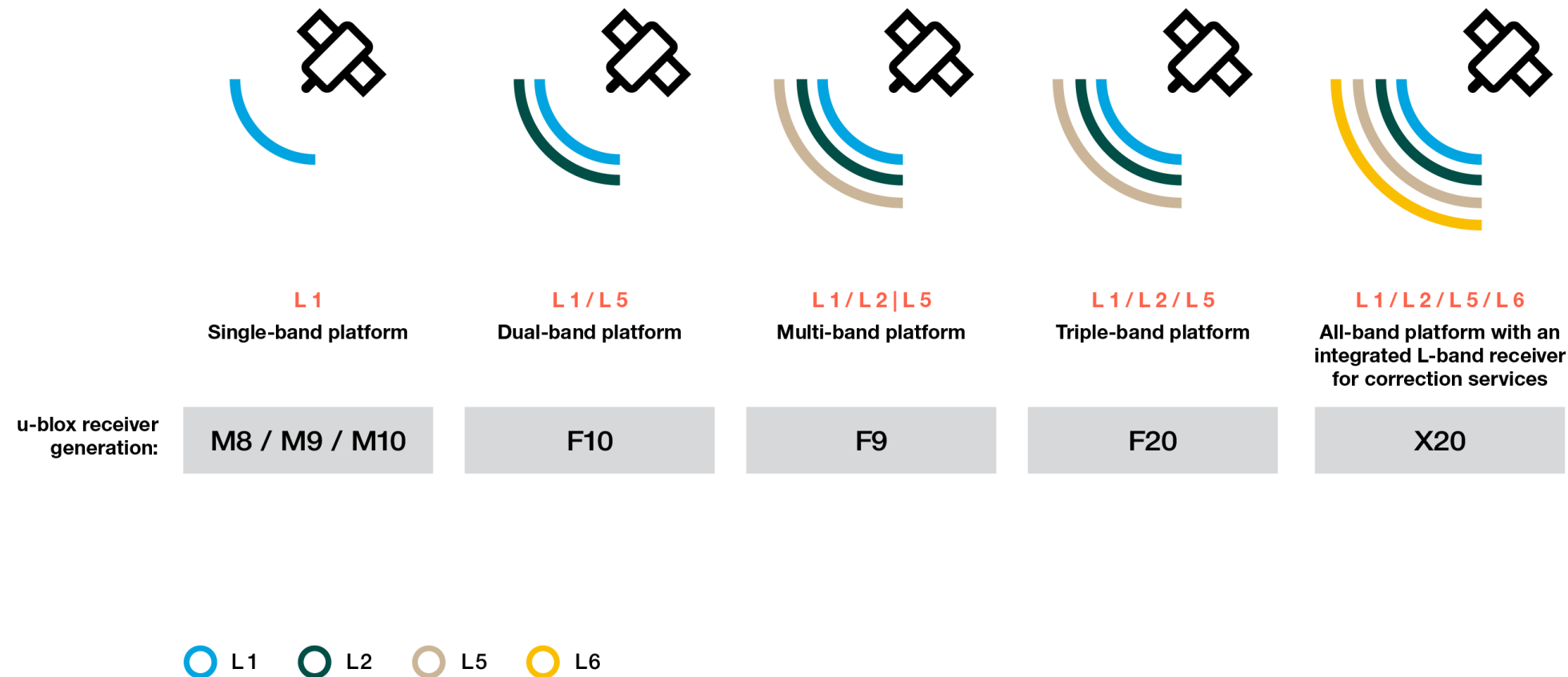


2025

- **All-band** receivers for mass market
- **Global PPP services**



Receiver Evolution - From Single-band to All-band



The path of u-blox platforms to all-band technology

Key Enablers – Correction services

✓ A Prerequisite for High-Precision Accuracy

- Indispensable for achieving sub-meter, decimeter, or centimeter-level positioning.

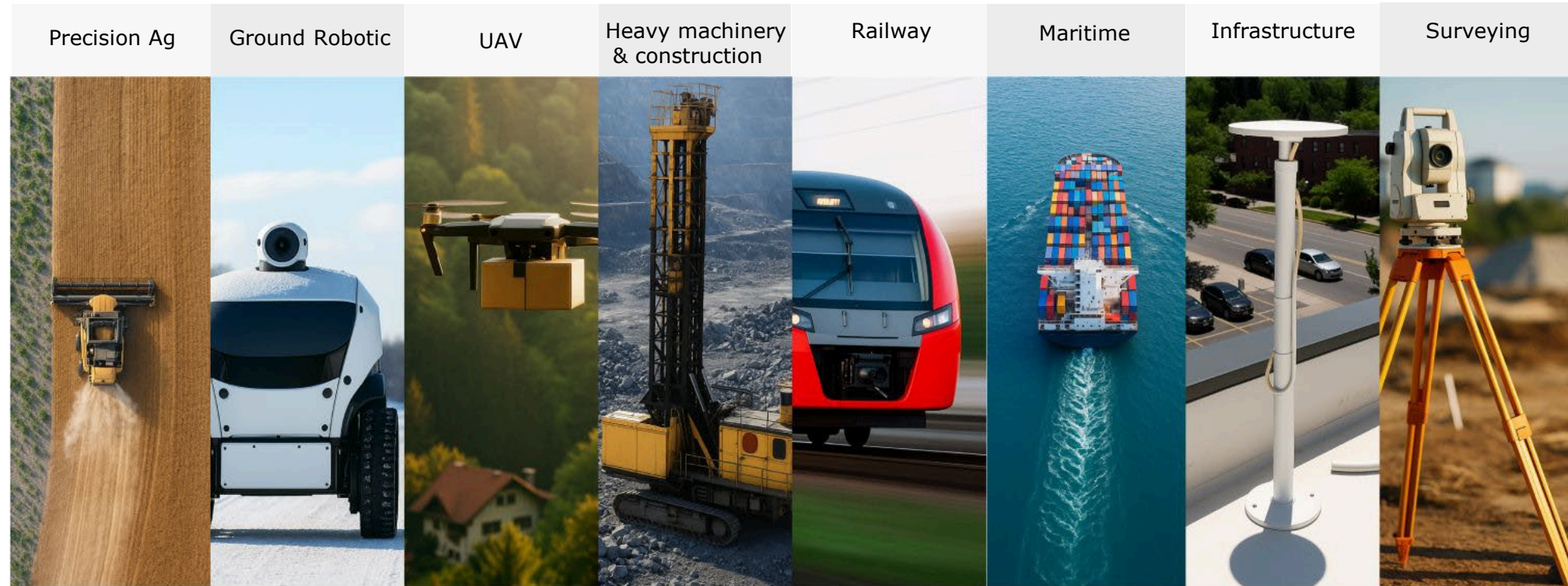
✓ High-Precision Services Now Provided by GNSS Constellations

- **Galileo HAS** (Europe, Initial Service Phase) – Centimeter-level corrections directly from the Galileo system.
- **BeiDou** (China) **B2b PPP** – Regional high-precision augmentation
- **QZSS** (Japan) **CLAS** – Regional cm-level PPP-RTK service, **MADOCA** – Global PPP service

✓ Seamless Integration with Modern Solutions

- **Evolving commercial correction services** and global service area expansion enable correction services to be an integrated part of modern GNSS solutions.
- **No longer a problem left to the end user**—corrections are becoming a **built-in feature of positioning systems**.

Industrial target markets for High Precision GNSS



Precision Agriculture



Seeding
Accuracy 4cm



Crop Care
Accuracy 10cm



Harvesting
Accuracy 15cm

Which products and services are suitable for these applications?

Introducing ZED-X20P



MARKS EVERY SPO

All-band global GNSS
ZED-X20P

X20 platform

- X20 is u-blox's next-generation platform based on the newest GNSS chip. A wide variety of products is based on this platform.
- X20 is a very advanced chip, with a focus on the mid- and high-end markets.

Automotive



High Precision

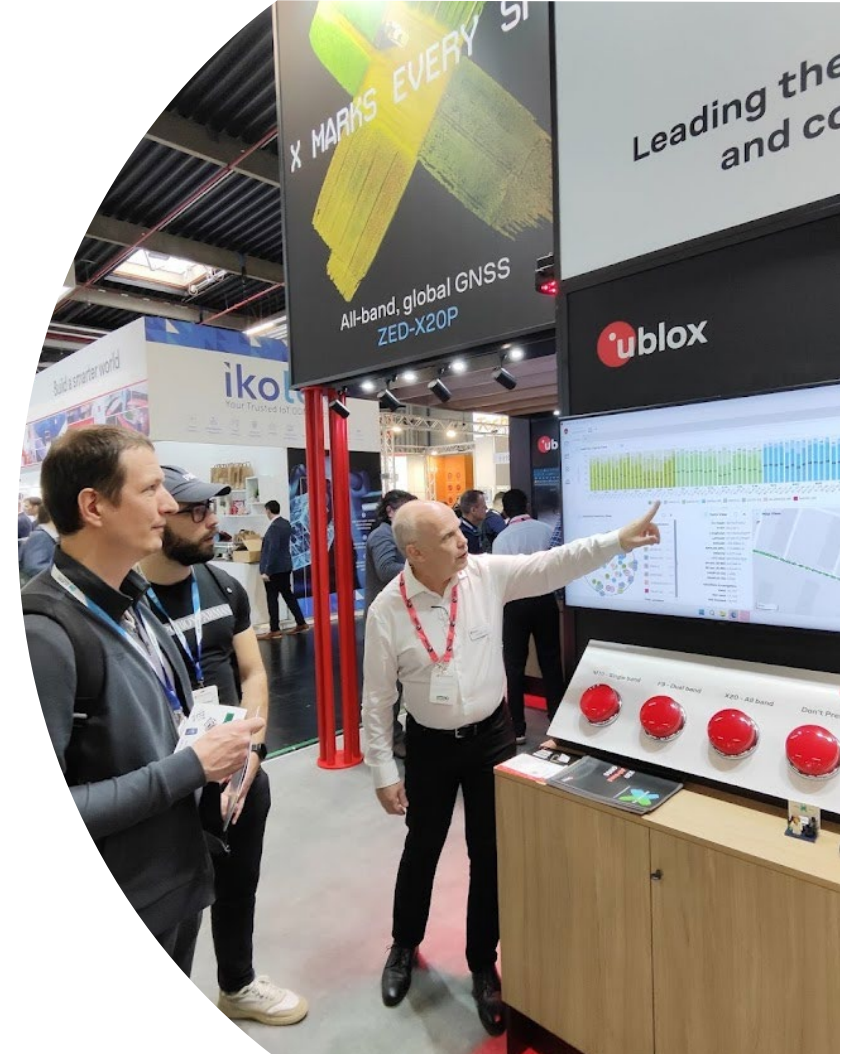


Timing



ZED-X20P – High-level update

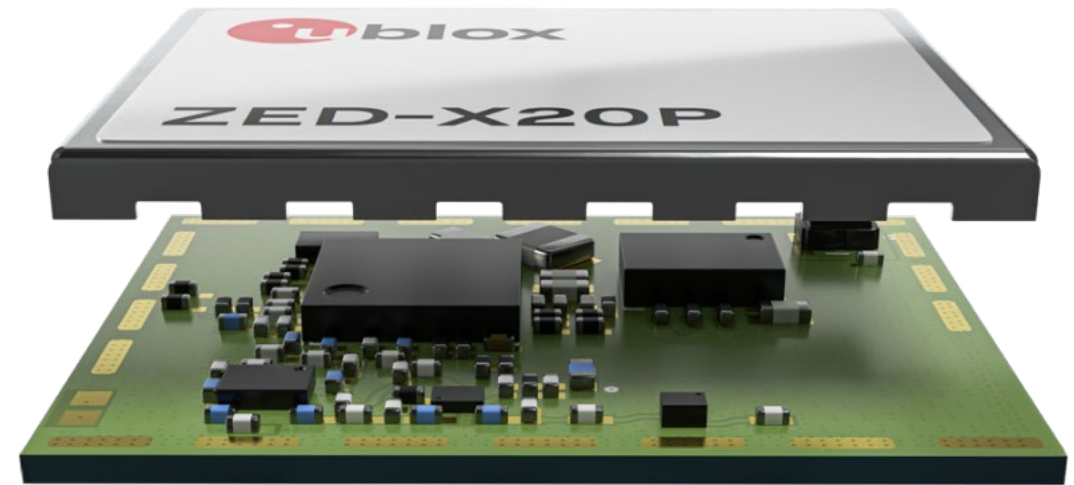
- ✓ Our first X20-based product
- ✓ Targeting Industrial Automation, high-end Industrial markets
- ✓ Product status: Engineering Sample
- ✓ Production schedule: August 2025



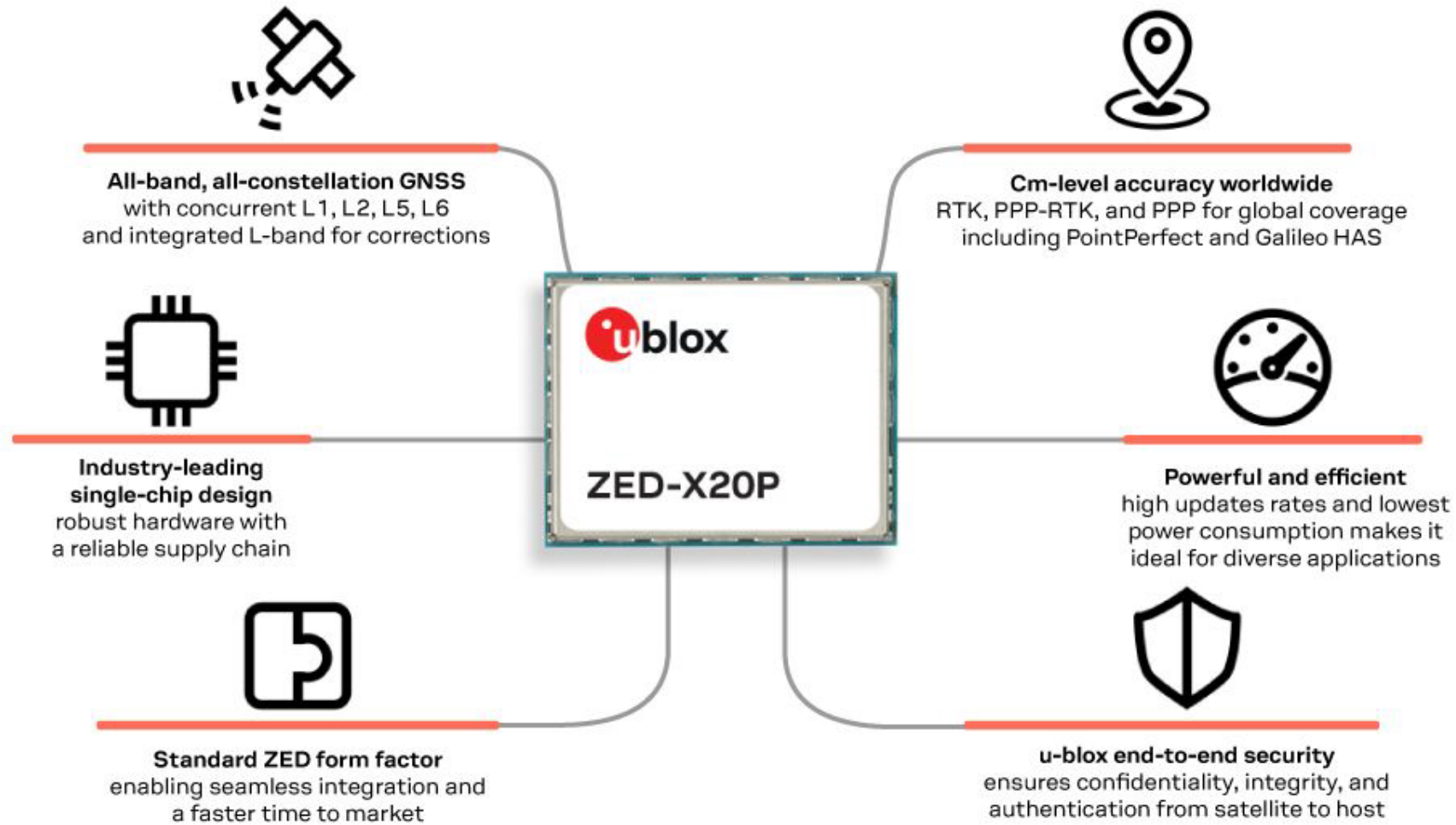
ZED-X20P: u-blox X20 high precision GNSS module

Raising performance worldwide

- All-band GNSS and cm-technology integrated in a small module (L1/L2/L5/L6 + L-band)
- World-leading RTK, PPP-RTK, and PPP support, including Galileo High Accuracy Services (HAS)
- u-blox End-to-end Security providing Confidentiality, Integrity and Authentication from satellites to the host

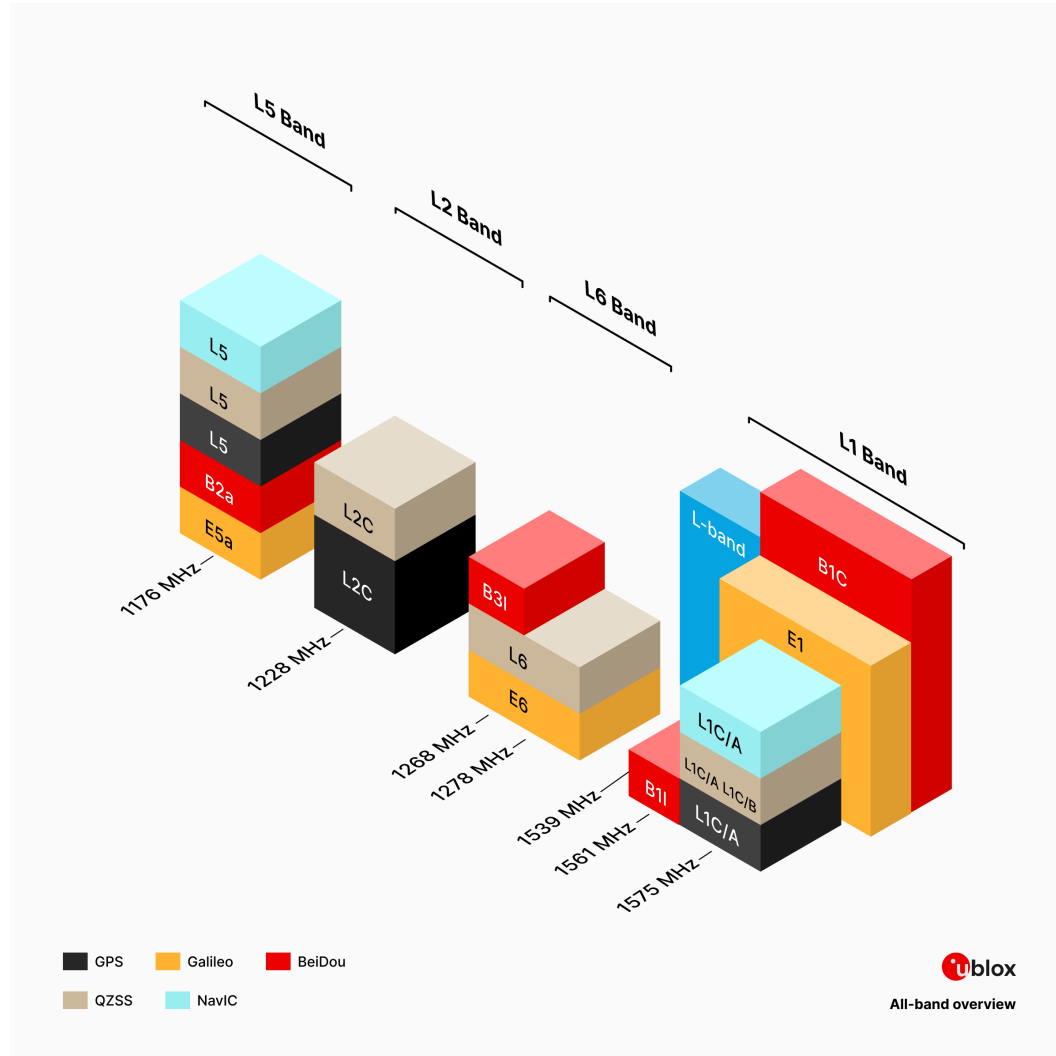


Key features



u-blox
ZED-X20P

ZED-X20P signal support



ZED-X20P is all-band

- It tracks all GNSS bands and systems concurrently.
- Including L-band.

All-band benefits



L1 / L2 / L5 / L6

**All-band platform with an
integrated L-band receiver
for correction services**

X20

- Brings access to all constellations and all GNSS bands.
- Brings the best availability of the best accuracy.
- Brings built-in access to correction services, both on L-band as well as PPP services.
- Brings PPP performance relevant to mass market applications.
- Brings GNSS integrity.

Product comparison

	ZED-X20P	ZED-F20P	ZED-F9P
Receiver type	All-band	Triple-band	Multi-band
GNSS Signal support	GPS L1C/A, L2C, L5 GAL E1, E5a, E6 BDS B1I, B1C, B2a, B3I QZSS L1C/A, L1C/B*, L2C, L5, L6 NAVIC L1*, L5 SBAS L1	GPS L1C/A, L2C, L5 GAL E1, E5a BDS B1I, B1C, B2a QZSS L1C/A, L1C/B*, L2C, L5 NAVIC L1*, L5 SBAS L1	GPS L1C/A, L2C or L5 GAL E1, E5a or E5b BDS B1I, B2I or B2a GLO L1OF, L2OF QZSS L1C/A, L2C, L5 NAVIC L5 SBAS L1
Accuracy by mode	Standalone: 1.2m RTK: 0.6cm + 1ppm PPP-RTK: <6cm PPP*: <10cm	Standalone: 1.2m RTK: 0.6cm + 1ppm PPP-RTK: <6cm	Standalone: 1.5m RTK: 1cm + 1ppm PPP-RTK: 3-6cm
RTK / PPP-RTK availability with fast convergence	●●●	●●●	●●○
Security	●●●	●●●	●●○
Max update rate with all GNSS enabled, RTK, RAW	25 Hz	25 Hz	8 Hz
L-band support	Integrated (1539-1559MHz)	-	NEO-D9S
Future-proof design	Industry-leading single-chip design	Industry-leading single-chip design	Dual-chip design
u-blox Service support	PointPerfect Live PointPerfect Flex PointPerfect Global* (PPP)	PointPerfect Live PointPerfect Flex	PointPerfect Live PointPerfect Flex

* In development

ANN-MB2 – our all-band antenna

Developed according to the u-blox all-band antenna specification,
tuned for the u-blox X20 high precision GNSS platform.

ANN-MB2



92.9x108.5x24.7mm, 5m cable with SMA connector

Band/application

L1, L2, L5/E5/B2/NavIC, E6/B3, L-band
High Precision, with RTK

Suitable
u-blox products

ZED-F9T-20B & other F9 customers need triple/wide-band antennas
ZED-X20P, ZED-F20P & other upcoming X20/F20 products

Product status

Initial production!

Excellent performance

Product summary ANN-MB2 antenna

All-band high precision GNSS antenna

- Easy-to-use, reliable all-band antenna as part of a u-blox high precision solution
- Robust L1/L2/L5/E5/B3/L active external GNSS antenna
 - High performance all-band antenna for the mass-market
 - Supports all major GNSS systems for maximum position availability
 - Versatile mounting options to meet diverse installation needs
 - Enables fast time-to-market



Product description

The u-blox ANN-MB2 multi-band (L1/L2/L5/E5/B3/L) active GNSS antenna is designed to reduce time-to-market for the modern wide-frequency, multi-correlation, high-precision GNSS applications, which require centimeter-level accuracy and a reliable RTK positioning fix even in challenging environments. Its robust design, excellent price-to-performance ratio, and flexible mounting options make the ANN-MB2 an ideal choice for mass market applications requiring an all-band high precision GNSS antenna.

The ANN-MB2 is a perfect match to the u-blox F9 high-precision products (e.g. ZED-F9X, ZED-F9T, LRA-F9T, and ZED-F9T) supporting L1, L2, and L5 bands, along with the L-band for RTK corrections. With ANN-MB2 customers have a reliable, ready-to-use all-band antenna that streamlines evaluation, minimizes design efforts, and speeds up mass adoption.

Patch antenna characteristics

	L1/L2 band	L5/L2/E5/B3 band
Frequency	1575 - 1602 MHz	1166 - 1385 MHz
Impedance	50 Ω	50 Ω
Peak gain (dBi)	L1: Typ. 5.4 dBi L2: Typ. 5.0 dBi	L5: Typ. 4.5 dBi L2: Typ. 5.0 dBi E5: Typ. 4.2 dBi
Efficiency	L1: Typ. 64% L2: Typ. 56%	L5: Typ. 55% L2: Typ. 60% E5: Typ. 50%
Axial ratio (dBi)	Typ. 0.5-1.3 dBi	Typ. 1.0-2.0 dBi
Polarization	RHCP	RHCP

1. Measured on 0.10 cm ground plane.

Amplifier characteristics

	L1/L2 band	L5/L2/E5/B3 band
Frequency	1575 - 1602 MHz	1166 - 1385 MHz
Gain without cable (dBi)	Typ. 4.8 at 5 V	Typ. 5.5 at 5 V
Noise figure (dB)	Typ. 2.2 - 2.3 dB	Typ. 2.3 - 2.5 dB
Output VSWR	Typ. 2.0	Typ. 2.0
DC voltage	3.0 - 6.0 V	
DC current (at 5 V)	Typ. 15.0 mA	

Mechanical data

Weight	260 g (typ. including cable)
Size	108.5 x 92.9 x 24.7 mm
Cable	5 m 50 Ω standard
Connector	SMA
Mounting	Magnetic base, fixed installation option (screw)
Housing color	Black

Environmental data

Operating temperature	-40°C to +85°C
Storage temperature	-40°C to +85°C
Water proof	IP67

Product variants

ANN-MB2-00	Multi-band (L1/L2/L5/E5/B3/L) active GNSS antenna, high precision, with 5-meter cable and SMA connector
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UBDOC-06300114-10001 - 5/01

Objective Specification - CS-Restricted

Further information

For contact information, visit www.u-blox.com/contact-u-blox.



PointPerfect services



PointPerfect correction services with X20 series

Best fit for every application



Evolving market requirements for high-precision GNSS

Accuracy and Performance

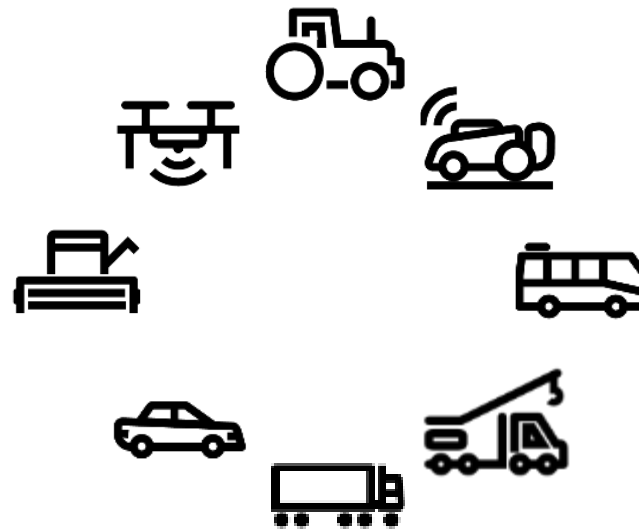
I need robust accuracy and fast convergence time to provide great user experience to my customers.

Flexibility and value

To drive my business case value, I need flexible pricing models that suit my needs and help me optimize my operating expenses.

Best fit

I want to use the RTK corrections solution that provides the best fit for my business case requirements.



Scalability

I need a scalable solution that supports all my receivers, without having to deploy and maintain my own base station hardware or manage different configurations across different markets.

Coverage

I need a solution that works in both urban centres and remote locations, over my whole market footprint around the world.

Expertise and support

I want the best expert support throughout my whole product life cycle.

Faster and easier go-to-market

A complete solution that brings together leading hardware, services, and support, covering the entire lifecycle from successful go-to-market to ongoing support throughout the solution's lifetime.



Covering the **whole spectrum** of customer cases



Covering the **whole spectrum** of customer cases



Optimal solution for every customer application

PointPerfect portfolio



PointPerfect Flex

- Unbeatable performance/price balance and scalability to mass-market solutions.
- Great solution for large fleets on verticals like mobile outdoor robotics, automotive, precision agriculture and UAVs.



PointPerfect Live

- Ultimate performance for the highest requirements.
- For demanding use cases in verticals like construction, surveying, precision agriculture and mining.



PointPerfect Global*

- Worldwide coverage for truly global reach – also over satellite L-band broadcast
- For applications requiring coverage world-wide and in the remote areas, for example in precision agriculture, outdoor robotics and UAVs.

*Upcoming service to be launched early 2026

PointPerfect: An optimal solution for every application

	 PointPerfect Live Superior performance for the most demanding applications	 PointPerfect Flex Scalable and flexible solutions for wide-ranging use cases	 PointPerfect Global* Seamless worldwide coverage for truly global solutions
Technology	network RTK OSR corrections format	PPP-RTK SSR and OSR correction formats	PPP-AR SSR corrections format
Error corrections	Satellite clock & orbits Code & phase biases Ionospheric & tropospheric delays	Satellite clock & orbits Code & phase biases Ionospheric & tropospheric delays	Satellite clock & orbits Code & phase biases
Accuracy**	1-2 cm	3-6 cm	<10 cm
Convergence time**	<10 sec	10-30 sec	<2 min
Data format	RTCM	SPARTN & RTCM	SPARTN
Required bandwidth	~6 kbit/sec	SPARTN: ~0.5 kbit/sec RTCM: ~6 kbit/sec	<0.5 kbit/sec
Coverage***	Key regions of Europe & USA	Europe & USA, Canada, Japan, Korea, Brazil, Argentina, Australia	Global
Data delivery	Internet	Internet, customer cloud & Satellite broadcast in Americas	Internet, customer cloud & Satellite broadcast

*Upcoming service to be launched early 2026, **Performance may vary depending on conditions, ***Partial coverage in some countries

PointPerfect: Service coverage



PointPerfect Live

Superior performance for the most demanding applications



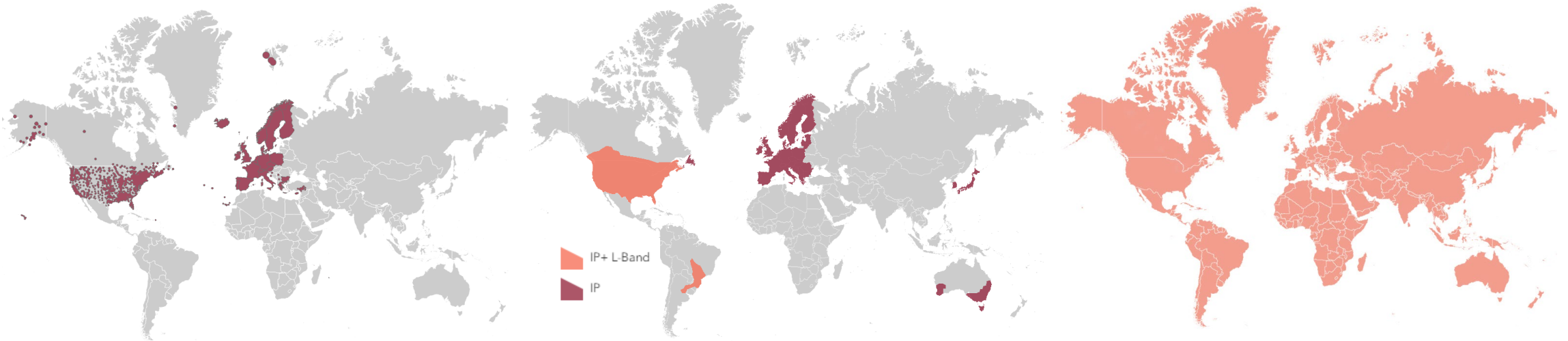
PointPerfect Flex

Scalable and flexible solutions for wide-ranging use cases



PointPerfect Global*

Seamless worldwide coverage for truly global solutions



*Upcoming service to be launched early 2026

Optimizing your Total Cost of Ownership

- Over the whole solution lifetime, cellular data costs can be a significant part of the solution's total cost of ownership.
- Compared to the RTCM data format, PointPerfect's SPARTN format corrections can reduce data usage up to **90%**.
- Slash your mobile data operating costs by using bandwidth-optimized PointPerfect SPARTN together with u-blox X20 series receivers.
- SPARTN data format is available with the PointPerfect Flex and PointPerfect Global services.

Data usage for 1 month, 24/7 access

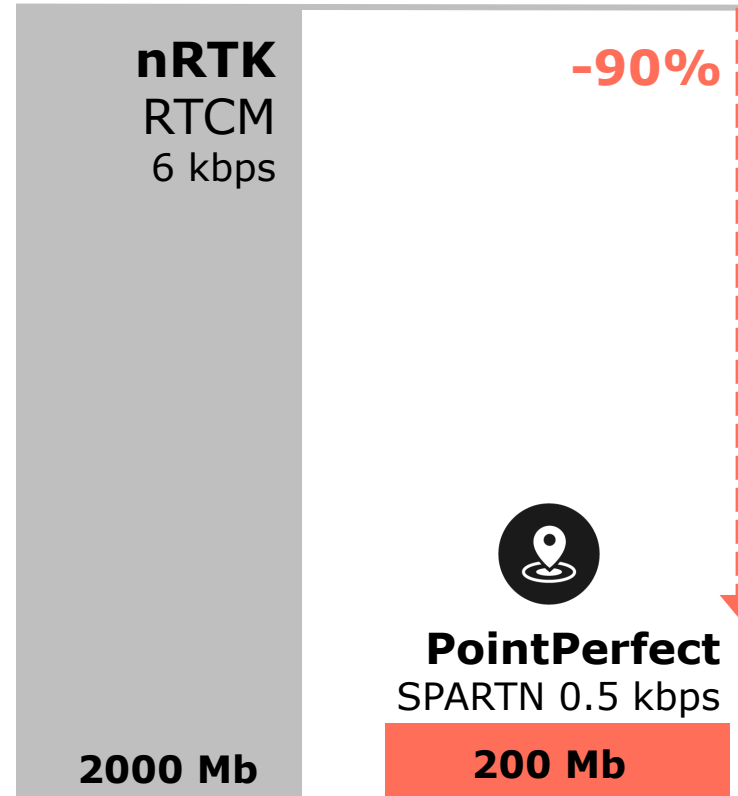


Diagram not to scale.
For illustration purposes only

PointPerfect benefits



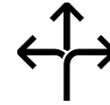
Pay only for what you use

- Reduce your operating expenses with flexible, usage-based price plans
- Optimize costs across your whole fleet by sharing hours via pooled plans
- Slash mobile data costs with data rates up to 90% lower than typical RTK services



Superior coverage

- Wide uniform coverage over entire countries, continents and even world-wide
- Stay connected with satellite L-band delivery and operate in areas without cellular coverage



Easy. Flexible. Seamless.

- Flexible access options, with cellular, satellite L-band and cloud connectivity
- Scale efficiently with zero-touch provisioning for device activation
- Enterprise ready with automation and integrations for managing large scale fleets



Reliable performance

- Achieve consistent high precision positioning with <10cm worldwide and 1-2cm for demanding applications in Europe and the USA
- Ensure uninterrupted performance with 99.9% uptime and 24/7 monitoring
- GNSS and RTK technology from u-blox, a trusted industry leader

Democratizing high precision

We aim to make high precision possible for every use case



Great
product fit
for every
application



Easy to get
going &
easy to scale



Unified
service
covering all
your
markets



Flexible
pricing
models for
different use
cases



Highly
optimized
mobile data
usage

See how it works yourself with the webinar offer:
Save \$100 on the EVK-X20P evaluation kit & **get a free 30-day trial** for PointPerfect Flex

Performance

X20 GNSS
u-blox

Dynamic testing - UAV

PointPerfect Live (VRS):

2D one-sigma: 1.2cm

3D one-sigma: 1.9cm

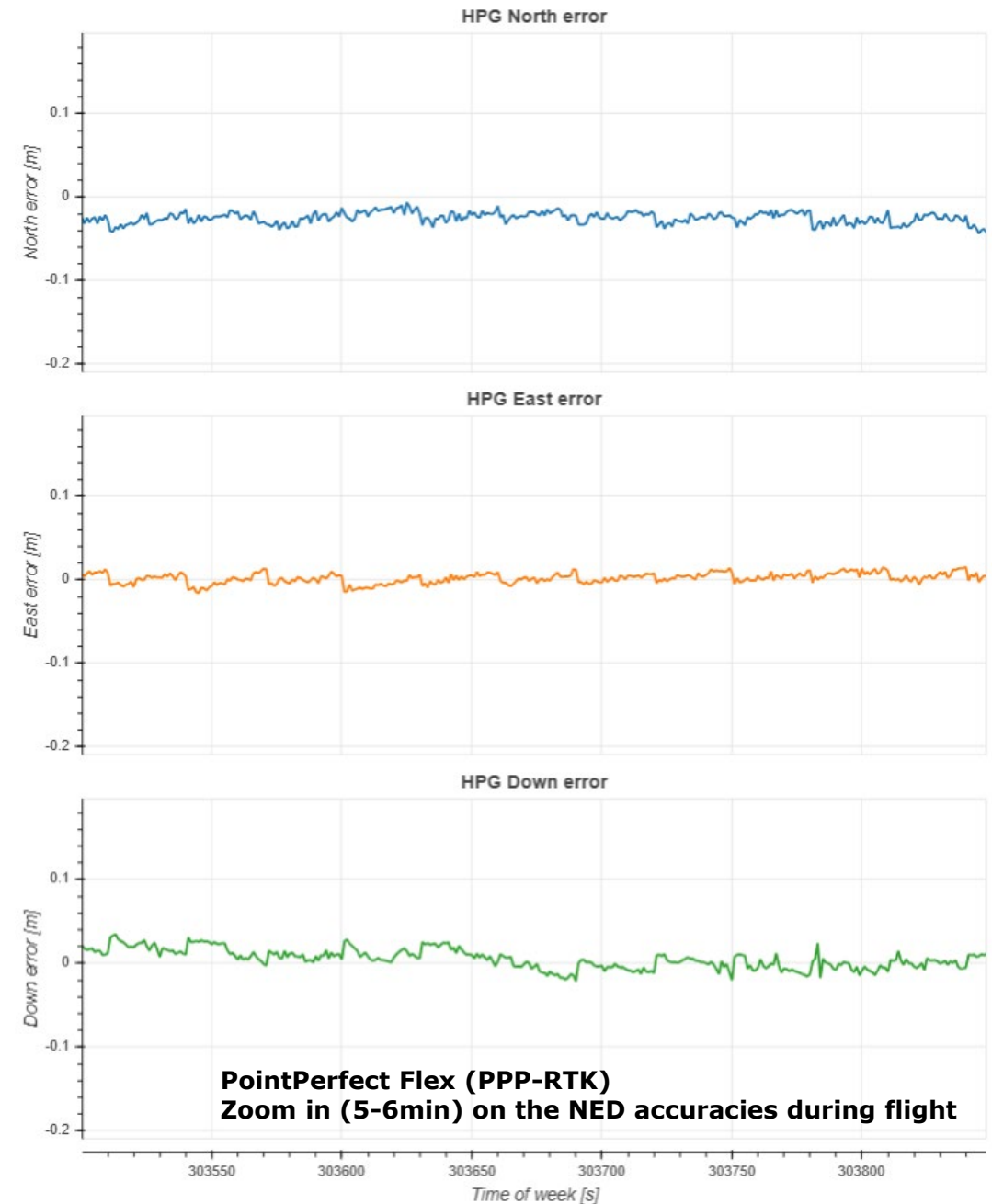
Max error (p100%, abs) components during flight:
N 2.2cm, E 2.3cm, D 3.6cm

PointPerfect Flex (PPP-RTK):

2D one-sigma: 3.3cm

3D one-sigma: 3.4cm

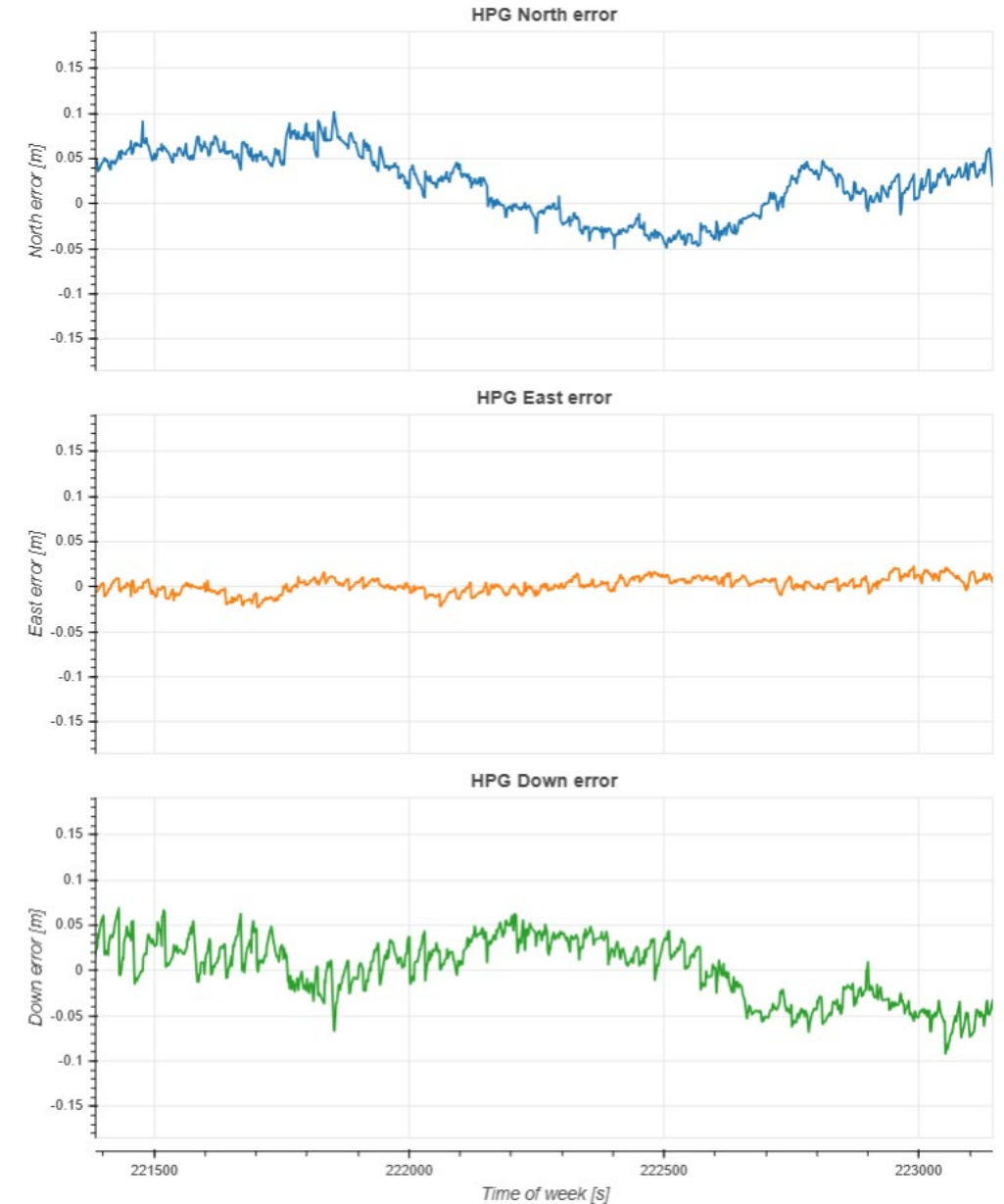
Max error (p100%, abs) components during flight:
N 5.6cm, E 2.8cm, D 6.0cm



Static testing – with PointPerfect Live (VRS) service

VRS / PointPerfect Live for 1 hour:

2D one-sigma: 6.0cm (N 4.4cm, E 2.3cm)



ZED-X20P performance



ZED-X20P
Competitor 1

GNSS fix
RTK float
RTK fixed

Reacquisition after the tunnel

- ZED-X20P quickly reacquires RTK solutions after exiting the tunnel.

ZED-X20P performance



ZED-X20P
Competitor 1

GNSS fix
RTK float
RTK fixed

Reacquisition after the tunnel

- ZED-X20P quickly reacquires RTK solutions after exiting the tunnel.

Best availability

- Maintains GNSS fix even while stationary under the overpass, ensuring continuous positioning.

Galileo HAS (PPP Service)

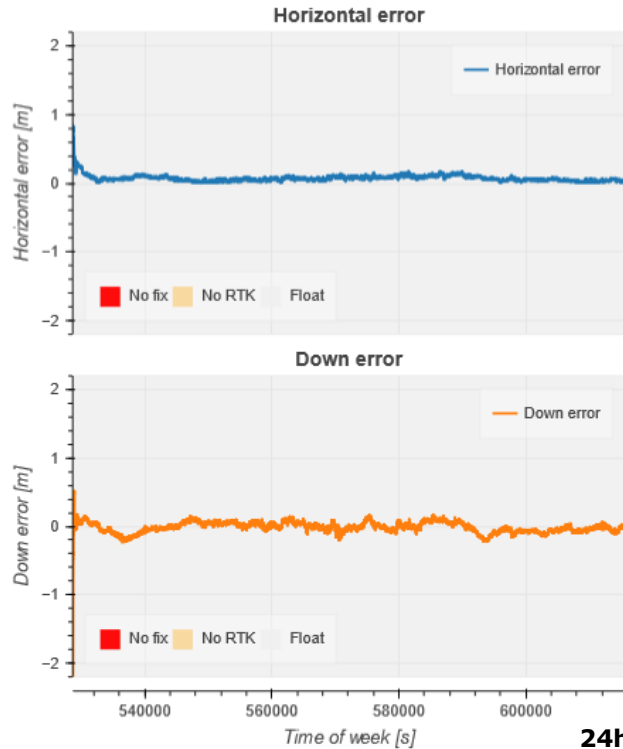


Galileo HAS - Summary

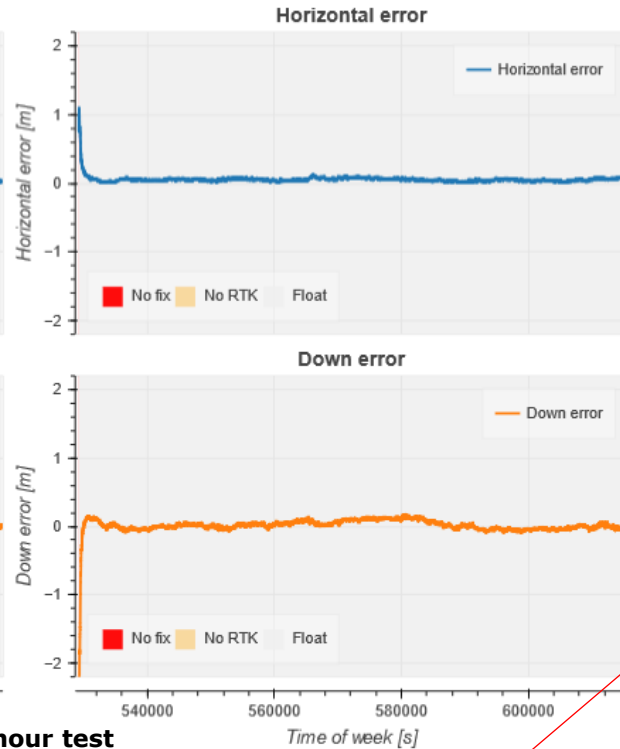
- Status: **Initial Service phase**
- Corrections for
 - GPS (L1/L5/L2C) and Galileo (E1/E5a/E5b/E5ab/E6)
 - Orbit, Clock, Code, and Phase biases (Phase bias corrections not currently available)
 - Ionospheric corrections over Europe (not currently available)
- Transmitted by every GALILEO Satellite on L6 signal (and over the Internet)
- HAS is the most interesting service of the free alternatives, thanks to
 - a) The global service area
 - b) The corrections being provided for the 3-bands for the two constellations and
 - c) the delivery channel where service data can be downloaded from any visible Gal SV
- With corrections on all three bands and an advanced receiver that includes the required L6/E6 support (as in ZED-X20P), relatively good performance is expected.

Early PPP performance with ZED-X20P

ZED-X20P with Galileo HAS (Initial Service)



ZED-X20P with PointPerfect Global (PPP)



- We see promising results in first PointPerfect Global and Galileo HAS performance data
- In 2025 we will focus on ensuring best availability and accuracy for dynamic applications, needed before PPP can be released in practical applications

FIGURE OF MERIT	TYPICAL PERFORMANCE	CONDITIONS AND CONSTRAINTS
HAS horizontal positioning accuracy	≤ 15 cm for Galileo + GPS	68th percentile - Over any 24 hours period - For the signal combinations supported by the HAS (specified in section 2.4.1) - Using the performance characterisation user algorithm - or HAS-UA - outlined in Appendix D - At least 8 satellites in view above 5 degrees elevation for Galileo + GPS users under open sky conditions - Static user - Applying orbit and clock corrections and code biases for the involved signals - At the AUL¹⁴ of the service area (specified in 3.1) - Usage assumptions as per section 2.4
HAS vertical positioning accuracy	≤ 20 cm for Galileo + GPS	

	2D p50	2D p68	2D p95	3D p50	3D p68	3D p95
PointPerfect Global	5cm	6cm	9cm	7cm	8cm	14cm
Galileo HAS	6cm	8cm	13cm	9cm	11cm	19cm

Galileo OSNMA



Galileo OSNMA – Introduction

What

- OSNMA = **O**pen **S**ervice **N**avigation **M**essage **A**uthenticati**c**
- Data message authentication for Galileo Open Service use
- Global service, free of charge

Why

- OSNMA provides GNSS receivers with the assurance that the received Galileo navigation message is coming from the system itself and has not been modified
- OSNMA strengthens GNSS receiver's robustness by increasing the capability of detecting spoofing events
- Galileo is the first and so far only GNSS to offer authentication to civilian users

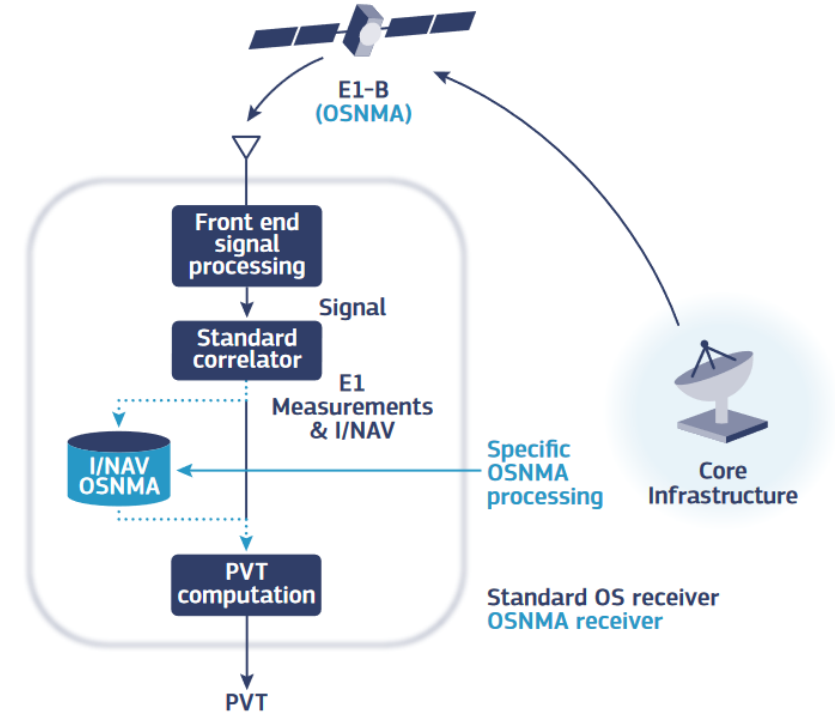
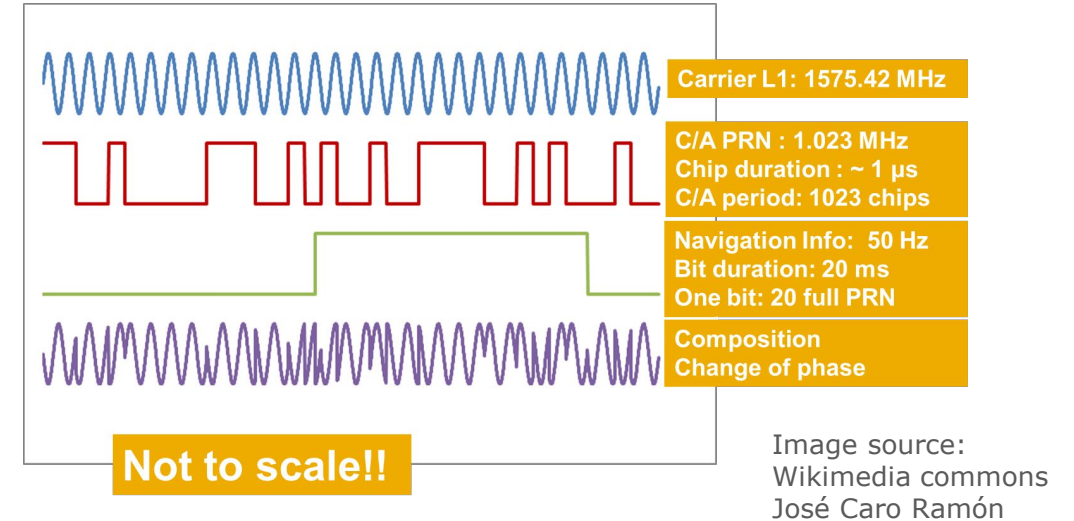


Image source: EUSPA
"Galileo OSNMA info note"

Galileo OSNMA – Signal structure

- GNSS broadcast signal consists of 3 parts:
 - RF carrier wave
 - Ranging code
 - Navigation data
- OSNMA leverages both E1-B and E5b-I to broadcast the authentication information, ensuring that receivers can verify the authenticity of the **navigation data** they receive from Galileo
 - Navigation data includes orbit data to calc PVT

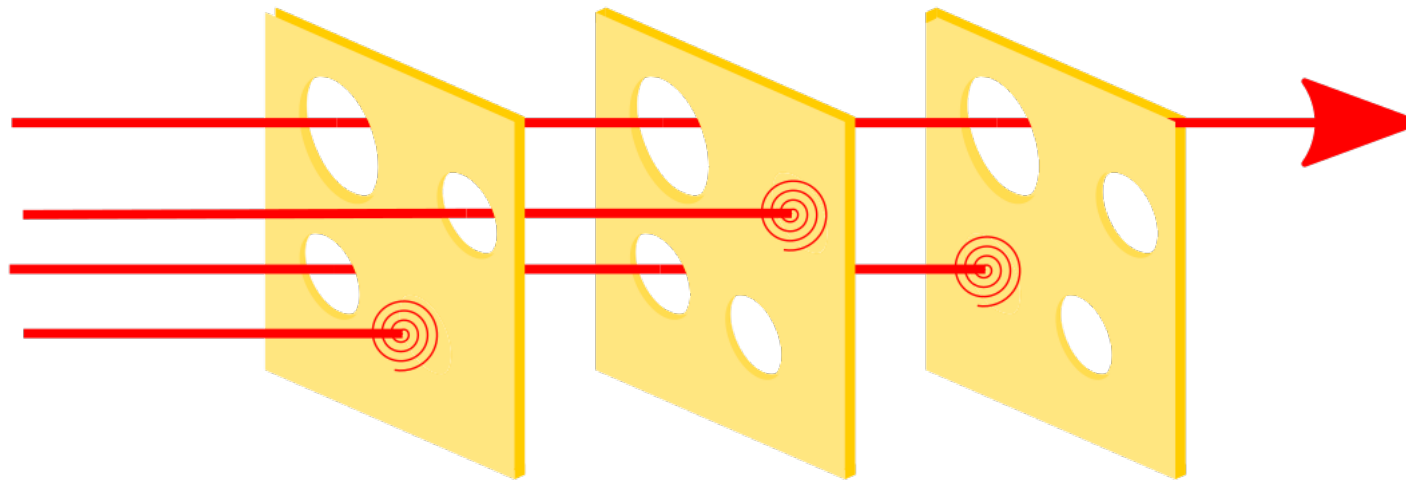


E1-B								
Even/odd=1	Page Type	Data j (2/2)	OSNMA	SAR	Spare	CRC _j	SSP	Tail
1	1	16	40	22	2	24	8	6
Total (bits)								
120								

Image source: EUSPA
"Galileo OSNMA
signal-in-space ICD"

OSNMA Summary

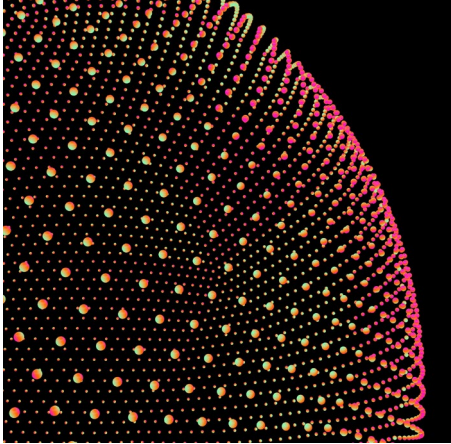
1. Protecting GNSS receivers against jamming and spoofing is done on many layers
- 2. Galileo OSNMA adds a strong layer of protection, globally, free of charge**
3. OSNMA requires key handling and optionally trusted time from the host



"Swiss cheese" model

Image source:
Wikimedia commons
User:BenAveling

Spoofing detectors beyond OSNMA



- **Navigation data consistency**

- Detect default simulator output
- DHS Allow List

- **Tracking abnormality**

- Reacquisition looking for frequency-code phase space

- **Time jump**

- Clock bias changes

- **GNSS constellation**

- CNO average
- Signal loss
- Time offset to others

- **Sensor-based (DR products only)**

- WT speed vs GNSS
- Lateral speed for cars

More information on u-blox.com



Product:

[u-blox X20](#)

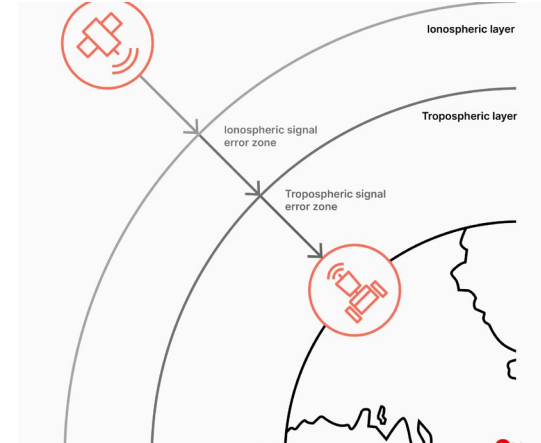
[ZED-X20P](#)

[ZED-F20P](#)



Whitepaper:

[All-band GNSS receivers enhance positioning, navigation, and timing performance](#)



Insights:

[High precision positioning](#)

[Real-Time Kinematic \(RTK\)](#)

[PPP-RTK GNSS correction services](#)



Blog:

[GNSS/GPS jamming and spoofing tests under actual conditions](#)

[A new security level against GNSS spoofing](#)

More information on u-blox.com



ANN-MB2

- Easy-to-use, reliable all-band antenna
- L1, L2, L5/E5/B2/NavIC, E6/B3, L-band. High Precision, with RTK



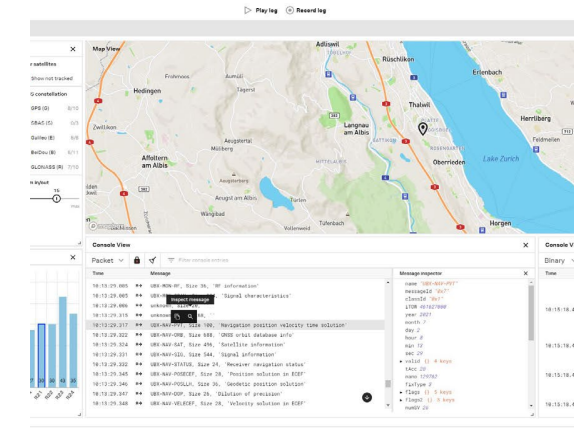
PointPerfect

- u-blox's portfolio of GNSS correction services
- Fast and accurate corrections using PPP-RTK, PPP-AR, or network RTK technology



EVK-X20P

- Evaluation kit for ZED-X20P and ZED-F20P receiver



u-center 2

- Free software for GNSS performance evaluation
- Quick product configuration for key use cases

**Thank you
for your attention**