High-Precision GNSS in a Four Constellation World

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Agenda

- 8:30a – Introduction
- Terminology review (Glossary)
- The Four Constellations (GPS, Glo, Galileo, BeiDou)
- 10:00a – 10:20a – Break
- Trends in GNSS Receivers and Correction services
- Lunch ~ 12:00a – 1:00p
- BYOD (Bring Your Own Device) data collector trend
- 4 constellation performance testing – prelim results
- 2:30p – 2:50p Break
- 4 constellation performance testing – prelim results
- Adjourn - ~4:00pm

“High-accuracy GNSS technology will change more in the next 2 years than it has in history”

GNSS Glossary

Glossary

- **GNSS** – Global Navigation Satellite System. GPS, Glonass, Galileo, BeiDou, etc.
- **GPS:** US Air Force constellation of 31 satellites.
- **Glonass:** Russian military constellation of ~24 satellites.
- **Galileo:** European Union constellation. In development. ~22 healthy sats.
- **BeiDou:** Chinese constellation. In development. ~22 healthy sats in global orbits deployed.

Glossary

- **Public SBAS:** L1 Satellite-based Augmentation System. Regional GNSS correction service. WAAS (North America), EGNOS (Europe), MSAS (Japan), GAGAN (India), SDCM (Russia).
- **Real-time PPP:** Precise Point Positioning. Technique used for global real-time decimeter/ centimeter positioning.
- **Commercial SBAS:** Multi-freq, high-accuracy real-time PPP services (e.g. RTX, Atlas, Terrastar, Sapcorda, etc.) delivered over satellite or internet.

Glossary

- **RTK:** Real-time Kinematic. Real-time, 2 centimeter GNSS accuracy.
- **RTK base station:** A stationary RTK GNSS receiver sending corrections to an RTK rover.
- **RTK network:** A group of RTK GNSS base stations networked together (eg. ORGN, WSRN).
- **Single frequency:** A GNSS receiver that uses L1 GNSS frequency.

Glossary

- **Multi-frequency:** A GNSS receiver that uses more than one frequency (e.g. L1, L2, L5).
- **Real-time:** A technique of applying GNSS corrections in the field for real-time results.
- **Post-processing:** A technique of collecting GNSS data in the field and then applying a GNSS correction back in the office.
- **NTRIP:** Network Transport of RTCM via Internal Protocol. Protocol used for real-time GNSS.

Precision vs. Accuracy - when do you care?

Precise/not accurate | **Accurate and precise**

Glossary – GNSS Metadata

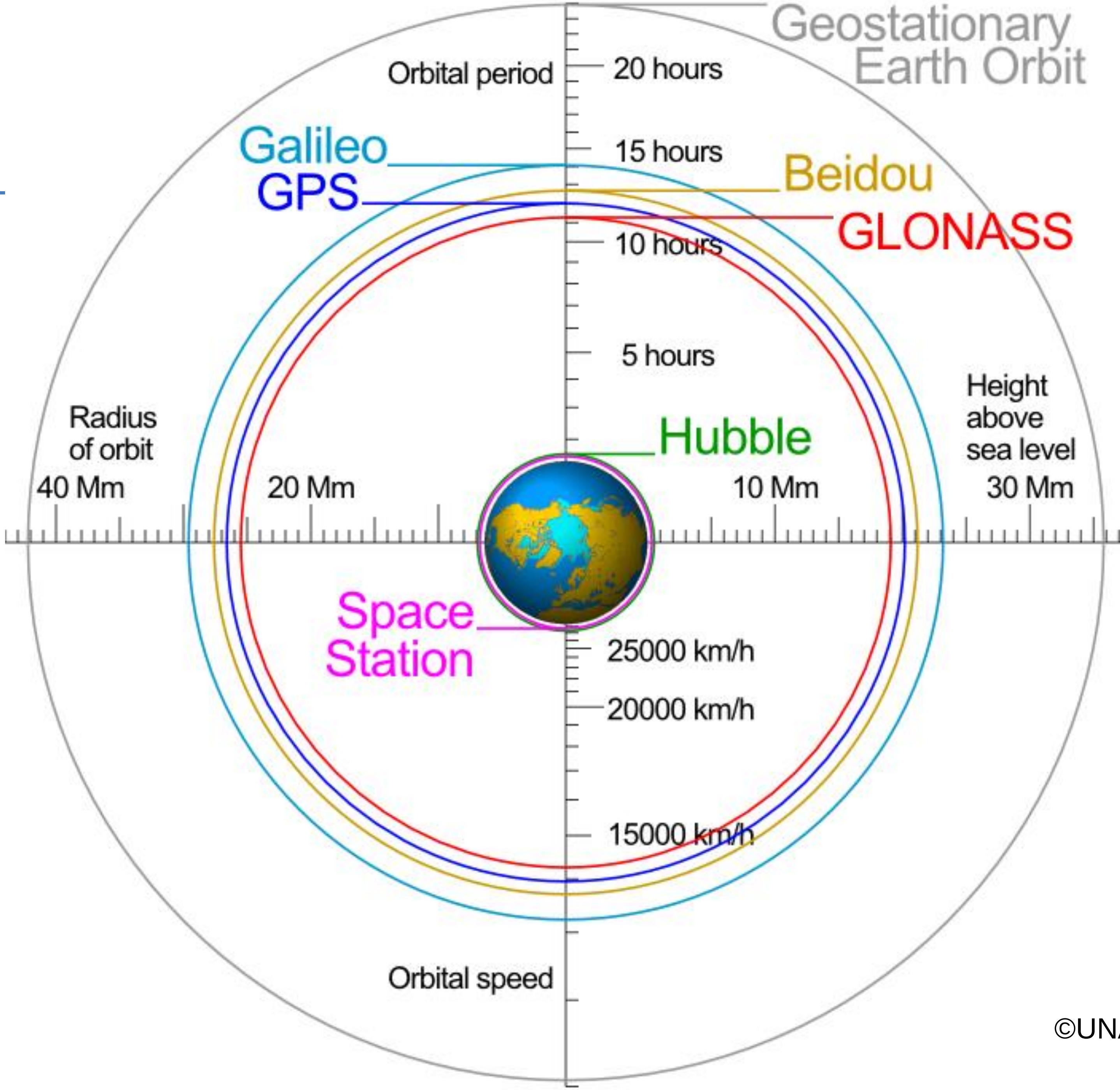
- **Estimated precision:** A value provided by the GNSS receiver estimating the precision of the measurement.
- **# of satellites used:** The number of satellites being used by the GNSS receiver to compute its position.
- **Correction Age:** In real-time positioning, the age of the GNSS correction data.
- **DSID:** Differential Station ID. Identifies where the GNSS correction data is originating from.

Glossary – GNSS Metadata

- **HDOP:** Horizontal dilution of precision. An indicator of the geometric quality of satellites being tracked for horizontal positioning.
- **VDOP:** Vertical dilution of precision. An indicator of the geometric quality of satellites being tracked for vertical positioning.
- **PDOP:** Position dilution of precision. An indicator of the geometry quality the GNSS receiver is tracking for a 3D position.

The Four Constellations

GPS, Glonass, Galileo, BeiDou


Geostationary Earth Orbit
Orbital period
20 hours
Galileo
15 hours
Beidou
GPS
GLONASS
10 hours
5 hours
Height above sea level
Radius of orbit
Hubble
40 Mm
20 Mm
10 Mm
30 Mm
Space Station
25000 km/h
20000 km/h
15000 km/h
Orbital speed

GNSS is the new GPS

ACTIVE Global GNSS:

-GPS (USA), 31

-GLONASS (Russia), 24

In Development Global GNSS:

-Galileo (Europe), ~22

-BeiDou (China), ~22

Navigation Satellite Signals

- ~12,000 miles in space.
- Signal broadcast is about the strength of a 50 watt light bulb.
- Weak signals can be blocked by buildings, terrain and other objects. Signals can be dithered by tree canopy.
- Works in all weather conditions.
- Accuracy in clear sky is easier to attain than under tree canopy or urban canyons.

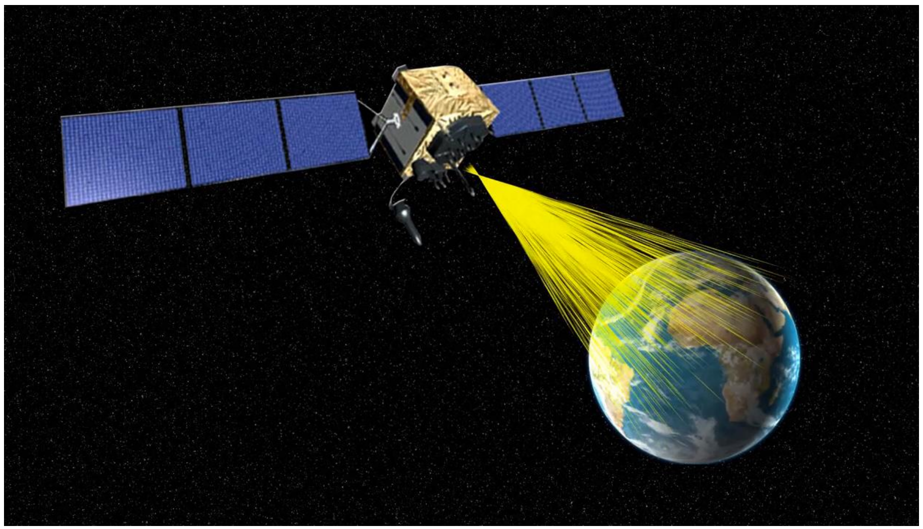
GPS

US Global Positioning System

GPS Constellation

- Declared fully operational in December 1993.
- 31 healthy satellites + several in reserve orbit.
- Funded and operated by the US Air Force.
- Committed to supporting civilian use.
- GPS contributes more than $68B to the US economy.
- More than 3.3M US jobs rely heavily on GPS.

Atlas V Rocket launcher



GPS Overview

Civil Cooperation

- 3+ Billion civil & commercial users worldwide
- Search and Rescue
- Civil Signals
  - L1 C/A (Original Signal)
  - L2C (2nd Civil Signal)
  - L5 (Aviation Safety of Life)
  - L1C (International)

Department of Defense

- Services (Army, Navy, AF, USMC)
- Agencies (NGA & DISA)
- US Naval Observatory
- PNT EXCOMS
- GPS Partnership Council

Spectrum

- World Radio Conference
- International Telecommunication Union
- Bilateral Agreements
- Adjacent Band Interference

34 Satellites / 31 Set Healthy

Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIA	1	25.0	25.0
GPS IIR	11	16.7	21.2
GPS IIR-M	7	11.2	13.0
GPS IIF	12	4.7	8.4
Constellation	31	11.1	25.0

AS OF 8 OCT 18

Maintenance/Security

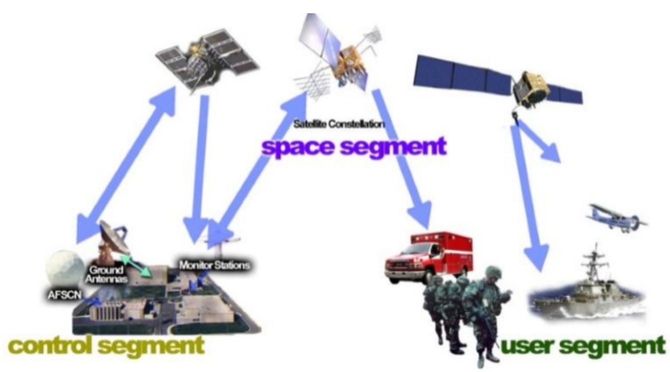
- All Level I and Level II
  - Worldwide Infrastructure
  - NATO Repair Facility
- Develop & Publish ICDs Annually
  - Public ICWG: Worldwide Involvement
  - Materials Available at: gps.gov/technical/icwg
- Update GPS.gov webpage
- Distribute PRNs for the World
  - 120 for US and 90 for GNSS

Department of Transportation

- Federal Aviation Administration

Department of Homeland Security

- U.S. Coast Guard



International Cooperation

- 57 Authorized Allied Users
  - 25+ Years of Cooperation
- GNSS
  - Europe - Galileo
  - China - Beidou
  - Russia - GLONASS
  - Japan - QZSS
  - India – NAVIC
  - Korea - KRNSS

GPS Constellation

There are currently 31 operational GPS satellites in a 24 + 3 configuration.

12 x GPS Block IIA/R. L1 C/A, L1/L2 P(Y)

7 x GPS Block IIR-M. L1 C/A, L1/L2 P(Y), L2C

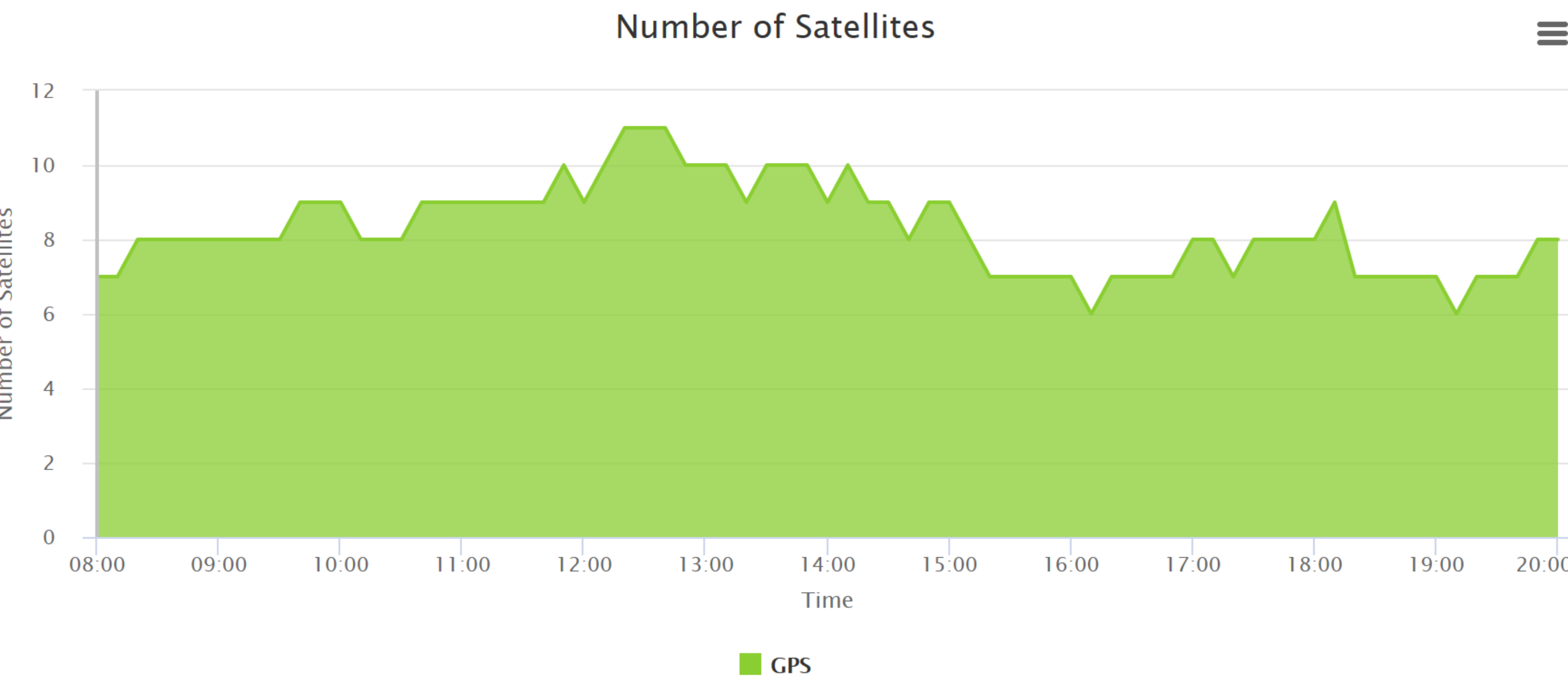
12 x GPS Block II-F. L1 C/A, L1/L2 P(Y), L2C, L5

L2C = More robust iono correction for high precision positioning. No need for cross-correlation (semi-codeless).

L5 = Similar to L2C, but 4x stronger signal.

Civil signals (red), Military signals (blue)

GPS sat visibility – 10 degree mask



Next Generation Operational Control System (OCX)

- Incremental Development
  - Block 0 Launch and Checkout System (LCS)
  - Block 1/2 Operational Control System
- Current Status
  - LCS ready to support GPS III SV01 launch
  - Block 1/2 development continues to meet milestones
    - Ready to Transition to Operations: Apr 2022
- Enhanced C2 and cybersecurity
- Modernized, agile architecture

First GPS III satellite – Dec. 23, 2018
Spacex Falcon Rocket launcher

Future GPS Constellation

- GPS III satellites – L1 C/A, L1C, L2C, L5
- L1C - fourth civil signal for tighter international compatibility and better performance than L1 C/A.
- OCX ground control – capable of managing more than 31 healthy satellites.
- Possible multiple satellites per launch vehicle.

A quick note on Semi-codeless (1)

- In 2008, the DoD announced it would discontinue supporting semi-codeless on Dec 31, 2020, potentially rendering hundreds of thousands of L1/L2 GPS receivers useless.
- Semicodeless is a technique used to exploit L2PY (military) for civilian use. It is the foundation of L1/L2 GPS receiver centimeter performance.
- DoD rationale is that enough GPS sats will broadcast L2C and L5 by 2020.

A quick note on Semi-codeless (2)

- In the 2017 US Federal Radio Navigation Plan, the DoD stated it would not implement any signal change until <u>two years after</u> twenty-four satellites are broadcasting the L5 signal.
- It is not expected that twenty-four satellites will be broadcasting L5 until 2024, so the earliest the DoD would stop supporting semicodeless would be 2026.
- Make sure any GNSS receiver you purchase supports L2C and L5.

GLONASS

Russia’s Satellite Navigation System

GLONASS Constellation

- Declared fully operational in December 2011.
- 24 operational satellites.
- Funded by the Russian Government (military)
- Valuable to high-precision users (RTK, sub-meter) because it increases productivity due to improved HDOP/VDOP.
- 5-10 satellites are added when using GLONASS.
- G1 and G2 frequencies. No "G5" at this time.

GLONASS Constellation

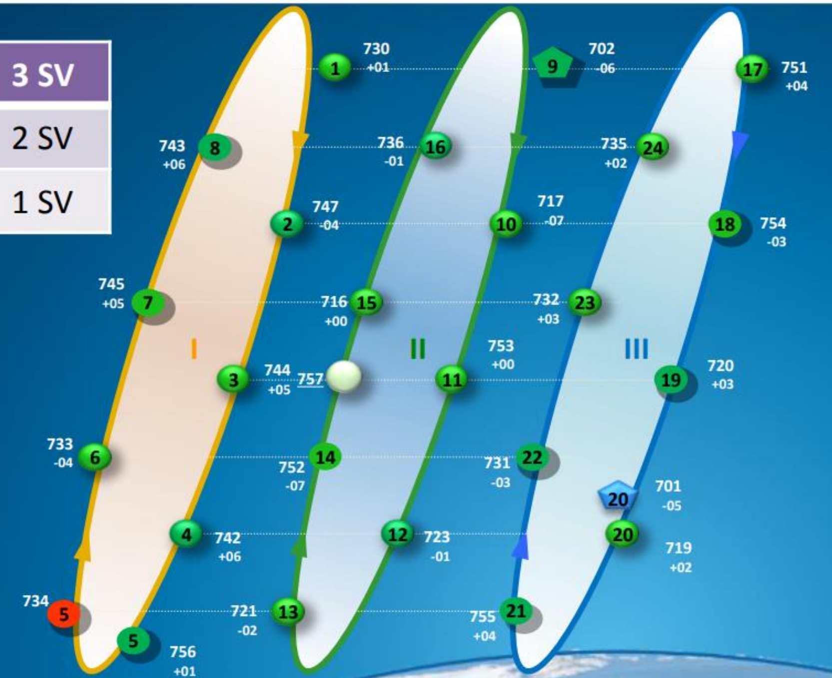
- Common feature in all GNSS receviers (consumer and professional).
- Complementary to GPS – augmentation,
- Doesn’t necessarily improve accuracy other than improving PDOP (TSA report). Improves productivity.
- Fundamentally different radio design than GPS, Galileo, and BDS. CDMA vs. FDMA.

ROSCOSMOS

GLONASS STATUS (AS OF 05.11.2018)

GEO satellites

In total	3 SV
Operational	2 SV
Maintenance	1 SV



MEO satellites

In total	27
Operational	24
Under Commissioning	**1**
Maintenance	1
Flight testing	1

AUGMENTATIONS of ROSCOSMOS
39 stations in Russia
11 stations abroad

GROUND CONTROL COMPLEX
- System Control Center
- One-way Reference Stations
- Uplink Stations
- Laser Ranging Stations

FUNDAMENTAL FACILITIES
- 3 Telescopes (32 m)
- 2 Telescopes (7 m)
- 3 Correlators
- 1 Cold-atom Optical Frequency Reference
- 50 Astronomic and Geodetic Network Stations

REGIONAL AND MUNICIPAL AUGMENTATION STATION NETWORKS
Over 4181 stations

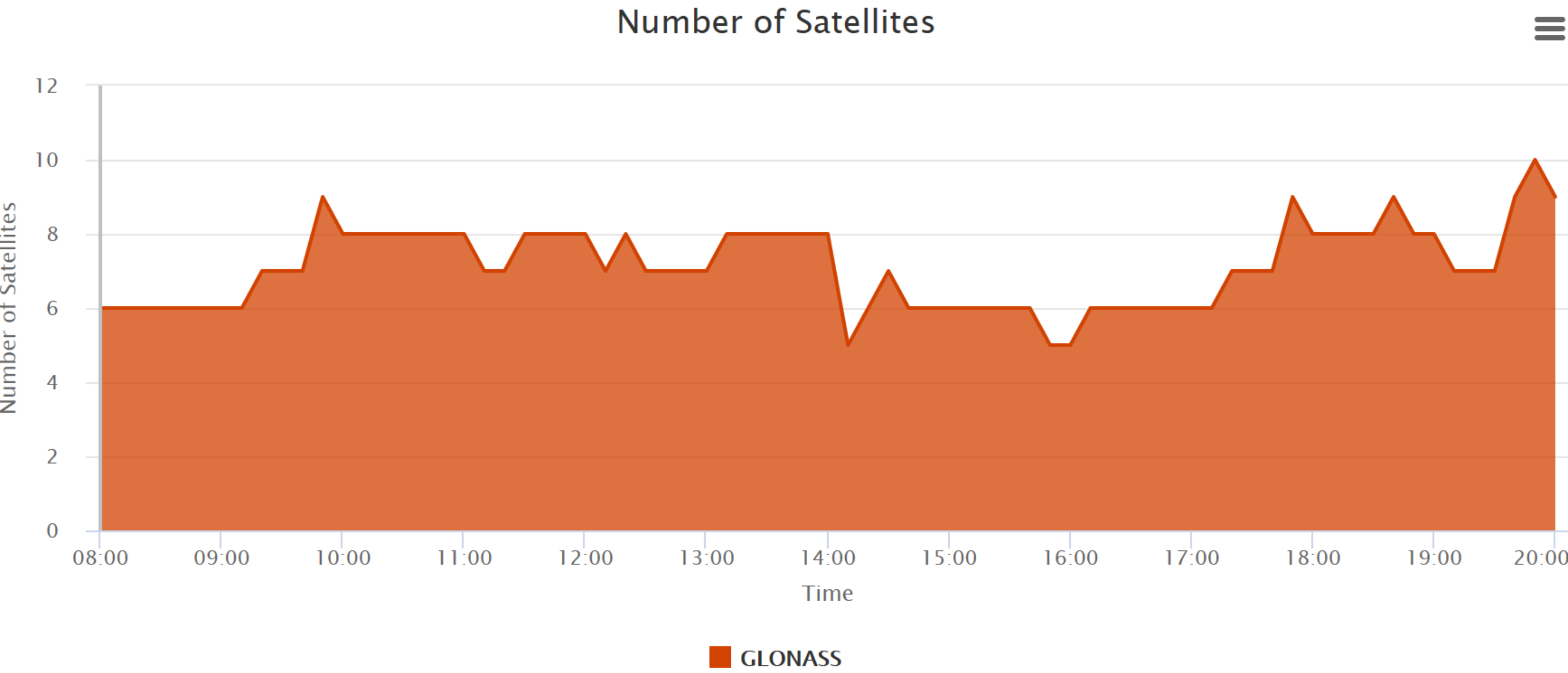
ORBITAL CONSTELLATION SUPPORT

Glonass-M satellites launches

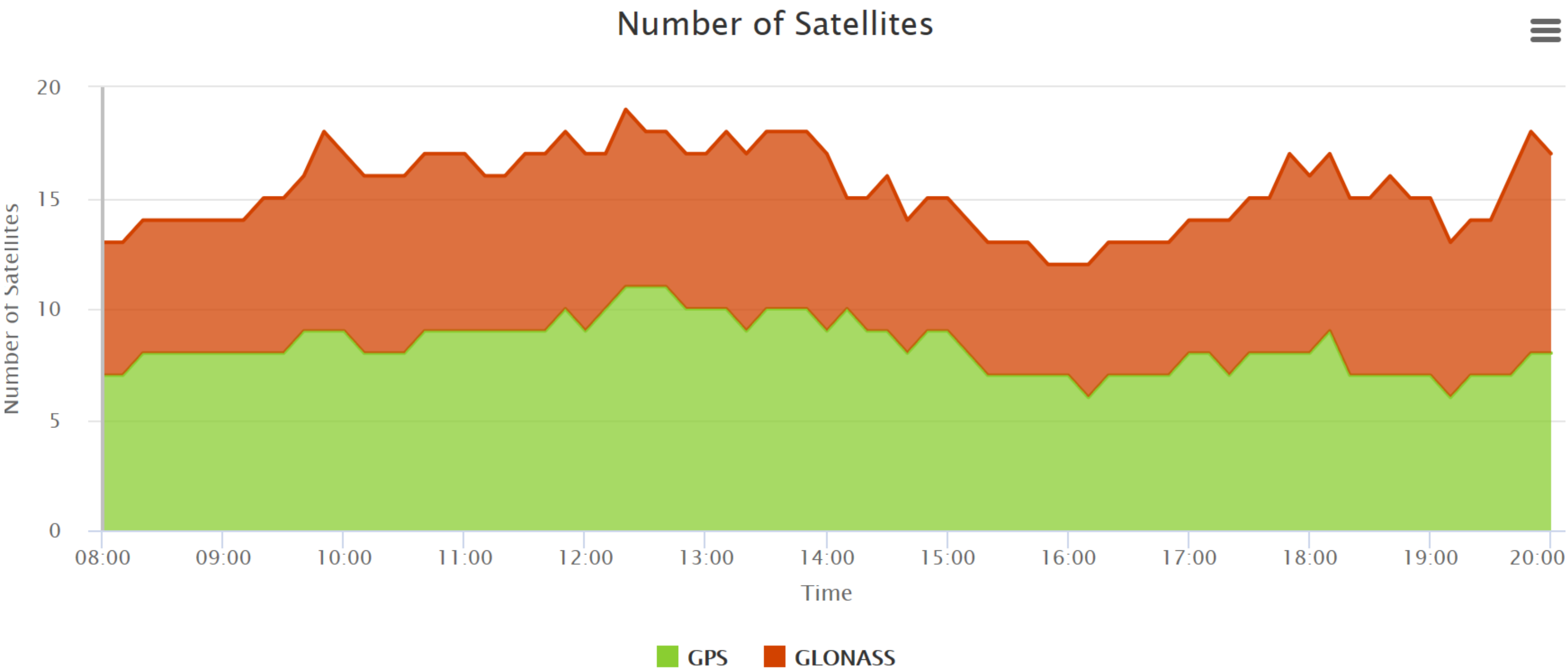
- 2 Glonass-M satellites were launched in 2016 (February 7th and May 29th)
- 1 Glonass-M satellite was launched in 2017(September 22nd)
- 1 Glonass-M satellite was launched 17rd of June 2018
- **1** Glonass-M satellite was launched **3rd of November 2018**

Glonass-M Launch
on 3rd of November 2018

Glo sat visibility – 10 degree mask



GPS/Glo sat visibility – 10 degree mask



Future Glonass Constellation

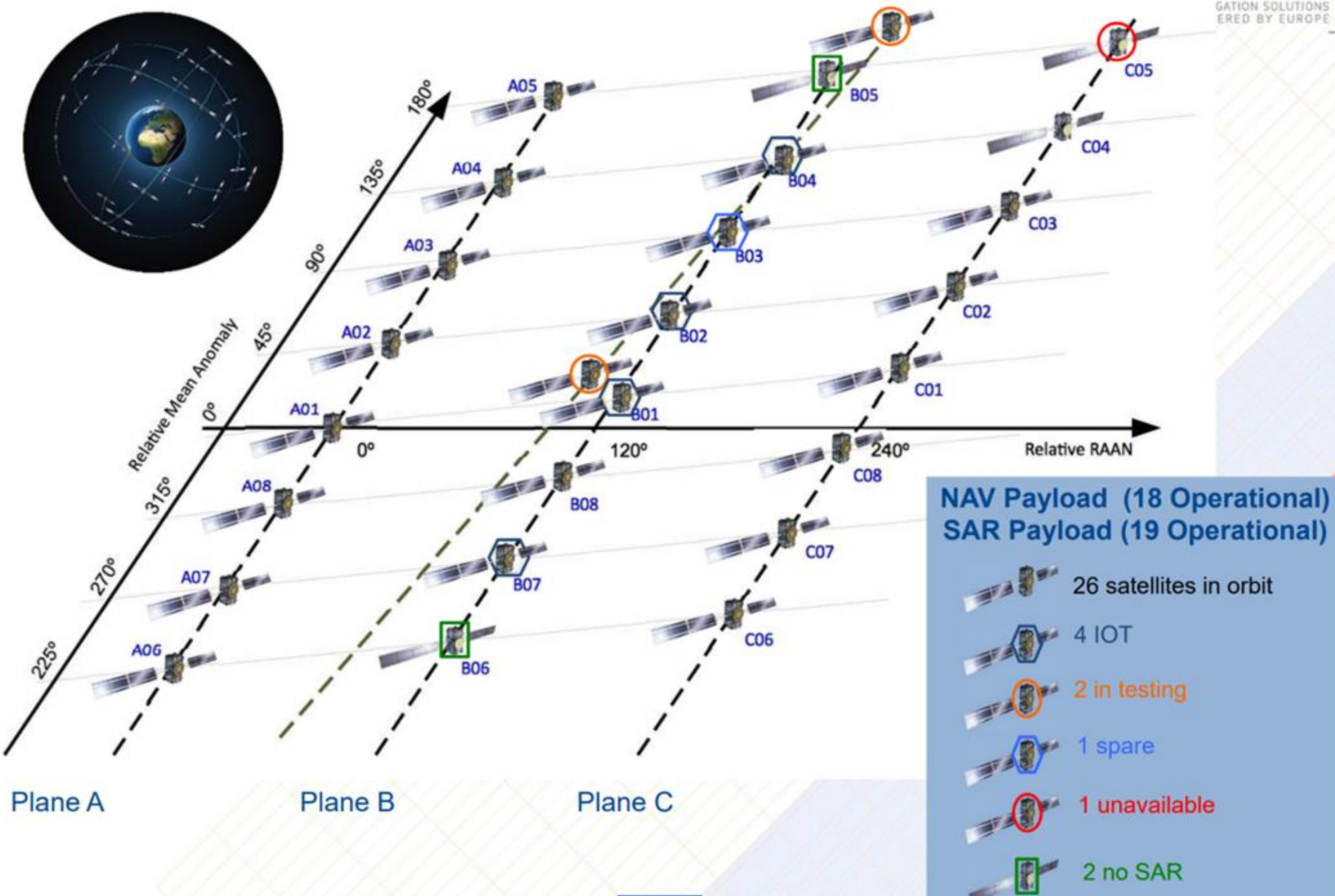
- GLONASS-K satellites will support CDMA radio design in addition to legacy FDMA design, to be more compatible with GPS, Galileo and BeiDou.
- Moving towards supporting four frequencies using CDMA; L1, L2, L3, L5.

Galileo
Europe’s Satellite Navigation System

Galileo Constellation

- Funded and operated by the European Union.
- Uniquely funded and operated with civilian resources.
- 21 healthy satellites in orbit.
- Four Galileo satellites launched at once.
- Next launch scheduled for this summer.
- Highly compatible with GPS L1 and L5. No L2 support today, or planned.
- 6-8 satellites are added when using Galileo.

Galileo Constellation Status

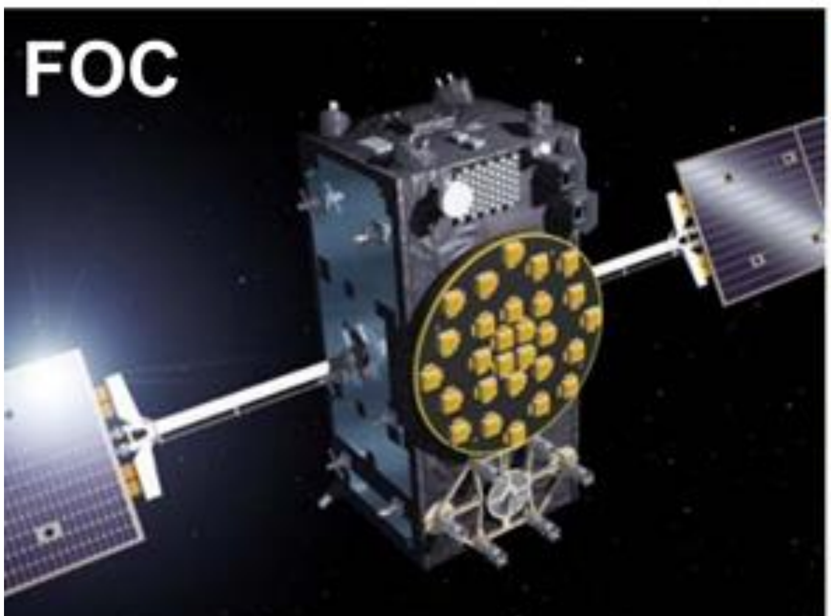


GALILEO Satellites

S/C Prime Contractor Astrium GmbH (now Airbus Defence & Space)

4 satellites – 4 In-Orbit

Mass at Launch	700kg
Power Consumption	1420W
Dimensions	2.7 x 1.6 x 14.5 m
Orbit Injection	Direct into MEO orbit
Attitude Profile	Yaw Steered

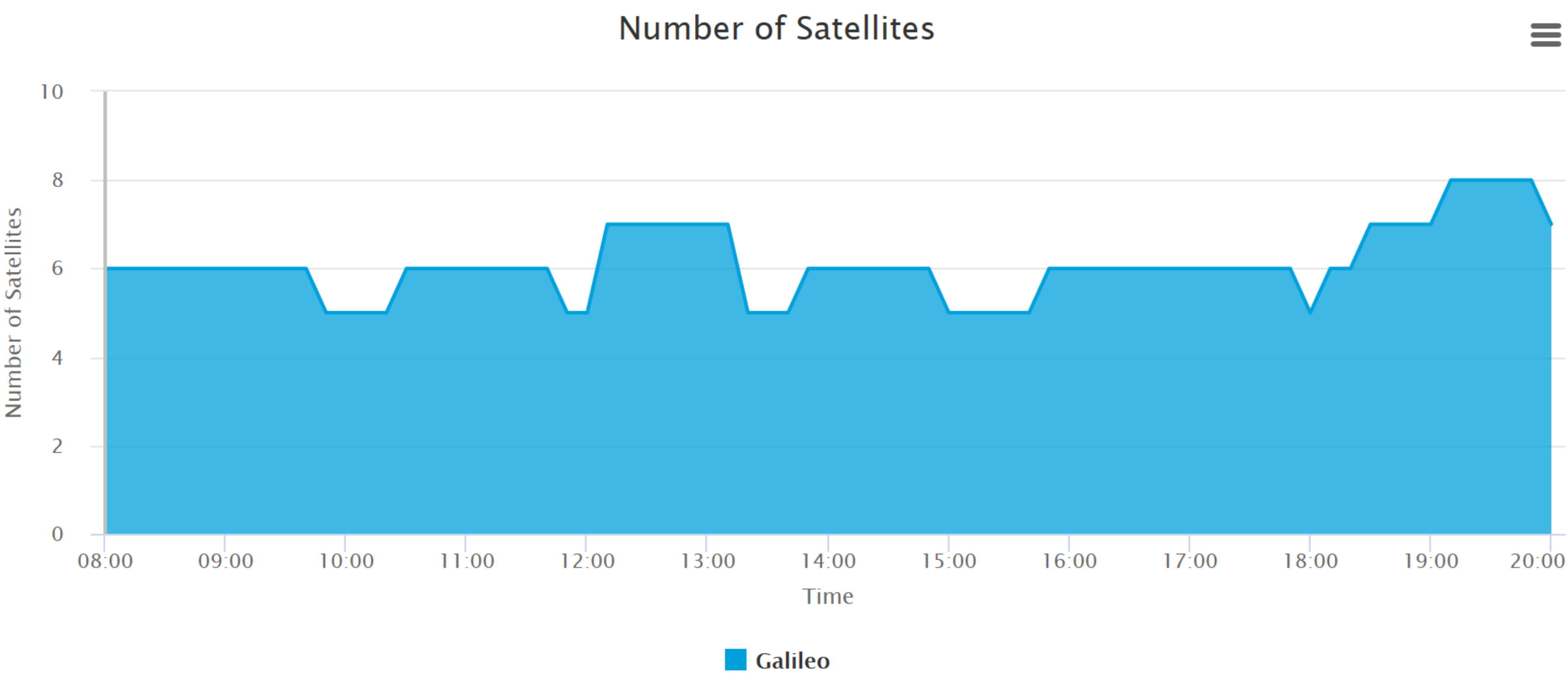


S/C Prime Contractor OHB Systems GmbH
P/L Prime Contractor SSTL Ltd

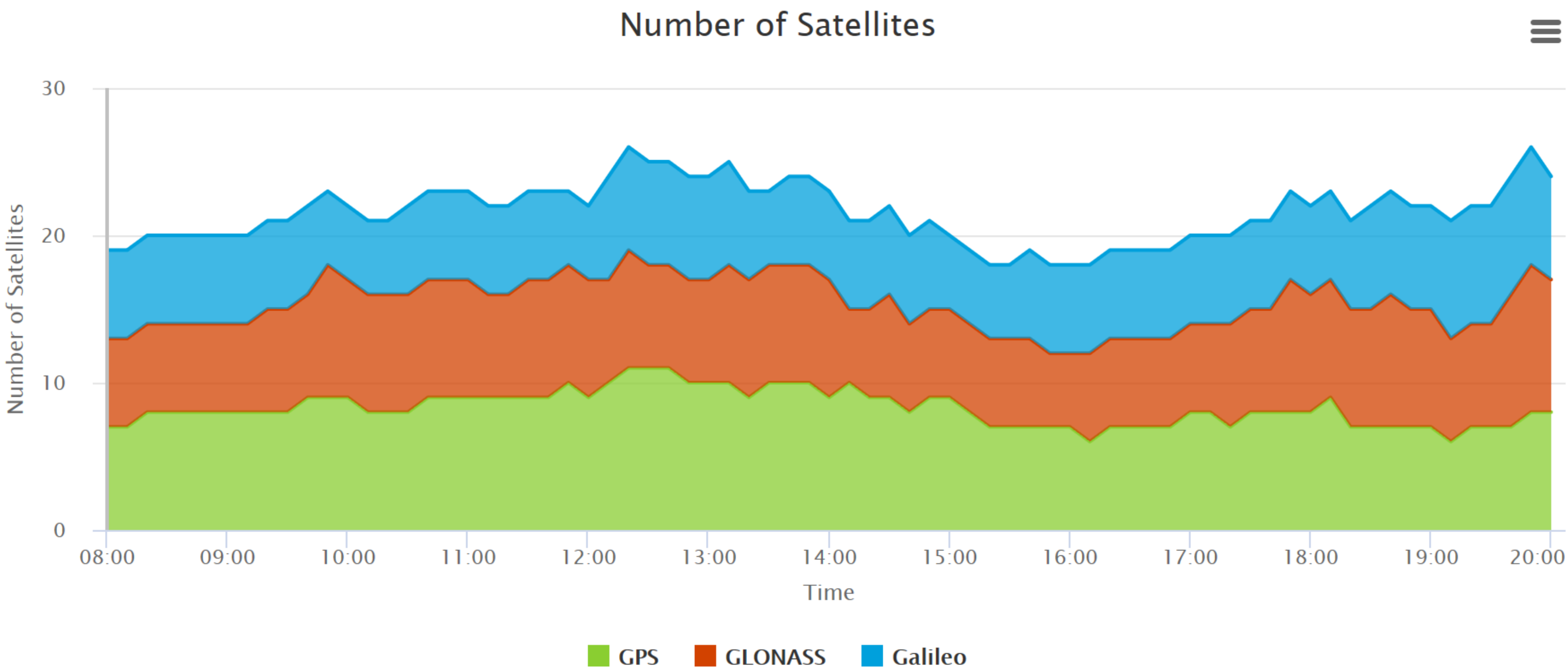
22 satellites – 22 In-Orbit

Mass at Launch	733kg
Power Consumption	1900 W
Dimensions	2.5 x 1.1 x 14.7 m
Orbit Injection	Direct into MEO orbit
Attitude Profile	Yaw Steered

Galileo sat visibility – 10 degree mask



GPS/Glo/Gal sat visibility – 10 degree mask



Future Galileo Constellation

- Full build-out by end of 2020.
- Free, real-time PPP service planned for E6 frequency. Correctors broadcast by each Galileo satellite so no geostationary satellite communication or internet communication required as with all other real-time PPP services.

BDS (Beidou)
China's Satellite Navigation System

BeiDou Constellation

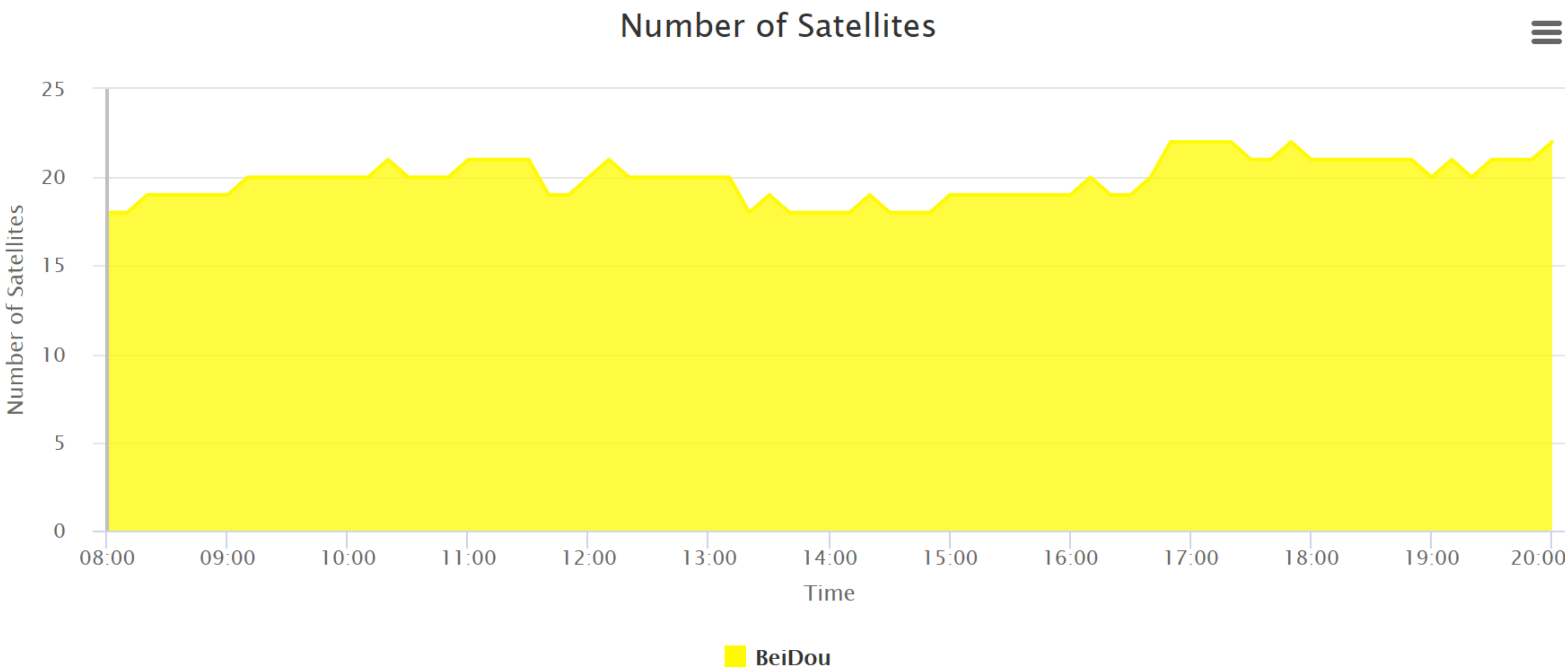
- Funded and operated by the Chinese government.
- 21 healthy satellites in global orbits and many more in a regional constellation over China.
- China plans to offer a global 30-satellite constellation by 2020.
- In 2018, launched 17 BeiDou satellites into global orbits. By contrast, the DoD never launched more than six GPS satellites in a year.

BeiDou Constellation

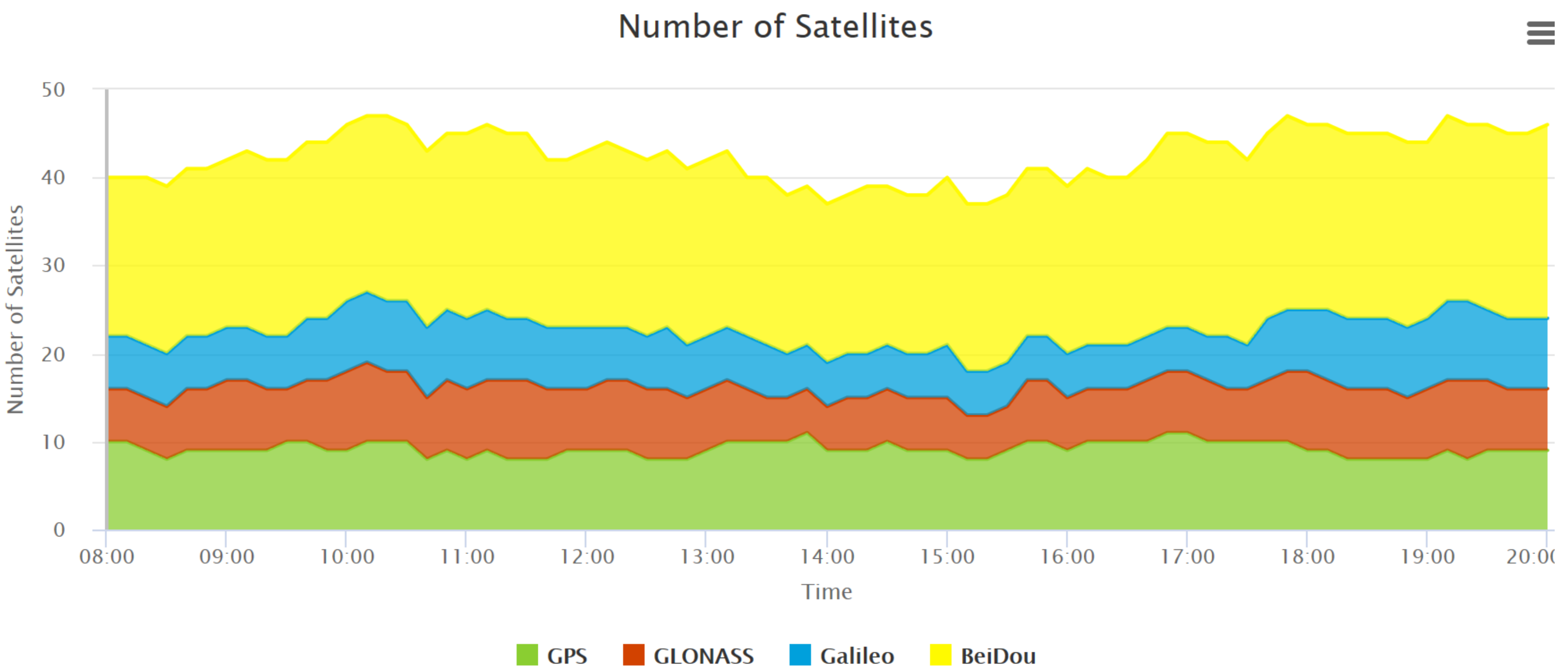
- More high-precision, multi-freq GNSS receivers are sold in China than the rest of the world combined.

- The RTK environment in China is better than any other place in the world due to the significant number of satellites in view.

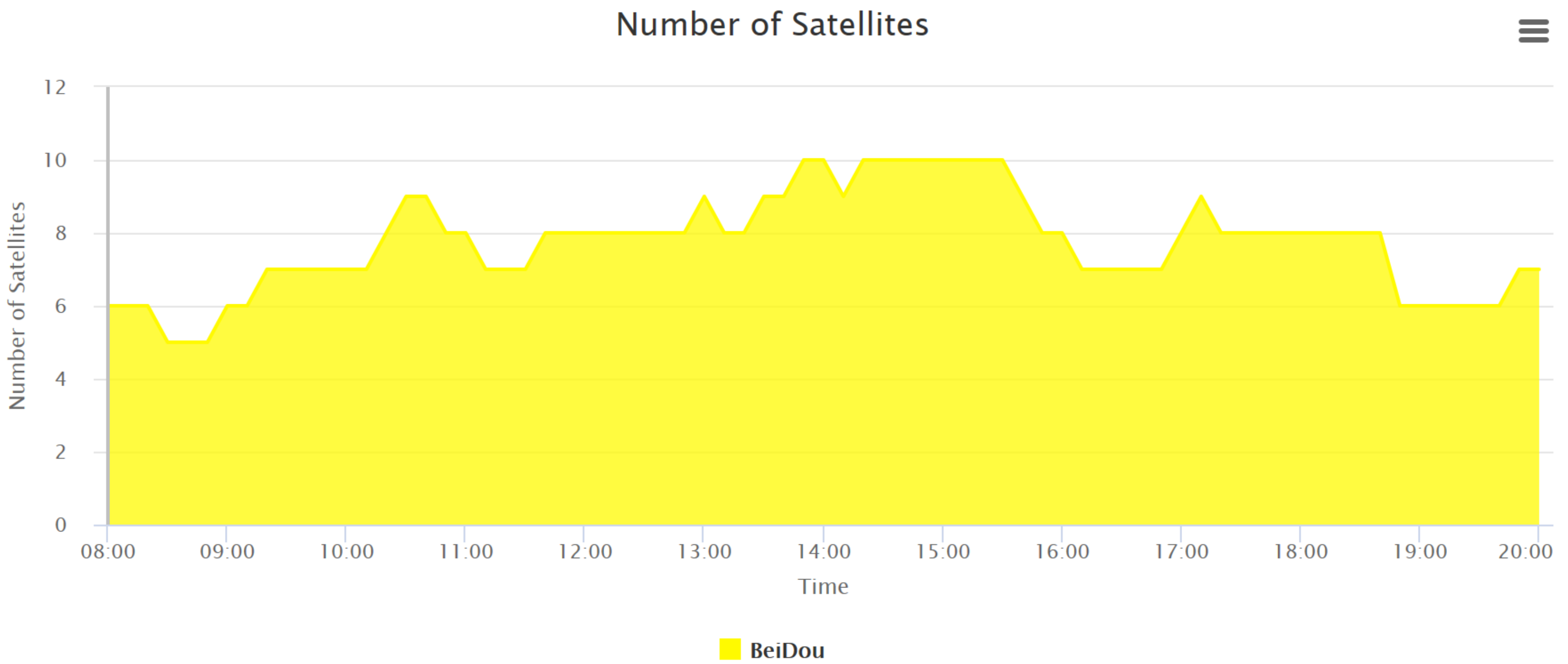
BeiDou sat vis in Beijing – 10 degree mask



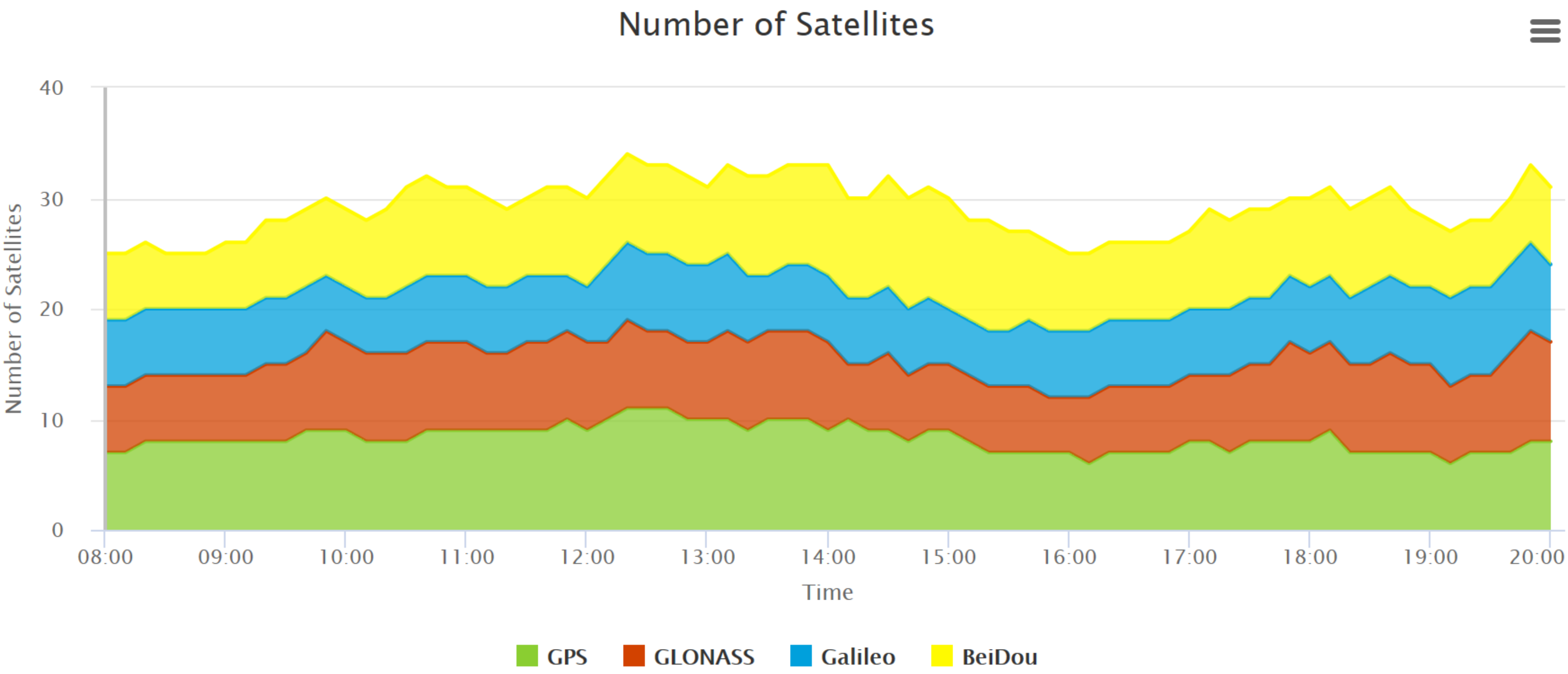
GPS/Glo/Gal/BeiDou sat visibility in Beijing – 10 degree mask



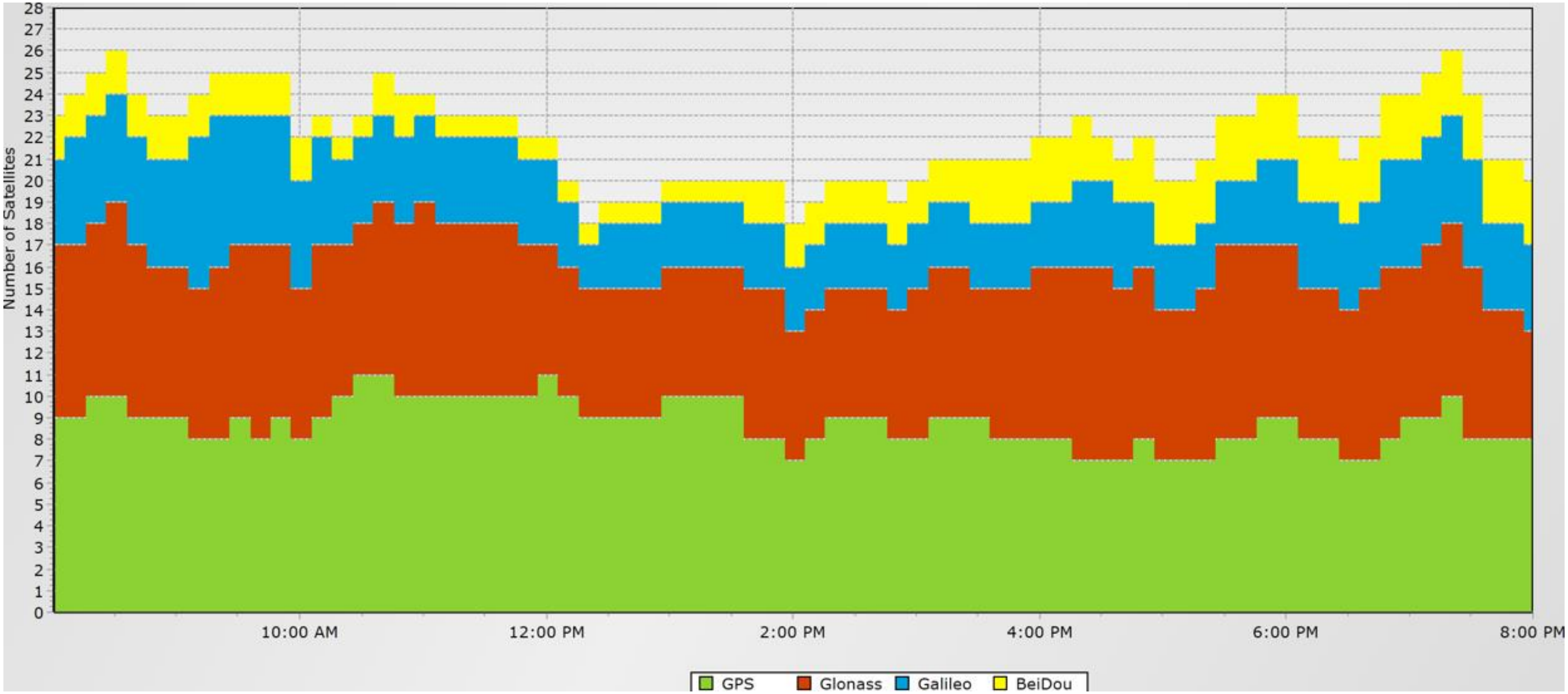
BeiDou sat vis in Portland – 10 degree mask



GPS/Glo/Gal/BeiDou sat visibility in Portland – 10 degree mask

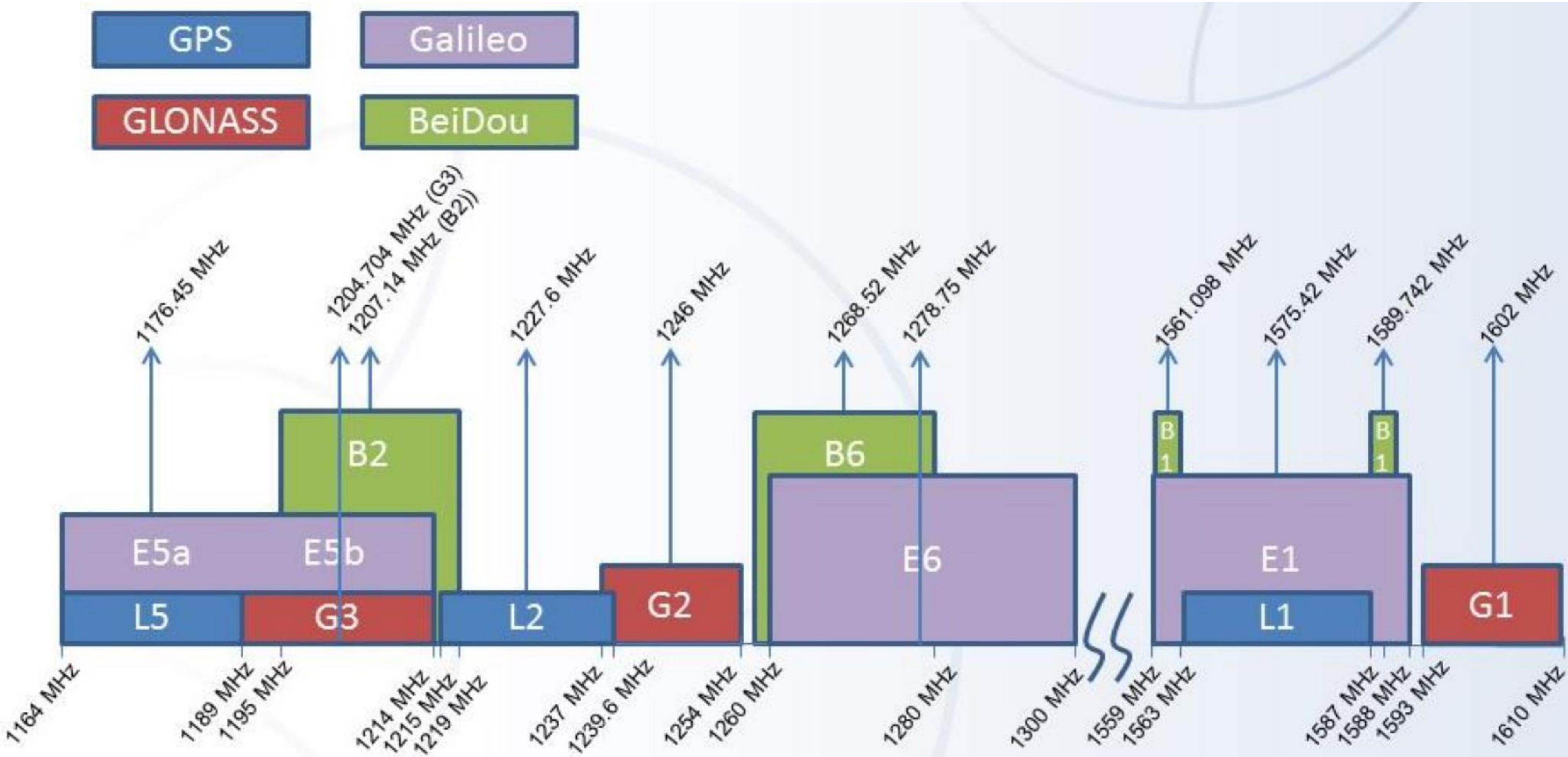


GPS/Glo/Gal/BeiDou sat visibility in South Dakota – 10 degree mask. February 2017



Constellation Frequencies – it's complicated

Four Constellation Frequencies



Source: Tallysman

Are More Satellites Better?

Are More Satellites Better?

- GNSS is a line-of-sight technology. Satellites send weak radio signals from 12,000 miles in spaces. About the equivalent of a 50 watt light bulb.
- Trees, buildings, terrain can block or reflect GNSS signals.
- Using only GPS, 8 to 12 satellites are in view at any one time based on clear sky. After considering your environment, maybe only 5 to 8 in use.
- With all four constellations, more than 30 satellites in use at times.

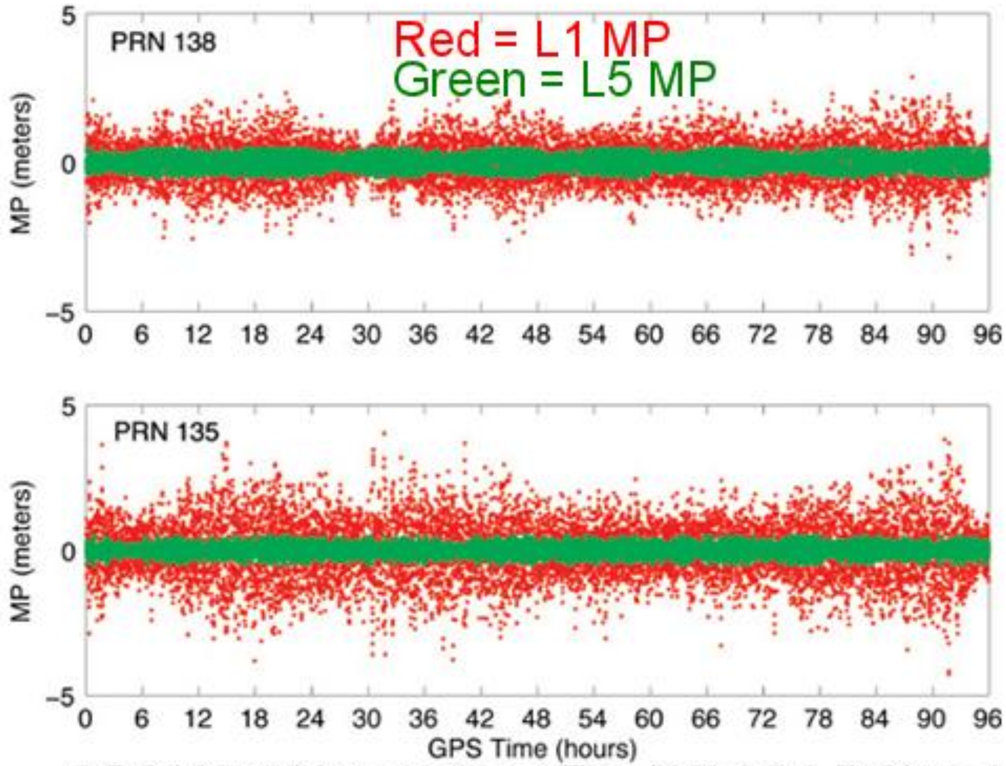
Do Four Constellations Solve these Problems?

Improving Signals

What’s So Special About GPS L5?

- GPS and other constellations have learned lessons from legacy GPS signals.
- L5 supported by other global GNSS and SBAS.
- Broadcast strength is ~4x more powerful than L2C.
- Longer code and error-correcting techniques for more robust tracking in difficult environments.
- Located in highly-protected aeronautical band.

Improvement of L5 Code Tracking over L1



GPS World Innovation: The WAAS L5 Signal
Richard B. Langley, Hyunho Rho

Trends in High-Precision GNSS Receivers, Correction services and Antennas

High-Precision GNSS Receiver Technology Trends

- High-precision GNSS receivers are expensive because world-wide market for them is relatively small compared to the heavy R&D investment.
- The world-wide market for high-precision GNSS receivers is under 150,000 units. The small market size has limited the number of competitors and not attracted consumer electronics manufacturers.
- In the past, technology patents limited competition.

High-Precision GNSS Receiver Technology Trends

- Mobile devices have been driving the demand for consumer-grade GNSS chips. GNSS has become ubiquitous in wireless chipsets, like Wifi and Bluetooth.
- With the first mobile devices, just GPS was being used. Now GPS+Glo receivers became the standard in consumer mobile devices, with Broadcom supplying GNSS chipsets to Apple and other mobile device manufacturers.

High-Precision GNSS Receiver Technology Trends

- In late 2017, Broadcom introduced the BCM47755 dual frequency (L1/L5) GNSS chipset targeted at consumer devices. It supports GPS L1/L5, Galileo E1/E5, Glonass L1, BeiDou L1.
- *"The GPS receiver in some of next year's smartphones will be accurate to within about 30cm or 1ft, instead of five meters or 16.4ft, according to IEEE Spectrum.*
- The Broadcom announcement raised a lot of questions about the future of the traditional high-precision GNSS receiver market.

High-Precision GNSS Receiver Technology Trends

- It’s April 2019. Where’s high-precision, dual-frequency GNSS in smartphones?
- Since 2017, three smartphones have embedded the Broadcom chip; Xiaomi Mi 8 and Mi Mix 3, Huawei Mate 20.

High-Precision GNSS Receiver Technology Trends

- It turns out that, out-of-the-box, Broadcom wasn't supporting high-precision. It was interested in using L1/L5 for mitigating multipath for pedestrian nav. 2-3 meters down from 10 meters was good enough.
- That said, the Broadcom chip is lower power than it's previous L1 GNSS chip, so no doubt that mobile device manufacturers will use it.
- ABI Research predicts that dual frequency chipsets will ship inside more than one billion mobile devices in 2023, just four years from now.

High-Precision GNSS Receiver Technology Trends

Final thoughts on the L1/L5 Broadcom chip

1. It’s capable of centimeter RTK, but Broadcom doesn’t provide that capability. An integrator would have to load its RTK software on the chip.
2. GNSS antennae in mobile devices are of horrible quality. Mobile devices have very limited space. Apple, Samsung, etc. have little tolerance for cost increase even of a few pennies.

High-Precision GNSS Receiver Technology Trends

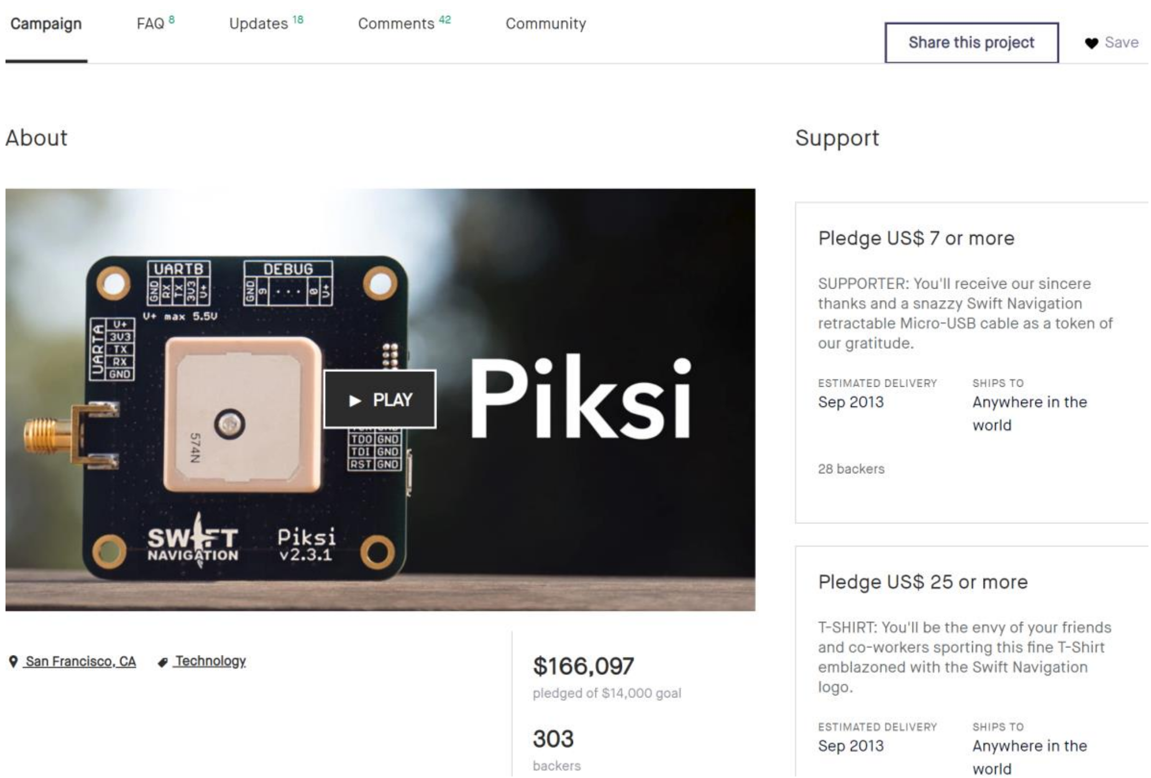
3. In October 2018, Swift Navigation announced it's RTK positioning software is running on the BCM47755 chipset and producing centimeter accuracy results. No products have been release yet to exploit this technology.

Conclusion: Without the antenna problem solved, it's difficult to see centimeter or decimeter precision in mobile devices in the foreseeable future. However, the wildcard is how well RTK software like Swift will run with a standard smartphone antenna.

High-Precision GNSS Receiver Technology Trends

Swift Navigation Piksi Kickstarter

- In 2013, Swift Navigation advertised a Kickstarter for a low-cost, open-source RTK GPS receiver.



High-Precision GNSS Receiver Technology Trends

Swift Navigation Piksi Kickstarter

- Swift's pitch was "an RTK GPS receiver with open source software that costs one tenth the price of any other available RTK system."
- The Kickstarter didn't inform you it's only an L1 RTK solution.
- Base/rover development kit for $900, or $2,000 for a base/rover field kit.

High-Precision GNSS Receiver Technology Trends

- Swift eventually realized that L1 frequency wasn’t enough. In 2017, it introduced the Piksi Multi that supports multi-frequency and multi-constellation.
- The Piksi Multi board, at $595, has not succeeded in gaining market traction. The full eval kit with enclosure is $3,395.
- After tens of millions of venture capital support, designing and selling an inexpensive RTK receiver has proven to be a tough road.

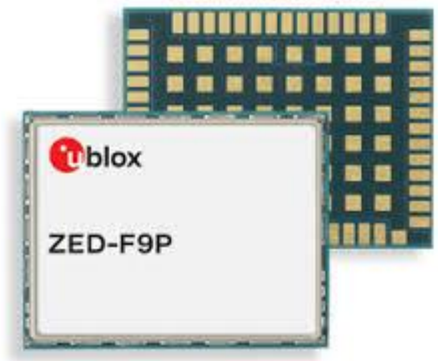
High-Precision GNSS Receiver Technology Trends

- Another entrant into the inexpensive RTK receiver market is Ublox, a Swiss company. Ublox makes no end-user GNSS receivers, only GNSS chipsets.
- While Ublox is not selling its GNSS into the smartphone market, it has gained considerable market share with consumer/prosumer products like drones and higher-end mobile devices.
- In 2016, it introduced an L1 RTK GNSS chip and was successful selling it to OEMs in the drone business and other OEMs like Bad Elf and Emlid/Reach.

High-Precision GNSS Receiver Technology Trends

- Like Swift, Ublox learned that L1 RTK GNSS offers very limited performance. In 2018, Ublox announced the ZED-F9P, a multi-frequency, multi-constellation GNSS receiver chip. The chip price starts at ~$140.
- Its focus is to enable mobile devices

to quickly and inexpensively integrate RTK.



High-Precision GNSS Receiver Technology Trends

- Companies are just starting to introduce products based on the ZED-F9P so it’s too early to understand how well it will perform compared to today’s mainstream RTK receivers.

High-Precision GNSS Receiver Technology Trends

- Still another trend is one originating from China. Whereas Chinese companies historically have purchased OEM RTK receiver boards from Trimble, Novatel and Hemisphere and integrated into their products, we're starting to see Chinese-designed RTK receivers penetrating the market.
- A good example of this is the new DJI Phantom 4 Pro RTK drone. DJI dominates the drone market with more than $2 billion annual revenue and 75+% market share.

High-Precision GNSS Receiver Technology Trends

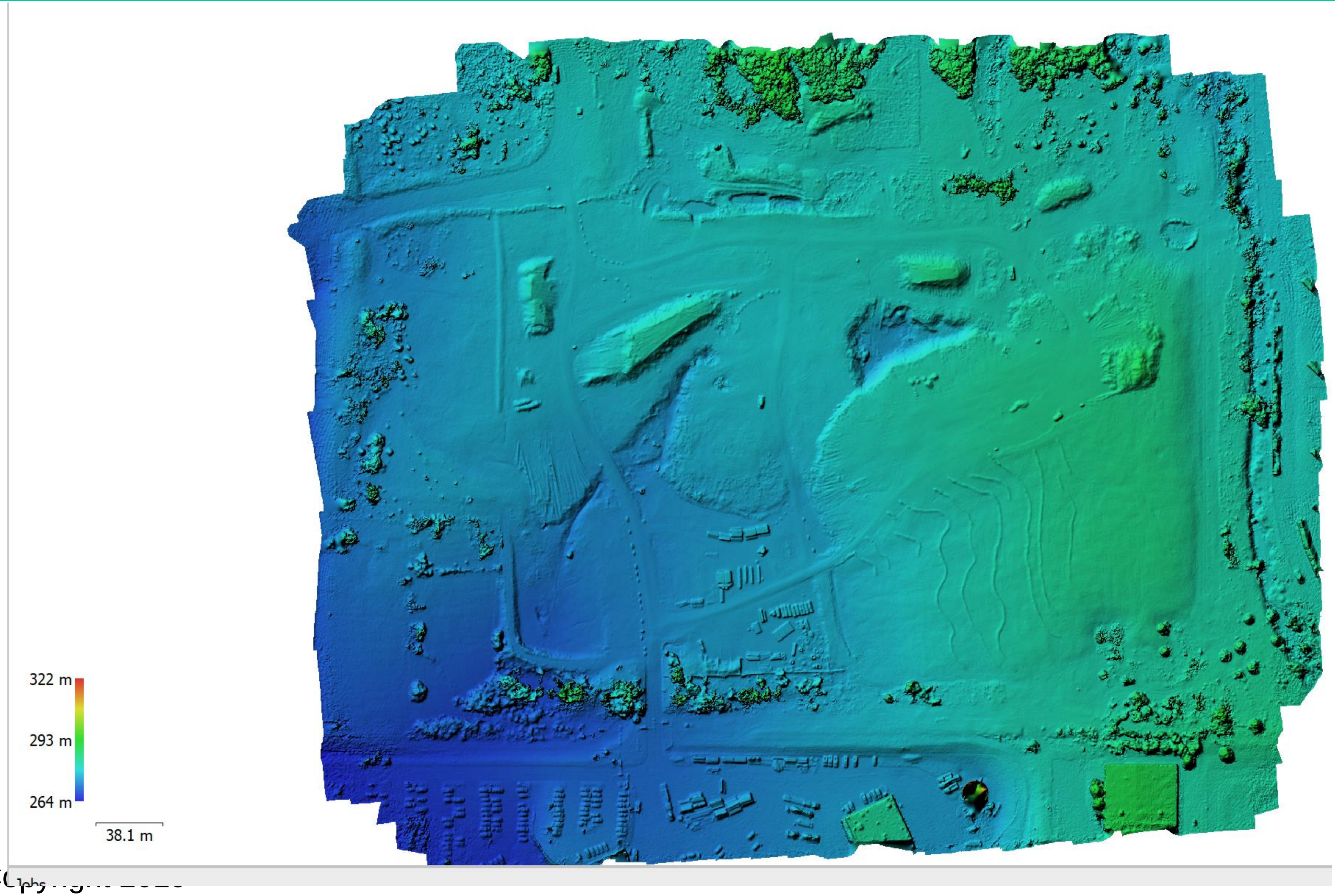
- We test flew the Phantom 4 Pro RTK using our office RTK base as well as an RTK network.

High-Precision GNSS Receiver Technology Trends

- Whereas DJI used a Swiss Ublox L1 GNSS chip for SBAS/RTK, with the Phantom 4 Pro RTK they have switched to using a Unicore (Beijing) L1/L2 RTK GNSS chip.
- The Phantom 4 Pro RTK costs $5,600 retail, creating a new low price point for L1/L2 RTK in a drone. The message this sends is that Unicore and likely others lacking name brand recognition will “buy” market sure with low-cost RTK receiver technology. Drones are a perfect market for phenomena given the tolerant conditions for RTK (clear sky).

High-Precision GNSS Receiver Technology Trends

High-Precision GNSS Receiver Technology Trends



What is The killer app for High-Precision GNSS?

- Certainly, what we discussed above are trends in high-precision GNSS technology. It’s somewhat surprising that smartphones aren’t the killer app for high-precision GNSS. It might be someday in the future, but it’s not today.

- The killer app for high-precision GNSS today is…

Autonomous Vehicles – The killer app for RTK

- RTK finally has the killer app that will bring high-precision GNSS receivers into the consumer market, driving new innovations and bringing the cost of RTK GNSS receivers and services to consumer levels.

August 8, 2017 – Sapcorda Joint Venture

Business Wire
A Berkshire Hathaway Company

HOME SERVICES NEWS EDUCATION ABOUT US

Search

Bosch, Geo++, Mitsubishi Electric and u-blox to Establish Joint Venture Sapcorda Services to Bring High Precision GNSS Positioning Services to Mass Markets

August 08, 2017 01:40 AM Eastern Daylight Time

TOKYO--(BUSINESS WIRE)--Bosch, Geo++, Mitsubishi Electric and u-blox today announced the creation of Sapcorda Services GmbH, a joint venture that will bring high precision GNSS positioning services to mass market applications. The four parties recognized that existing solutions for GNSS positioning services do not meet the needs of emerging high precision GNSS mass markets. As a result, they decided to join forces to facilitate the establishment of a worldwide available and affordable solution fo System Integrators, OEMs and receiver manufacturers. Each partner brings its unique expertise to the joint venture **Sapcorda Services.**

April 2017 – Point One wins Self-Racing Car Event

Precise Location as a Service

Tomorrow's vehicles require precision to be safe and effective in the real world. Point One delivers an accurate, cost effective localization solution that scales.

April 13, 2019 – Trimble RTX Auto

Trimble RTX Auto enables precision positioning for vehicles

April 13, 2019 - By Tracy Cozzens

0 Comments

Trimble has announced the availability of Trimble RTX Auto, a GNSS software library written for use in safety critical automotive applications.

After 2020, Super Cruise will will be available on all General Motors brands (Photo: GM)

The RTX Auto library can be integrated with any GNSS device and enables the decoding of Trimble's RTX correction stream for centimeter-level absolute positioning accuracy, the company said.

RTX Auto works with other on-vehicle sensors to deliver a positioning solution that satisfies advanced driver assistance systems (ADAS) and autonomous driving requirements.

RTX Auto is both Automotive Safety Integrity Level (ASIL) and Automotive Software Process Improvement and Capability Determination (ASPICE) certified. These certifications validate that Trimble RTX Auto meets functional safety requirements for ADAS and autonomous applications in the auto industry.

March 20, 2018 – Skylark service

Swift Navigation launches cloud-based GNSS service for autonomous vehicles

Permanent Link to Swift Naviga

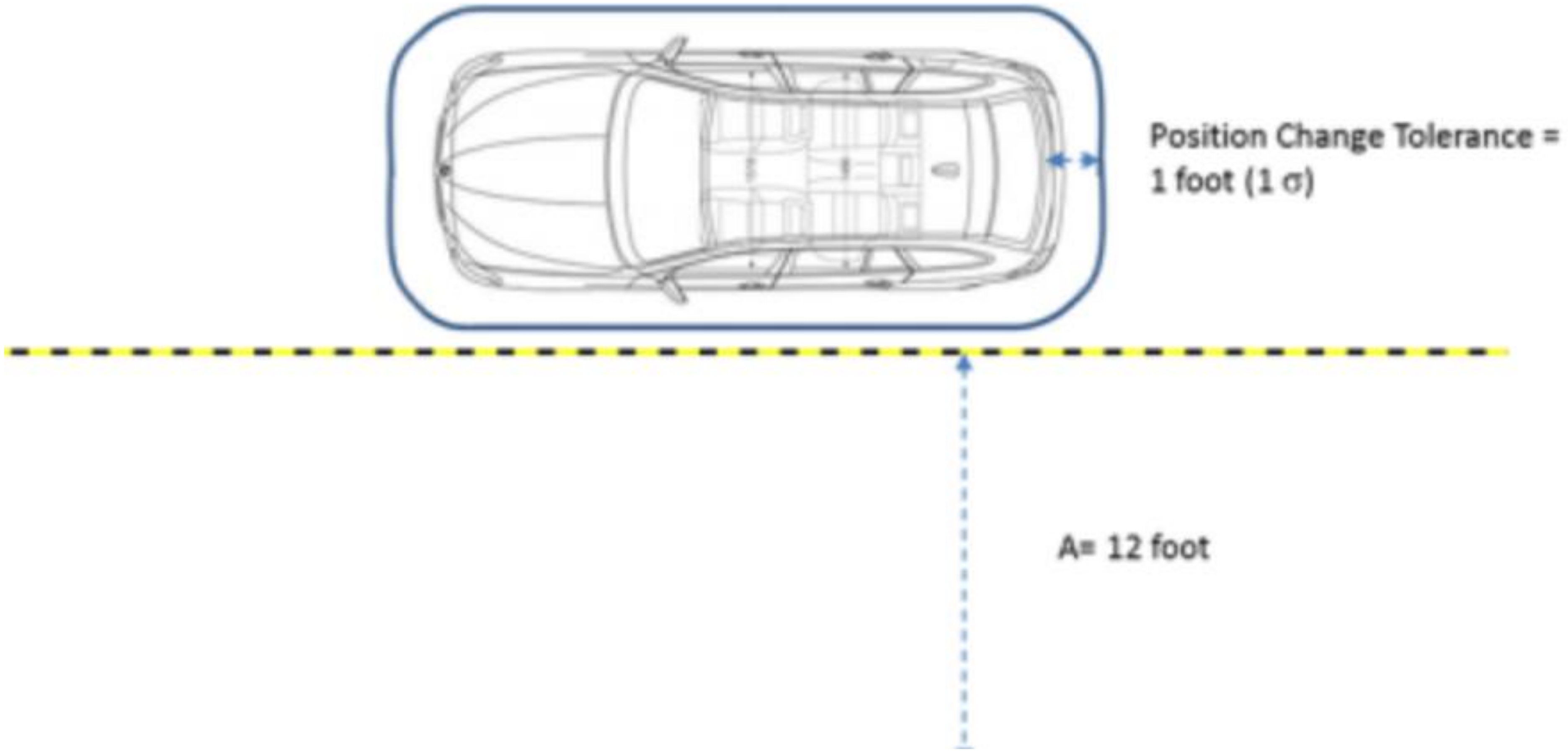
March 20, 2018 - By GPS World Staff 0 Comments Est. reading time: 3:30

Swift Navigation has released Skylark, a cloud-based GNSS corrections service delivering centimeter-level accuracy without deploying and maintaining a GNSS network. Skylark targets autonomy applications at scale and enables high-precision positioning for mass market automotive and autonomous vehicle applications.

Skylark works with both of Swift's multi-band, multi-constellation GNSS receivers, the Piksi Multi and the Duro ruggedized industrial receiver. Swift added GLONASS support in its 1.4 firmware upgrade, announced earlier this month, and aims to include Galileo and BeiDou in the near future.

Previously known as a hardware company, Swift Navigation appears to be shifting its focus a bit, including an Internet-delivered service in addition to its GNSS receivers. It has recently focused more closely on the automotive sector; it also has customers in drone technology, robotics and precision agriculture.

Autonomous Vehicles – The killer app for RTK



Source: NovAtel Inc.

Three GNSS components for the Autonomous vehicle Market

1. Multi-frequency, multi-constellation high-precision RTK/PPP GNSS receiver.
2. Multi-frequency GNSS antenna.
3. Reliable GNSS correction service.

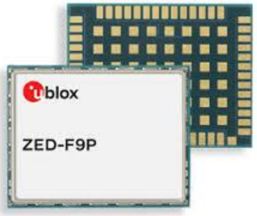
And, the automobile industry is only willing to pay consumer electronics prices.

High-precision GNSS players enter the Autonomous market in 2018

- Novatel introduces the PIM7500.

- Septentrio introduces the Mosaic.

- Ublox ZED-F9P



- Trimble SDR?

High-precision GNSS players enter the Autonomous market in 2018

- ST Micro - $10B semiconductor company.
- Feb 27, 2018. “STMicroelectronics Launches World’s First Multi-Band GNSS Receiver with Autonomous-Driving Precision and Automotive Safety Compliance.”
- Mar 6, 2018. “NovAtel Demonstrates Precise Positioning Using the Teseo APP and Teseo V Automotive GNSS Chipsets from STMicroelectronics”

High-precision GNSS players enter the Autonomous market in 2018

- Qualcomm - $22B wireless company.

- "Qualcomm leaned on its existing patent portfolio; it merges data from existing GNSS satellites (including GPS, Europe's Galileo, Russia's GLONASS, and more) with something called VEPP, or vision enhanced precise positioning."

Autonomous isn't just about GNSS receiver hardware

- A critical component of high-precision GNSS for autonomous vehicles is the correction services.
- Traditional RTK Networks don't work due to lack of connectivity and heavy infrastructure requirements.
- Traditional real-time PPP doesn't work because convergence time takes too long.
- What's the solution?

New GNSS Correction Services

- Bosch, Mitsubishi, Ublox and Geo++ formed Sapcorda, which is focused on providing high-precision GNSS corrections to the auto market.
- Sapcorda claims 1 foot accuracy with a convergence time of under 30 seconds with a high degree of confidence (think 99.999%).
- The autonomous market doesn’t require centimeter accuracy, but it requires fast convergence (and reconvergence) and reliable accuracy.

New Correction Services

- It achieves its stated performance with a more dense infrastructure than traditional real-time PPP, but not at RTK levels. GNSS base station spacing is ~200km.
- Sapcorda intends to be the default open format system that will work with any multi-frequency GNSS receiver via automotive satellite or internet.
- It will not be an end-user subscription service.

Finally…..GNSS Antenna trends

- Historically, multi-frequency antennas have been relatively expensive.
- Automotive manufactures won’t pay the price that we are used to paying.
- L1/L2 antenna components will likely be about $10.
- The automotive market will drive

mass production of multi-frequency antennae, which will increase competition and drive the costs down.

Other GNSS Technology Trends

-$350.

-Centimeter accuracy.

-Relies on smartphone CPU for intense processing.

-GPS/Galileo only (essentially GPS-only for now)

-Android-only. No iOS.

-Specific Android devices only

-Uses phone battery quickly.

-Requires USB cable connection.

-Catalyst II?

Trimble Catalyst brings high-accuracy positioning to Android devices

July 6, 2017 - By GPS World Staff

Est. reading time: 1 minute

Facebook Twitter Google LinkedIn

The Trimble Catalyst software-defined GNSS receiver for Android devices is now available through Trimble's global distribution network.

Through Catalyst and a special antenna, customers can access positioning-as-a-service to collect geolocation data with Trimble or third-party apps on smartphones, tablets and mobile handhelds.

When combined with a plug-and-play digital antenna and subscription to the Catalyst service, the receiver provides on-demand GNSS positioning capabilities to turn consumer Android devices into centimeter-accurate data-collection systems.

Catalyst requires only a few components:

- Any location-enabled mobile app.
- A Catalyst subscription, with accuracy

Indoor (or really tough outdoors) Mapping

- High-precision indoor positioning will become a reality. Will GNSS ever work indoors?

- Technology fusion (e.g. indoor ranging infrastructure; Bluetooth or beacons?).

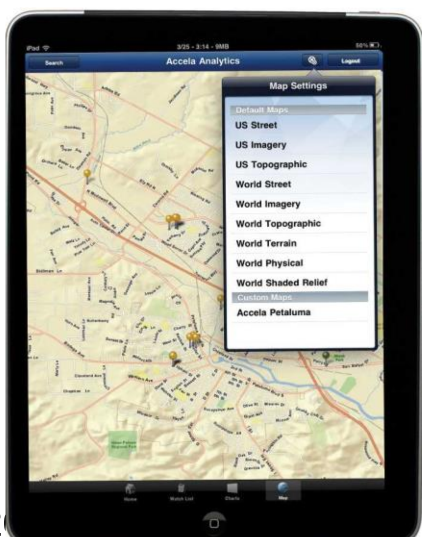
BYOD (Bring Your Own Device)

Trends in GNSS Field Data Collection

BYOD vs. All-in-One

-All-in-one = Simplicity

-BYOD = Flexibility…



or

+

BYOD Advantages

- Use YOUR choice of data collector.
- Less $$ than proprietary data collectors.
- Change your data collector without changing your GNSS receiver.
- Bigger screen.
- Lightweight.
- Evolve with the latest mobile device technology.

BYOD Disadvantages

- Two pieces of equipment (data collector and GNSS). Two batteries to manage.
- Usually not rugged or temp tolerant without a waterproof case (eg. add Otterbox).
- Limited data collection software choices.
- Limited battery life on some devices.

All-in-One Advantages

- One-stop shopping. Same mfr for data collector, GNSS, and software (mostly).
- Easier to manage. One handheld device.
- Built to be rugged (typically).

All-in-One Disadvantages

- Not flexible.
- Shorter product life cycle (CPU and operating system).
- Heavier (typically).
- Smaller display (typically).
- More expensive.

When BYOD Makes Sense

- Deployments where users already have the mobile device.
- When flexibility is important. iPhone on one project, iPad on the next project.
- When you plan on keeping the GNSS receiver for a long time.
- Limited budget.

When BYOD Doesn't Make Sense

- When simplicity is the ultimate goal at the expense of cost and longevity.
- One-stop shopping for support.
- If you want to post-processing your data (but why would you want to do that ☺).

A look at BYOD Hardware

Operating Systems

- **iOS** – Only Apple devices. Proprietary.
- **Android** – Open source. Non-proprietary. Customizable.
- **Windows** – Microsoft licenses to lots of companies.

- 99.6% of new smartphones run either Android or iOS.

Android

- The most popular smartphone operating system. ~81.7% market share.
- Available on a wide variety of mobile devices.
- Open source = lots of potential incompatibilities between devices, which leads to app developers having to select a handful of Android devices to support.
- Open source = security concerns with IT depts.

iOS - Apple

- The second most popular smartphone operating system. ~17.9% market share.
- Proprietary Apple ecosystem.
- Consistent compatibility among devices except for screen size.
- Difficult to design hardware and software for.

Windows

- Windows Mobile/Embedded Handheld (not smartphones). End of life 2019.
- Windows 10 desktop/tablet/phone.
- 0.3% market share in smartphones.
- Well-established and maintained security features and network compatibility.
- Target for virus and malware.

Audience Poll

- **Which device do you use?**
- A) Apple
- B) Android
- C) Windows
- D) Other (eg. Blackberry).

Which Device is best for you?

Two approaches:

1. Hardware-based decision (eg. I want to use an iPad).

2. Software-based decision (eg. I want to use ArcGIS Collector).

Which Approach?

- Individual deployment vs. enterprise. Enterprise involves IT support, greater security concerns, established hardware/software standards.
- Cloud app vs. stand-alone app.
- Existing contracts with hardware/software suppliers.
- Familiarity with hardware and software.

Hardware-Based Decision

- Windows, Android or iOS device?
- Data collection apps for selected device?
- Availability of device. Consumer devices have a shorter life cycle than industrial devices.
- Consumer devices are less expensive than industrial devices.
- Ergonomics, ruggedness, battery life, temp range, outdoor screen readability.
- Enterprise policies and support.

Software-Based Decision

-Which GIS data collection software do you want to run? Which operating system does it run on?

-Does it collect the type of data you want? Points, Lines, Polygons?

-Can you create the data collection forms you need?

-Does it display the data you want to see?

-Does it output the data format you need?

The Devil is in the Details

- Datum/coordinate system selection. Matching your data with others.
- GNSS metadata (estimated precision, DSID, Correction Age, # of sats) display and recording.
- Elevations? GEOID Model support?
- Basemap support (raster and/or vector).
- Did I mention outdoor screen readability?

BYOD Device Trends

- Windows 10 mobile devices will gain market share momentum, but Android and iOS will continue to dominate.

- More and more professional apps will become available for Android and iOS devices.

- Consumer devices will become more rugged.

- Consumer devices will become more powerful (eg. faster CPUs).

- Microsoft Windows Mobile is retired.

BYOD Device Trends

- Devices will continue to change. New devices based on Android, iOS, Windows will be introduced.

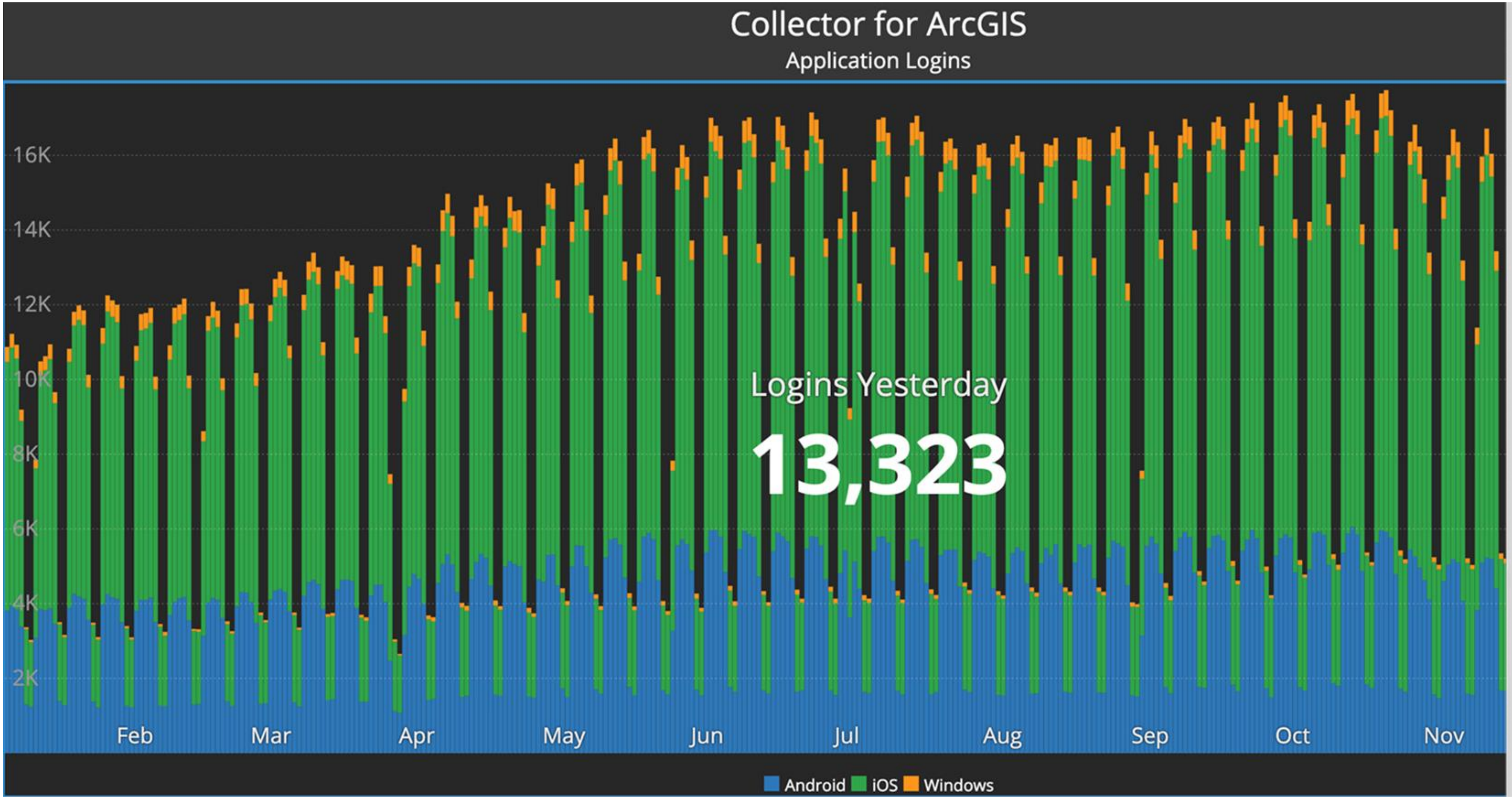
- The operating system “landscape” will largely remain the same.

- With four constellations and multi-frequency, GNSS receivers will largely remain the same, albeit smaller, faster, cheaper.

A Quick Word About Esri

- Esri's mobile data collection software (Collector and Survey123) is embracing high-precision GNSS (e.g. RTK, datum trans, NTRIP, elevation support, etc.).
- Esri has re-partnered with Autodesk. Esri will be developing Autodesk's field data collection software for iOS, Android and Windows.
- As a result of the Esri/Autodesk partnership, I think you'll see a new set of data collection features (e.g. topo mapping, staking, COGO).

A Quick Word About Esri



Questions?

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