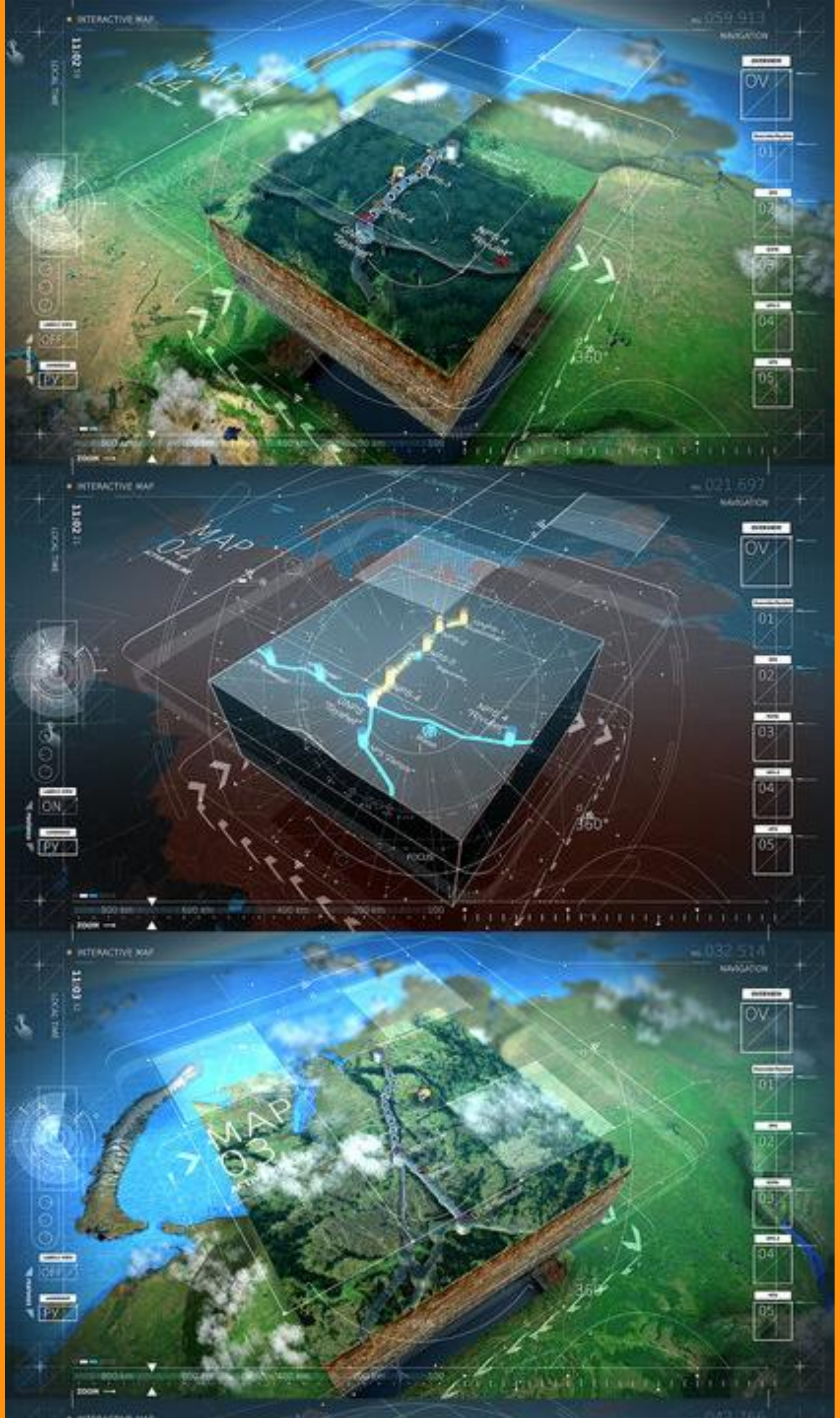
INTRODUCTION TO HIGH-END GNSS RECEIVERS

January 2020

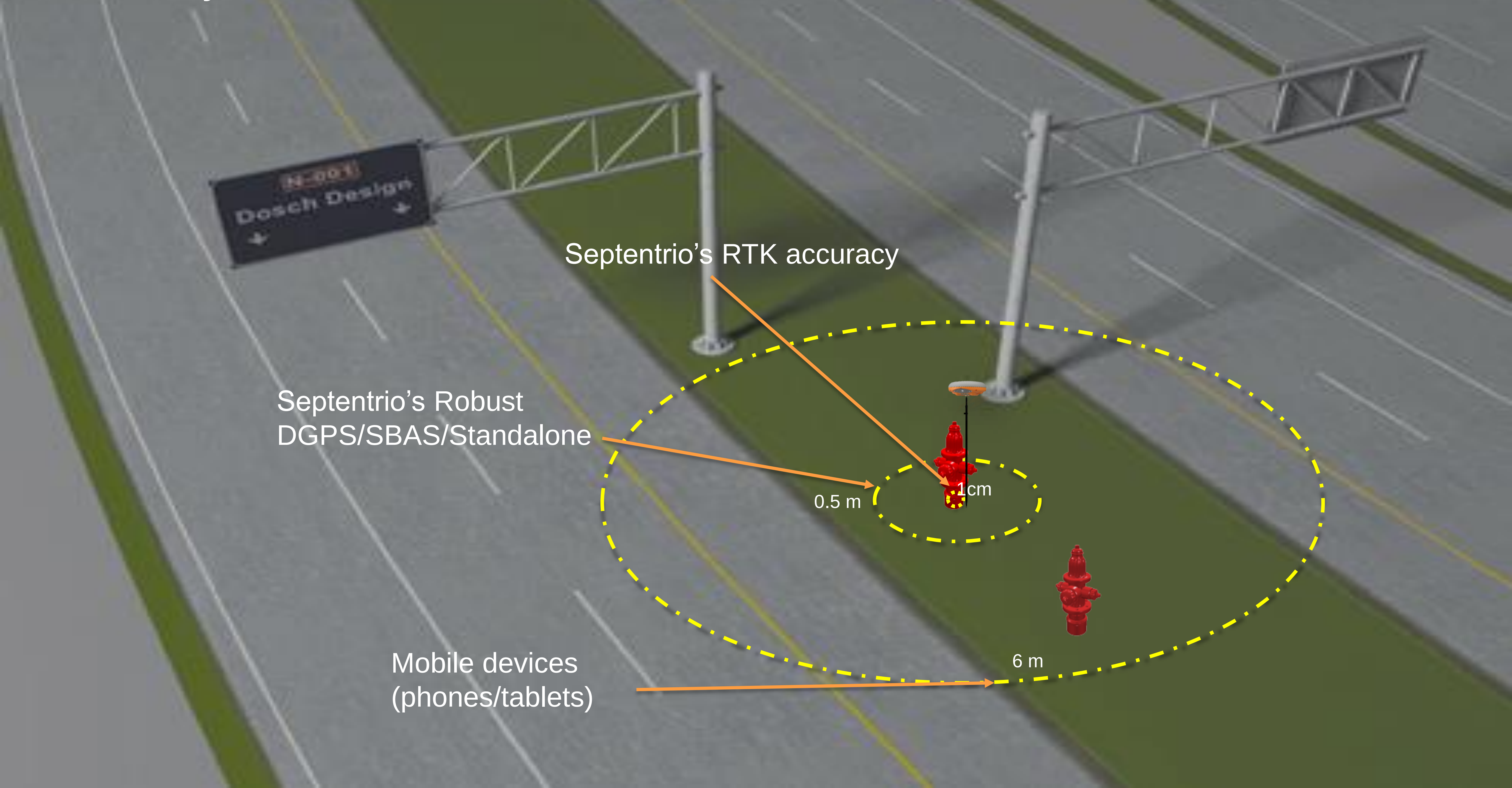
Koen Gutscoven

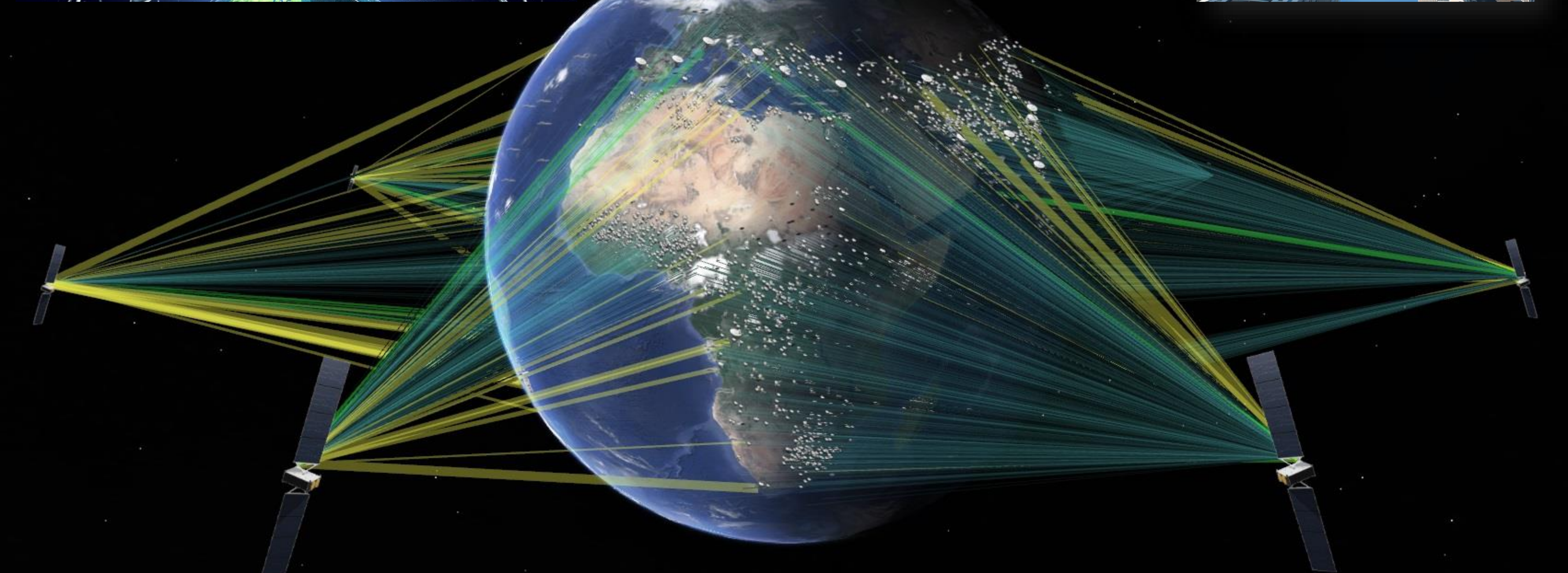

A professional
equipment
50mm
Still easy to use



Why a high-end receiver?

Accuracy matters



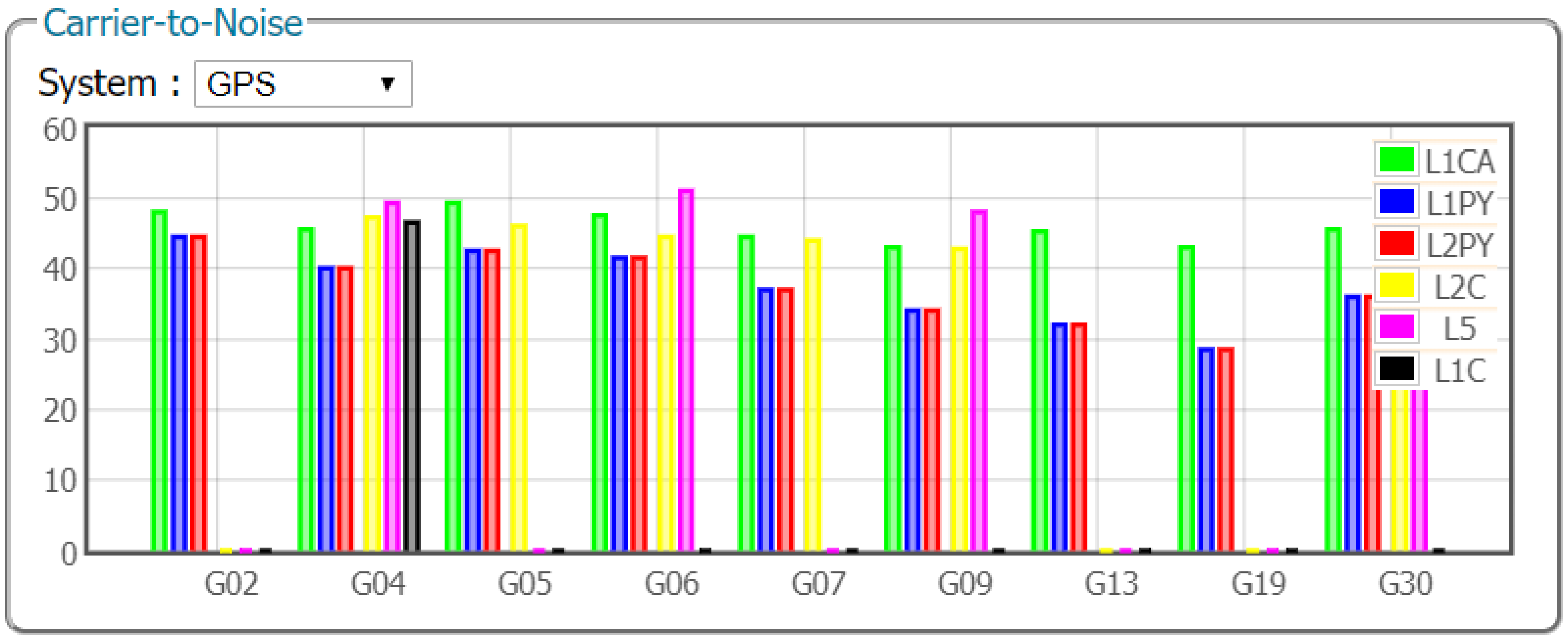


Multi-constellation?

The difference

- **Smartphone / Tablet**
  - GPS (Glonass) L1
- **Septentrio**
  - GPS L1, L2, L5
  - Glonass L1, L2, L5
  - Galileo E1, E5a, E5b, AltBoc, E6
  - Beidou B1, B2, B3
  - IRNSS L5
  - QZSS L1, L2, L5

Tracks all visible signals (GPS, GLONASS, GALILEO, BEIDOU, IRNSS, QZSS, SBAS)



G04	4	45° ↓	47°	Tracking L1CA,P1(Y),P2(Y),L2C,L5,L1C [unhealthy signal(s): L1CA,P1(Y),P2(Y),L2C,L1C]

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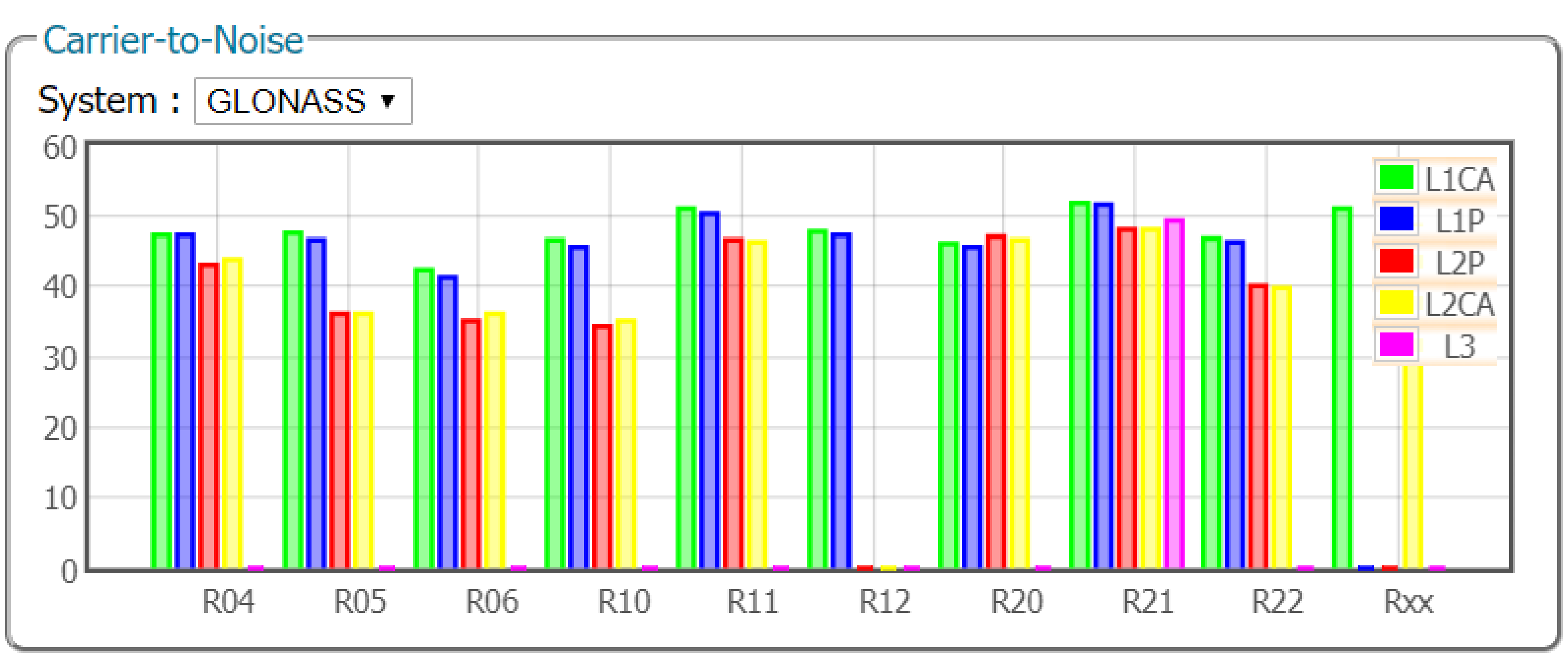

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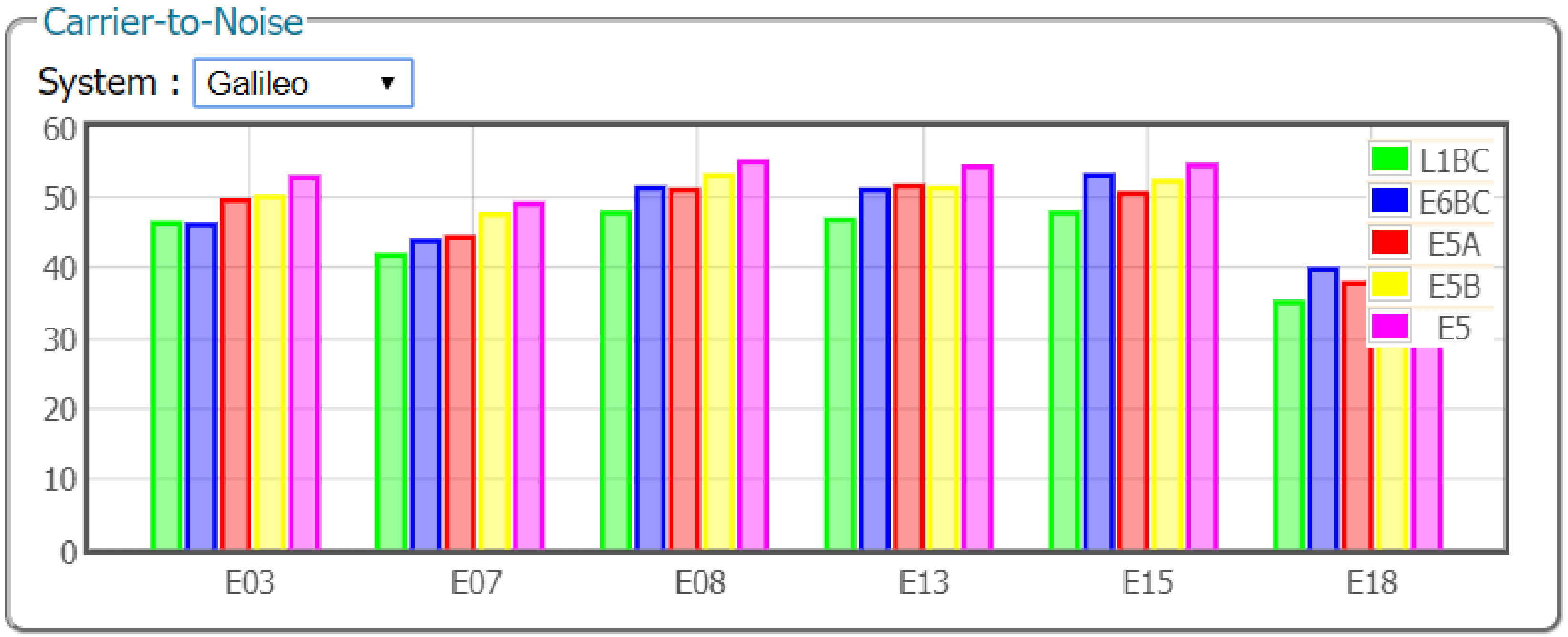

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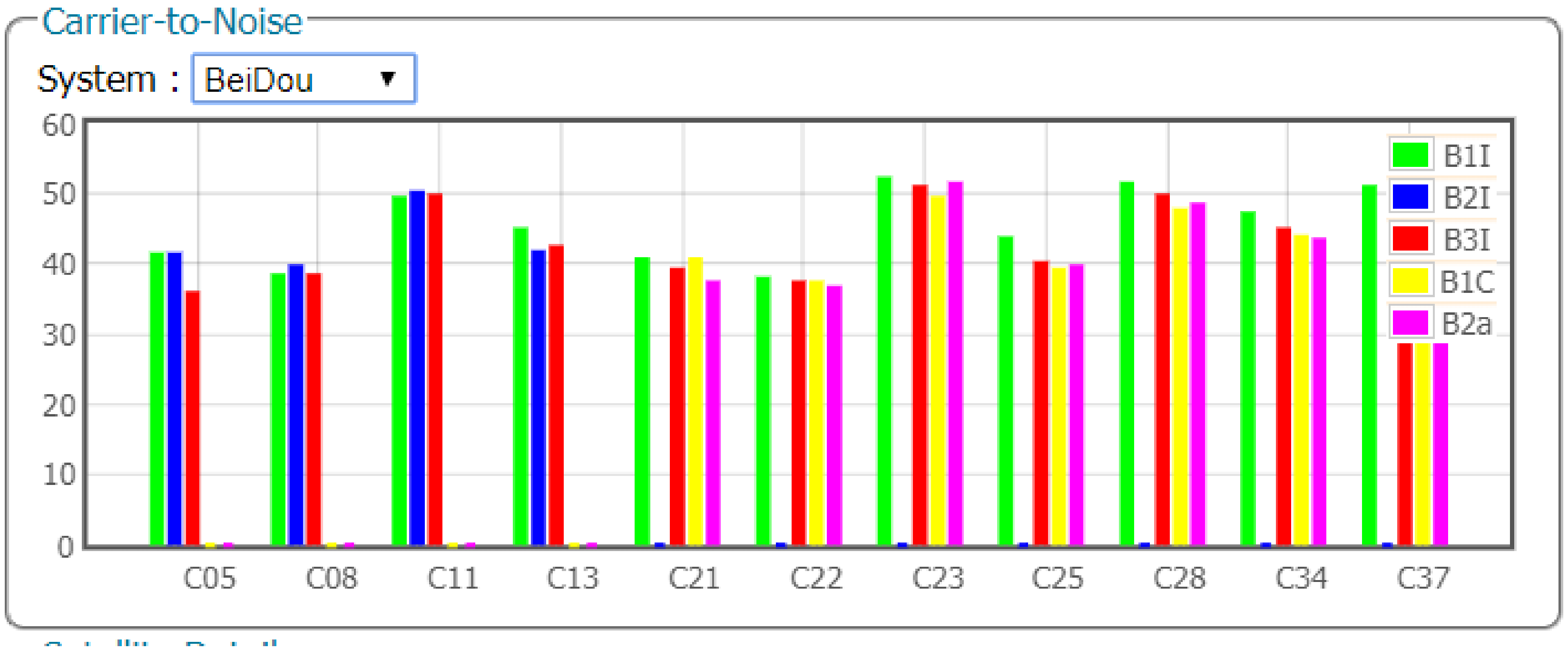

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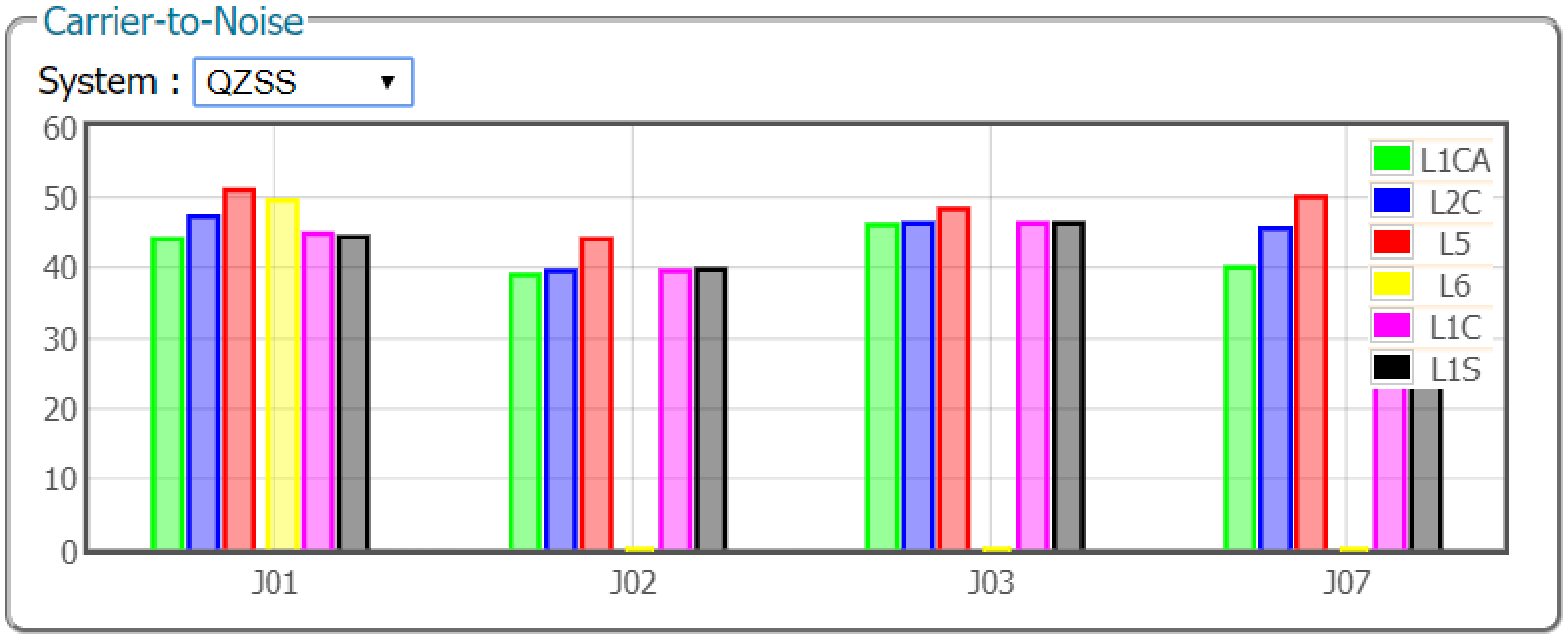

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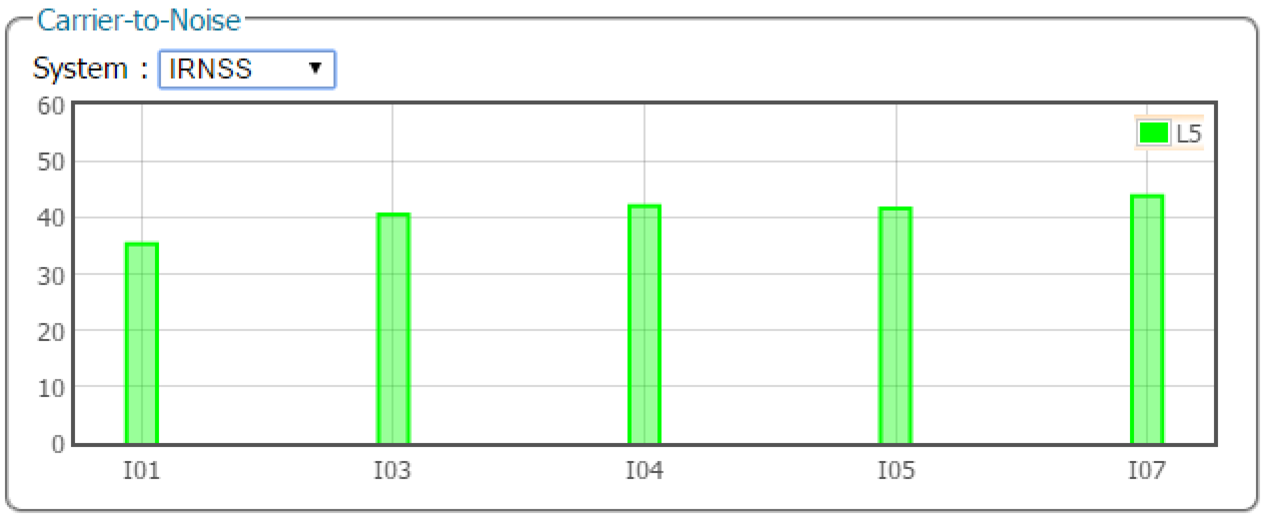
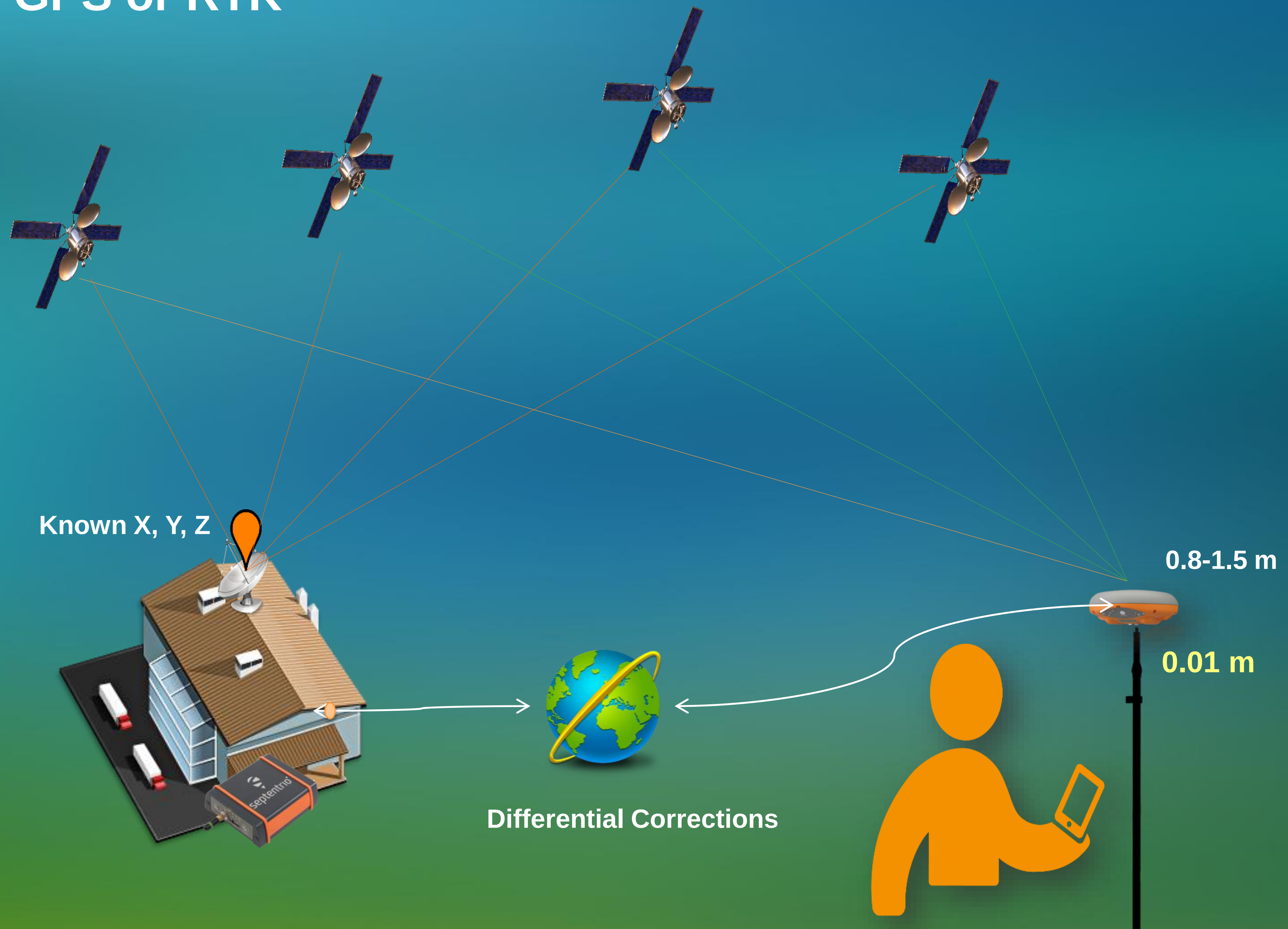


Differential GPS or RTK



GNSS Augmentation Techniques

	HORIZONTAL	VERTICAL
• Stand Alone , Multi Constellation, Multi Frequency	1,20 m	1,90 m
• SBAS (EGNOS, WAAS, GAGAN, MSAS, ...)	0,60 m	0,80 m
• DGNSS	0,40 m	0,70 m
• PPP (Precise Point Positioning)	0,04 m	0,06 m
• RTK (or PPK)	0,006 m + 0,5 ppm	0,01 m + 1 ppm

GNSS Augmentation Techniques

• Stand Alone , Multi Constellation	No ground infrastructure
• SBAS (EGNOS, WAAS, GAGAN, MSAS, ...)	No ground infrastructure, limited area
• DGNSS	Base stations (or CORS network) required
	Based on code information only
• PPP (Precise Point Positioning)	World wide network of reference stations, low density
	Code and phase information required
	Corrections usually provided by satellite
	Long convergence time (10 to 20 minutes)
• RTK (or PPK)	Nearby base station or high density CORS network required
	Code and phase information required
	Short convergence time

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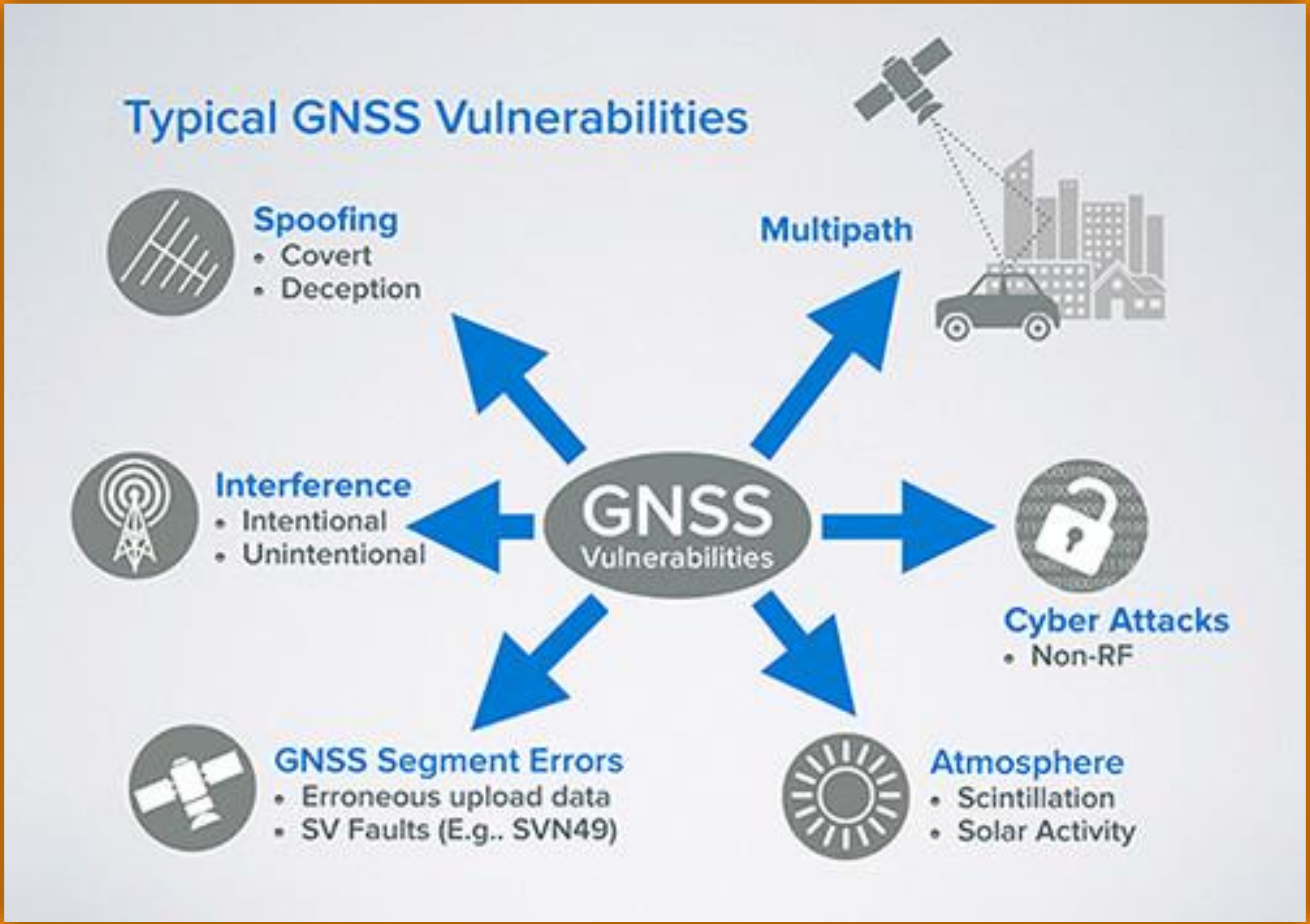
Typical GNSS Vulnerabilities
Spoofing
• Covert
• Deception
Multipath
Interference
• Intentional
• Unintentional
GNSS
Vulnerabilities
Cyber Attacks
• Non-RF
GNSS Segment Errors
• Erroneous upload data
• SV Faults (E.g.. SVN49)
Atmosphere
• Scintillation
• Solar Activity

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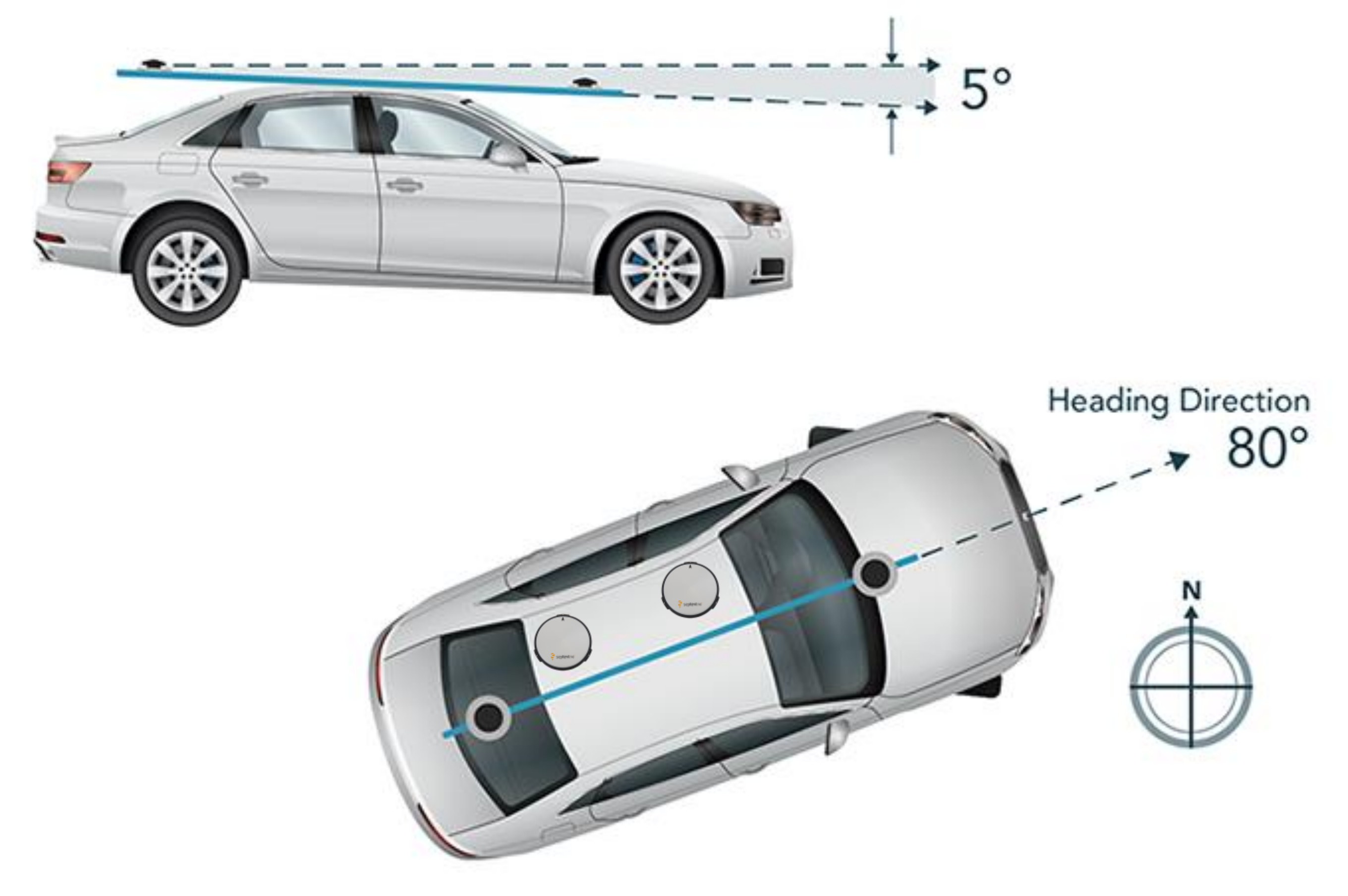
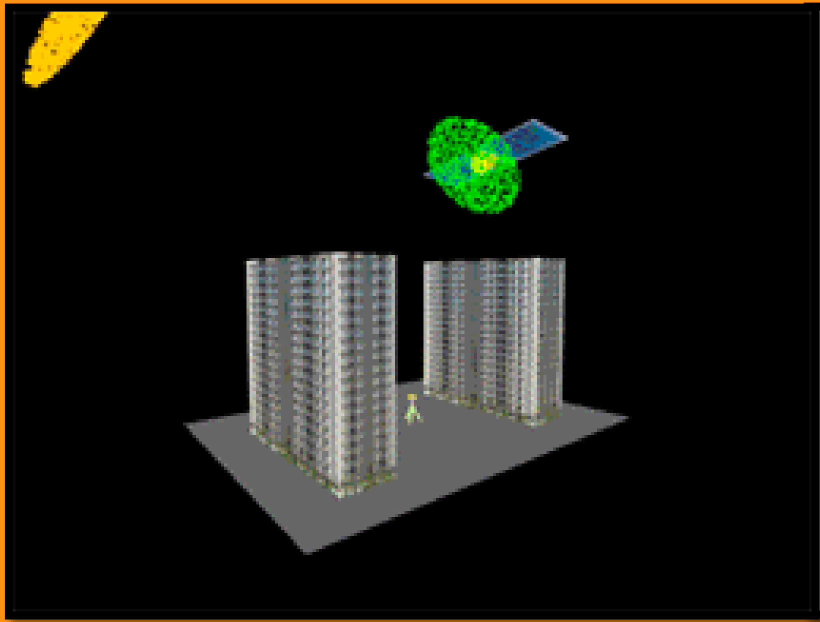
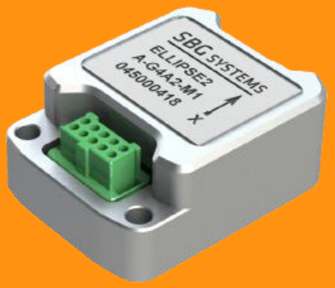
Heading





GNSS

IMU



GNSS/INS?

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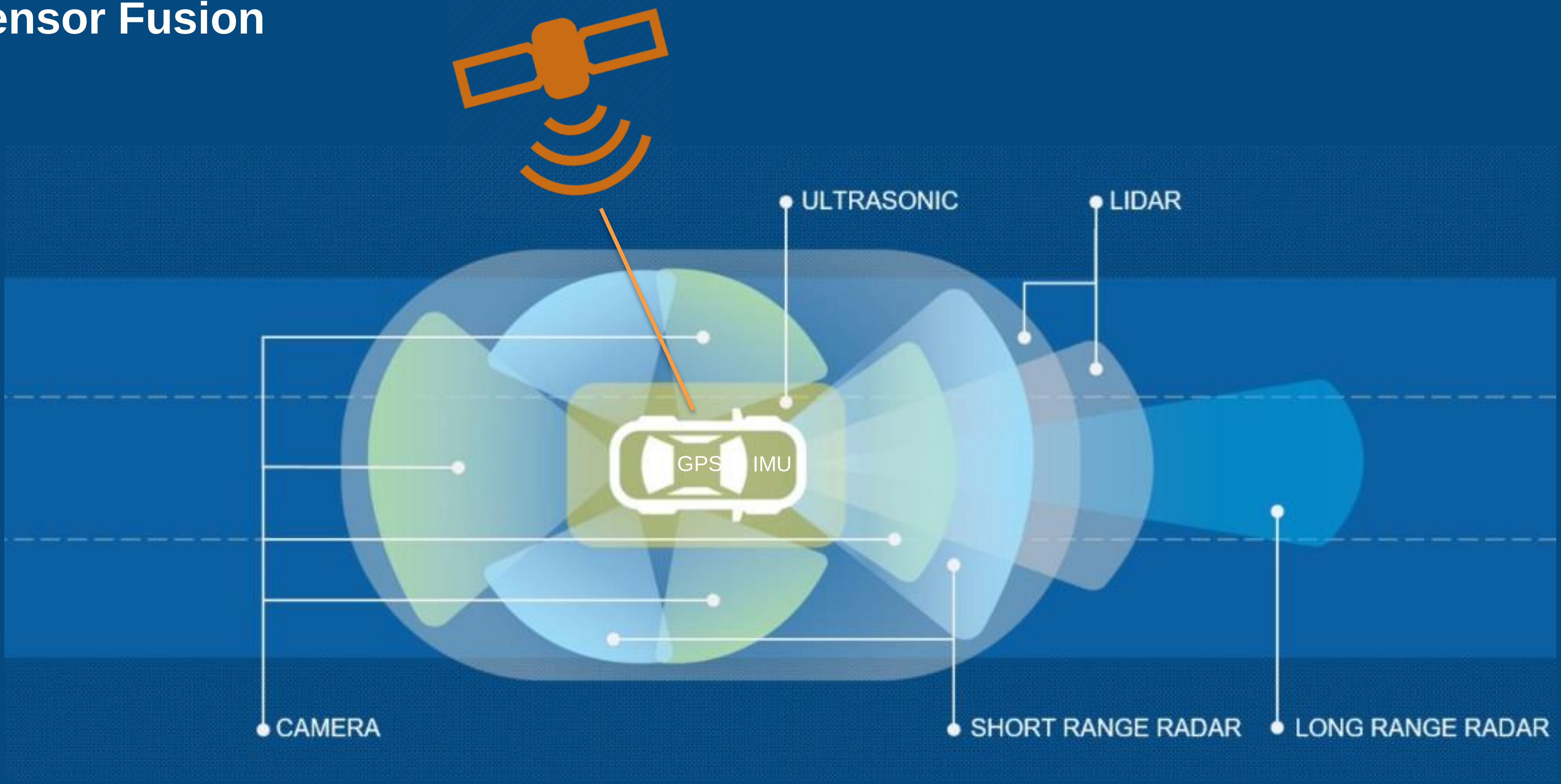
Sensor Fusion



GPS as an essential element of sensor fusion
ABSOLUTE POSITIONING

Our markets

Machine Automation

Marine

Construction

Mining

Logistics

Agriculture

Autonomous driving

Survey and Mapping

Survey

GIS

Mobile Mapping

Unmanned Systems

Scientific/Reference

Reference Receivers

Timing Receivers

Space Weather

Aerospace/Defense

Aerospace

Defense

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Flexible installation
Robust Housing
Professional connector
AIM+
Multi Const
Reliable
Accurate

AIM+
Multi Const
Reliable
Accurate
Robust Housing
Professional connector

BIO
Flexible installation
Robust Housing
Wireless
AIM+
Multi Const
Reliable
Accurate

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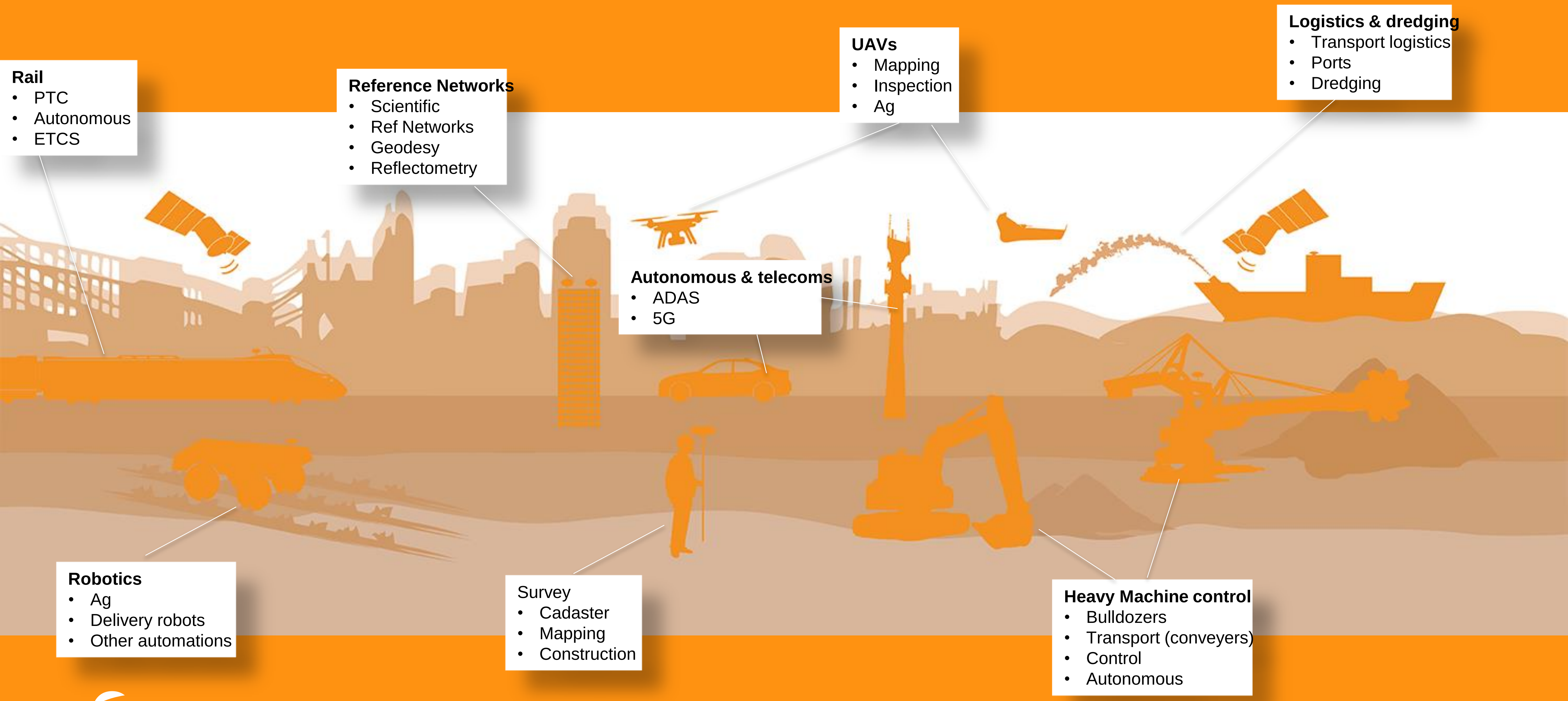
Rail
• PTC
• Autonomous
• ETCS
Reference Networks
• Scientific
• Ref Networks
• Geodesy
• Reflectometry
UAVs
• Mapping
• Inspection
• Ag
Logistics & dredging
• Transport logistics
• Ports
• Dredging
Autonomous & telecoms
• ADAS
• 5G
Robotics
• Ag
• Delivery robots
• Other automations
Survey
• Cadaster
• Mapping
• Construction
Heavy Machine control
• Bulldozers
• Transport (conveyers)
• Control
• Autonomous

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Core Market Segments / Key Customers

Machine Automation

FUGRO
BNSF RAILWAY
RAVEN INDUSTRIES
DEME Dredging, Environmental & Marine Engineering
JAN DE NUL GROUP
GE
PSA The World's Port of Call
Honeywell
VALE

Survey & Mapping

senseFly a Parrot company
FLYING CAM
DELAIR AERIAL INTELLIGENCE
Google
kespry Drones At Work
IXBLUE DEEP INSIGHT. SHARPER SENSES.

Scientific/Reference

USNO
MIT HAYSTACK OBSERVATORY
Berkeley UNIVERSITY OF CALIFORNIA
USGS
NASA
UNAVCO

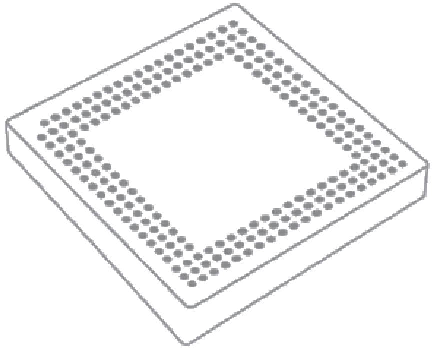
Aerospace / Defense

AIRBUS
esa European Space Agency
GENERAL DYNAMICS Mission Systems
BLUEFIN ROBOTICS
QINETIQ

Our Products

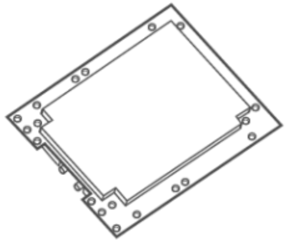
mosaic

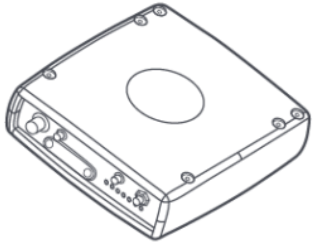
Compact receiver module



AsteRx

Rover Receivers and OEM boards for automation and machine control



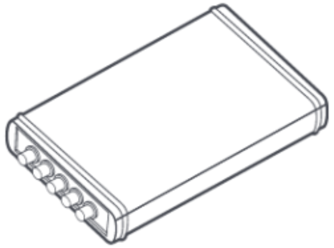


Altus

Smart antennas for GIS and survey

PolaRx

Reference receivers for science and networks



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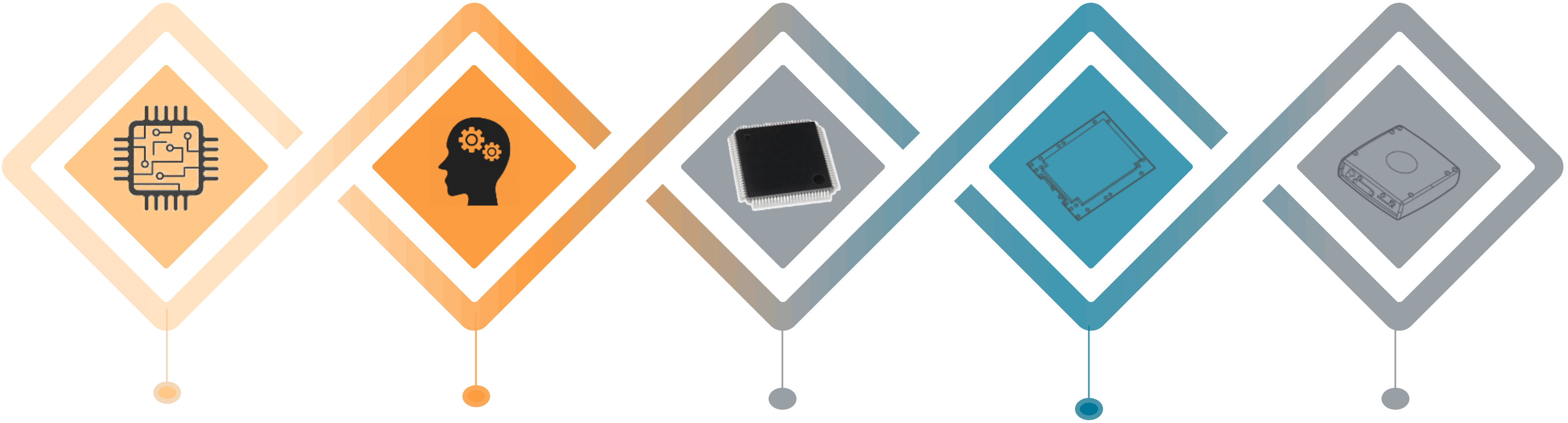
Robust high precision GNSS receivers in many forms



Chipset

Reference design

IP blocks

Measurement Engine

Positioning Engine

GNSS Module

OEM boards

Packaged GNSS Receivers

Our approach

Application Understanding

Application Engineering Assistance

Easy-to-integrate

Reliability

Availability

Accuracy

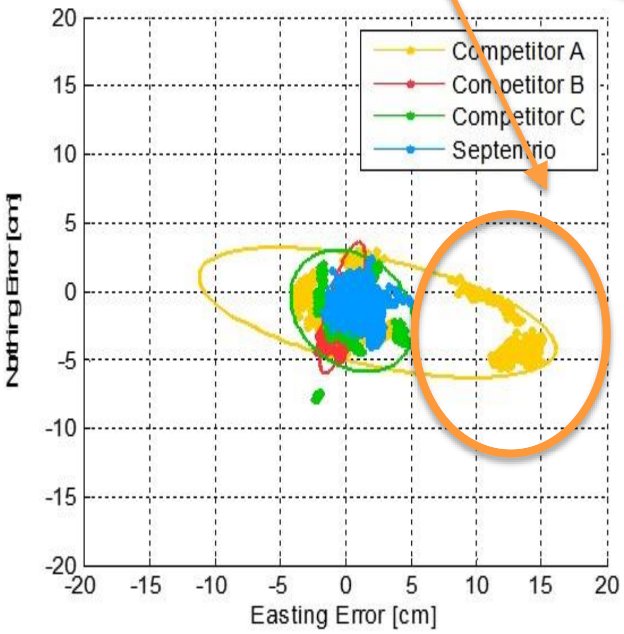
Security

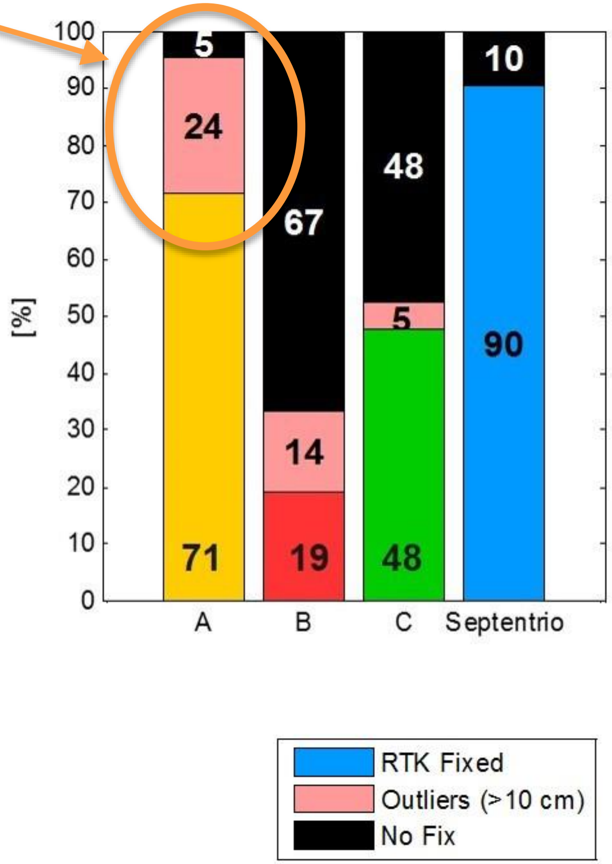
Technology

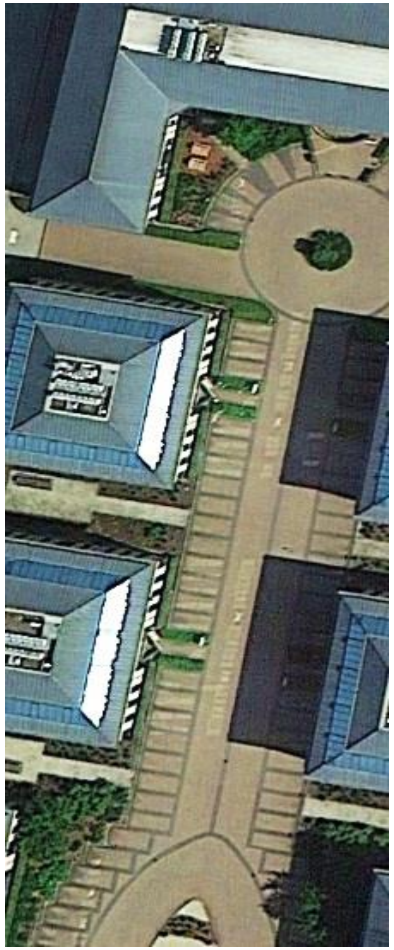
Septentrio’s differentiation

It’s not just about accuracy !

- Can the position be **trusted** ?







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Septentrio GNSS Products

Flexible choise for your integration

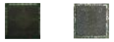
GNSS

GNSS/INS

Integrated GNSS Receivers

OEM Receiver Boards

OEM Receiver modules



Platform S (chipsets)

Products

Complete housed receivers and smart antennas for machine control and robotics

AsteRx-SB

- Compact and versatile package
- COM, Ethernet, USB
- Wifi, Bluetooth
- Low power (1.5W)
- IP68

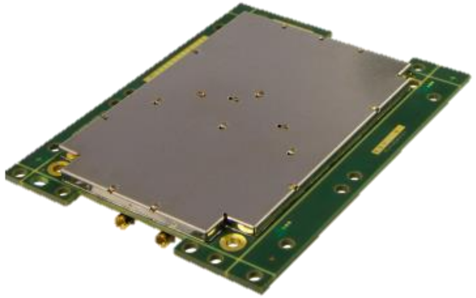
AsteRx-U

- Rugged receiver
- Integrated celullar modem
- optional UHF
- 2-antenna input for heading
- Ethernet, USB and Serial

APS-NR3

- Integrated antenna and receiver
- Internal webserver
- Internal data logging
- Works all day with internal batteries
- Integrated communications (WiFi, Bluetooth, cellular modem)

AsteRx
OEM boards for integration

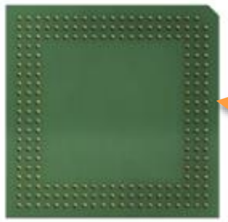


- Dual antenna multi-frequency GNSS receiver
- All signals and constellations
  - GPS/GLO/GAL/BDS/QZSS
  - L1, L2, L5/E5, L6/E6
- Stand-alone, DGNSS, PPP, RTK, heading
- Scalable power consumption
  - 1-3W depending on configuration
- On-board webserver and multiple interfaces

- Low power compact single-antenna multi-frequency GNSS receiver
- GPS/GLO/GAL/BDS
- Stand-alone, DGNSS, PPP, RTK
- Compact & low power
  - 300mW in single frequency
  - 600 mW 20 Hz GPS/GLO RTK
- Single/Dual anntenna
- UAS carrier board

mosaic™ Compact GNSS receiver module

GNSS receiver module



SMT (surface mount) solderable
LGA (Land Grid Array)
Simple integration (no ext. Components needed)

Integrated GNSS receiver

Same capabilities as AsteRx-m2 :

- Cm accurate position (RTK/SSR)
- High update rates
- Advanced interference mitigation

Tools included (Rx Tools ...)

Compact form factor

31x31X4mm
9g
600mW

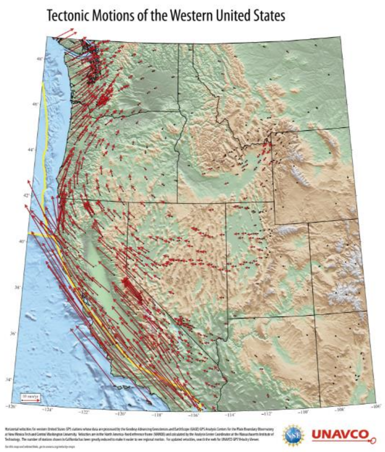
Interfaces

Wide array of interfaces, UART, USB, Ethernet

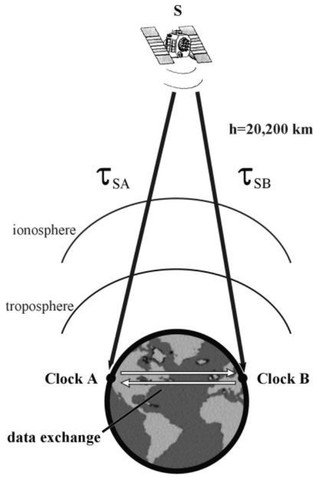
PolaRx5
Multi-frequency GNSS Scientific/CORS Receiver

- Tracks all visible signals (GPS, GLONASS, GALILEO, BEIDOU, IRNSS, QZSS, SBAS)
- High-precision, low-noise measurements
- Best in class interference monitoring and mitigation
- Low and scalable power consumption
- Powerful web interface and logging tools
- Logging up to 24 parallel data records both internally and to an external device

PolaRx5
Scientific users & reference stations



PolaRx5TR
Precise timing applications



PolaRx5S
Ionosphere monitoring

Applications

Autonomous is not a revolution !

PRECISION AGRICULTURE	MACHINE CONTROL	DRONES	AUTOMATED X
2002	2008	2015	

Shift from **Pilot** to **User** focus

- From technological innovation to pragmatic business
- Social challenges: legislation and skepticism

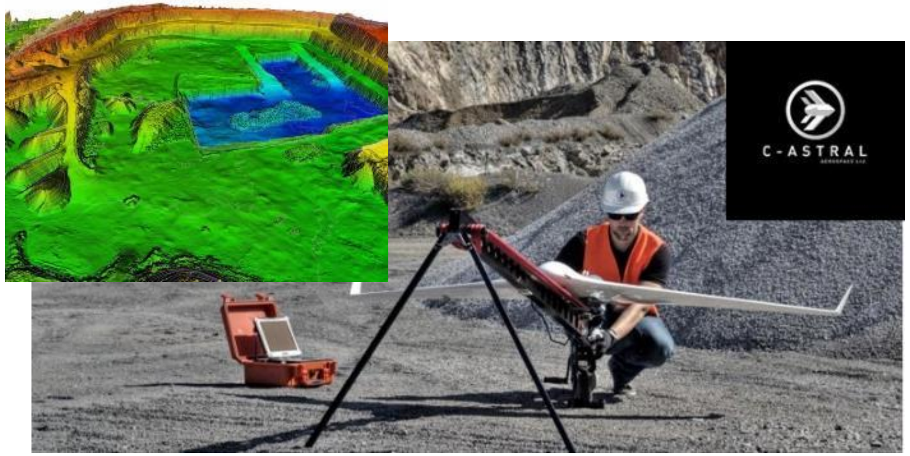
Commercial use of drones is now a reality

- Focus on data and services
- Professional products need reliable positioning
  - For Safety
  - For multiple Applications

Fixed-wing or Rotary?

	Fixed-wing	Rotary / Multi-rotor	VTOL
Projects	Mapping	Small area mapping & inspection	Mapping (large area Inspection)
Applications	Land surveying, AG, GIS, Mining, environmental, construction, humanitarian	Inspection, real estate, surveying (urban), construction, emergency response, law enforcement	Land surveying, AG, GIS, Mining, environmental, construction, humanitarian
Cruising speed	High	Low	High
Coverage	Large	Small	Large
Ground resolution	cm per pixel	Mm per pixel	cm per pixel
Take-off/landing area	Large	Very small	Very small
Flight times & wind resistance	High	Low	

GEO-REFERENCING



- Offline cm geotagging of images or sensordata

- Accurate synchronization with camera
- Integration in image processing chain

NAVIGATION

- Hover for stable camera pointing
- Take off & landing (cm-level)

- Reliable position !!!
  - Anti-jam
  - Anti-spoof
  - Multi-constellation
  - Error reporting

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Purposes and use cases of high-end GNSS

Flying cam
Movie making of James Bond
(accuracy and heading)

Aerialtronics and TMobile inspections of communication towers

Using a high end GNSS for

- Navigation
- Geo-referencing (survey mapping)
- Stable Hovering
- Take off and landing
- Reliability (legislation)
- Cinema

senseFLY and Turkish 140kms corridor (mountains, roads, urban) Project proved better than traditional methods

Service drones flying next to high power lines (possible intereference)

kespry stockpile volumetrics

Dronebox
Take off and landing accuracy
(remote drones)


RTK
eBee
senseFly
HOLD
RESUME MISSION
START MISSION
RESTART FIELD
GO LAND
ABORT LANDING
LAND NOW Click 3x
110 m/ATO
4:50
Taking photo #72
Autonomy
Battery
100 %
(11.4 V)
Flight data
Ground speed:
Altitude:
Instruments
Autopilot:
35.0°C
Identification
Name:
Drone Flight Log:
Camera type:
Camera settings:
Camera state:
Number of photos:
Internal storage:
External storage:
Simulator
eBee Plus

Wingtra

VTOL = vertical take-off and landing

VTOL? For mapping

Requirement for PPK

Industrial applications - Rail

Working on PTL with GE and BNSF

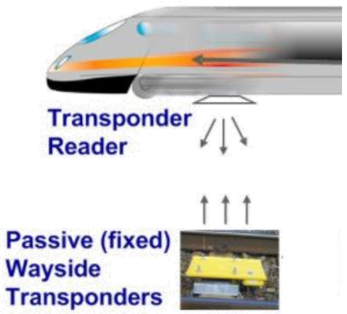
10k receivers in

Triggered by 2008 Safety act (US mandate)

➔Full efficiency

➔Reliability (multiple sensors) “fail safe”

- PCT not new!

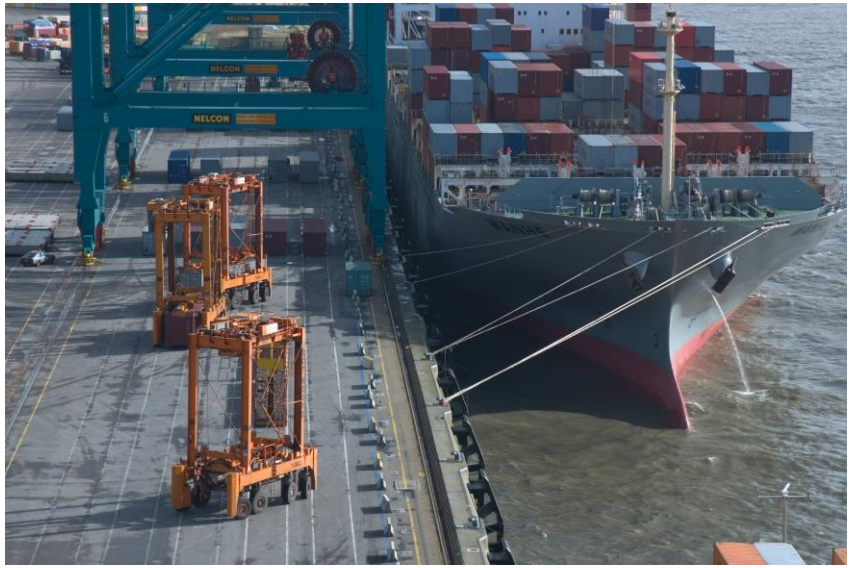


How PTC works?

Industrial applications – Harbour and Marine

GNSS receivers for world leading dredging companies (Jan de Nul, DEME) and offshore energy construction : Oil and Gas, Wind, ...

Equipping fleet of >300 straddle carriers in Antwerp Container Port for imrpoved safety and efficiency



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Industrial applications – Agriculture

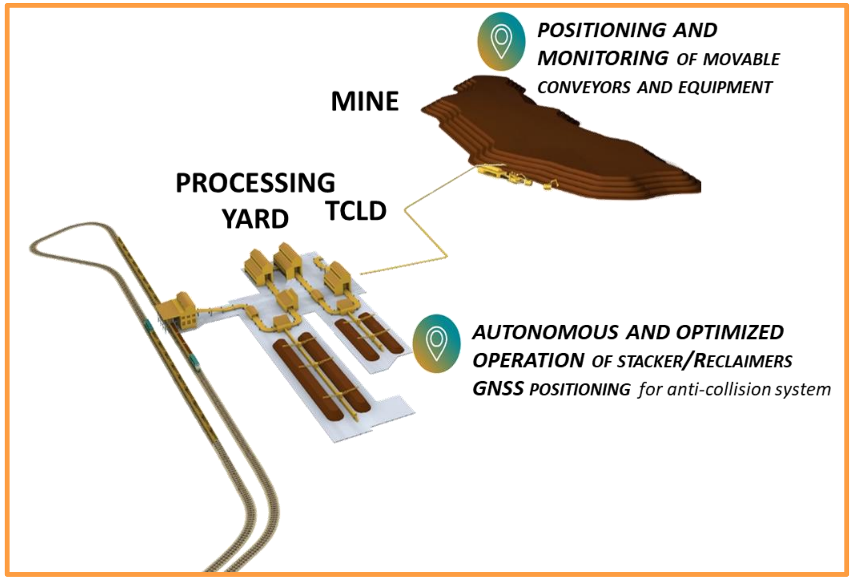
Tractor auto-steer and specialized control applications with unique dual –antenna set-up

Autonomous agriculture robots

Industrial applications – Machine automation

Positioning for machine control on excavators and dozers operating in challenging environments

GNSS positioning for VALE S11D automated mine project in Carajas - Brazil



Vibrotrucks

With improved reliability and accurate position Vibrotrucks can detect failures in the ground.

In this case vibrotrucks drive in Munich Germany and detect accurately the places where underground thermal waters can be found as an ecological way for providing heating to the city.

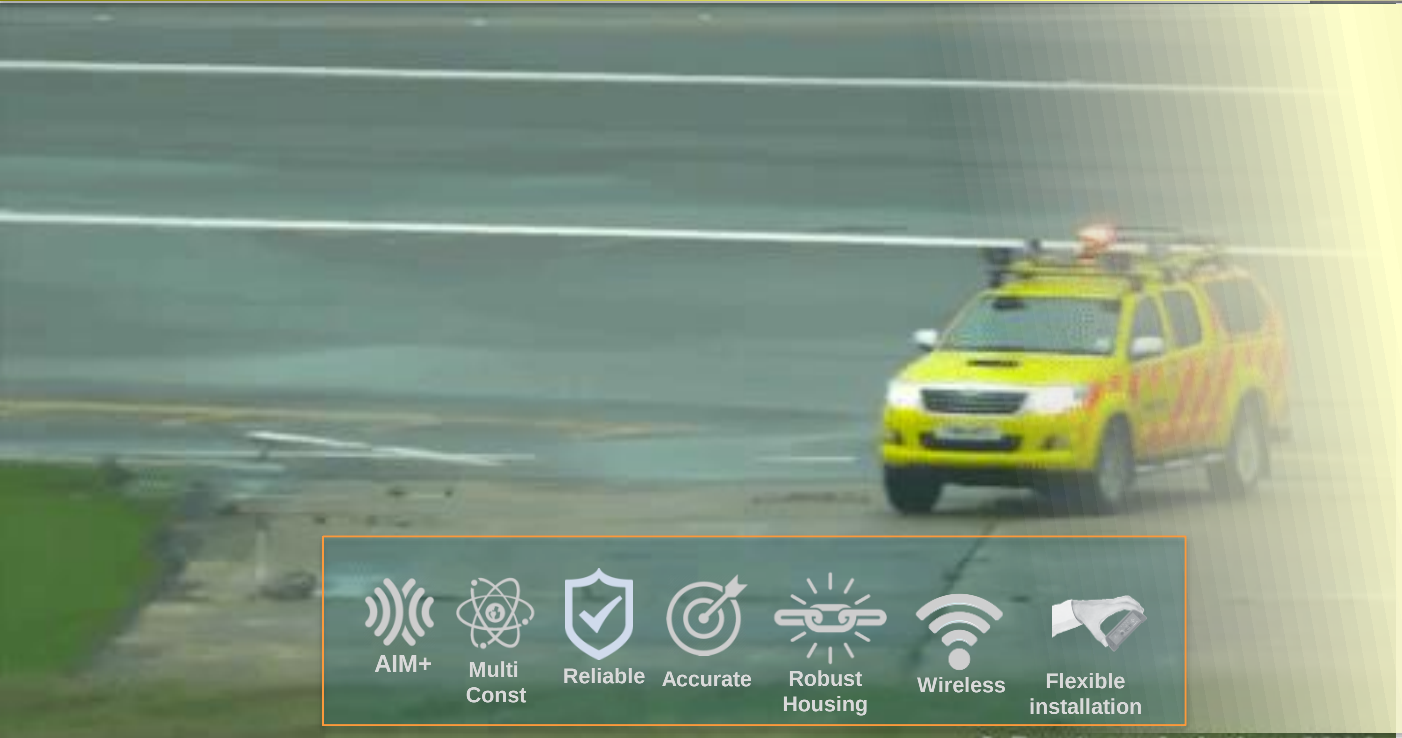
Vertical drain installation

With improved position accuracy vertical drillers can make efficient jobs in even the more difficult environments.

The practical installation of AsteRx SB is ideal for applications requiring flexibility.

Sewer cleaning trucks

With improved reliability and accurate position sewer cleaning trucks can map exactly the areas of maintenance. Septentrio helps in bringing technology which is reliable and easy to install in vehicles.



Airport vehicle tracking

With improved position accuracy and reliability in the most difficult dynamic and difficult environments, airports can manage their vehicle infrastructure keeping safety as a main objective.

Agriculture Robots

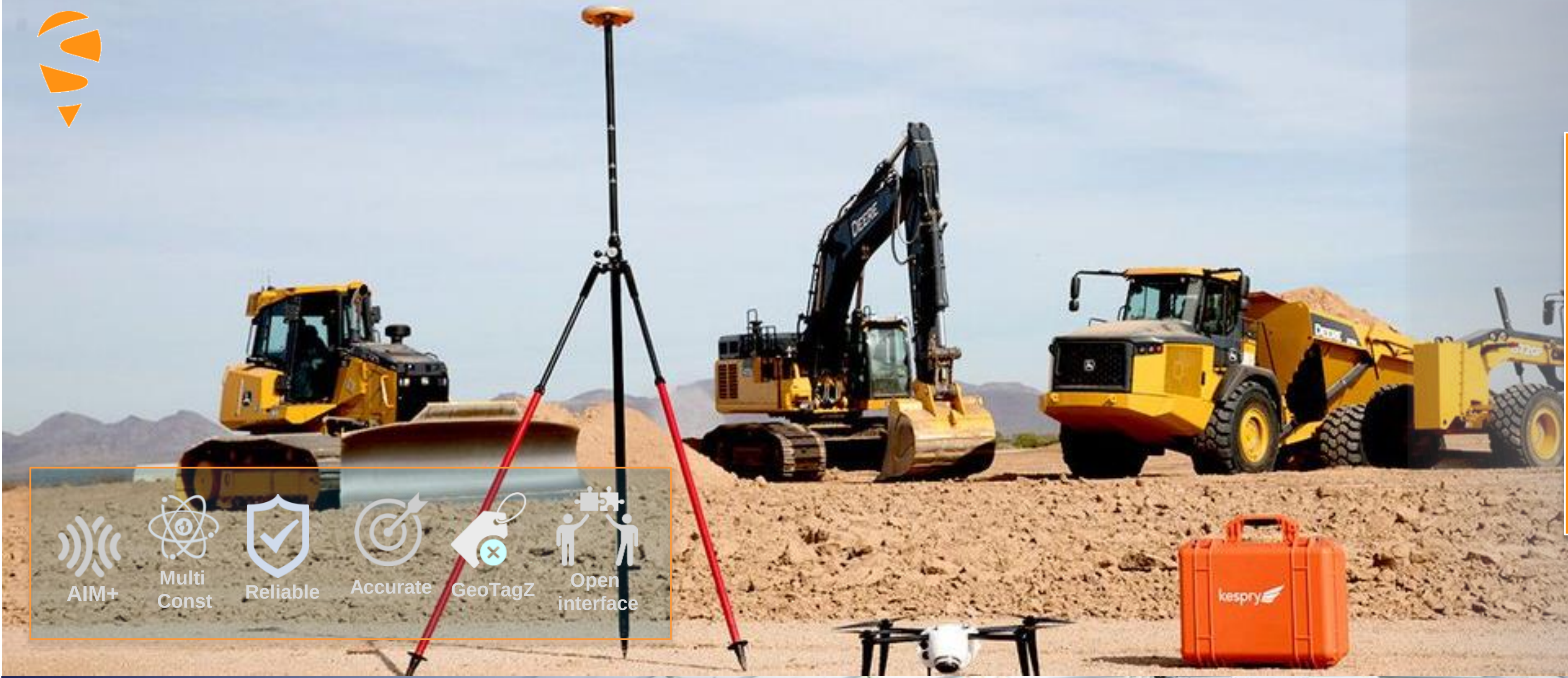
With improved reliability and accurate position agriculture and other robots can autonoumsly work in even the more difficult situations.

The flexibility of the small box and its robustness makes it an ideal product for these applications.

Base station or Static monitoring

With basic features for base station, the Asterx SB can be deployed as a simple base station product in flexible installations requiring basic corrections.

The AsteRx SB can also be used by integrators of structural monitoring solutions.

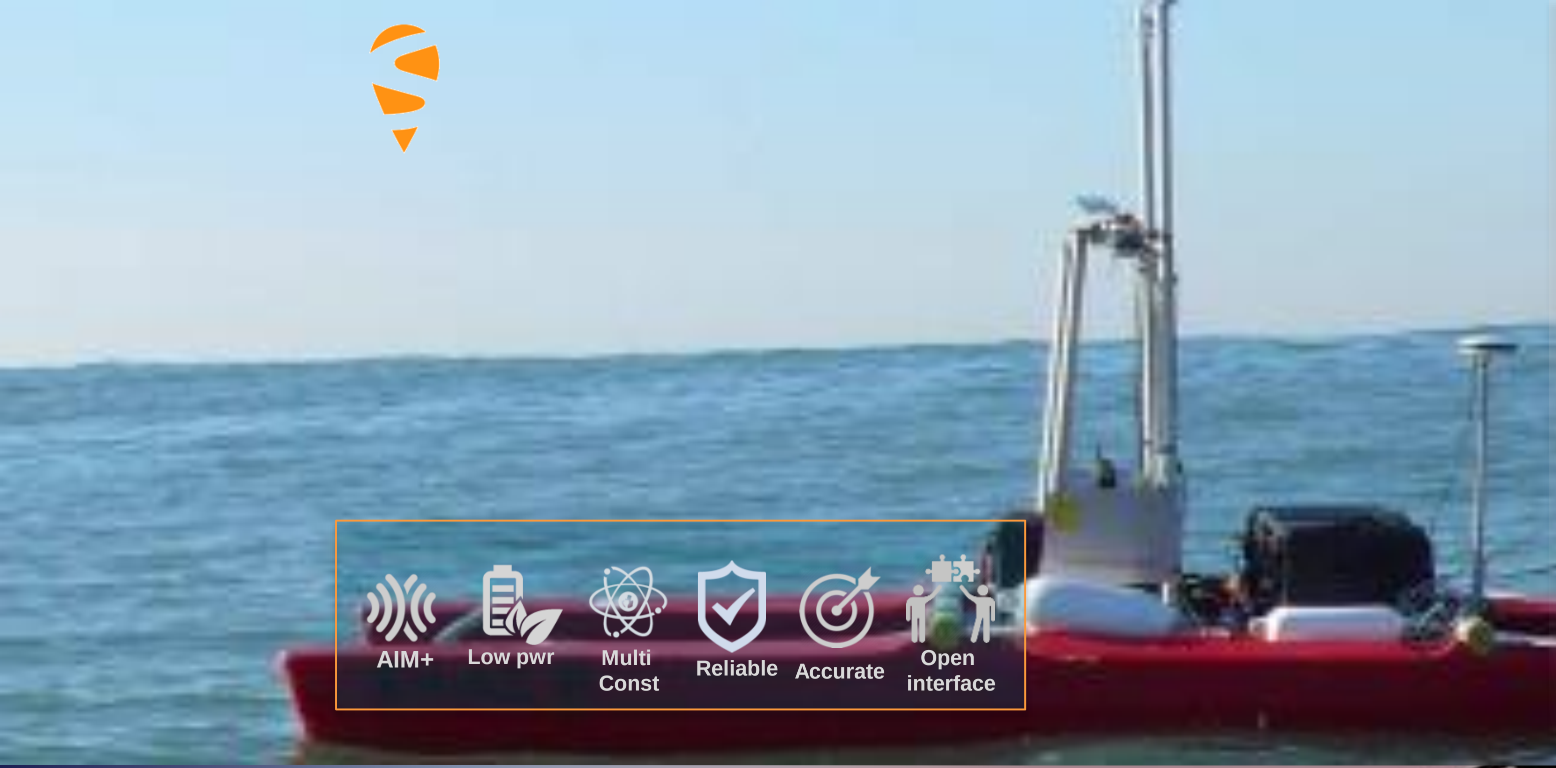


UAS base station

With wireless communication and open interfacing UAS integrators can use the NR2 as reliable base station.

Agriculture Robots

With improved reliability, embedded web interface and open interface Agriculture robots can use an smart antenna for the more demanding jobs.



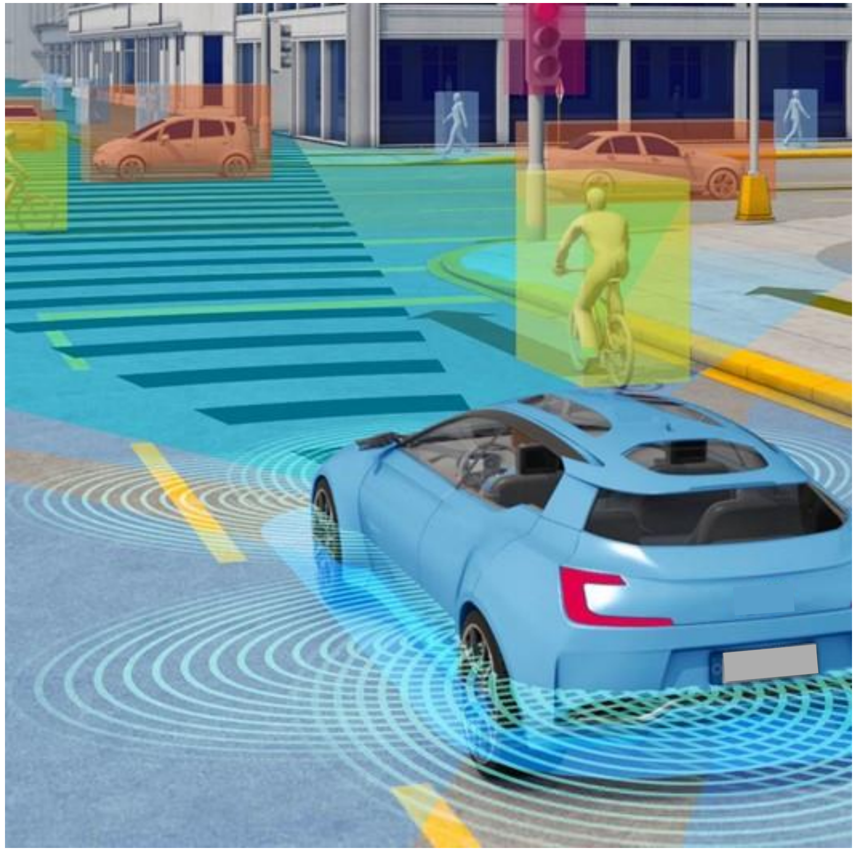
Marine survey & Barimetry

With improved performance and open interference mitigation marine survey integrations can easily and accurately be done.

Machine control

With improved reliability, accuracy, external connectivity and open interface – machine control applications can benefit of Septentrio's technology for best performance in demaning industrial applications

GNSS for autonomous



High availability measurement engine

High integrity cm-accurate positioning engine

Open architecture for multiple correction systems (RTK, PPP, SSR)

GNSS/INS integration

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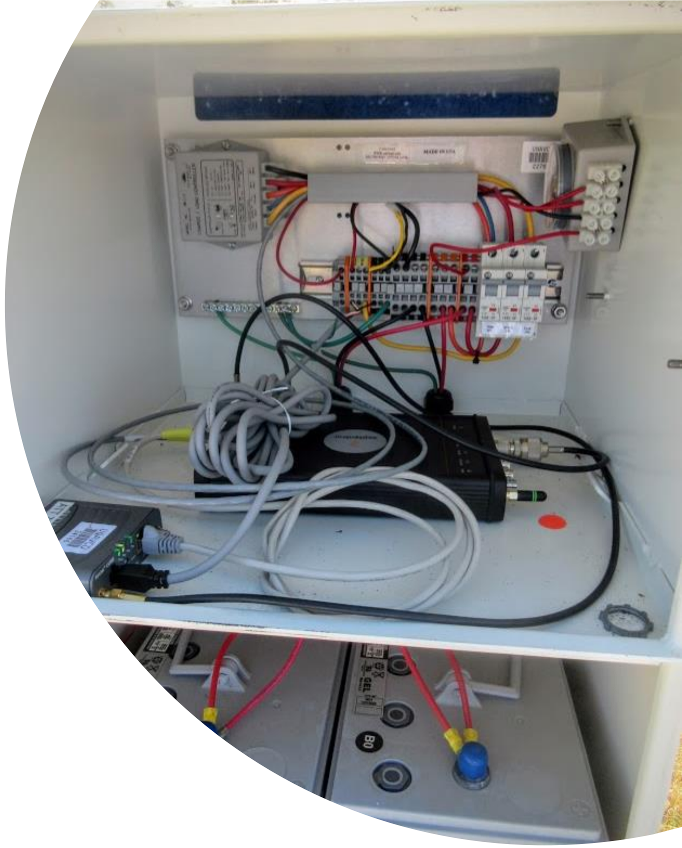
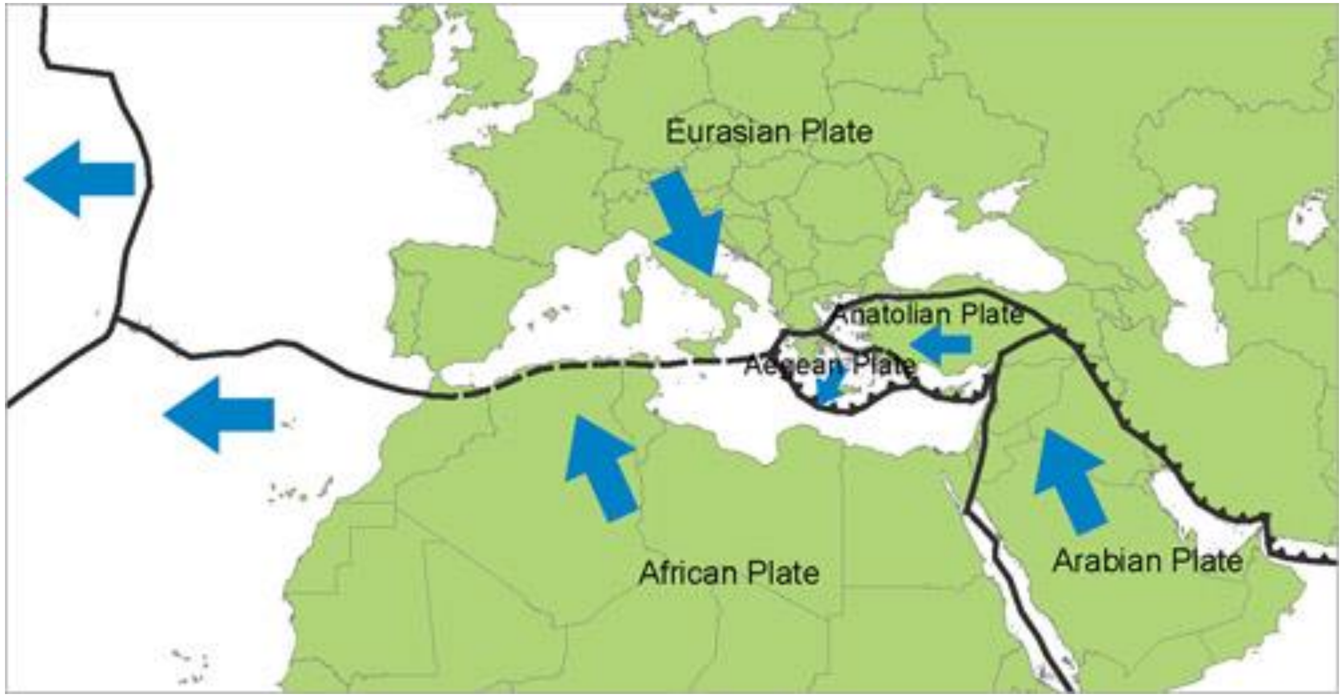


UNAVCO typical installations

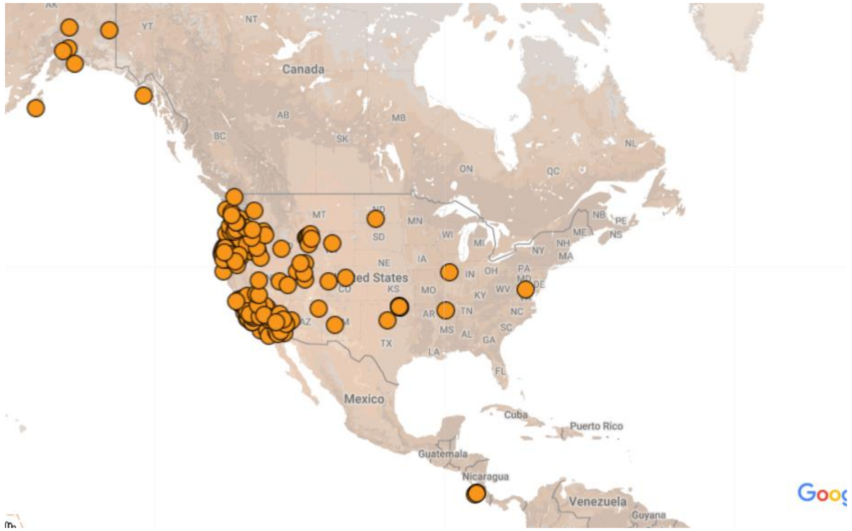
PolaRx5

USA PACIFIC PLATE BOUNDARY OBSERVATORY

Tectonic plates motion…continental drift, earthquakes, volcano activity,



Reference networks



Monitoring

UNAVCO PBO deployment

146 PolaRx5

Mainly in USA west coast

Also in Costa Rica, Greenland, Bangladesh

Geoscience Australia, Iceland, NRCAN, CHAIN, …

RTK and PPP networks

Veripos WW PPP network

RTK networks :

Germany (BW, SAPOS),

UK (OS),

…

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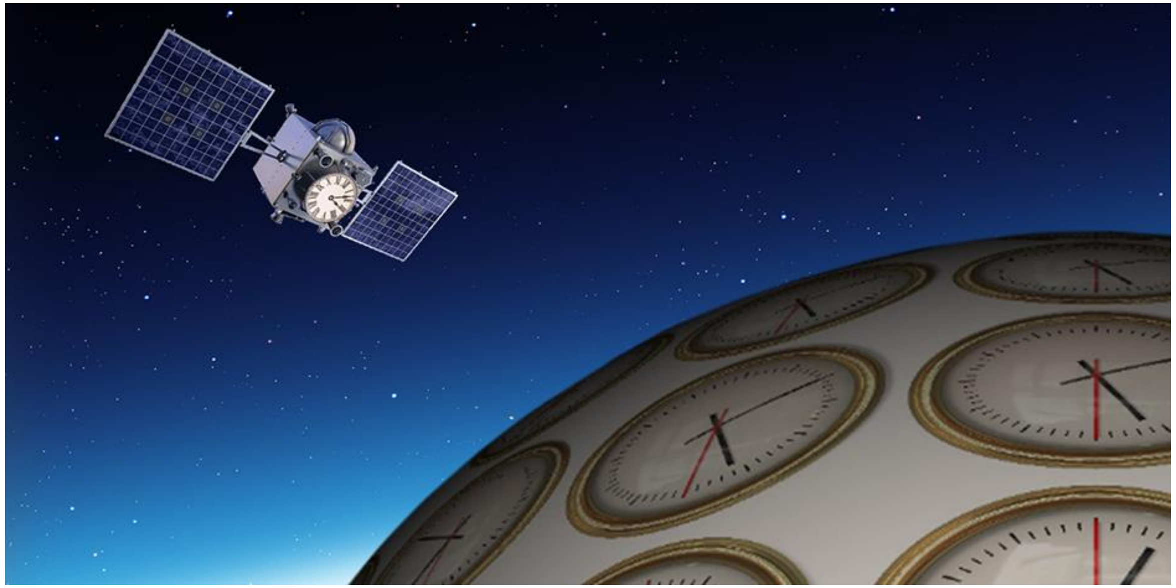
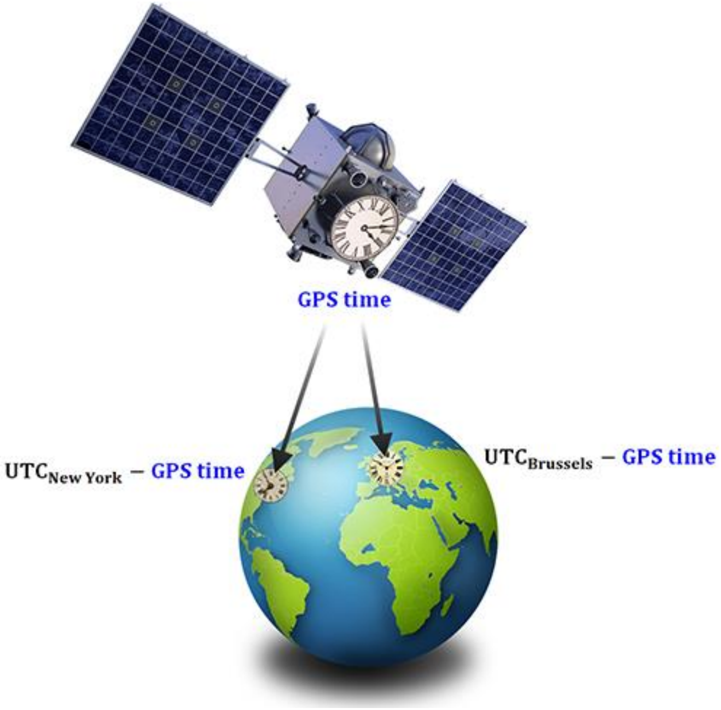
What about PolaRx5TR?

GNSS for time transfer

UTC Universal Time Coordinated determination

Precise (ns) synchronization of equipment





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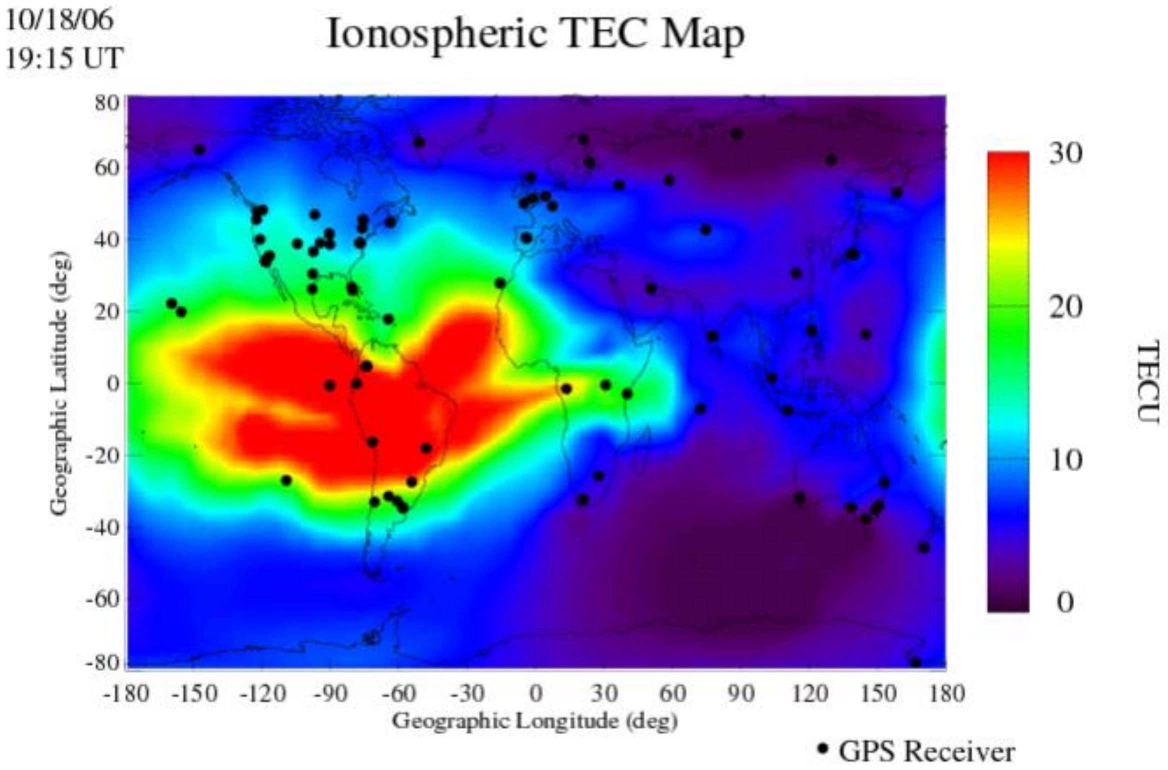
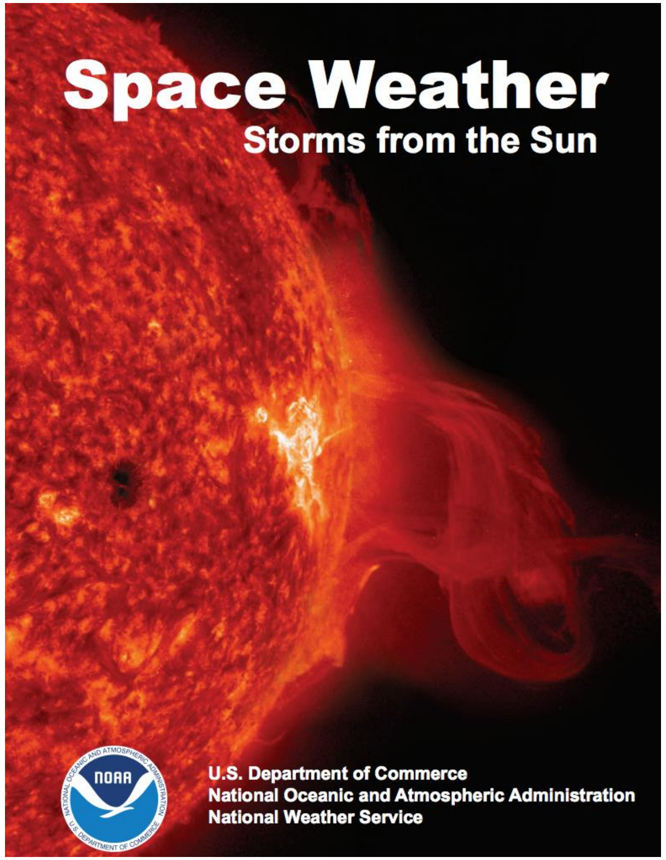
Tracking Electrons from Solar Storms





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Map from NASA; Report Cover from NOAA

EMEA (HQ)

Greenhill Campus
Interleuvenlaan 15i,
3001 Leuven, **Belgium**

Americas

Los Angeles, **USA**

Asia-Pacific

Melbourne, **Australia**
Shanghai, **China**
Yokohama, **Japan**

septentrio.com

sales@septentrio.com

PolaRx5 product line intro

- GPS / GNSS recap
- What is a reference station
  - Geodetic application
  - RTK networks
- PolaRx5 unique selling points
- PolaRx5S and PolaRx5TR specificities

Disclaimer: the content is simplified with approximations to make it digestible by the most

What is GNSS?

GPS= Stands for "Global Positioning System." GPS is a USA satellite navigation system used to determine the ground position of an object.

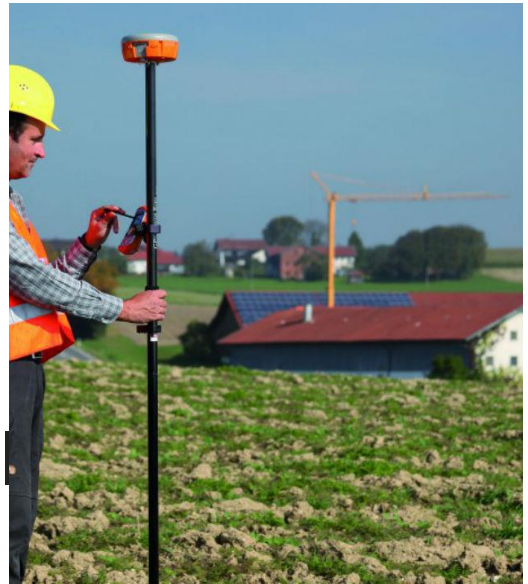
There are more satellites systems (usually named constellations) similar to the American GPS: Europe has Galileo, Russia has Glonass, China has Beidou, etc.

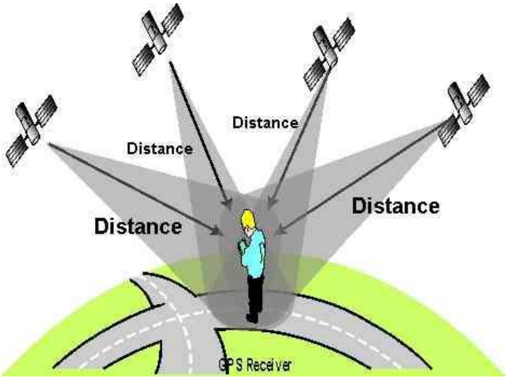
When we talk about positioning based on multiple constellations acronym GNSS (Global Navigation Satellite System).

GNSS delivers a position (a velocity and the time) of an object.

You need a receiver and an antenna.

These can be separated or integrated in a single box.

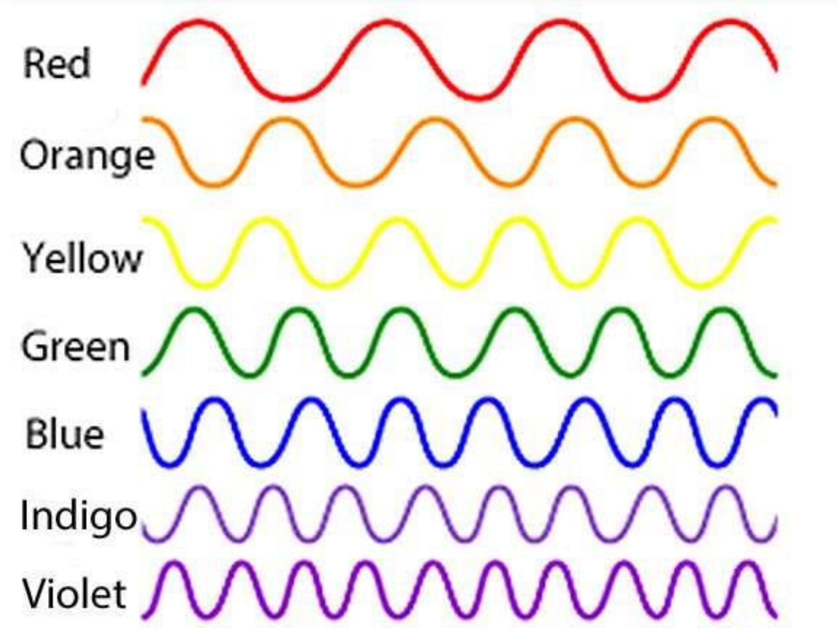


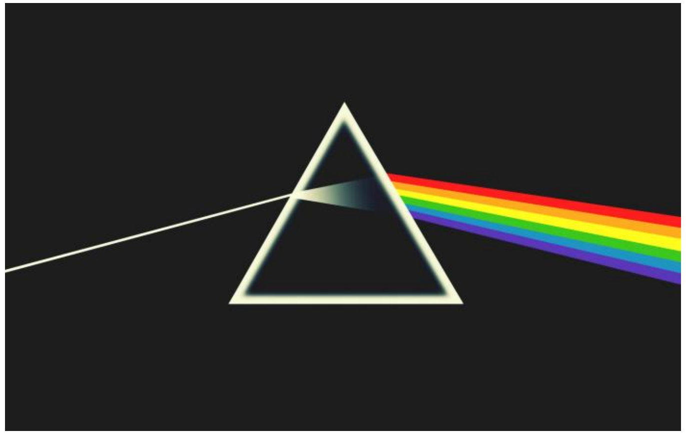


Smartphone vs high-end GNSS

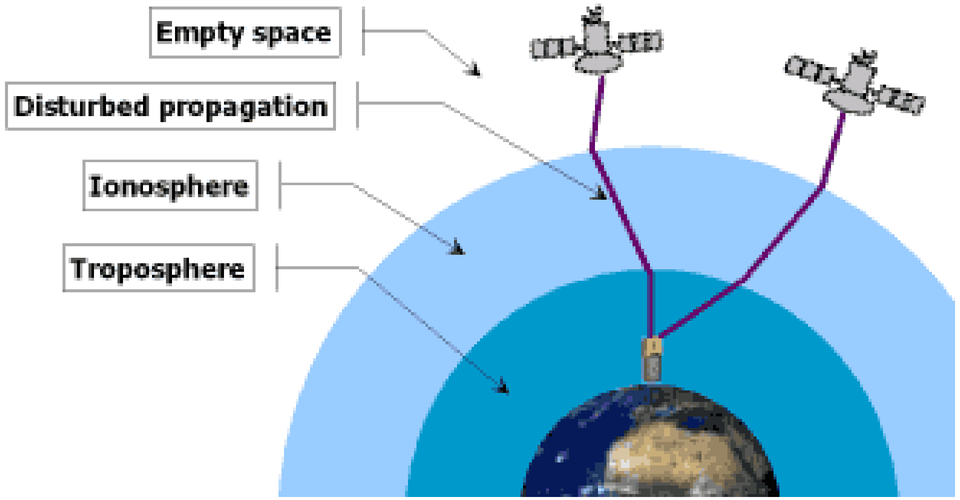
	Smartphone/SatNav	Septentrio	Note
How many constellations?	Typically 1 (GPS) but in recent devices more than one is becoming available	Several	More constellations=more satellites=more availability
How many frequencies	typically 1	3 or more	A frequency is way to define “color” of an em wave.
Accuracy	Meter level	Down to cm	More accurate with corrections

Main errors in GNSS positioning





Main errors in GNSS positioning



More frequency = more accurate

remove the errors due to travelling in the atmosphere

Lost in Brussels?

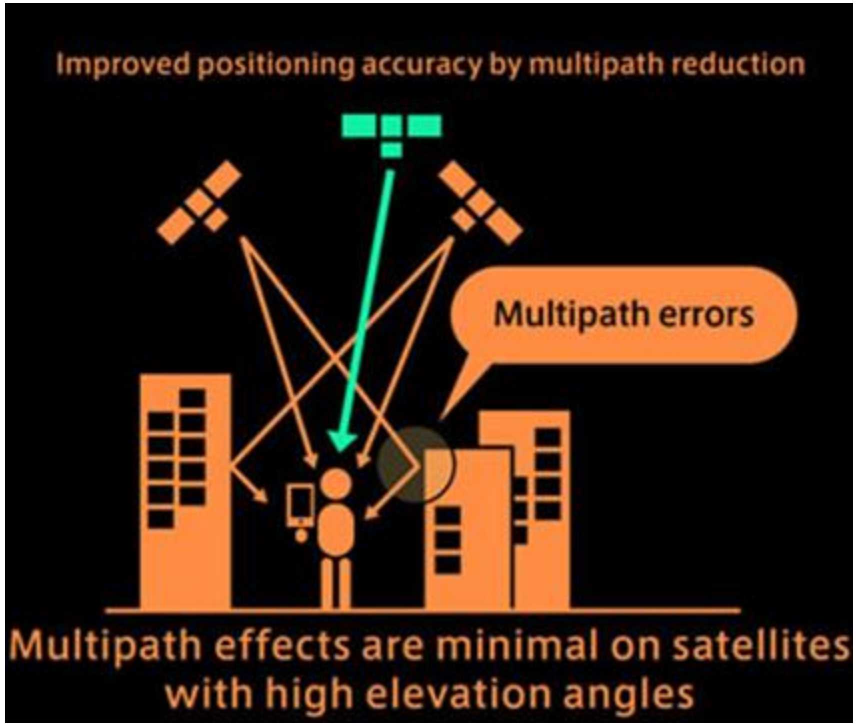
Why the SATNAV does not work well in Brussels, New York, Hong Kong…?

You see less sky.

(having more than GPS helps because you see more satellites)

You get distorted signals bounced by buildings, called multipath.

(high end receivers have the intelligence to mitigate and reject the reflected signals)



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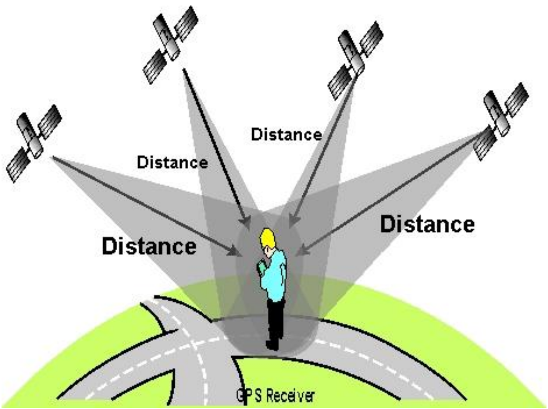
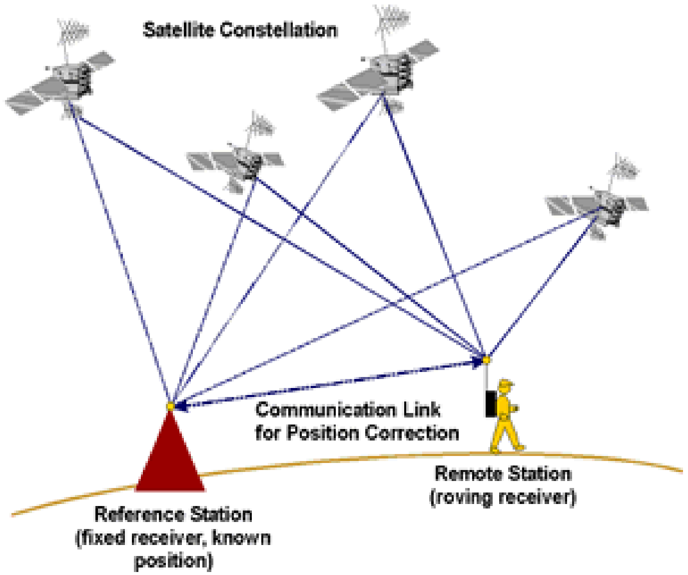
Standalone vs augmented



Stand …alone!
just you your receiver (and antenna) looking at what GNSS sends to you.
You know where you are at meter level.



You have your receiver, you still look at what GNSS send you but you get additional information from a one (or network of) reference stations.
The correction come to you via a radio, a modem, a satellite, “any” communication link.

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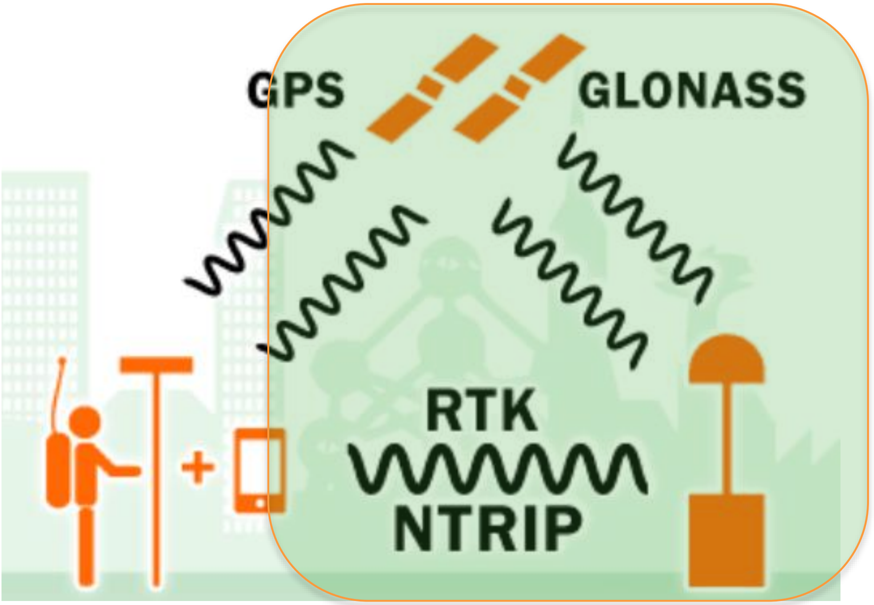
What can you do with GNSS?

Let's look at our website

Land survey, aerial mapping, marine and dredging, machine control, agriculture

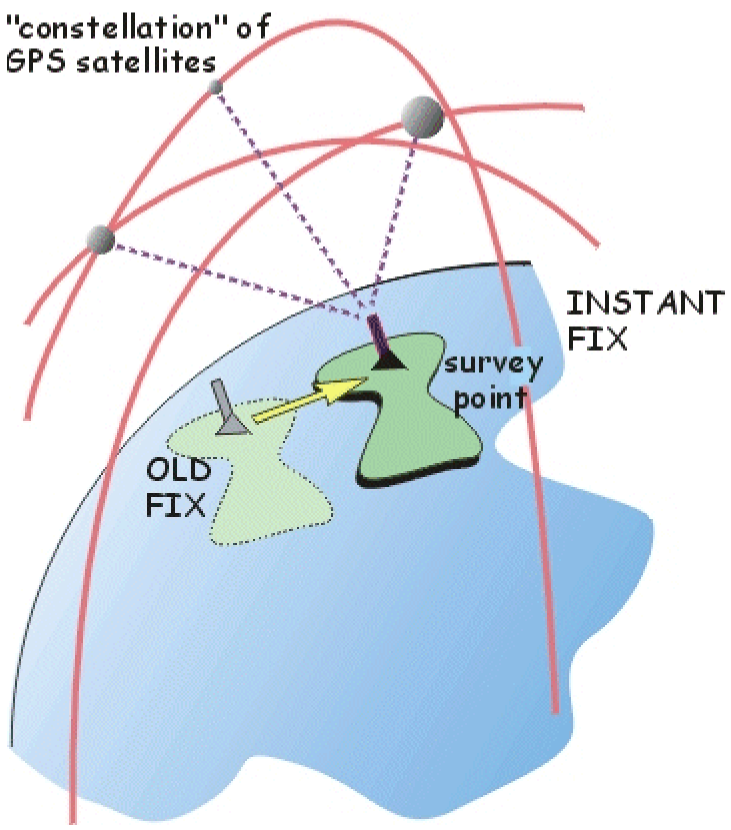
or…be reference station.



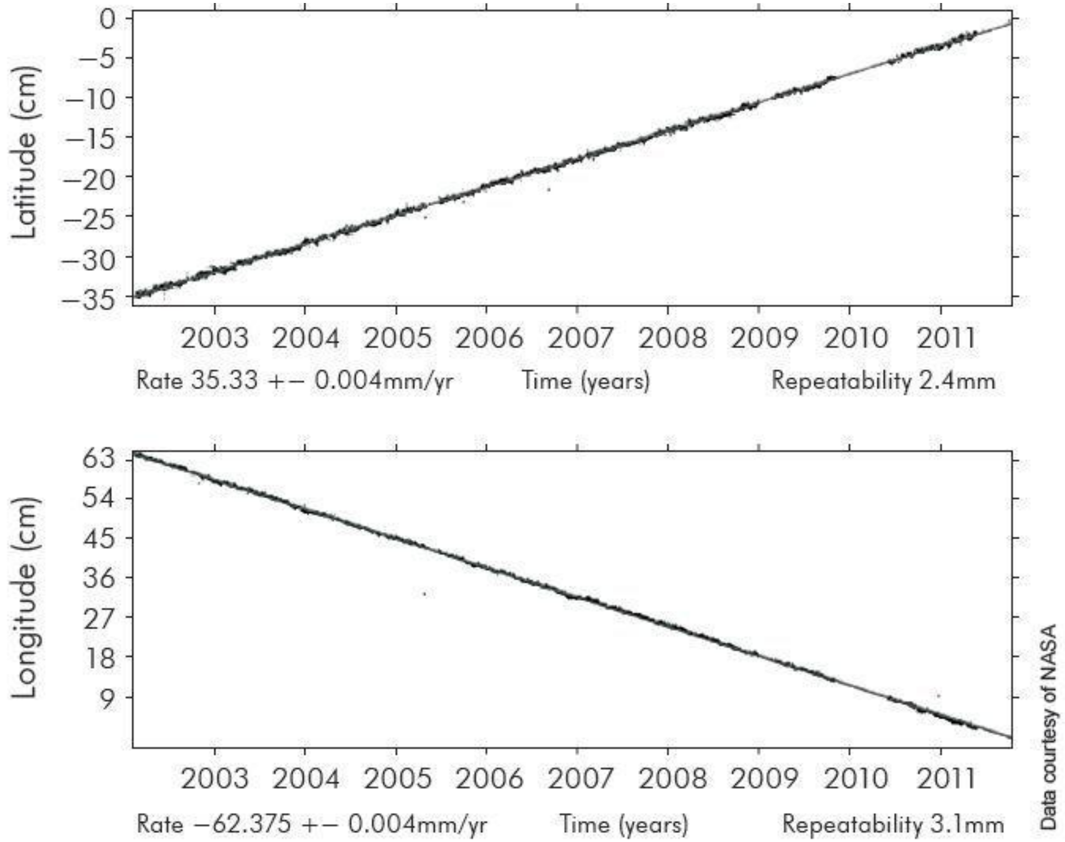
Science

septen

The dynamic earth…DRIFT!



“time lapse” of the measured position by GNSS



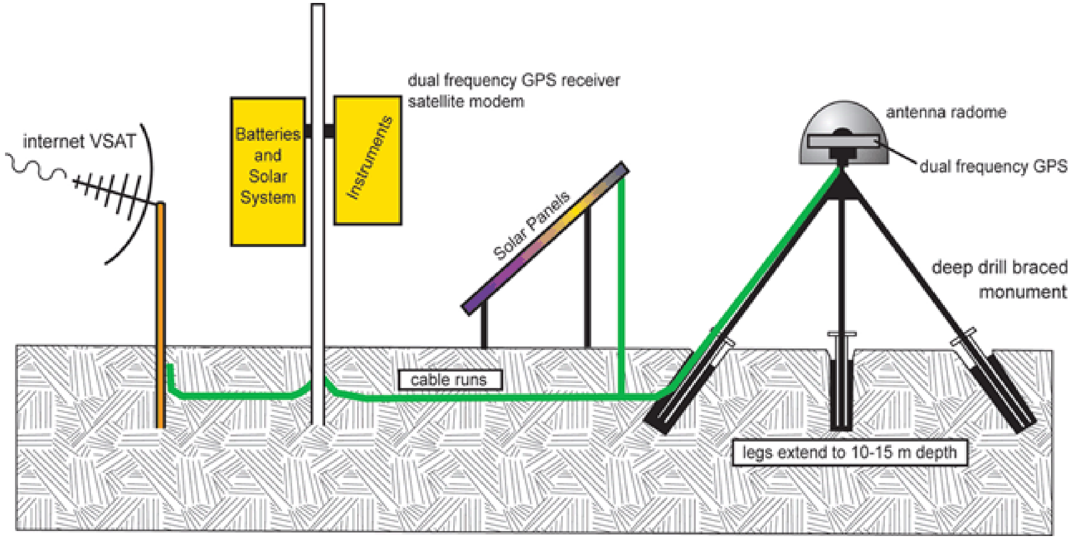
Volcano, earthquakes, continental drift…

Science needs DATA, as many as possible, as continuously as possible, as precise and complete as possible.

Amazing places on the planet…Iceland, Antarctica, Alaska, Himalaya, South America…deserts, top of mountains, volcanos, slides…

No 220V sockets for power supply

Not easily accessible



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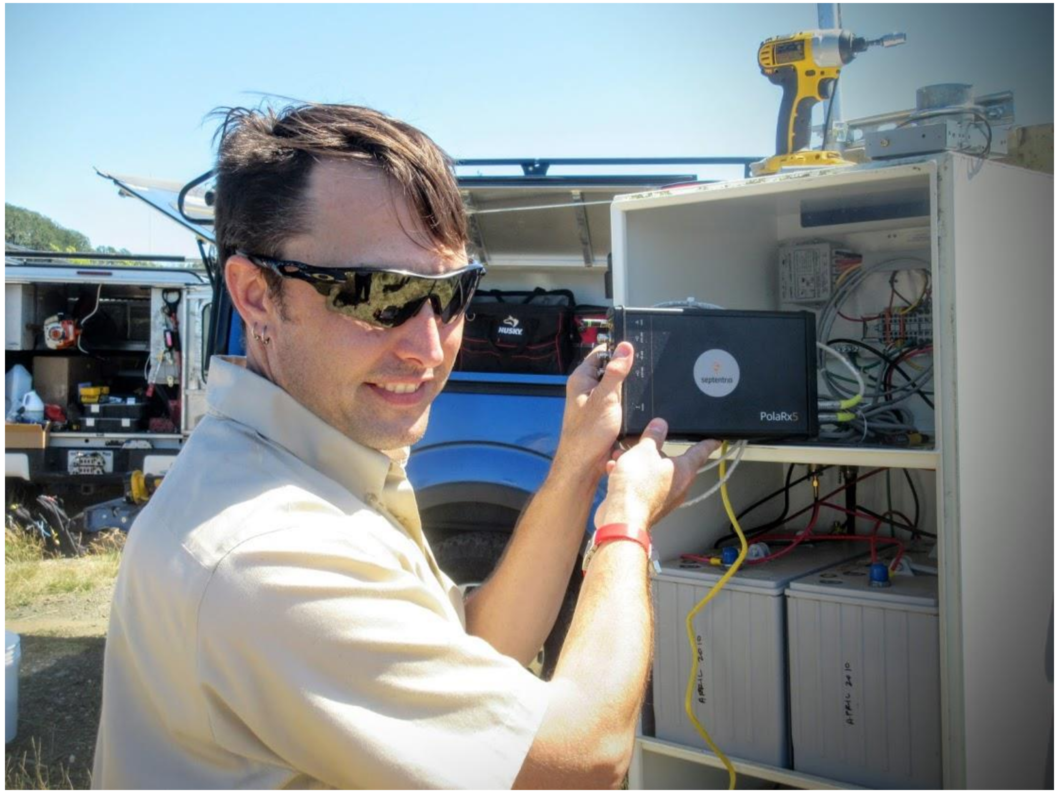
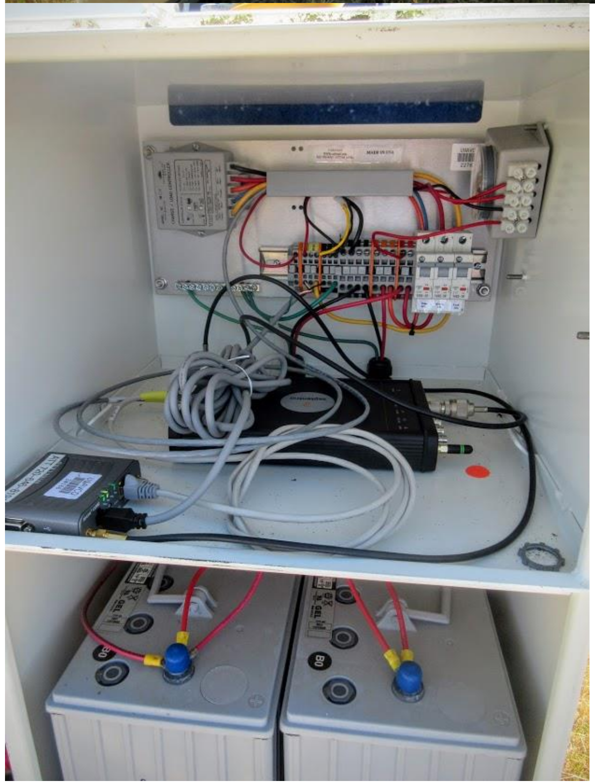
Unavco typical installations





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USA PACIFIC PLATE BOUNDARY OBSERVATORY

USA PACIFIC PLATE BOUNDARY OBSERVATORY

USA PACIFIC PLATE BOUNDARY OBSERVATORY

ANTARCTICA

What is an ideal receiver for these applications?

Low (and scalable) power consumption

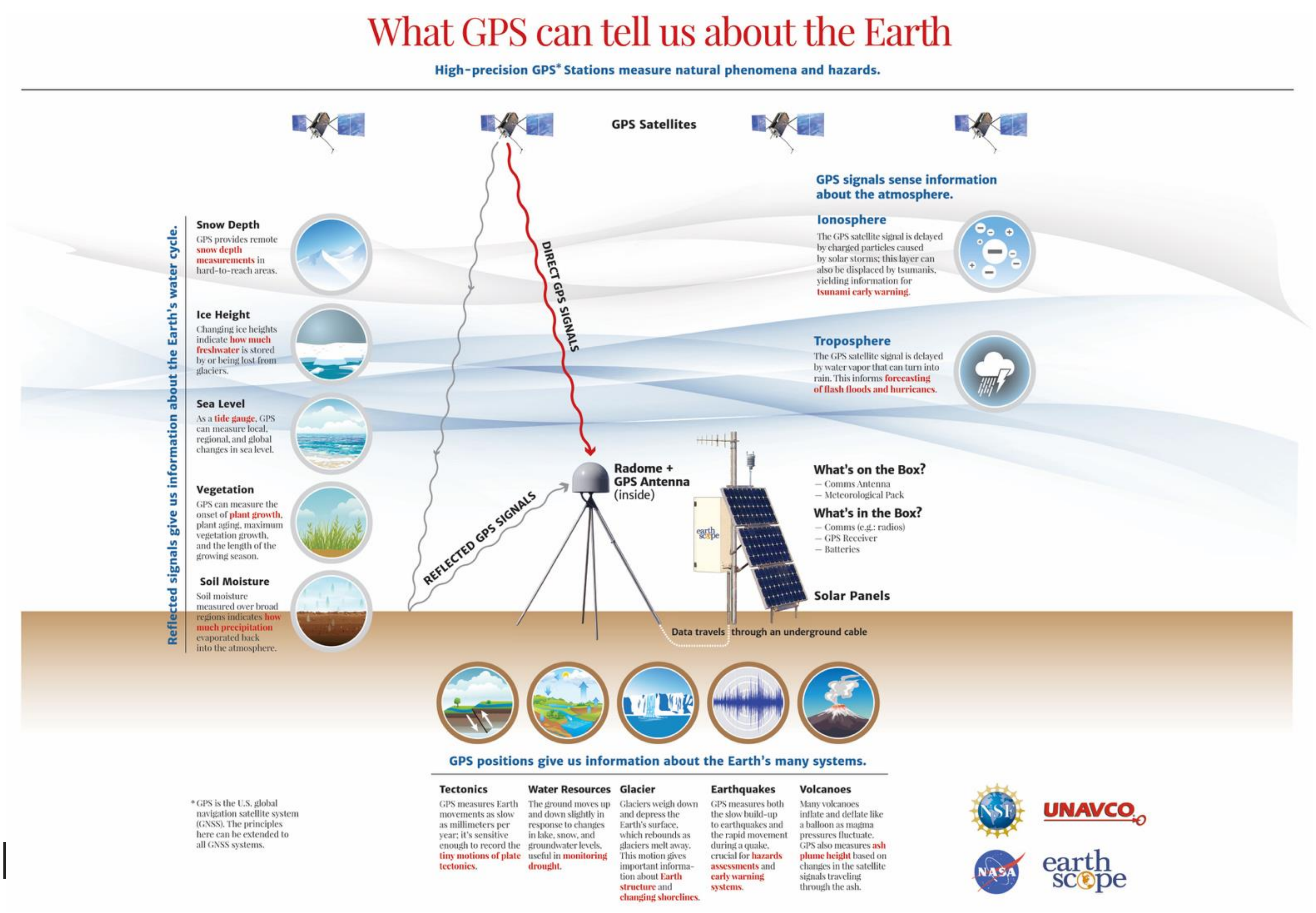
Robust and reliable measurements

Immune (as much as it is possible) to interference

Complete data and easy data transfer/management

In case of problems, competent and fast support

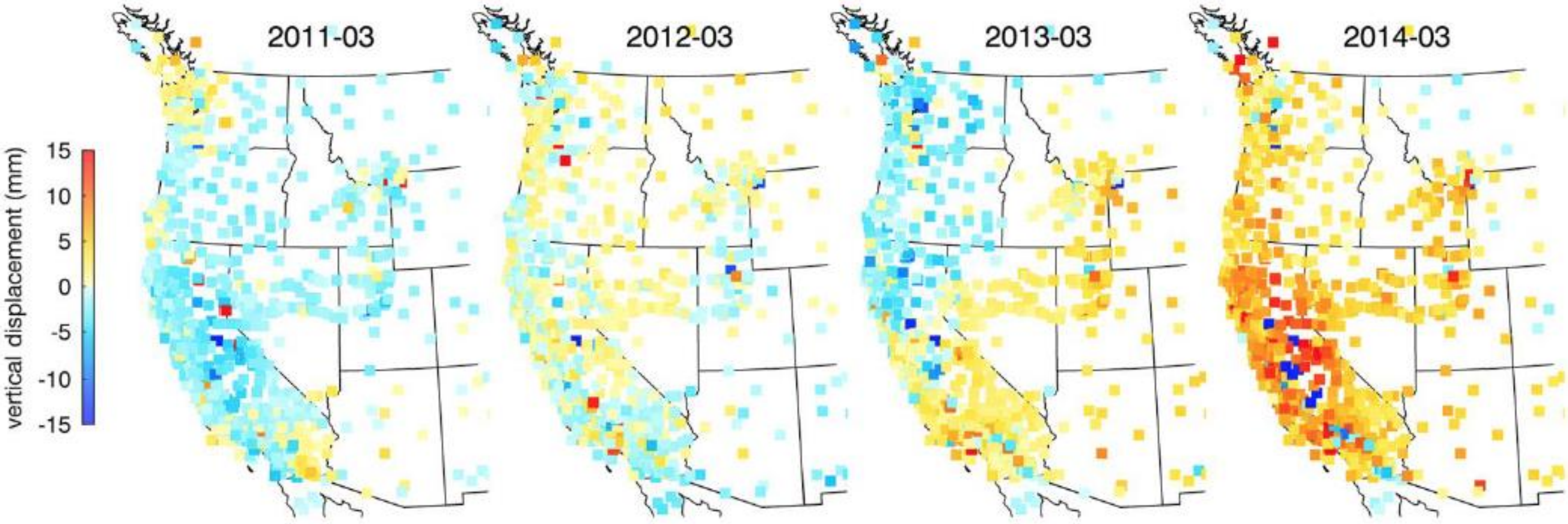
= POLARX5! Best in class ☺



What GPS can tell us about the Earth
High-precision GPS* Stations measure natural phenomena and hazards.
GPS Satellites
Reflected signals give us information about the Earth's water cycle.
Snow Depth
GPS provides remote snow depth measurements in hard-to-reach areas.
Ice Height
Changing ice heights indicate how much freshwater is stored by or being lost from glaciers.
Sea Level
As a tide gauge, GPS can measure local, regional, and global changes in sea level.
Vegetation
GPS can measure the onset of plant growth, plant aging, maximum vegetation growth, and the length of the growing season.
Soil Moisture
Soil moisture measured over broad regions indicates how much precipitation evaporated back into the atmosphere.
DIRECT GPS SIGNALS
REFLECTED GPS SIGNALS
GPS signals sense information about the atmosphere.
Ionosphere
The GPS satellite signal is delayed by charged particles caused by solar storms; this layer can also be displaced by tsunanis, yielding information for tsunami early warning.
Troposphere
The GPS satellite signal is delayed by water vapor that can turn into rain. This informs forecasting of flash floods and hurricanes.
Radome + GPS Antenna (inside)
What's on the Box?
— Comms Antenna
— Meteorological Pack
What's in the Box?
— Comms (e.g.: radios)
— GPS Receiver
— Batteries
Solar Panels
Data travels through an underground cable
GPS positions give us information about the Earth's many systems.
Tectonics
GPS measures Earth movements as slow as millimeters per year; it's sensitive enough to record the tiny motions of plate tectonics.
Water Resources
The ground moves up and down slightly in response to changes in lake, snow, and groundwater levels, useful in monitoring drought.
Glacier
Glaciers weigh down and depress the Earth's surface, which rebounds as glaciers melt away. This motion gives important information about Earth structure and changing shorelines.
Earthquakes
GPS measures both the slow build-up to earthquakes and the rapid movement during a quake, crucial for hazards assessments and early warning systems.
Volcanoes
Many volcanoes inflate and deflate like a balloon as magma pressures fluctuate. GPS also measures ash plume height based on changes in the satellite signals traveling through the ash.
* GPS is the U.S. global navigation satellite system (GNSS). The principles here can be extended to all GNSS systems.
UNAVCO
earth scope

se|

Drought



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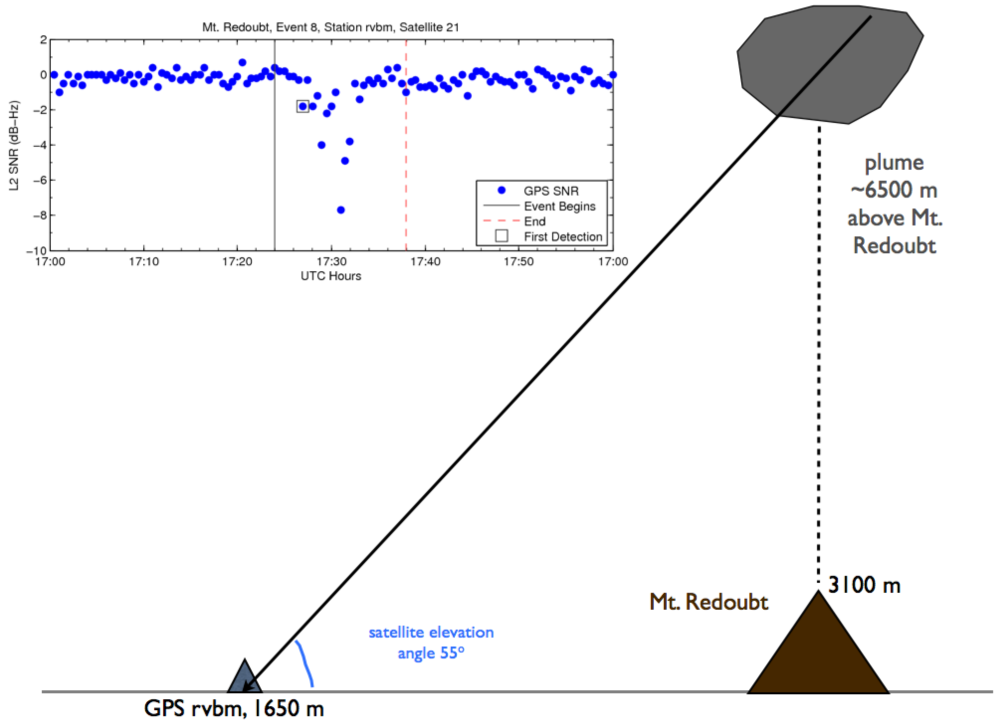
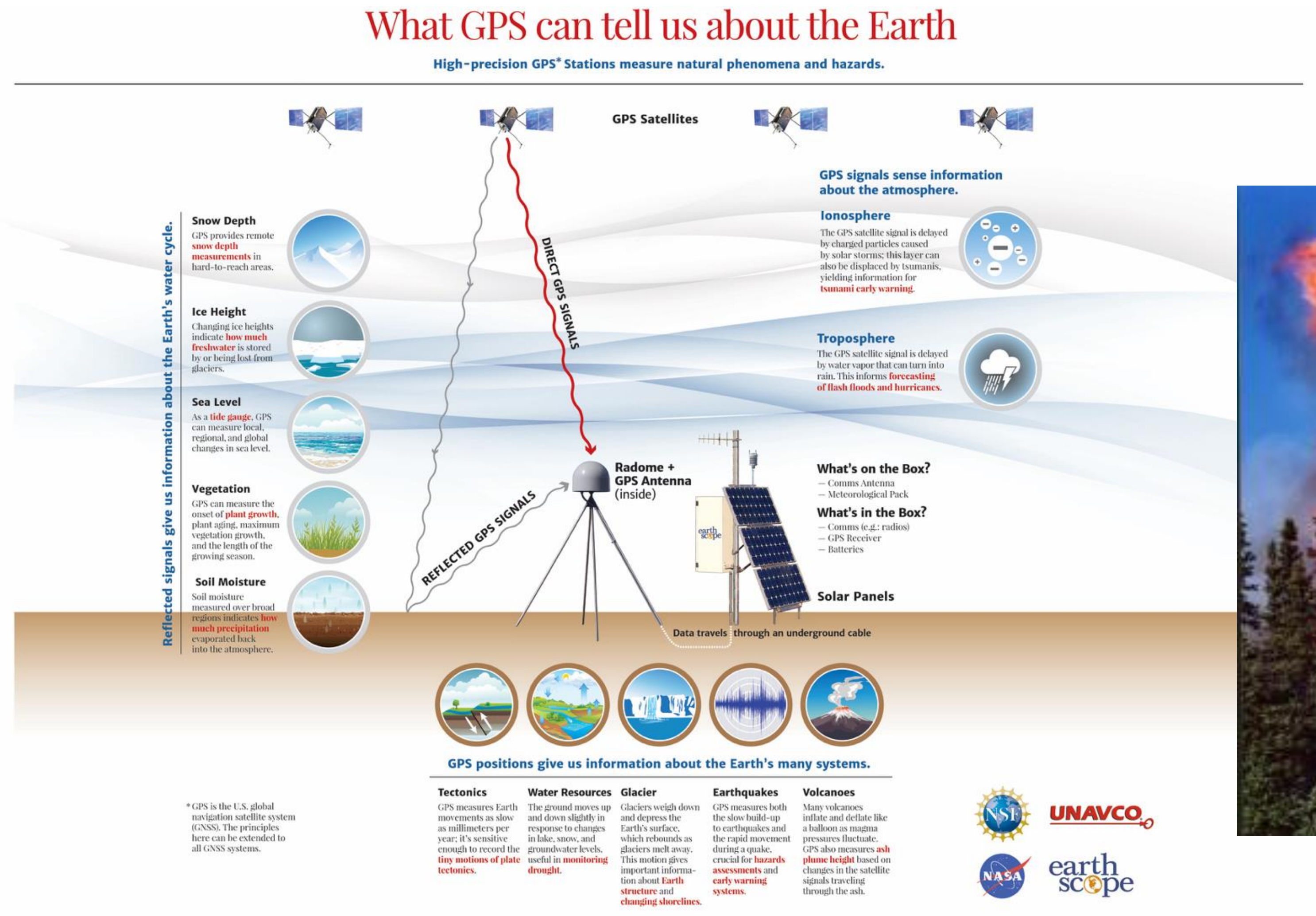
Ongoing drought-induced uplift in the western United States, A. A. Borsa, D. C. Agnew, D.R. Cayan, Science, 2014

Volcanic Ash Plumes



A New Way to Detect Volcanic Plumes, K. M. Larson *Geophys. Res. Lett.*, 40, 2013

Wildfires



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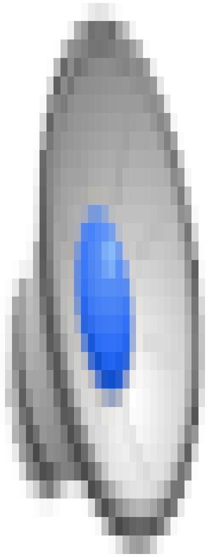
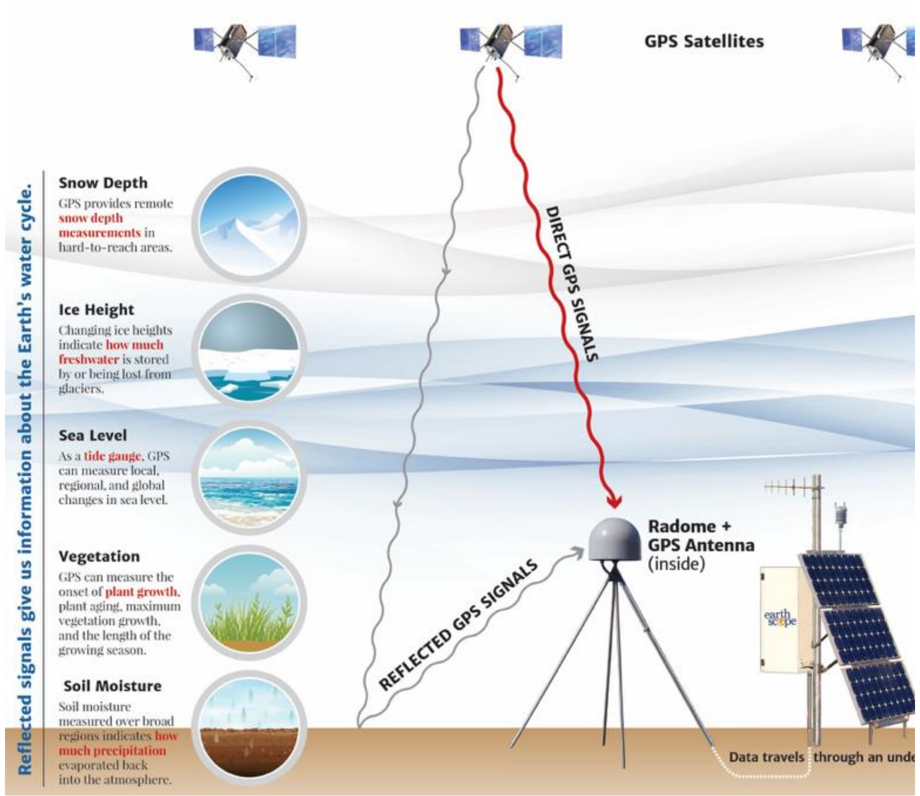
Awesome graphic from UNAVCO and random fire photo

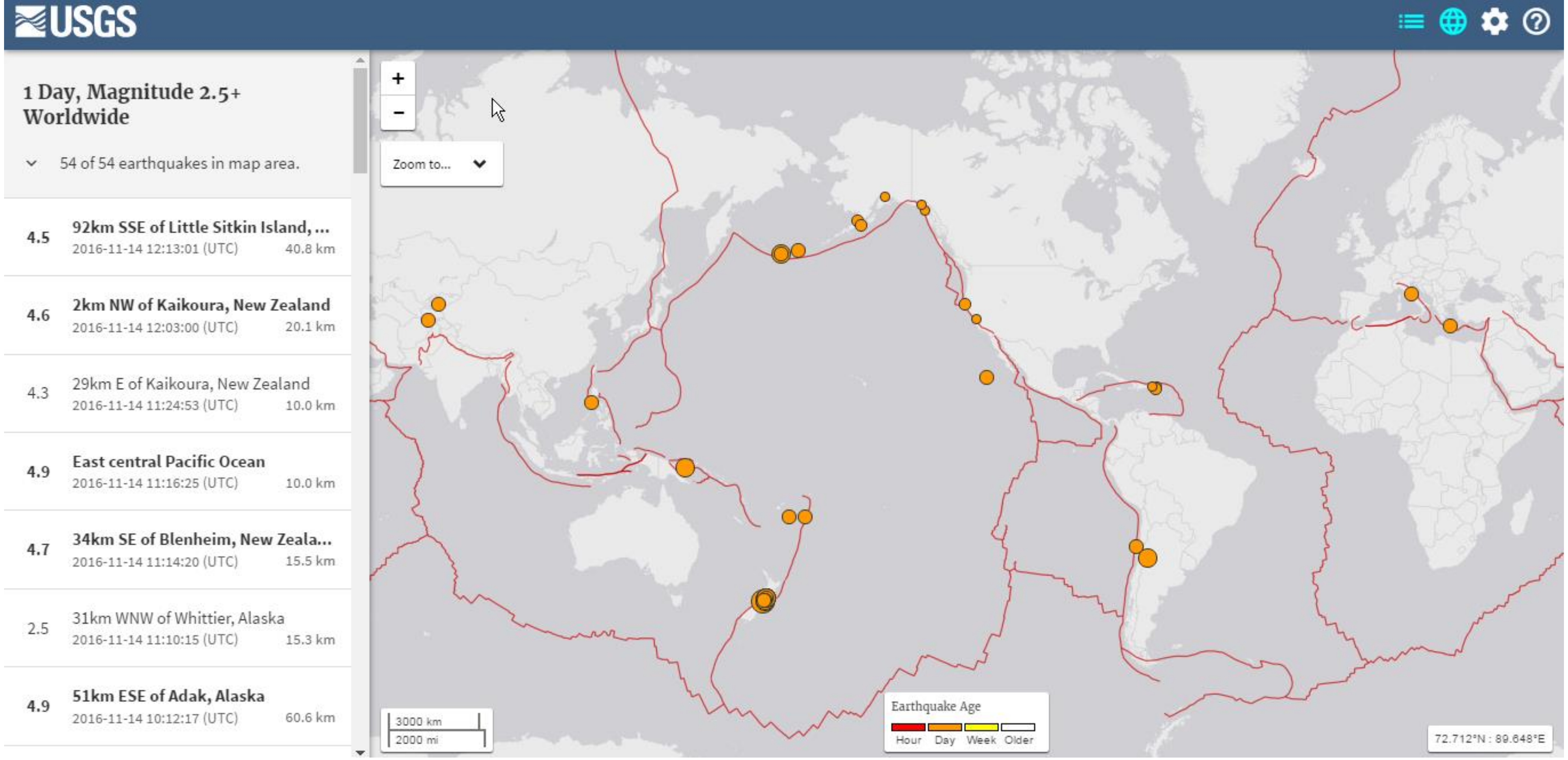
Snow Depth: Avalanche or Flood



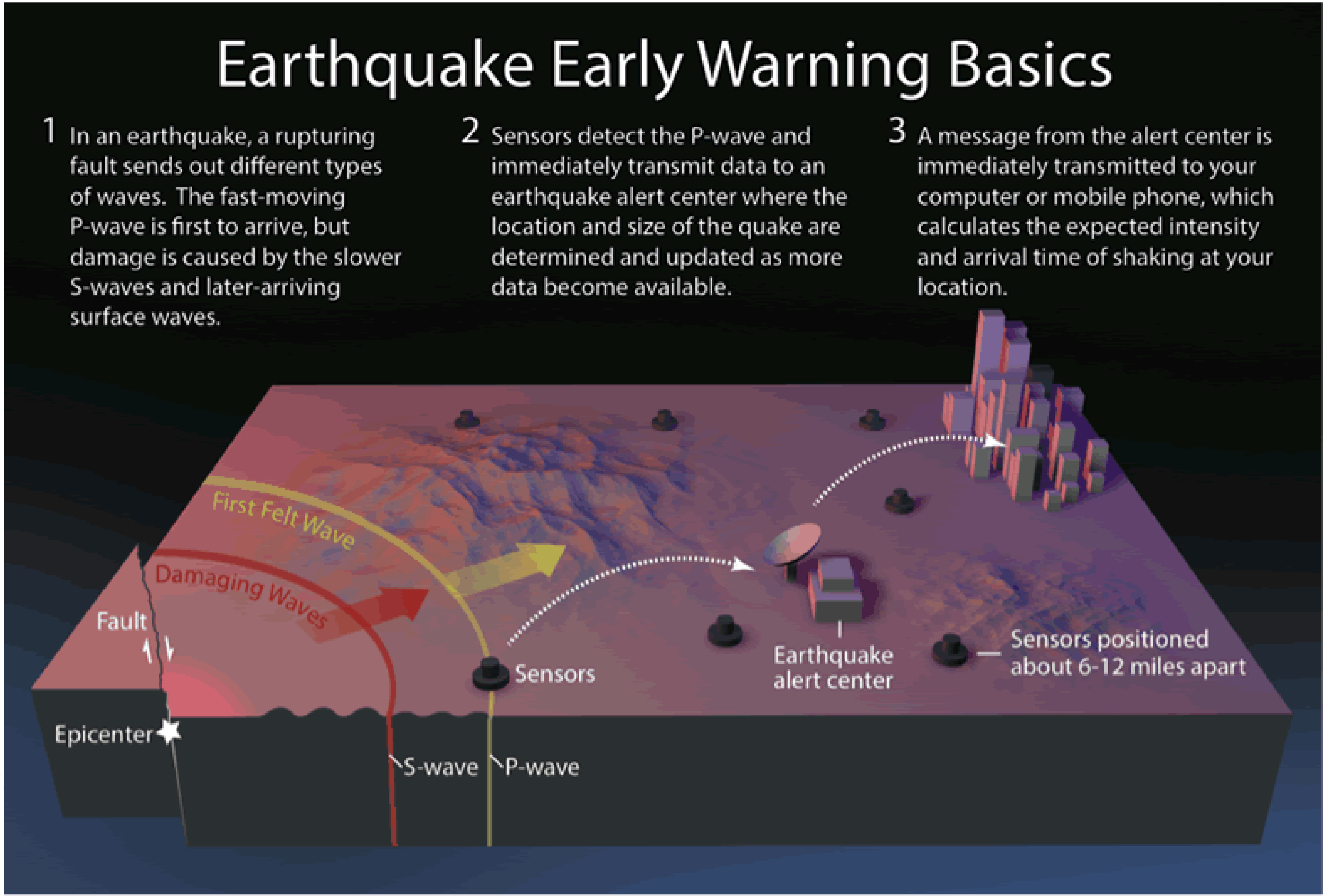


GPS Snow Sensing: Results from the EarthScope Plate Boundary Observatory, K. M. Larson, K.M. & F.G. Nievinski, *GPS Solutions*, 17(1), 2013

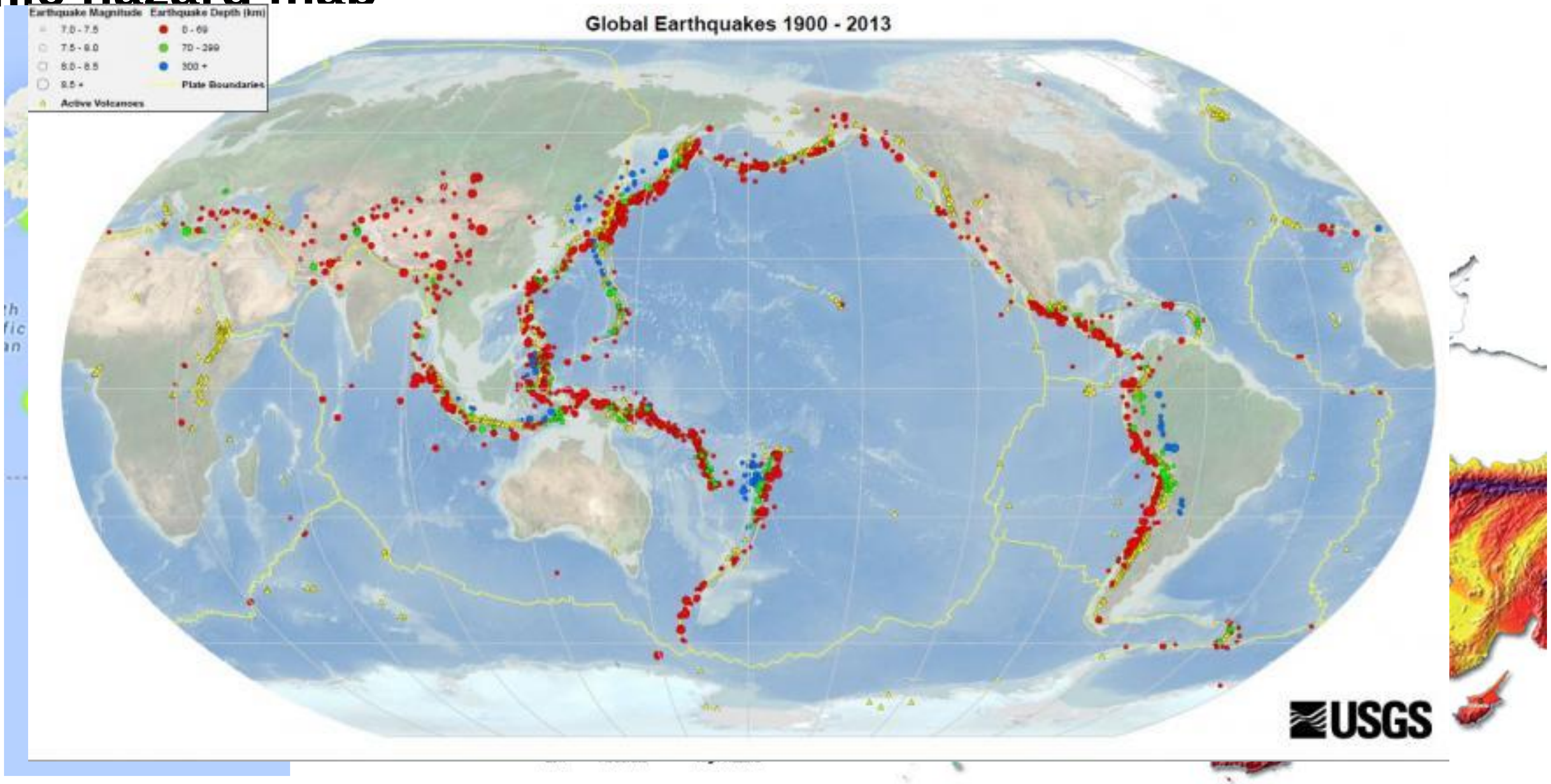
I fell into a burnin' ring of fire
I went down, down, down
As the flames went higher,
And it burns, burns, burns,
The ring of fire, the ring of fire.


USGS
1 Day, Magnitude 2.5+ Worldwide
54 of 54 earthquakes in map area.
4.5 92km SSE of Little Sitkin Island, ... 2016-11-14 12:13:01 (UTC) 40.8 km
4.6 2km NW of Kaikoura, New Zealand 2016-11-14 12:03:00 (UTC) 20.1 km
4.3 29km E of Kaikoura, New Zealand 2016-11-14 11:24:53 (UTC) 10.0 km
4.9 East central Pacific Ocean 2016-11-14 11:16:25 (UTC) 10.0 km
4.7 34km SE of Blenheim, New Zeala... 2016-11-14 11:14:20 (UTC) 15.5 km
2.5 31km WNW of Whittier, Alaska 2016-11-14 11:10:15 (UTC) 15.3 km
4.9 51km ESE of Adak, Alaska 2016-11-14 10:12:17 (UTC) 60.6 km
Zoom to...
3000 km
2000 mi
Earthquake Age
Hour
Day
Week
Older
72.712°N : 89.648°E

PPP for seismic monitoring



Seismic hazard map



USGS
science for a changing world

U.S. Geological Survey

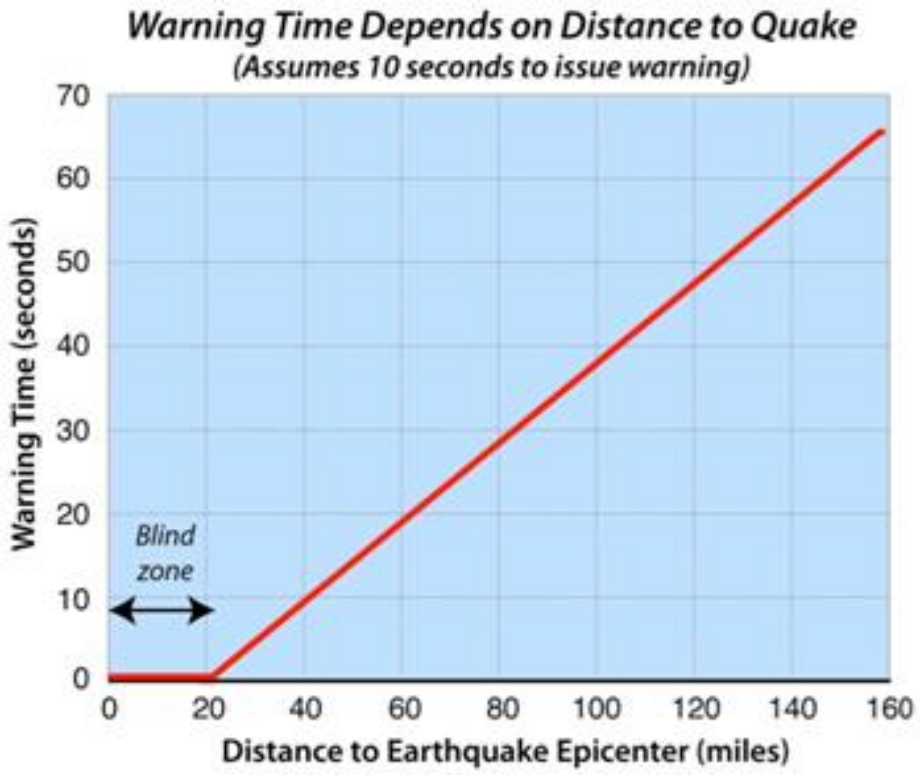
Early warning

Up to 1 minute warning

Since seismic waves travel slower than internet and phone communication it is possible to quickly detect the start of the earthquake and send warning out to locations farther away.

Shut down gas lines, electricity etc

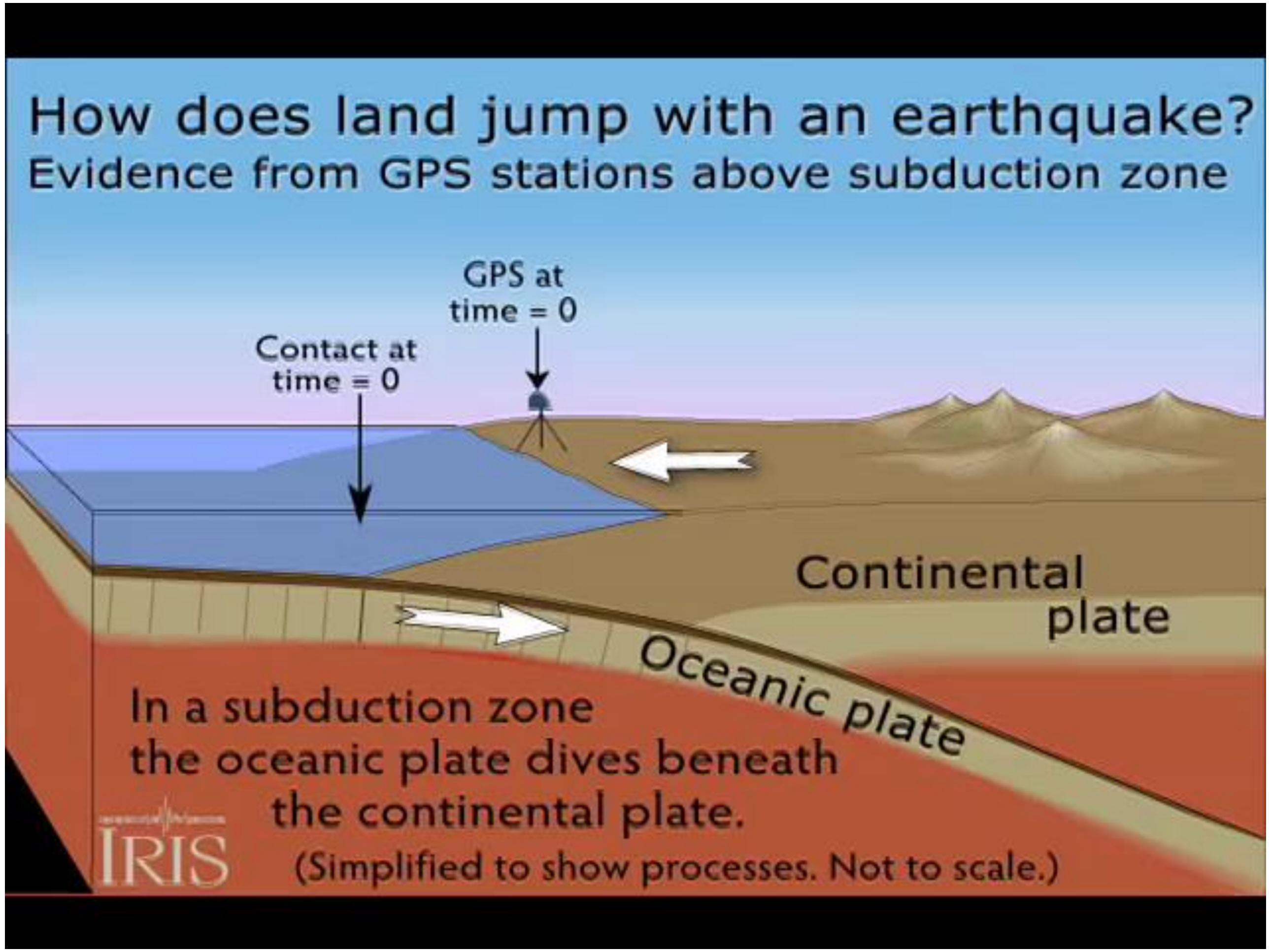
Early warning

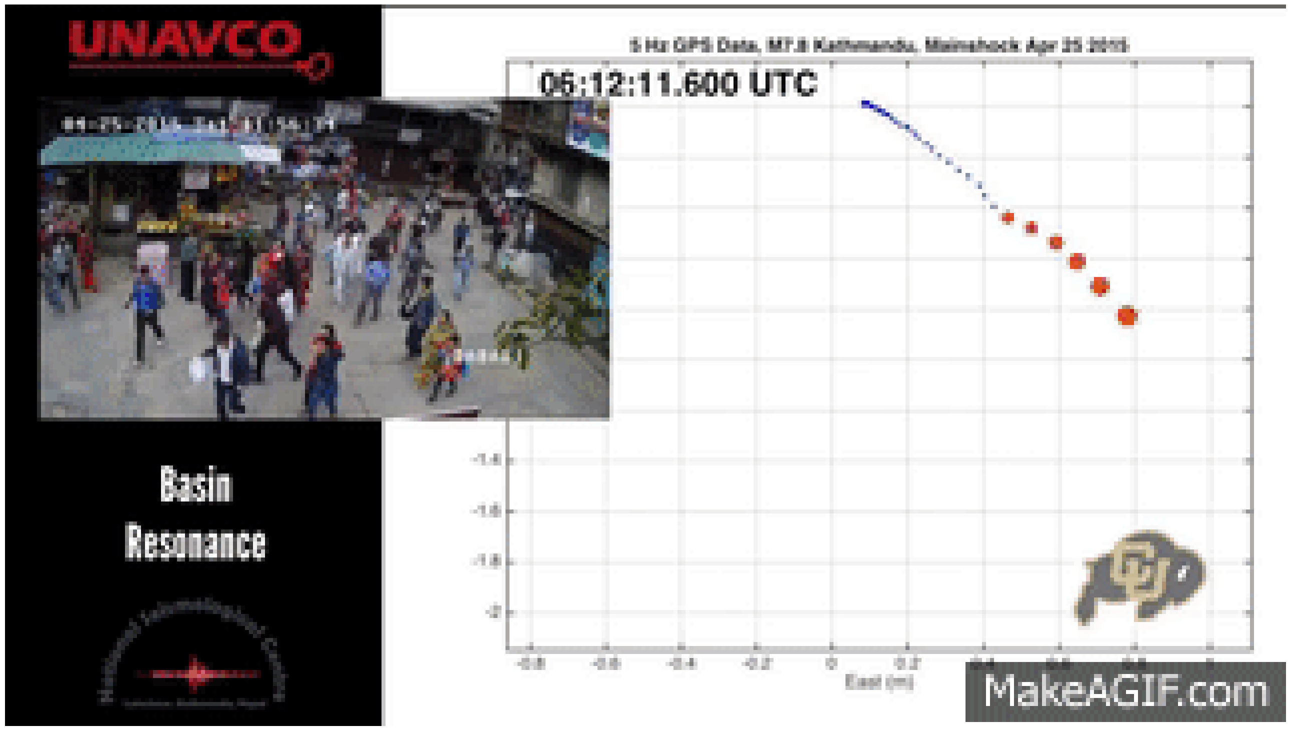


http://www.shakealert.org

earthquake early warning (EEW) system called ShakeAlert for the west coast of the United States

Some examples





UNAVCO video

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What about PolaRx5S?

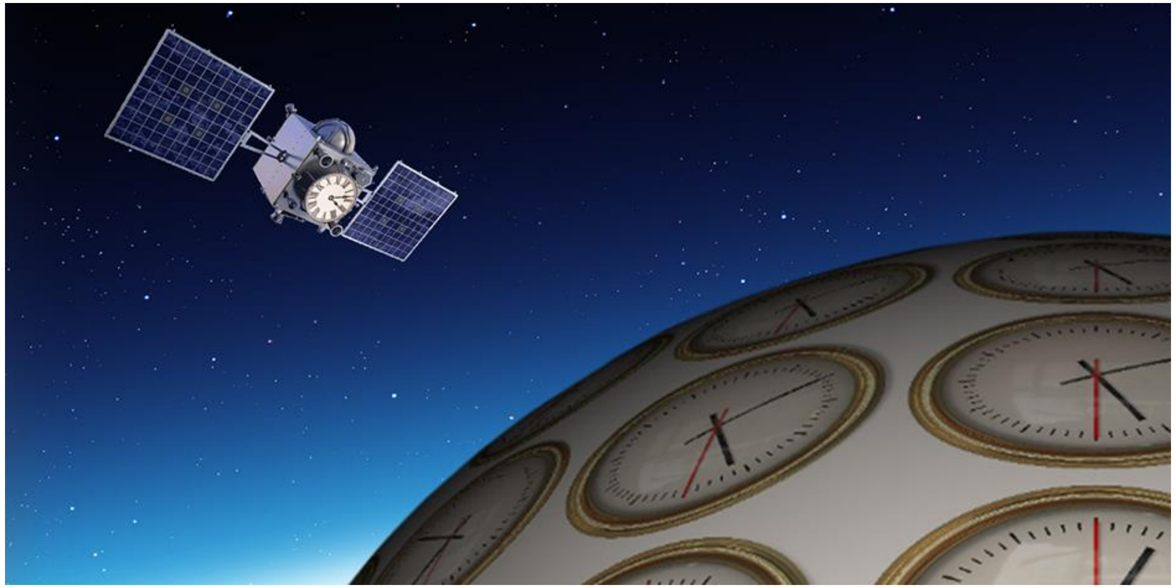
GNSS as sensor to
study the ionosphere

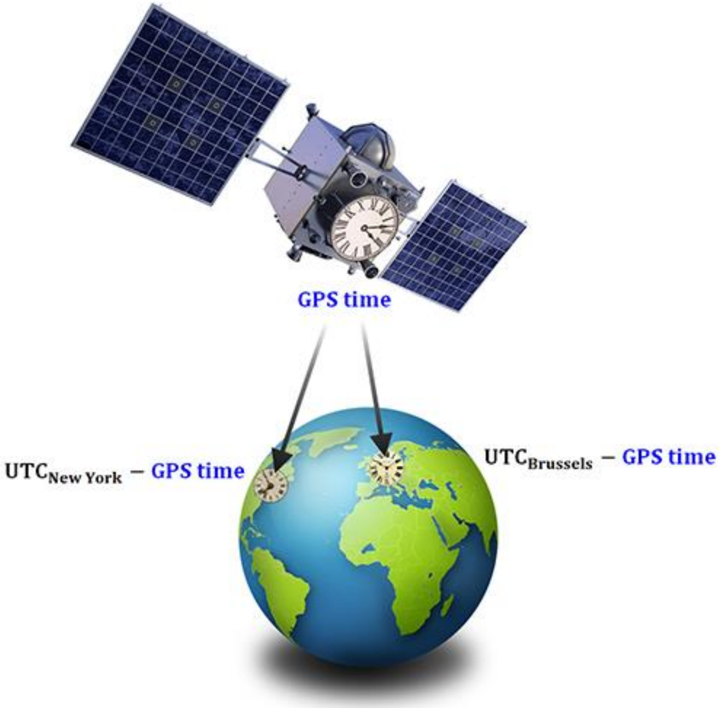
What about PolaRx5TR?

GNSS for time transfer

UTC Universal Time Coordinated determination

Precise (ns) synchronization of equipment





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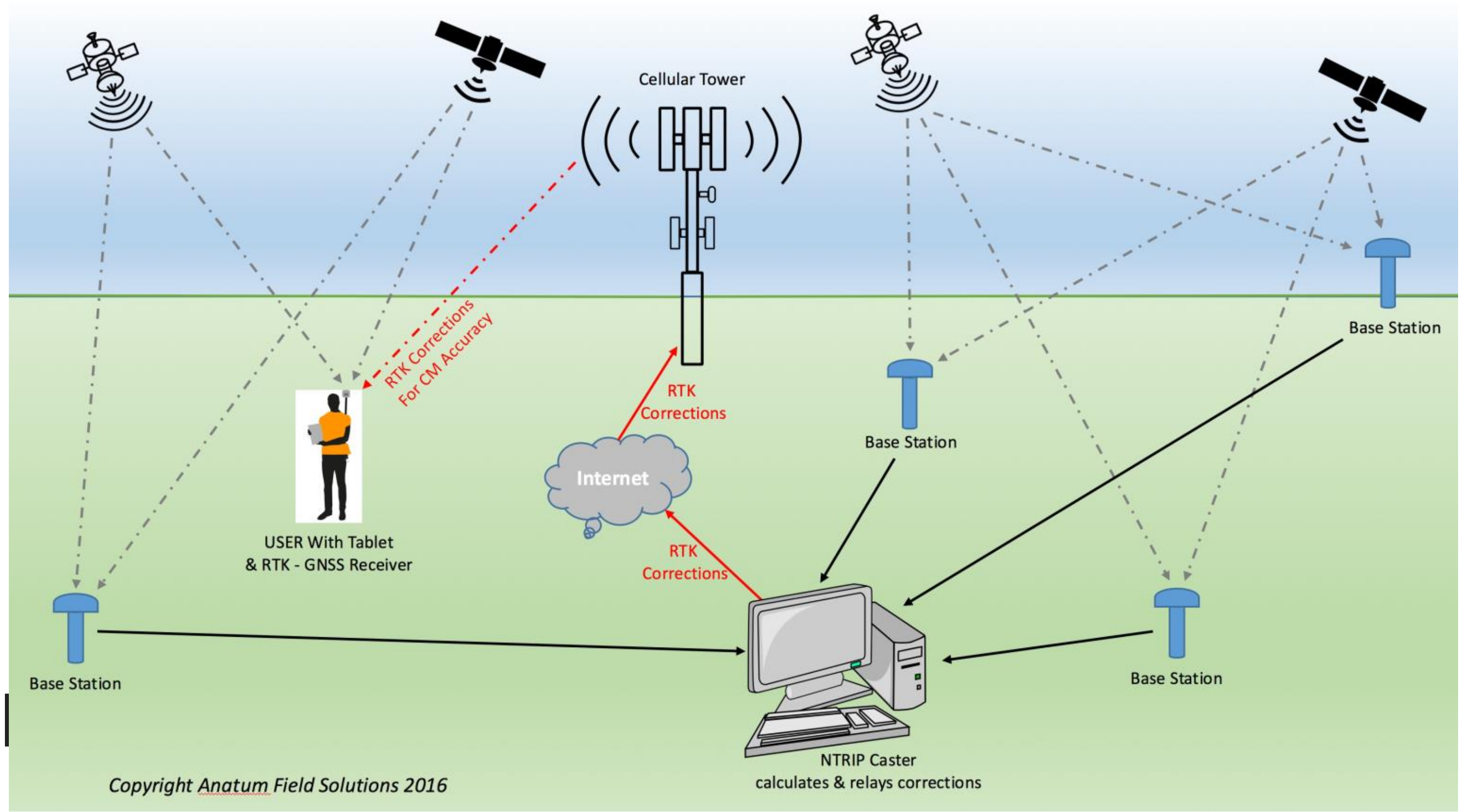
Not only science…RTK networks



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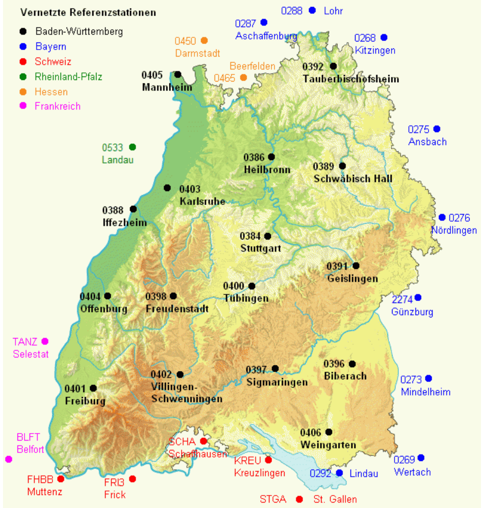
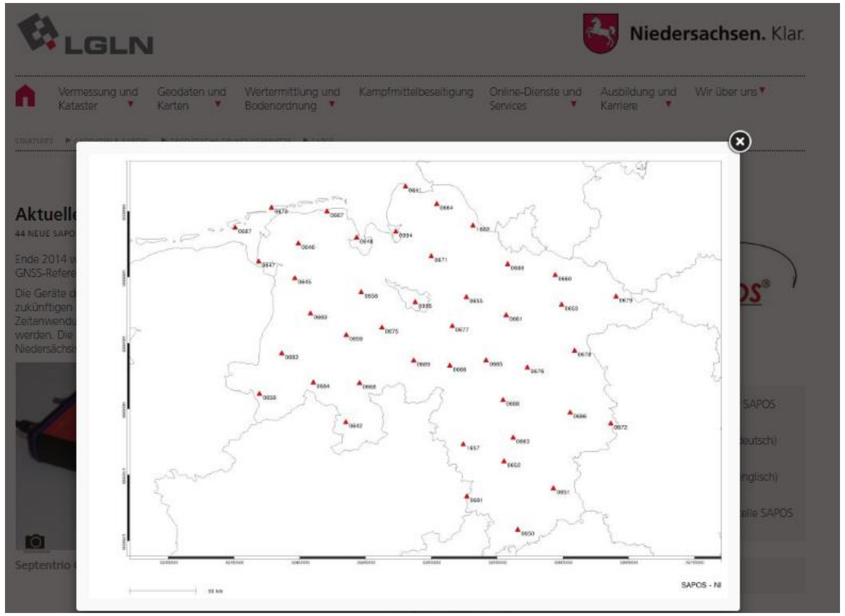
RTK & PPP Networks



veripos ON TARGET

septentrio

SAPOS: 100 PolaRx for SAPOS



SAPOS deployments in:

MecklenBurg
Köln
LGL

About 40 PolaRx4 and about 60 PolaRx5 deployed

Aktuelle SAPOS®-Entwicklungen in Niedersachsen

44 NEUE SAPOS®-EMPFÄNGER BESCHAFFT

Ende 2014 wurden von der Landesvermessung und Geobasisinformation in einer europaweiten Ausschreibung 44 neue GNSS-Referenzstationsempfänger für Niedersachsen und Bremen beschafft.

Die Geräte des Herstellers Septentrio B.V. werden in Leuven in Belgien produziert und sind für alle gegenwärtigen und zukünftigen GNSS sowie SBAS konzipiert. Damit können sämtliche für Positionierungs-, Navigations- und Zeitanwendungen vorhandenen GNSS- (GPS, GLONASS, Galileo, Beidou) und SBAS-Satelliten (EGNOS, WAAS, ...) genutzt werden. Die Beschaffung, die SAPOS®-Nutzern zahlreiche Vorteile bringen wird, wurde mit Erlass des Referats 43 des Niedersächsischen Ministeriums für Inneres und Sport ermöglicht.

Ordnance Survey UK: 60 PolaRx5

Part of network update

Interference detection and mitigation as requirement

Thorough evaluation of the receiver performances

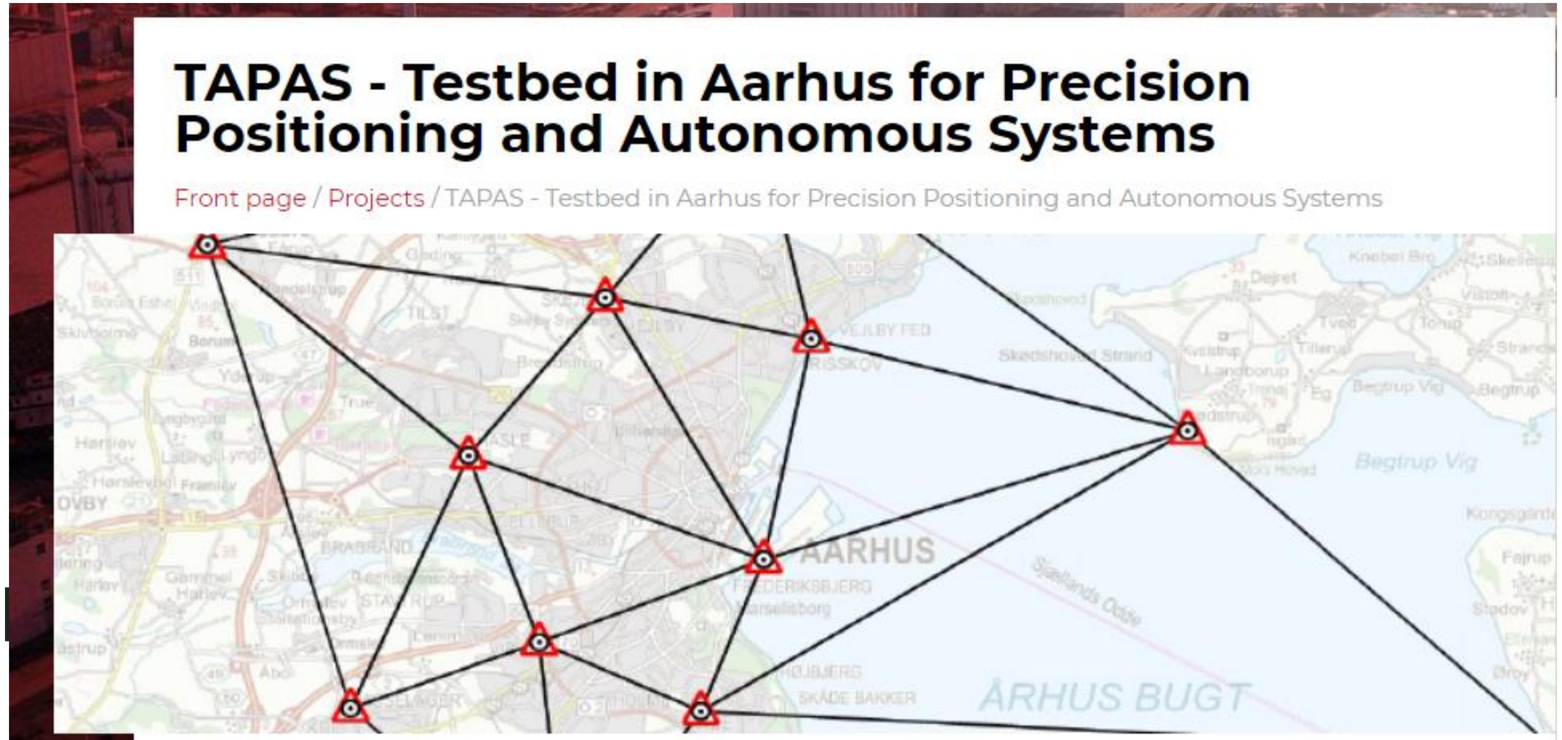
Ordnance Survey

septentrio

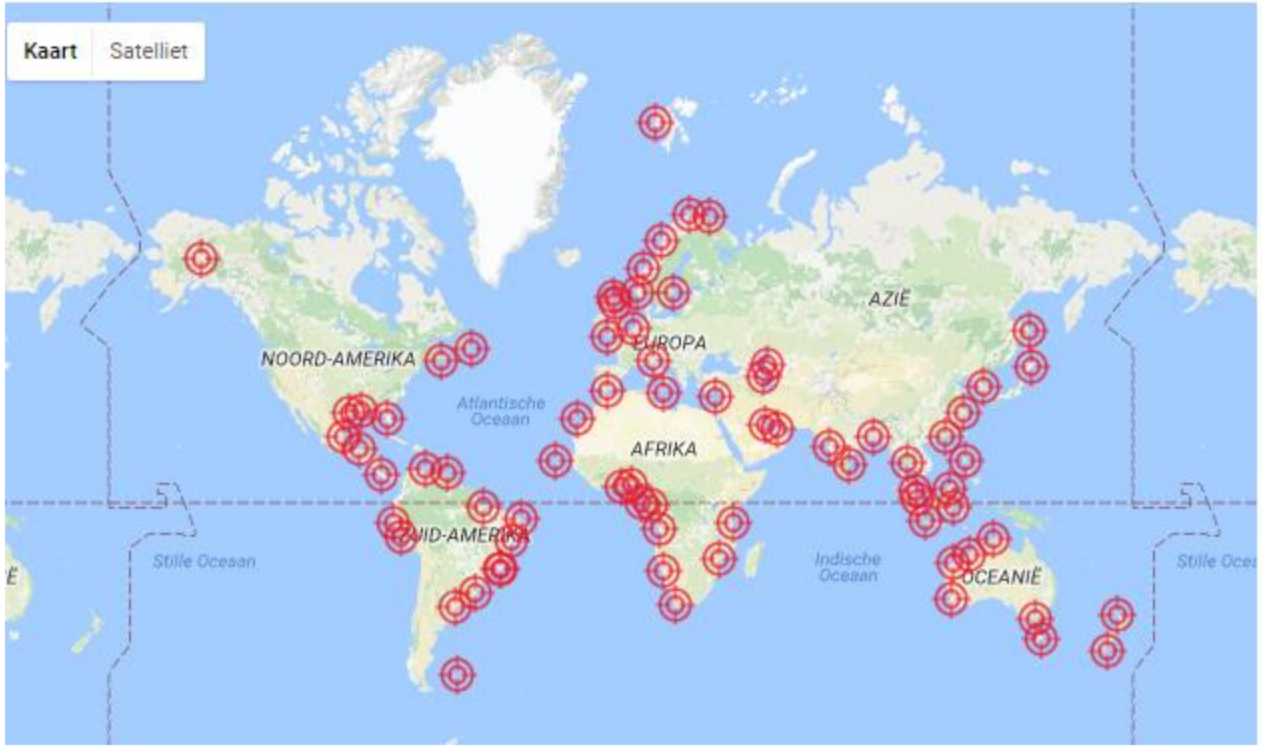
TAPAS – Denmark

11 PolaRx5/PolaRx5S for test bed applications

TAPAS is a science and research project aimed to verify to which extend an improved infrastructure can contribute to exploit the full advantage of the technical achievements of the new Global Navigation Satellite Systems (GNSS)



80 reference stations Veripos/Terrastar network



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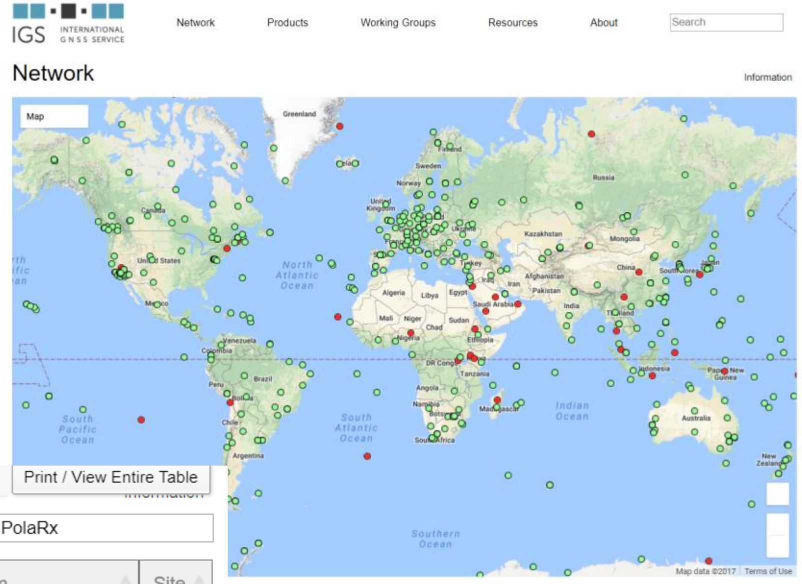
IGS Network

http://igs.org/network

Receivers in IGS Network



Network

Show All entries <<< Expand Site Table Print / View Entire Table Search: PolaRx

Site	Country	Agency	Receiver	Sat System	Site
ABPO	Madagascar	JPL	SEPT POLARX5	GPS+GLO	ABPO
AGGO	Argentina	BKG	SEPT POLARX4TR	GPS+GLO+GAL+BDS+SBAS	AGGC
ARUC	Armenia	JPL	SEPT POLARX5	GPS+GLO+GAL+BDS+SBAS+IRNSS	ARUC
BJNM	China	NIM	SEPT POLARX3ETR	GPS+GLO	BJNM
BRUX	Belgium	ROB	SEPT POLARX4TR	GPS+GLO+GAL+BDS	BRUX
CEBR	Spain	ESOC	SEPT POLARX4	GPS+GLO+GAL+BDS+SBAS	CEBR
CEDU	Australia	GA	SEPT POLARX5	GPS+GLO+GAL+BDS+QZSS+IRNSS	CEDU
CHPI	Brazil	JPL	SEPT POLARX5	GPS+GLO+GAL+BDS+SBAS	CHPI
COCO	Australia	GA	SEPT POLARXS	GPS+GLO+GAL+BDS+QZSS	COCC
DARW	Australia	GA	SEPT POLARX5	GPS+GLO+GAL+BDS+QZSS+IRNSS	DARW
DAV1	Antarctica	GA	SEPT POLARX5	GPS+GLO+GAL+BDS+QZSS	DAV1
DUBO	Canada	NRCan	SEPT POLARX5	GPS+GLO+GAL	DUBO
EPRT	United States	NGS	SEPT POLARX4	GPS+GLO+GAL	EPRT
FAA1	French Polynesia	ESOC	SEPT POLARX4	GPS+GLO+GAL+BDS+QZSS+SBAS	FAA1
FALK	Falkland Islands	JPL	SEPT POLARX5	GPS+GLO	FALK
GAMG	Republic of Korea	CNES	SEPT POLARX4TR	GPS+GLO+GAL+BDS+QZSS+SBAS	GAMG
HERS	United Kingdom	NSGF	SEPT POLARX3ETR	GPS+GLO	HERS
HOB2	Australia	GA	SEPT POLARX5	GPS+GLO+GAL+BDS+QZSS+IRNSS	HOB2
KAT1	Australia	GA	SEPT POLARX5	GPS+GLO+GAL+BDS+QZSS+IRNSS	KAT1

Showing 1 to 50 of 50 entries (filtered from 508 total entries) Previous 1 Next

50 PolaRx units n the network.
Old PolaRx2/3 still active, demonstrating quality and durability of Septentrio receivers