Relative positioning with Galileo
E5 AltBOC code measurements
Context

Google opens up GNSS code measurements access

Possibility of precise positioning with ANDROID raw code pseudoranges?
Challenge

Codes

- Expected precision on a position:

Metres
Challenge

Mass market applications

- Required precision on a position:

Decimetre
Hypothesis

Galileo E5 signal

AltBOC Modulation
- High tracking accuracy
- Strong multipath resistance

Improvement of the code pseudoranges’ precision
Method

Double difference:

Difference between two **SIMULTANEOUS** receivers’ observations of the two same satellites
Configurations

**ZERO BASELINE**

**SHORT BASELINE**

**MEDIUM BASELINE**
Configurations

**ZERO BASELINE**

**SHORT BASELINE**

**MEDIUM BASELINE**

**Theoretical case**
Baseline length: 0 metre

**Not used in practice**
Estimation of receiver’s observation noise

Receiver’s observation noise
Configurations

**ZERO BASELINE**

**SHORT BASELINE**

**MEDIUM BASELINE**

**Analytical case**
Baseline length: 5 metres

**Observable precision**
Estimation of the precision of the OBSERVATIONS

- Multipath
- Noise
Configurations

**ZERO BASELINE**

**SHORT BASELINE**

**MEDIUM BASELINE**

**Practical case**

Baselines length:
- 23 kilometres (Liège – Waremme)
- 87 kilometres (Liège – Brussels)

**Position precision**

Precision of the estimated **POSITIONS**

Atmospheric errors +
Multipath +
Noise
Equipment

Septentrio PolaRx5  Septentrio PolaRxS

University of Liège

Trimble NetR9  Septentrio PolaRx4

Waremme
Septentrio PolaRx4

Brussels
Septentrio PolaRx4TR
## Observable precision (metres)

### GPS

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<th>L1</th>
<th>L2</th>
<th>L5</th>
<th>E1</th>
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### Galileo

<table>
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<tr>
<td>Septentrio</td>
<td>0.06</td>
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Short baselines in Liège  
Days Of Year 145 – 154 (2016)
Different precisions for different receiver’s types

Galileo E5 AltBOC outperforms other GPS and Galileo signals

Galileo signals are more precise than GPS signals

Galileo E1 & GPS L1 show the worst precision

GPS L2/ GPS L5, Galileo E5a/Galileo E5b show similar quality
Precision of the estimated position (metres)

Liège
5 metres baseline

RMS 3D
0.53 metres

DOY 17 of 2016

Galileo E5 AltBOC
Precision of the estimated position (metres)

Waremme
23 kilometres baseline

RMS 3D
0.61 metres

DOY 91 of 2015

Galileo E5 AltBOC
Precision of the estimated position (metres)

Brussels
87 kilometres baseline

RMS 3D
1,73 metres

DOY 91 of 2015

Galileo E5 AltBOC
Conclusions

Galileo shows a precision highly superior to GPS signals
Analysis on both Trimble and Septentrio receivers

Among all signals, Galileo E5 AltBOC is outstanding
Analysis on both Trimble and Septentrio receivers
Conclusions

**Observation precisions**

Limited number of available Galileo satellites degrades the solution

When compared to reduced-GPS constellations, Galileo results are very promising

**Position precisions**

Days with good satellite visibility allow reaching few decimetres precision

For baselines from 5 metres to 23 kilometres