

GPS: Mass market user perspective

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Google, Inc.

Civil GPS Service Interface Committee, Sep 2022

Outline

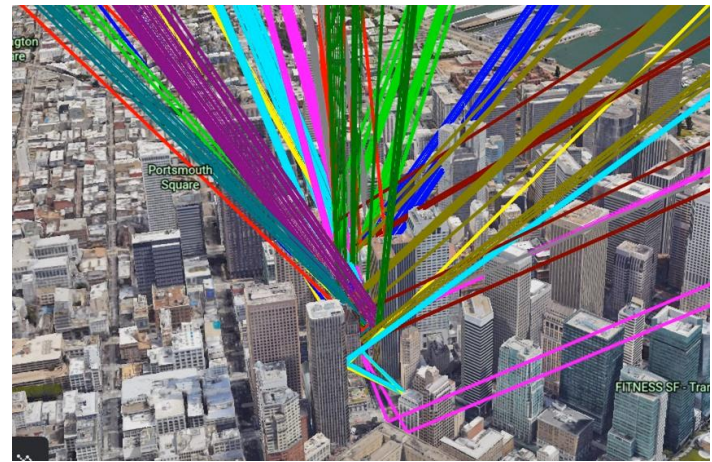
1. Review of where we are
2. Technical trends
3. Mass market carrier phase DGNSS
4. WiFi RTT
5. Resources for developers
6. Summary



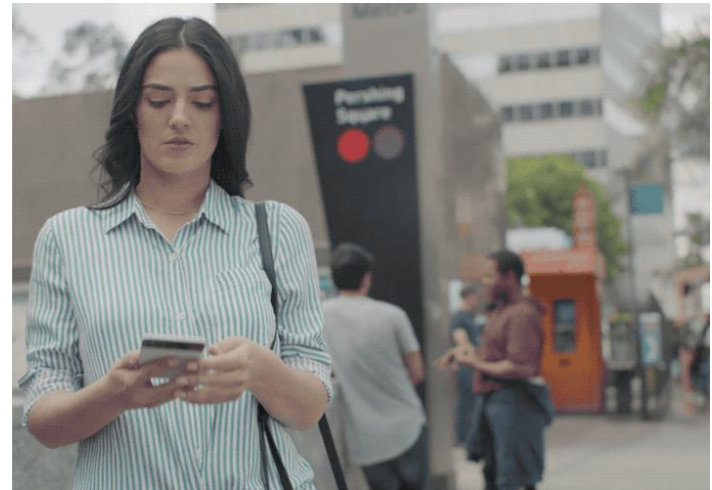
Review of where we are:

- Every smartphone has GNSS, WiFi, Inertial and Pressure sensors
- GNSS-WiFi integration is standard for indoor location
- Emergency Location Service integrated into phones
- 3DMA is standard in Android phones
- Visual positioning and Augmented Reality is standard in Google Maps.

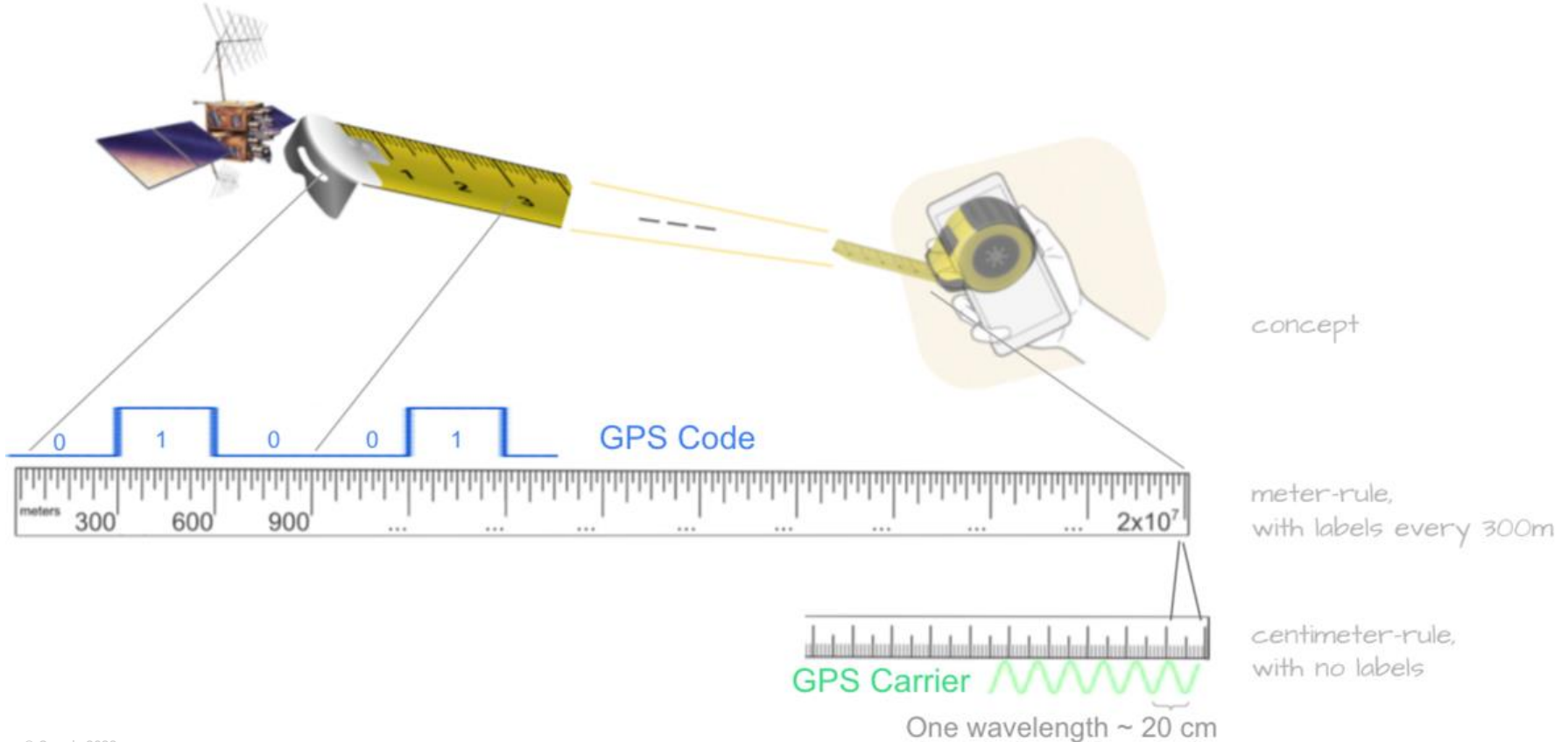
3DMA: 3D Mapping Assistance, use of 3D models to remove reflection errors

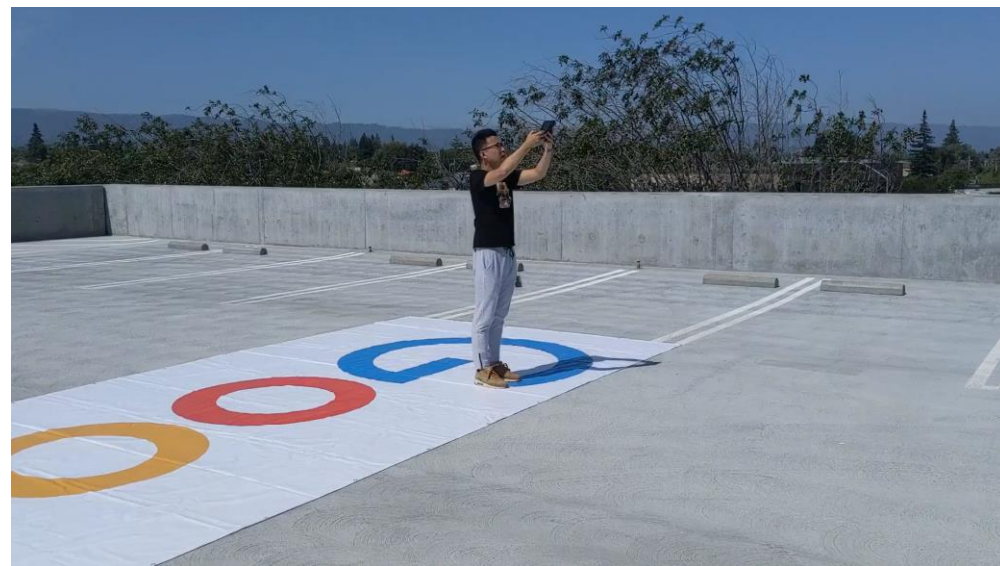


InsideGNSS and Youtube, ION ITM Plenary 2021:
Google's use of 3D building models



Technical trends in consumer GNSS: L1,L5; and Carrier Phase measurements.

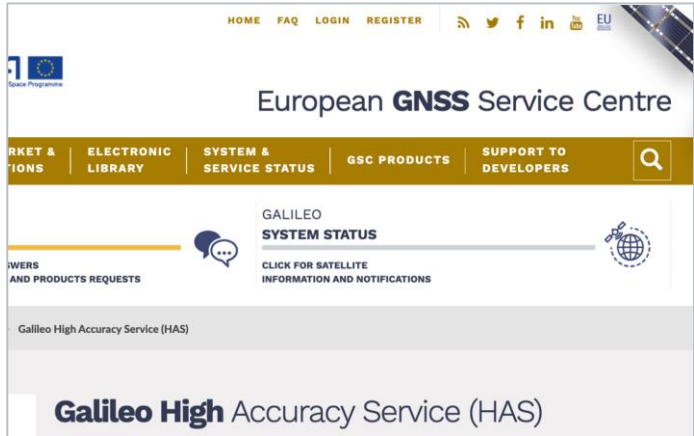




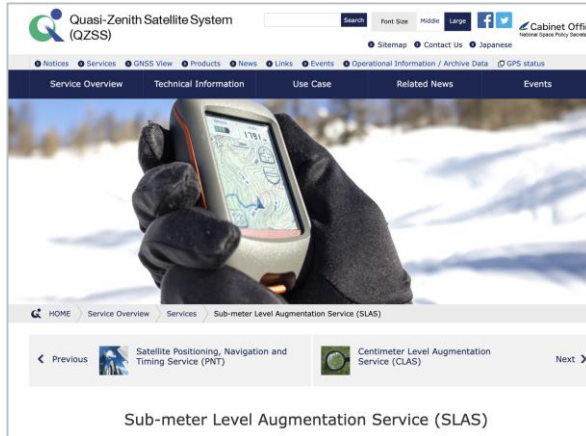
DGNSS for the mass market

Galileo, QZSS, BeiDou: all provide High Accuracy Services in their broadcast signals.

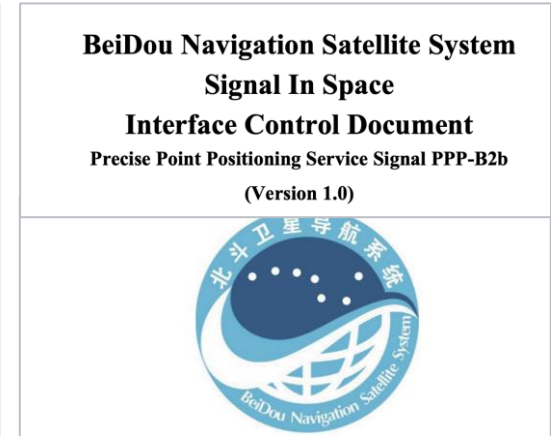
Galileo HAS will also be distributed over the internet.



The screenshot shows the European GNSS Service Centre website. The header includes navigation links for HOME, FAQ, LOGIN, and REGISTER, along with social media icons for RSS, Twitter, Facebook, LinkedIn, YouTube, and the European Union flag. The main content area features a search bar and a section titled "GALILEO SYSTEM STATUS" with a sub-link "CLICK FOR SATELLITE INFORMATION AND NOTIFICATIONS". Below this, there is a section for "Galileo High Accuracy Service (HAS)".



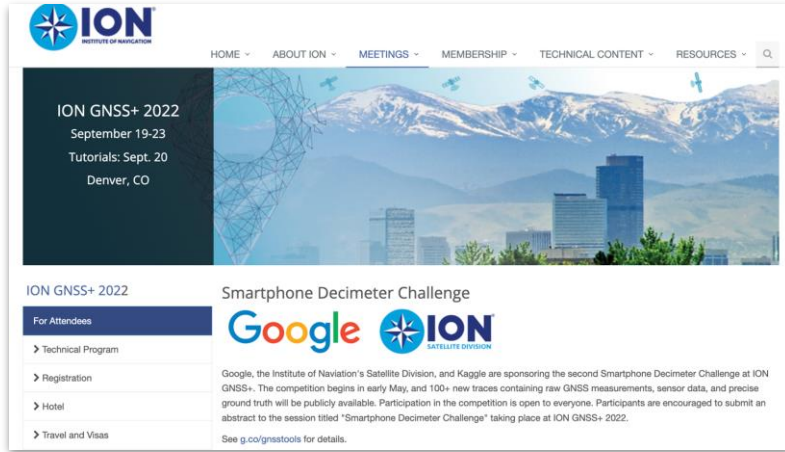
The screenshot shows the Quasi-Zenith Satellite System (QZSS) website. The header includes a search bar, font size options, and social media icons for Facebook, Twitter, and LinkedIn. The main content area features a navigation menu with links for Service Overview, Technical Information, Use Case, Related News, and Events. Below the menu is a large image of a hand holding a GPS device displaying a map. The page title is "Sub-meter Level Augmentation Service (SLAS)".



The cover of the BeiDou Navigation Satellite System Signal In Space Interface Control Document. The title is "BeiDou Navigation Satellite System Signal In Space Interface Control Document" followed by "Precise Point Positioning Service Signal PPP-B2b (Version 1.0)". Below the title is the logo of the BeiDou Navigation Satellite System, which features a blue circular design with the Chinese characters "北斗卫星导航系统" and the English text "BeiDou Navigation Satellite System".

GPS PNT Advisory Board investigating a similar service for GPS

Smartphone Decimeter Challenge (SDC)



The screenshot shows the ION GNSS+ 2022 website. The header includes the ION logo and navigation links: HOME, ABOUT ION, MEETINGS, MEMBERSHIP, TECHNICAL CONTENT, and RESOURCES. The main content area features a banner for "ION GNSS+ 2022" with dates "September 19-23" and "Tutorials: Sept. 20" in "Denver, CO". Below this is a section for the "Smartphone Decimeter Challenge" with the Google and ION logos. The text describes the competition, mentioning that it begins in early May and involves 100+ new traces. It also lists a menu for attendees: Technical Program, Registration, Hotel, and Travel and Visas.

Summary:
submeter accuracy (median) from smartphones.



Wednesday afternoon, Session E2a
1:45 - 5:30 pm.
Smartphone Decimeter Challenge

Capitol Ballroom 5-7 (4th floor)

SDC Legacy

AI researchers, especially machine learning, use open datasets for standardized testing of models.

The GNSS community has not yet adopted similar standards.

A typical ION paper will have:

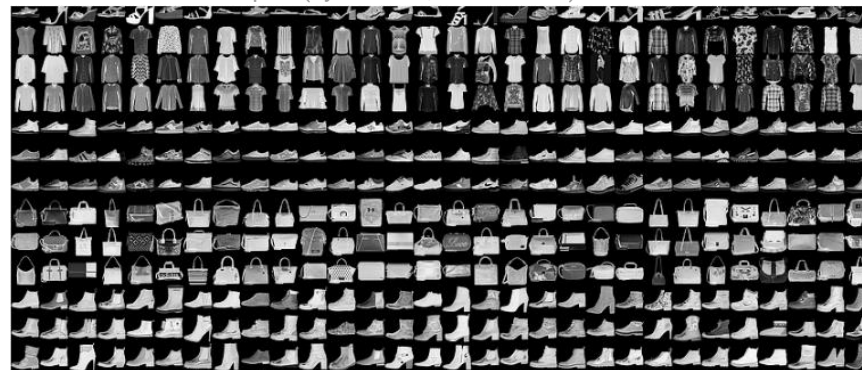
- very few real datasets to show results
- inconsistent metrics (50% here, rms there, etc)

Kaggle and the collection of >100 labeled datasets (~200,000 epochs) with verified GT can bring GNSS to the R&D standards of AI.

<https://www.tensorflow.org/tutorials/keras/classification>

70,000 grayscale images of clothing in 10 categories.

Fashion-MNIST samples (by Zalando, MIT License).



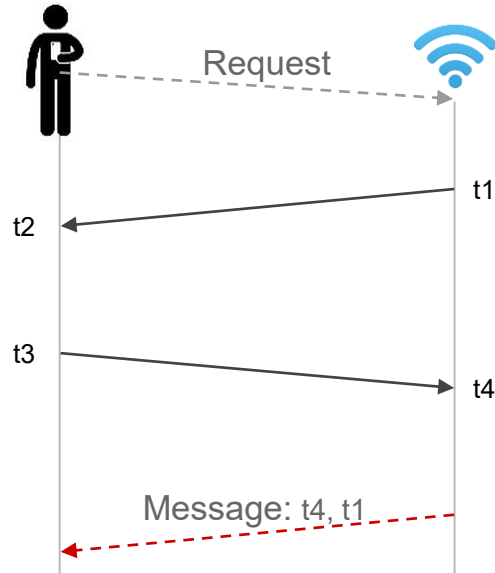
[https://www.kaggle.com/competitions/...](https://www.kaggle.com/competitions/)

>100 labeled traces (~200,000 epochs) with verified ground truth

Image: courtesy Taro Suzuki, ION GNSS+ 2022

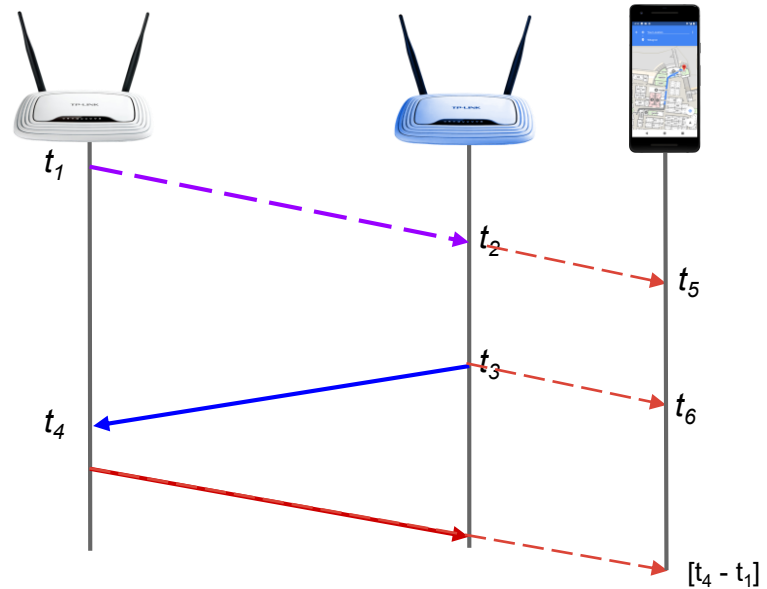
Indoor Positioning with Wi-Fi RTT

2017: IEEE 802.11mc



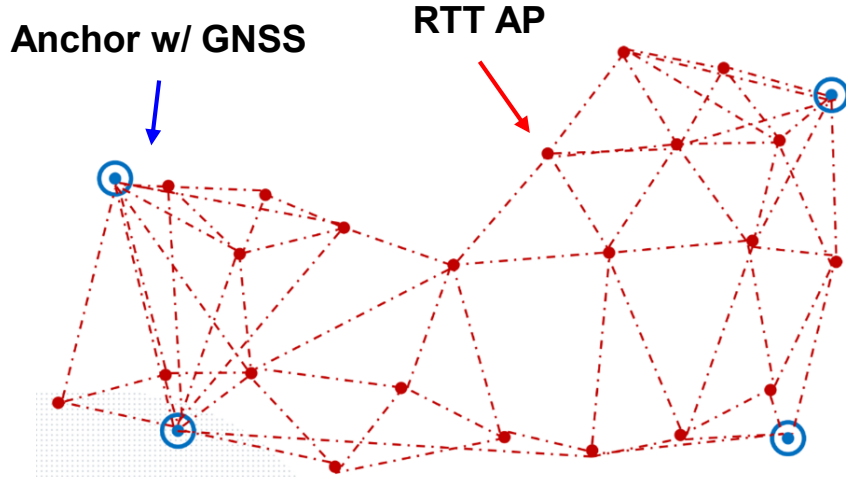
Active Mode: phone transmits & receives

2023: IEEE 802.11az; scalable passive mode

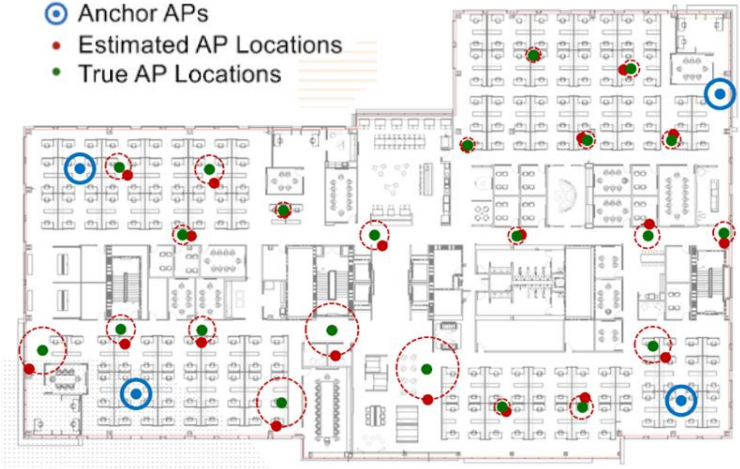


Passive Mode: phone only listens

Wi-Fi RTT & Aruba's *OpenLocate*: A Complete Positioning System



ASSESSING ACCURACY OF SELF-LOCATED NODES



Enables large-scale self-maintained Wi-Fi positioning infrastructure

AP mesh formed using RTT relative to four APs anchored by GNSS near windows

Civil GNSS : WiFi RTT 802.11 az



Feature/Attribute	GNSS	WiFi RTT
Time-of-flight trilateration	Yes	Yes
“Satellite-to-satellite” comm’s	Yes	Yes
Broadcast ephemeris	Yes	Yes
Multi-user	Yes	Yes
Bandwidth	2 – 50 MHz	20 – 160 MHz
Nav message authentication	Yes*	Yes
Code encryption	No	Yes
Common mode (clock) error	Yes	No

* coming to Galileo

Summary:

WiFi RTT is not a “signal of opportunity”, it is a complete location system

GNSS (outdoors) + WiFi RTT (indoors) = a truly ubiquitous navigation system.

Resources for developers

- Raw measurements, incl. carrier phase, from Android phones.

- GNSS tools



GnssLogger: log raw GNSS measurements on Android



Gnss Analysis Tools: desktop app for measurement analysis →

- Standard test cases, with Ground Truth, on Kaggle platform.

- WiFi tools



WifiRttScan: phone-to-access-point distance



WifiRttLocator: positioning with 802.11mc →



Summary

Technology for sub-meter accuracy in phones (and cars and watches) is now in place, both indoors and outdoors.

The next decade will see an explosion of high-accuracy mass-market applications.