ION GNSS+ 2016

MOVING FORWARD TO THE FUTURE LOW-COST PPP PARADIGM

September 16TH , 2016

Session D5b: Next-generation Sensors in Phones, Tablets and Wearables

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INNOVATING SOLUTIONS

OUTLINE

GNSS Receivers & PPP Trends

magicGNSS Evolution towards Low-Cost precise positioning

Preliminary experimentation results

Conclusions and Way-Forward

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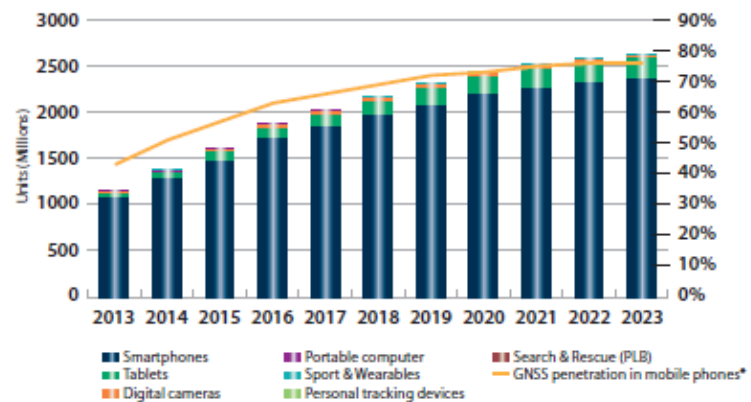PPP & GNSS RECEIVERS TRENDS

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GNSS RECEIVERS MARKET

- Two markets: high-end receivers and low-cost receivers
  - Current expected performances: centimeter level vs meter level
  - Price: $10000s vs $1-100

- Huge growth of the number of sold low cost receivers during the last years thanks to mobile devices
  - Single frequency
  - Integrated Antenna

- Improve positioning service performances for low-cost users.
  - Phase measurements provision in smartphones' chipsets
  - Multifrequency
  - Implement advance positioning algorithm
  - Reduce power consumption

- Market Opportunity!
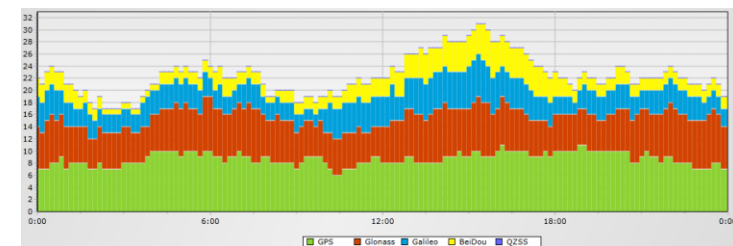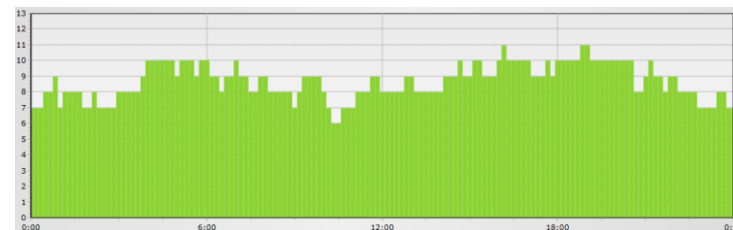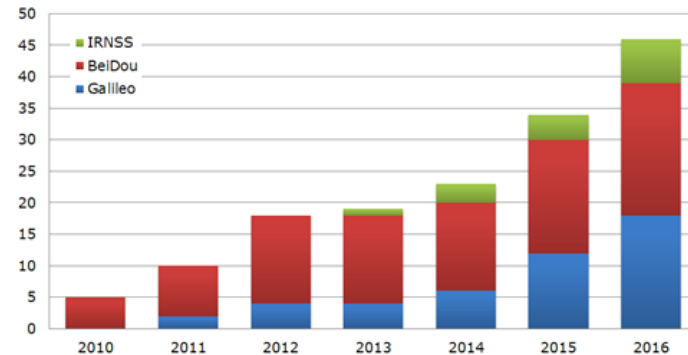
Price: $10K-$20K

Price: $1-$100

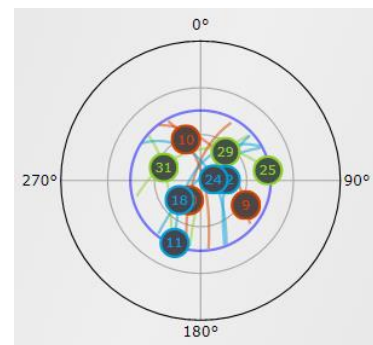**https://www.gsa.europa.eu/market/market-report**

PPP TECHNIQUES EVOLUTION

- MultiGNSS and GNSS modernization:
  - Better achievable positioning and timing solution
  - Drastically **increases the satellite availability**
  - Better performances in challenging environments

- Single-Frequency Processing:
  - Explore new markets
  - Cost-saving alternative

- Gap-bridging:
  - Avoid reconvergences
  - Achieve solution continuity

- Reduce Convergence Time
  - Major PPP drawback.
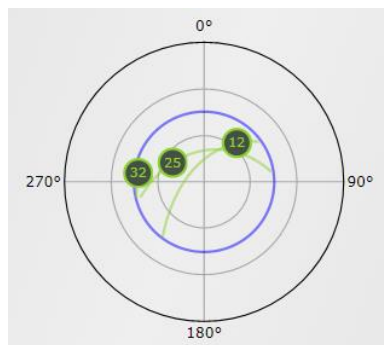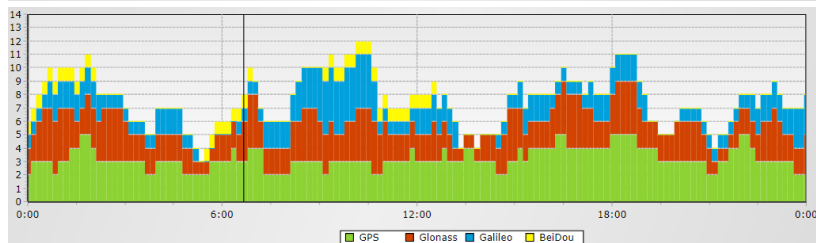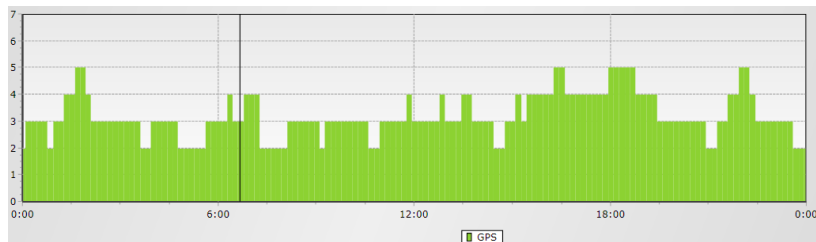 - One of the main topic being investigated by the industry

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  - Explore **new markets**
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- **Gap-bridging:**
  - Avoid reconvergences
  - Achieve solution continuity, not only from signal losses, but from data losses

- **Reduce Convergence Time**
  - Major PPP drawback.
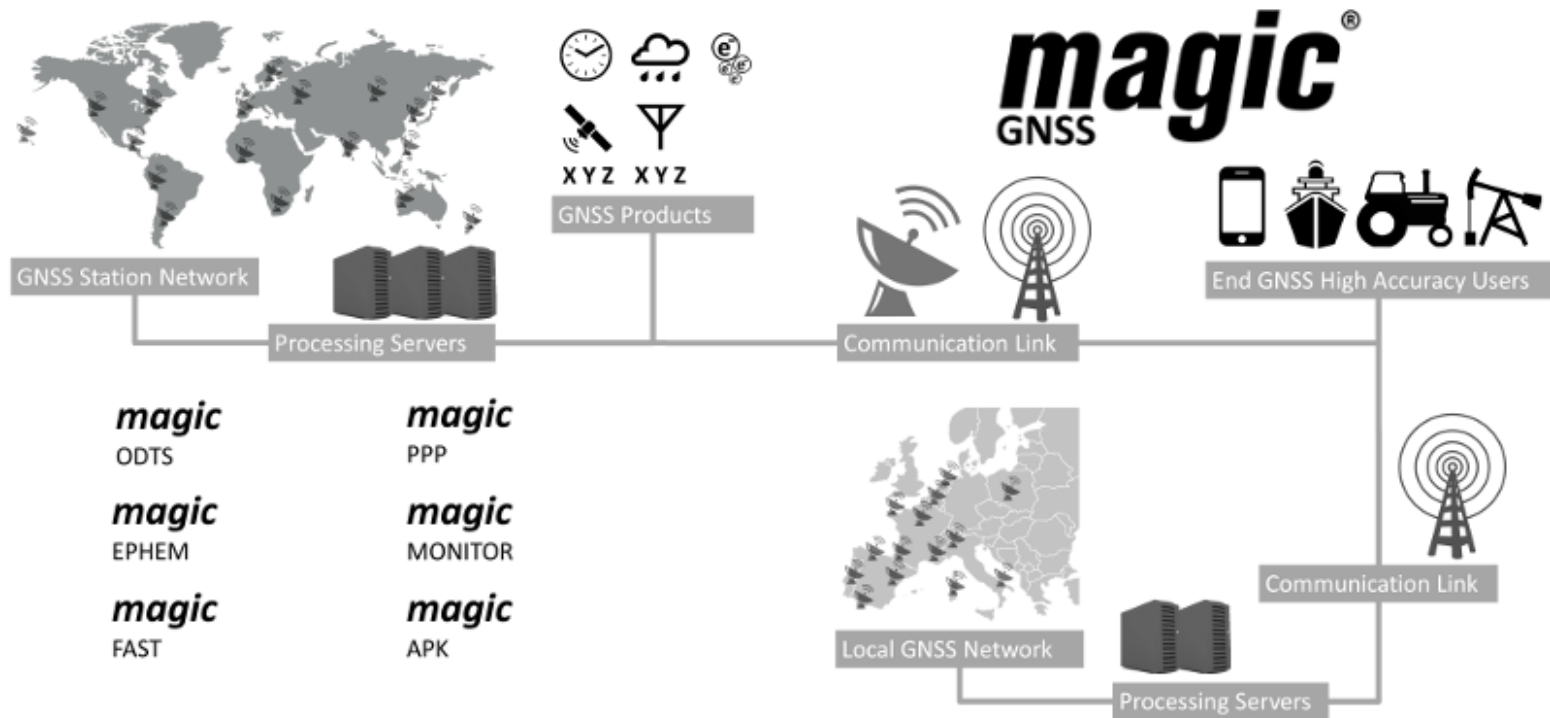 - One of the main topic being investigated by the industry

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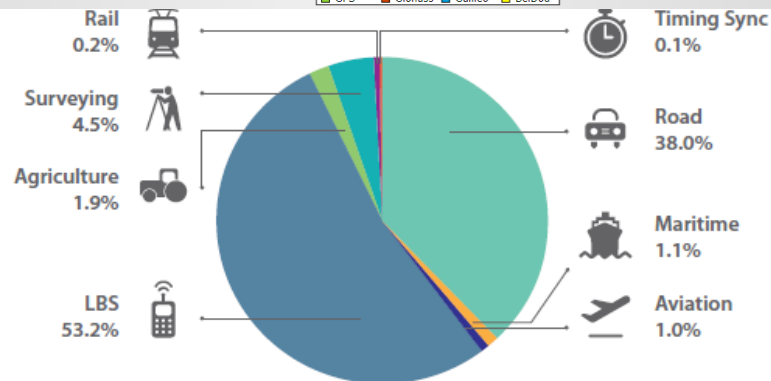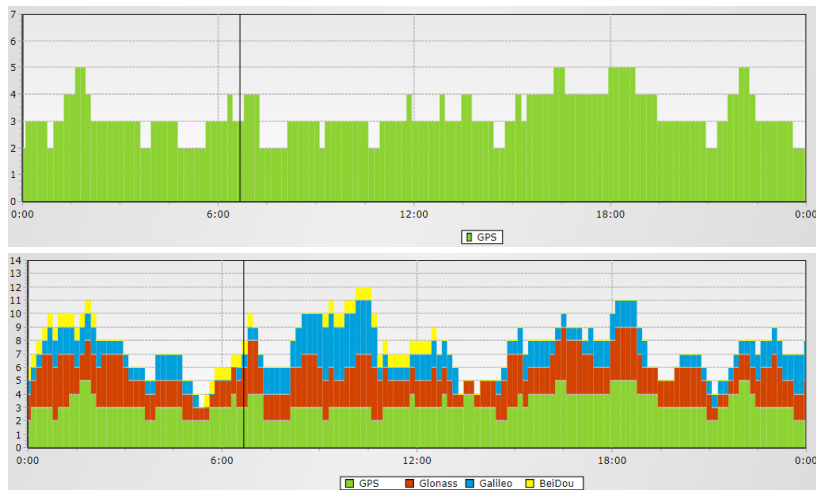
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magicGNSS EVOLUTION TOWARDS LOW-COST PRECISE POSITIONING
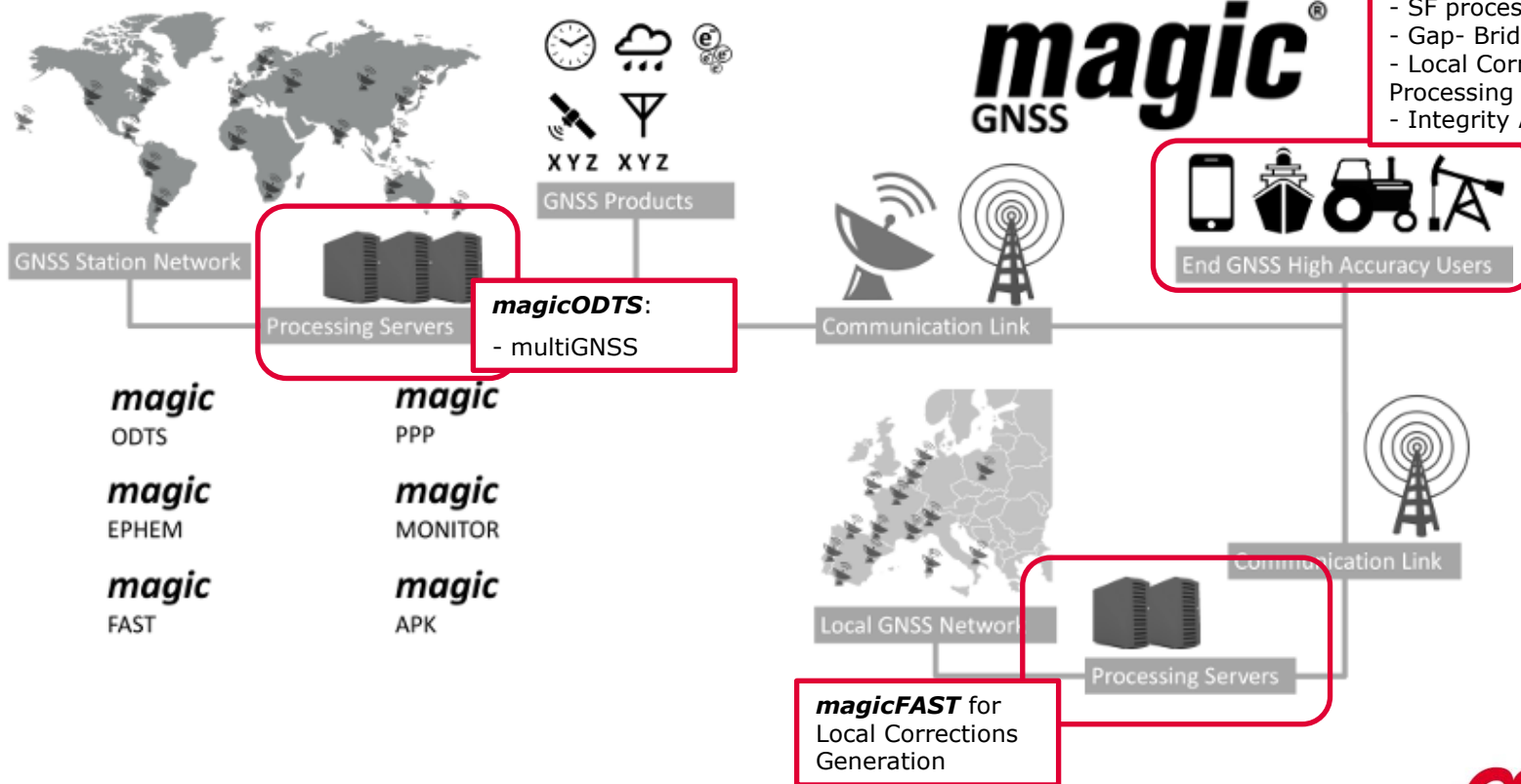
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magicGNSS' REAL TIME INFRASTRUCTURE

END-TO-END PPP SERVICE

magicGNSS' REAL TIME INFRASTRUCTURE

UPGRADES FOR LOW-COST PPP

magicPPP capabilities:

- MultiGNSS
- SF processing
- Gap- Bridging
- Local Corrections Processing
- Integrity Algorithm

GNSS Products

GNSS Station Network

Processing Servers

magicODTS:

- multiGNSS

Communication Link

End GNSS High Accuracy Users

magic ODTS

magic PPP

magic EPHEM

magic MONITOR

magic FAST

magic APK

Local GNSS Network

Processing Servers

Communication Link
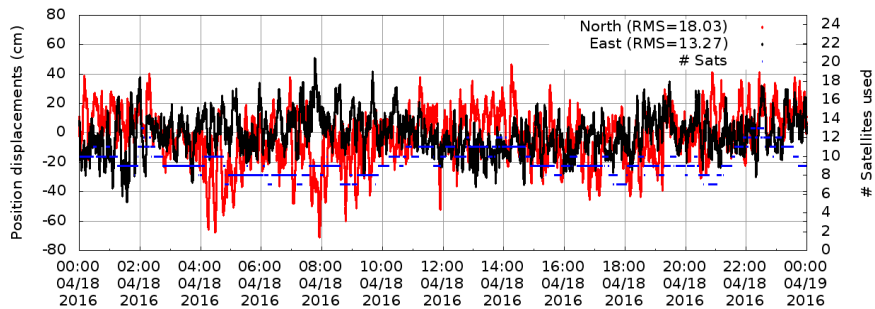
magicFAST for Local Corrections Generation

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magicPPP EVOLUTION
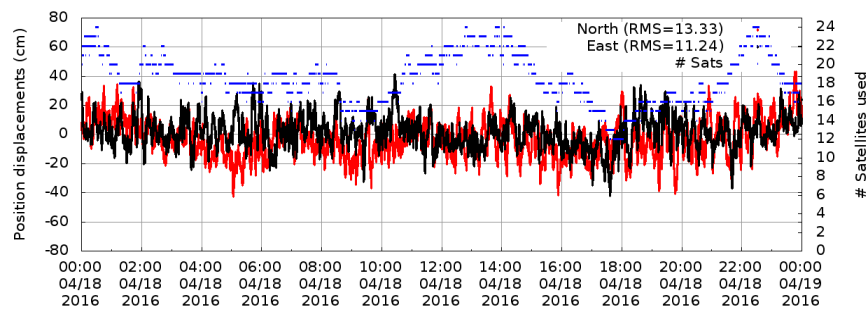
- MultiGNSS and SF processing

  - Both server and client sides support multiGNSS processing (GPS, GLONASS, Galileo, BeiDou and QZSS)

  - Client upgraded for working on slingle-frequency mode

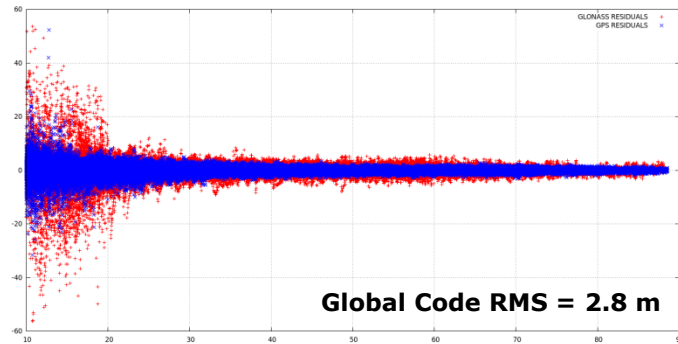**uBlox m8t + Geodetic antenna**

SF-PPP G-only

SF-PPP GRE
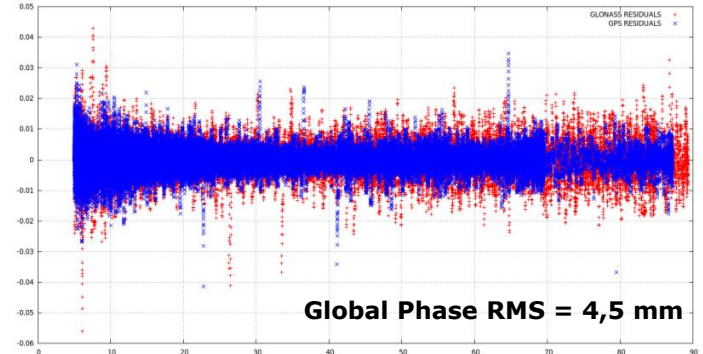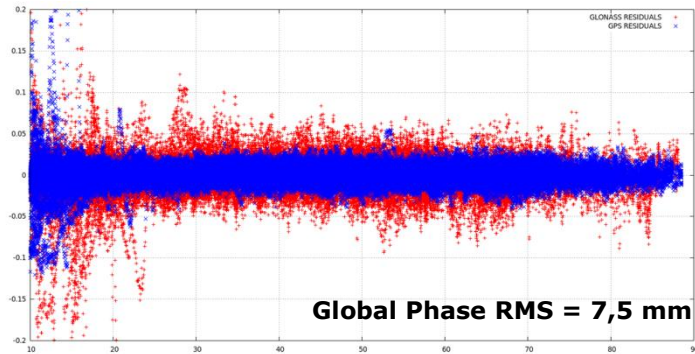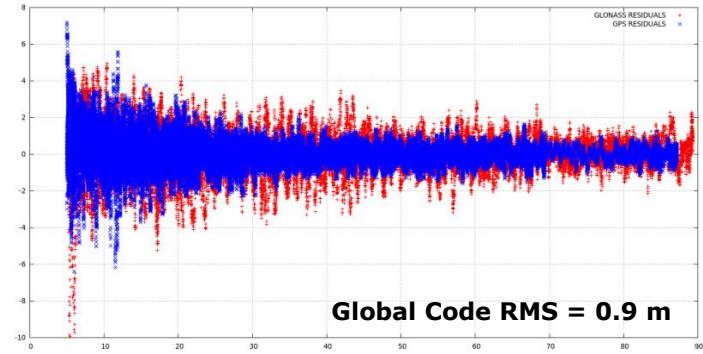
Horizontal Accuracy below 15cm RMS !!

magicPPP EVOLUTION

- Strong R+D effort for improving the PPP accuracy with cheap antennae (patch and device integrated) and low cost receivers

uBlox m8n + Patch antenna

Global Code RMS = 2.8 m

Global Phase RMS = 7,5 mm

uBlox m8n + Geodetic antenna

Global Code RMS = 0.9 m

Global Phase RMS = 4,5 mm
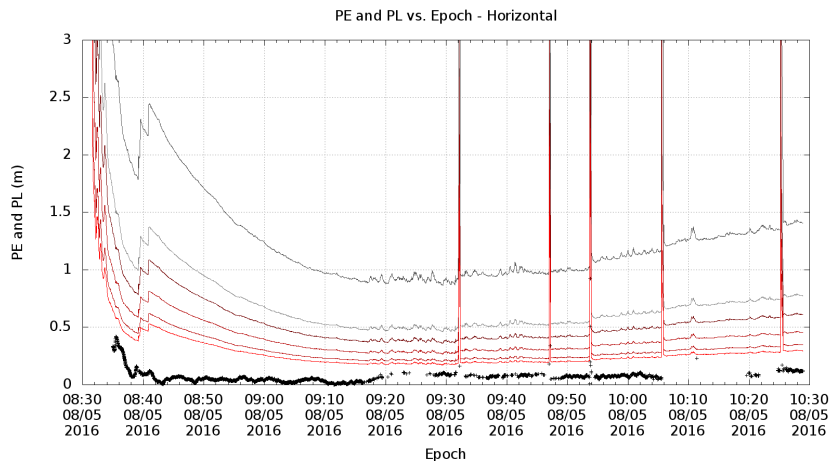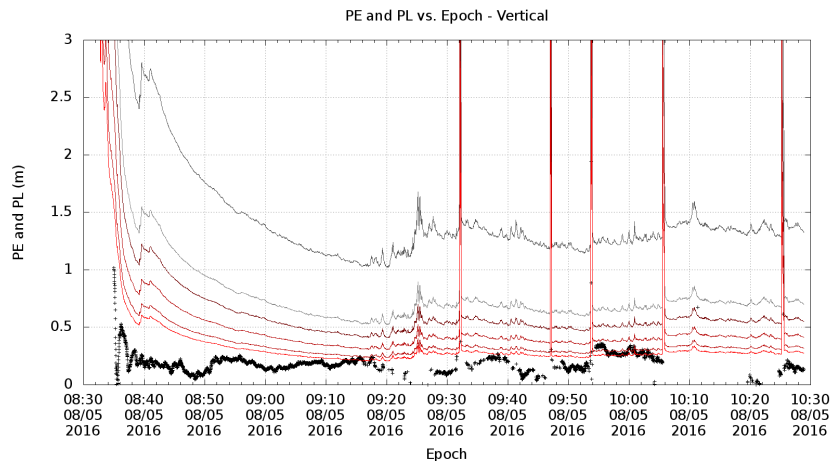
magicPPP EVOLUTION

- Integrity algorithm

  - Algorithm developed for positioning based on Kalman filters, whereas the historical approach is focused on batch processing.

  - Provides horizontal and vertical Protection Levels for bounding the error

  - Proven to provide very good results under challenging conditions

PE and PL vs. Epoch - Horizontal

PE and PL vs. Epoch - Vertical

magicPPP EVOLUTION

- ■ Android Application
  - – Up-to-date user application **compatible with most Android devices**
  - – Compatible with multiple receivers providing information in RTCM format via Bluetooth, USB, TCP/IP, NTRIP Client and NTRIP Caster.
  - – Working on the retrieval of raw measurements provided by the internal GNSS chip

magicFAST − REGIONAL CORRECTIONS

- ***magicFAST*** is a solution for convergence time improvement
  - Wide regions service with a reduce number of monitor stations
  - Significant reduction in convergence time
  - Improvement in solution performances

- PPP accuracy after 180 seconds is:
  - Below 20 cm horizontal accuracy in DF-PPP
  - Below 50 cm horizontal accuracy in SF-PPP
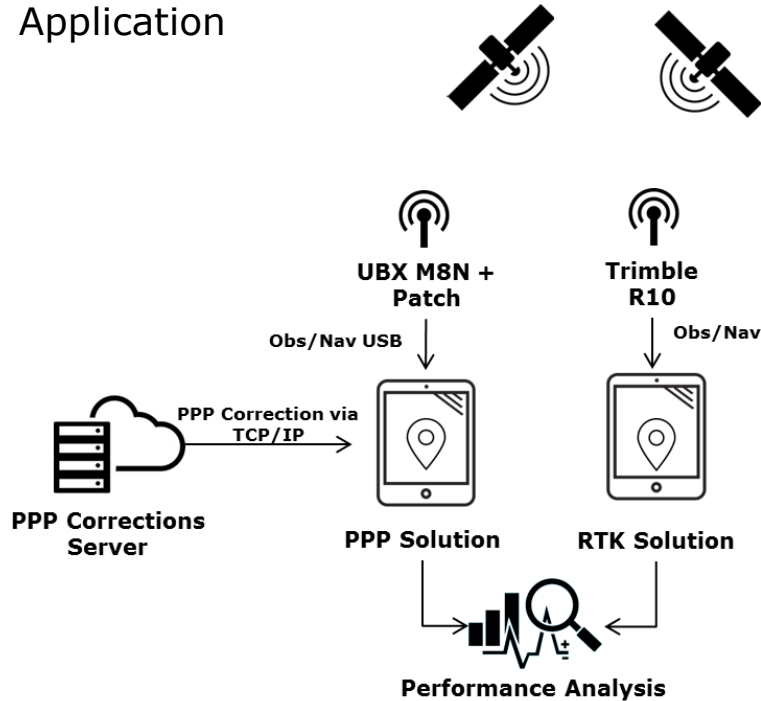
Time (15 mins)

180 secs

Double Frequency - PPP+magicFAST vs PPP

H-Error PPP+magicFAST
H-Error PPP

2D Error (cm)

Single Frequency Ublox - PPP+magicFAST vs PPP

H-Error PPP+magicFAST
H-Error PPP

2D Error (cm)

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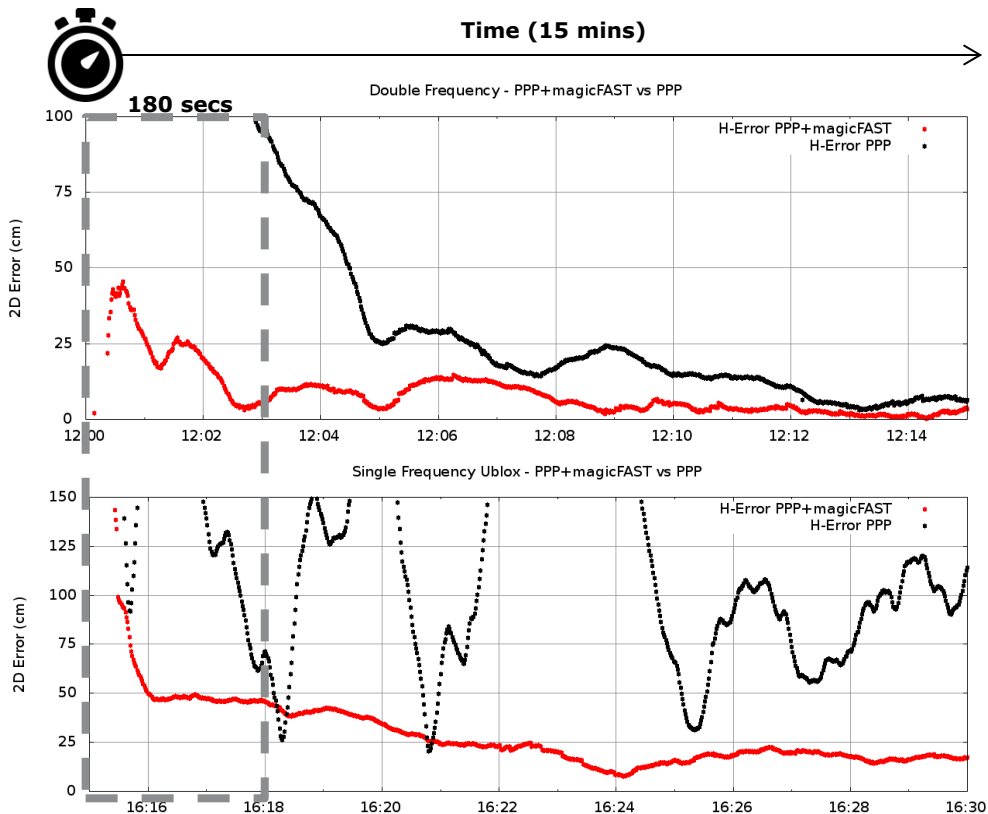
DEVICES UNDER TESTING

- Reference trajectory: Trimble R10 + RTKLib

- Device Tested: uBlox NEO-M8N (GPS+GLONASS) with antenna patch + PPP Android Application
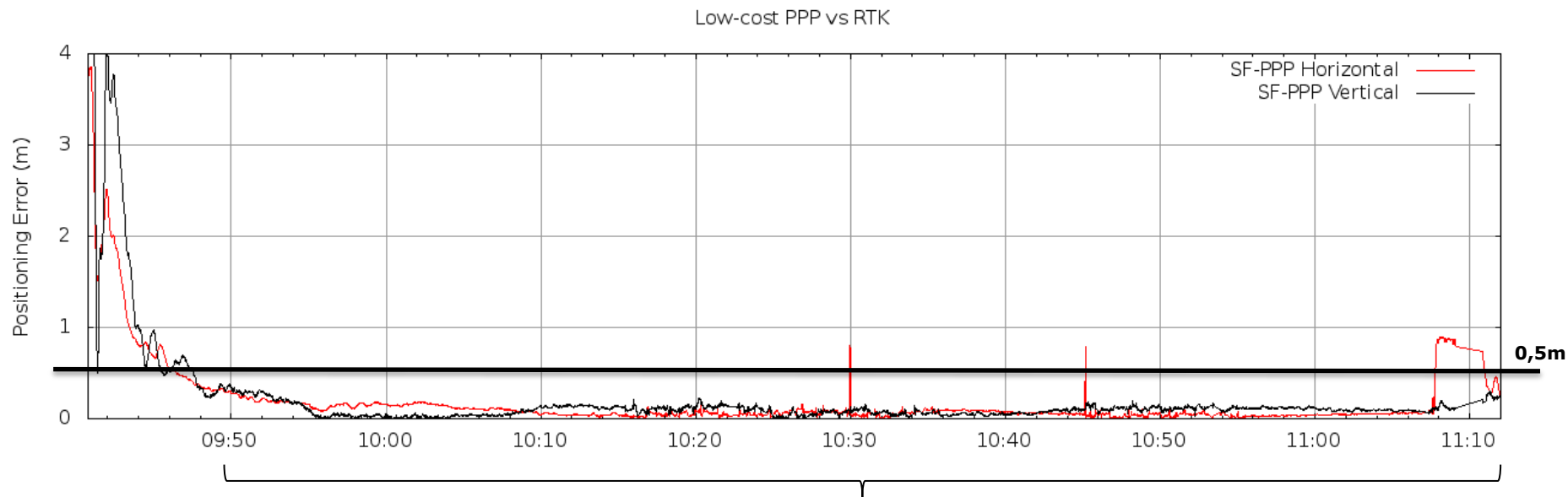
TEST #1 – DESCRIPTION

- Kinematic scenario:
  - Open sky + urban conditions
  - Including high-way
  - Duration ~1,5 hours

- NEO-M8N+patch and Trimble R10 placed on top of a car

- Reference trajectory obtained with Trimble R10 + RTKLib. Applied correction between antenna positions.

- Local corrections:
  - *magicFAST*

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TEST #1 – RESULTS

- Horizontal convergence below 0.5m in less than 3 minutes

- Vertical convergence below 0.5m in less than 10 minutes

Low-cost PPP vs RTK

RMS Horizontal: 0.107
RMS Vertical: 0.110

TEST #2 – DESCRIPTION

- Kinematic scenario:
  - Open sky + urban conditions
  - Duration ~1,5 hours

- NEO-M8N and Trimble R10 placed on top of a car

- Reference trajectory obtained with Trimble R10 + RTKLib. Applied correction between antenna positions.

- Local corrections:
  - *magicFAST*

TEST #2 – RESULTS

- Horizontal convergence below 0.5m in less than 3 minutes

- Vertical convergence below 0.5m in ~10 minutes

SF-PPP with Low-cost Rx vs RTK
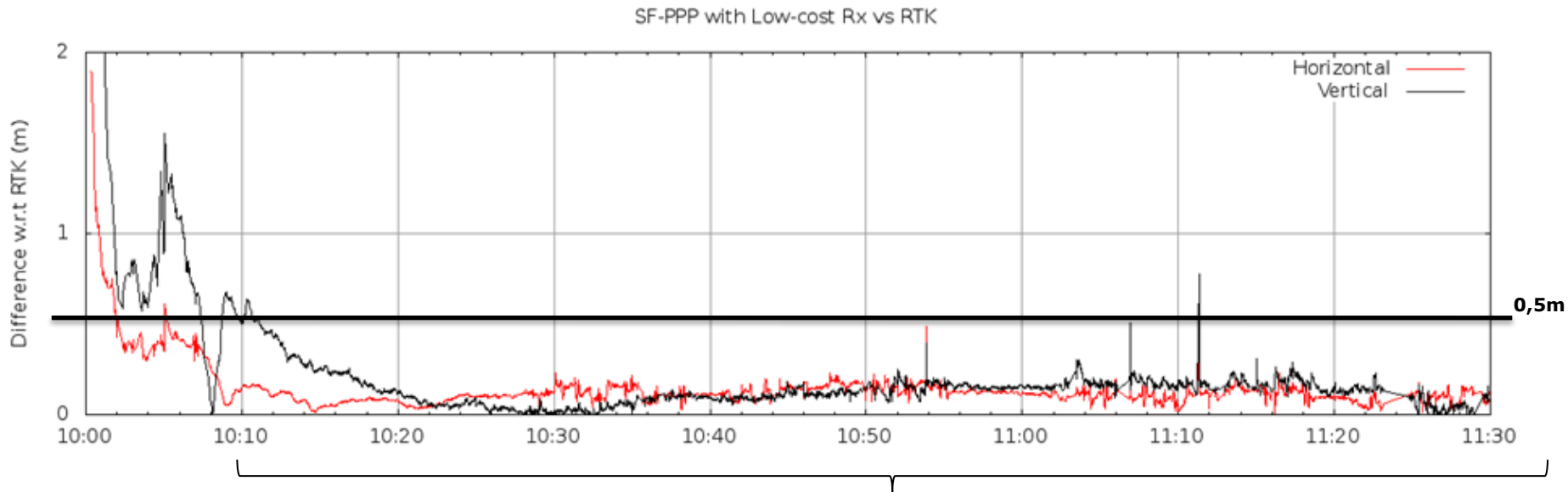
RMS Horizontal: 0.089
RMS Vertical: 0.169

TEST #2 - RESULTS

TEST #2 - RESULTS

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CONCLUSIONS AND WAY-FORWARD

- Low-cost PPP is possible
  - Antenna+receiver equipment cost < $100
  - Achievable accuracy below 0.40 m horizontal.

- Fast convergence both for SF and DF PPP thanks to *magicFAST*
  - Local Corrections

- Integrity algorithm implemented and integrated within the PPP algorithm

- Future evolutions of the system
  - Processing of the GNSS data gathered by the chipset of the mobile and tablets → Android 7 Nougat will ease this step!!

THANK YOU