

## Analysis of IfE-Robot based Group Delay Variations for the Positioning and Navigation of Mobile Platforms

- European Navigation Conference (ENC) 2013 -

Session D4 - Scientific GNSS (1)

Institut für Erdmessung  
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## Motivation

### Question

- ① Do Group Delay Variations have significant impact on the positioning and navigation of mobile platforms?

### Answer

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## Motivation

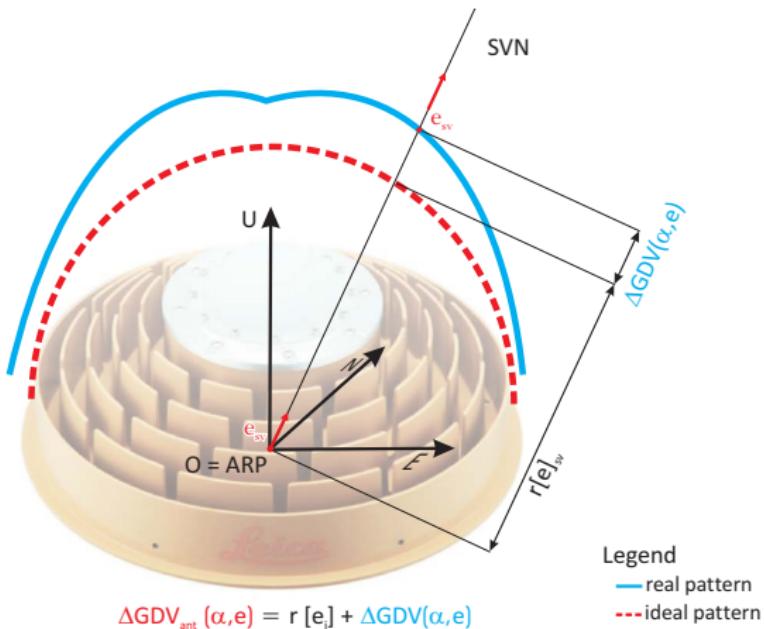
### Question

- ① Do Group Delay Variations have significant impact on the positioning and navigation of mobile platforms?
- ② Why is there no concrete answer?

### Answer

- ① Yes and No!
- ② The correct answer depends on various conditions:
  - ▶ GDV is an antenna specific effect
  - ▶ GDV is an interaction of antenna and receiver
  - ▶ depends on the type of calculation

## GNSS Antenna and Group Delay Variations (GDV)



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### Objective

Determination of code delays caused by the **antenna**.

## GPS C/A and P1(Y) Group Delay Variations of several Antennas



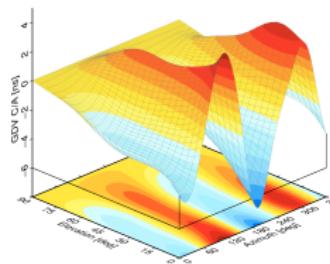
(1)  $\mu$ blox ANN-MS\_GP



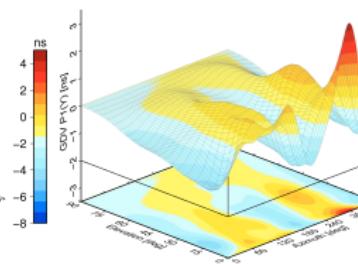
(2) Ashtech ASH700700.B



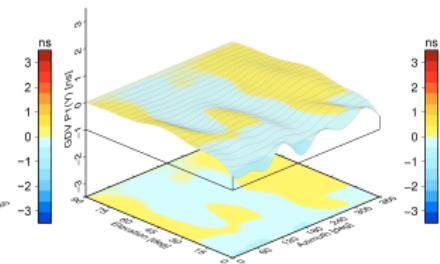
(3) Leica AX1202GG



(4) C/A:  $-6 \text{ ns} < \text{GDV} < +6 \text{ ns}$



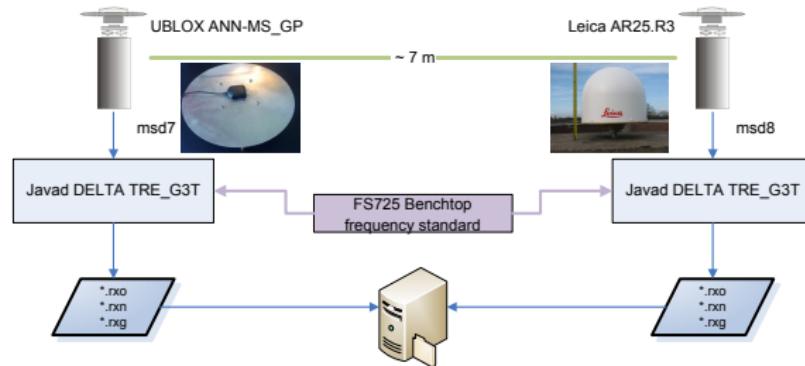
(5) P1:  $-2 \text{ ns} < \text{GDV} < +3 \text{ ns}$



(6) P1:  $-1 \text{ ns} < \text{GDV} < +1 \text{ ns}$

**Figure:** Retrieved GDV from C/A and P1(Y) code observable for navigation antennas. Large variations were expected from static experiments and can be determined for C/A code on the  $\mu$ BLOX antenna.

## Application on Static Positioning - Observation Domain



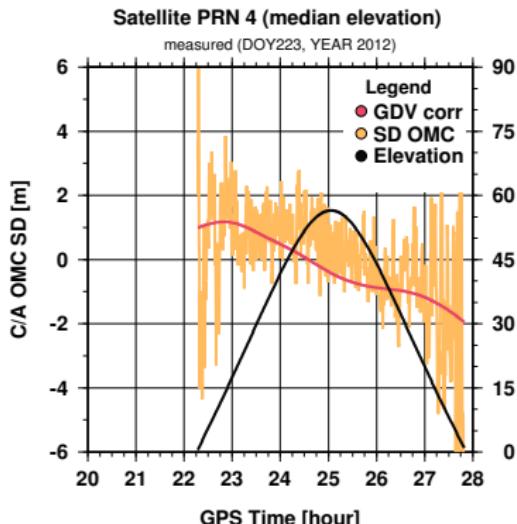
### Parameter

- ▶ common clock (CC) on short baseline (SB), GPS only, @1 sec data interval for DOY223-225, Year 2012
- ▶ changed antenna orientation on DOY224, 2012 to +240° (divide GDV from far field multi-path)
- ▶ validation via Single Point Positioning (SPP) software, w/o GDV, phase smoothed pseudo-ranges; software developed at IfE

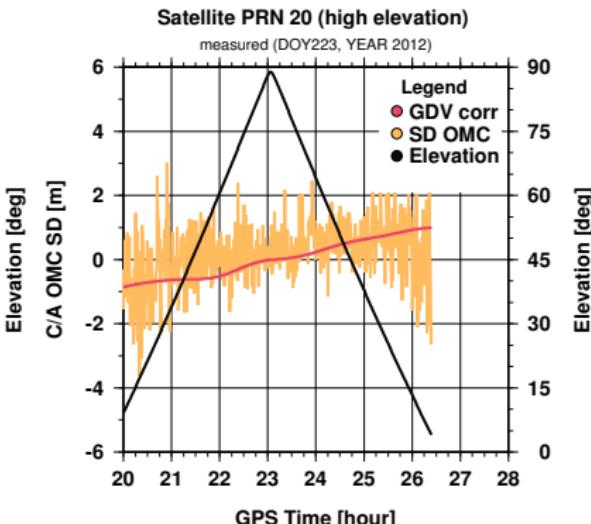
## Application on Static Positioning - Observation Domain

### Observed Minus Computed (OMC)

- ▶ Single Differences (SD) on a short baseline on DOY223, 2012



(1) μBlox ANN-MS\_GP

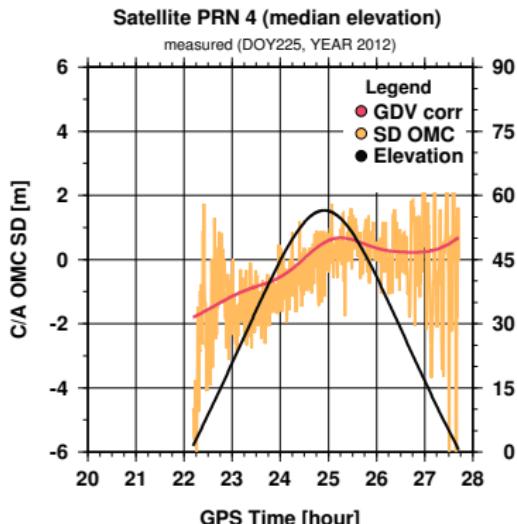


(2) μBlox ANN-MS\_GP

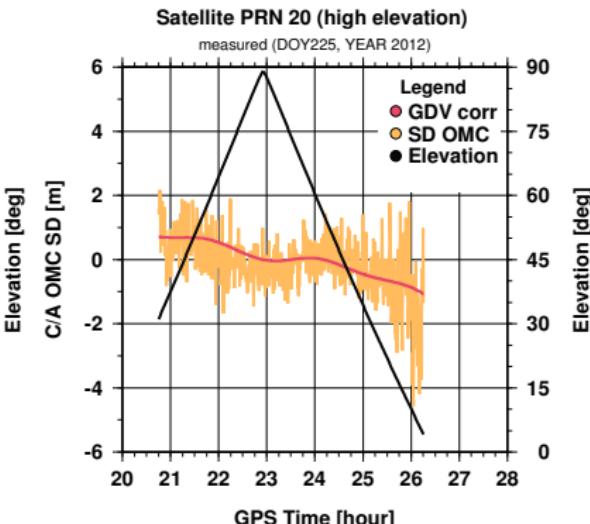
## Application on Static Positioning - Observation Domain

### Observed Minus Computed (OMC)

- ▶ Single Differences (SD) on a short baseline on DOY225, 2012

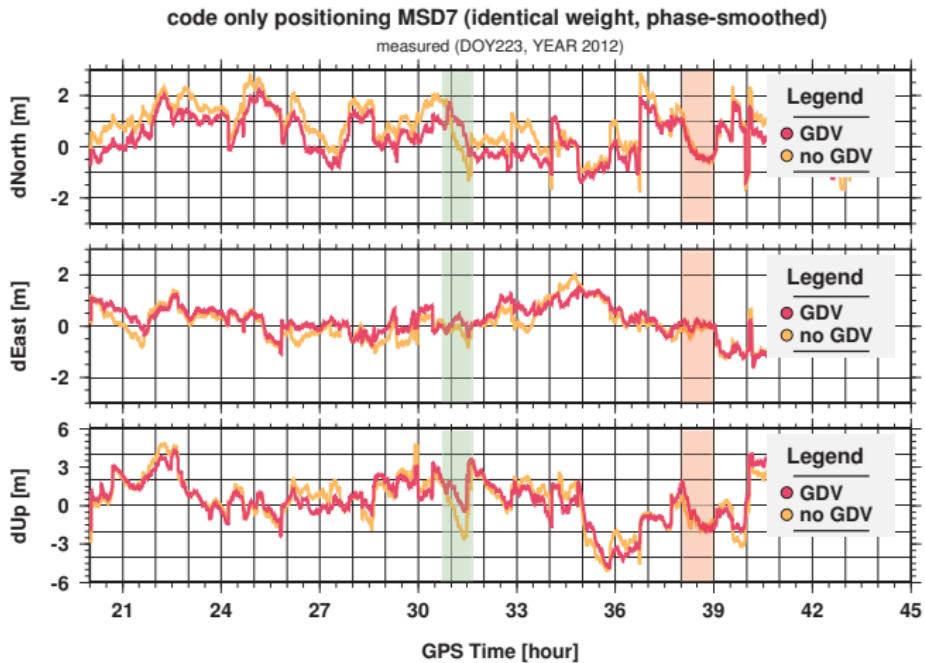


(3) μBlox ANN-MS\_GP



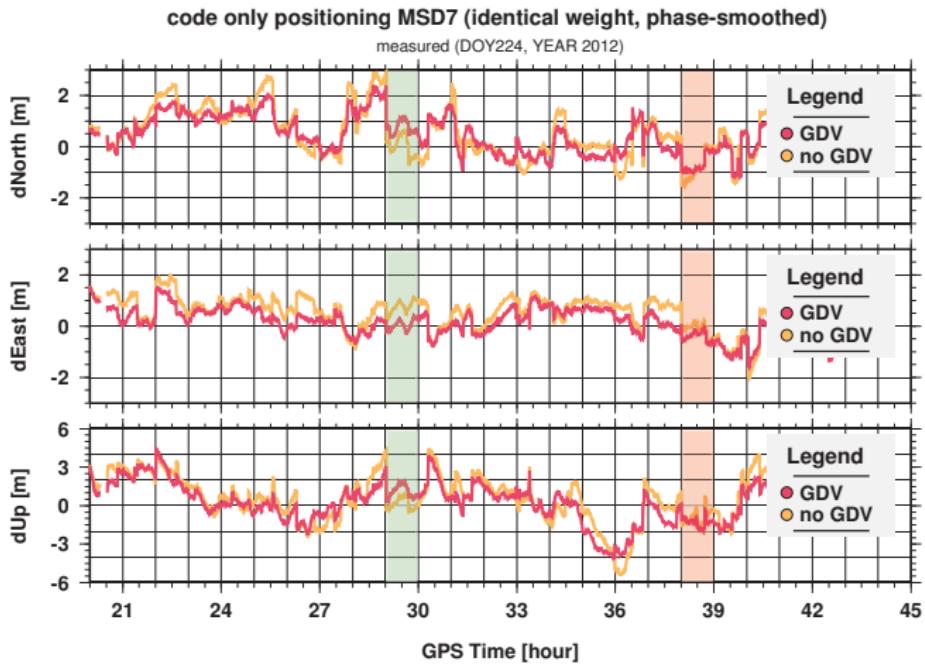
(4) μBlox ANN-MS\_GP

## Application on Static Positioning - Position Domain



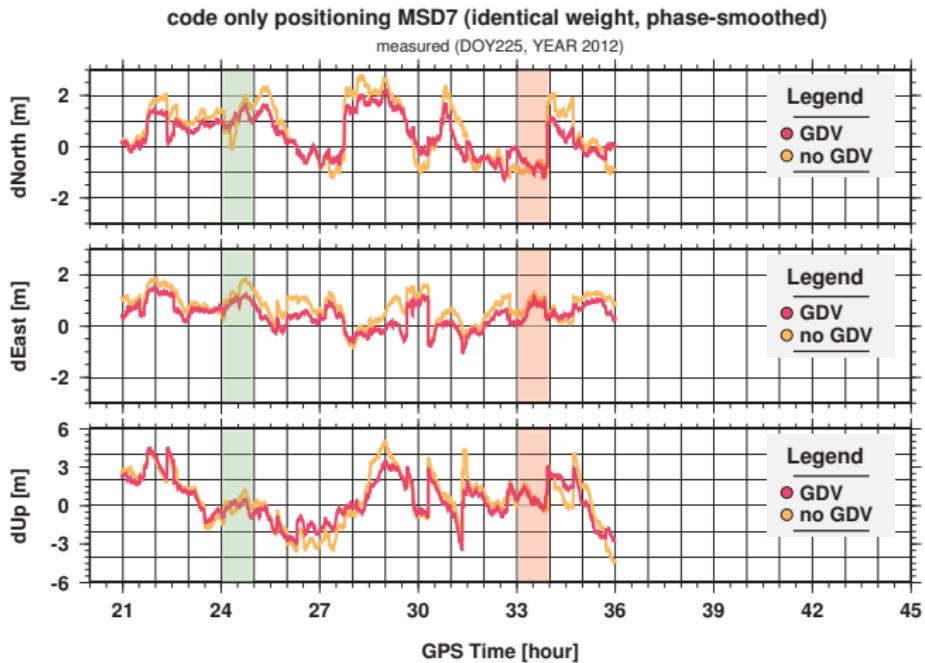
(1) μBlox ANN-MS \_ GP, DOY223, 2012

## Application on Static Positioning - Position Domain



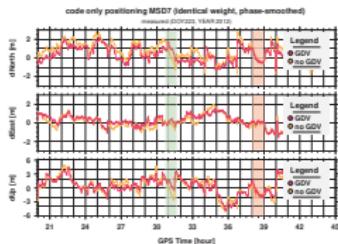
(2) μBlox ANN-MS \_ GP, DOY224, 2012

## Application on Static Positioning - Position Domain

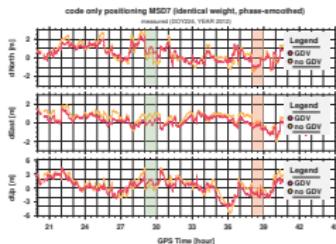


(3) μBlox ANN-MS \_ GP, DOY225, 2012

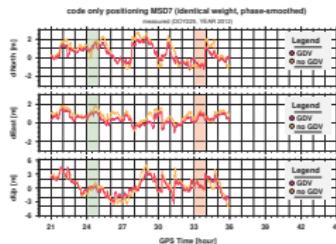
## Application on Static Positioning - Position Domain



(1) DOY223, 2012



(2) DOY224, 2012



(3) DOY225, 2012

### Summary

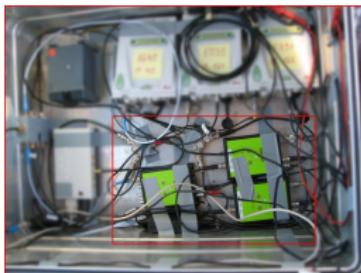
- ▶ improvement by GDV consideration
  - ▶ up to 1.8 m in north and up component
- ▶ repeatable improvement for RMS of time series
  - ▶ 0.1-0.2 m (+10%) for north and east component
  - ▶ 0.2-0.3 m (+15%) for up component
- ▶ further improvements for differential GPS (code based) presented in conference proceedings<sup>1</sup>

<sup>1</sup>Kersten T., Schön S.: Analysis of IfE-Robot based Group Delay Variations for the Positioning and Navigation of Mobile Platforms. In *Proceedings of the European Navigation Conference 2013 (ENC2013)*, 23-25. April, Vienna, Austria, 2013.

## Application on Kinematic Positioning - Set-up



(1) antennas mounted on roof



(2) TRE\_G3T receiver

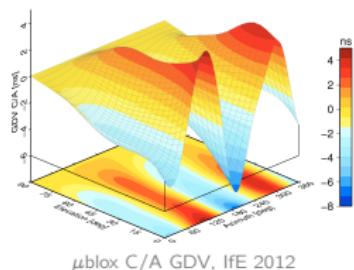
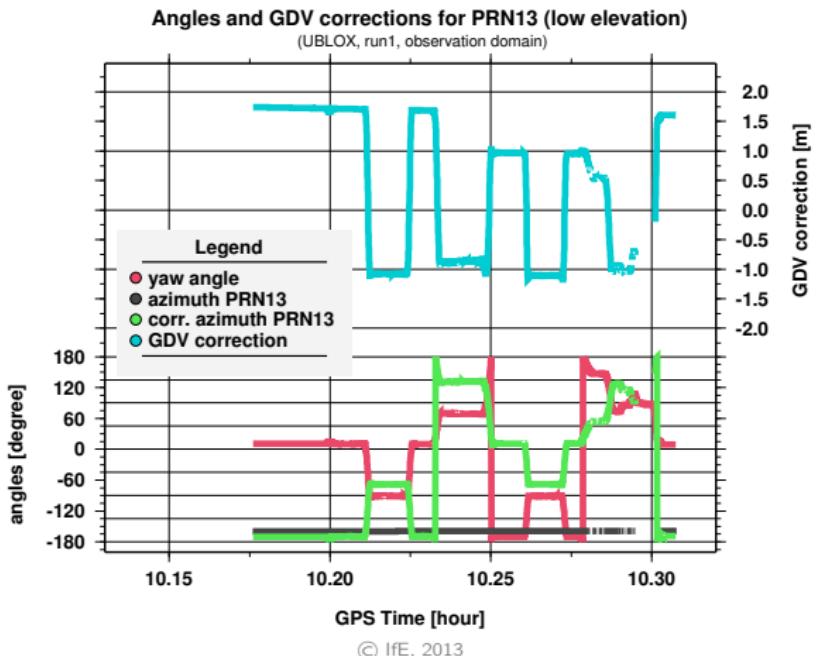


(3) Test field in Ahlten (City of Lehrte/Hannover)

### Method

- ▶ 3 different antennas to collect 3 trajectories simultaneously
- ▶ identical receiver (Javad Delta TRE\_G3T) @ 1 sec data rate; using internal receiver clocks
- ▶ IGI CCNS (computer controlled navigation system, IGI Systems GmbH) determines attitude  $\alpha_{nav}$  of mobile platform

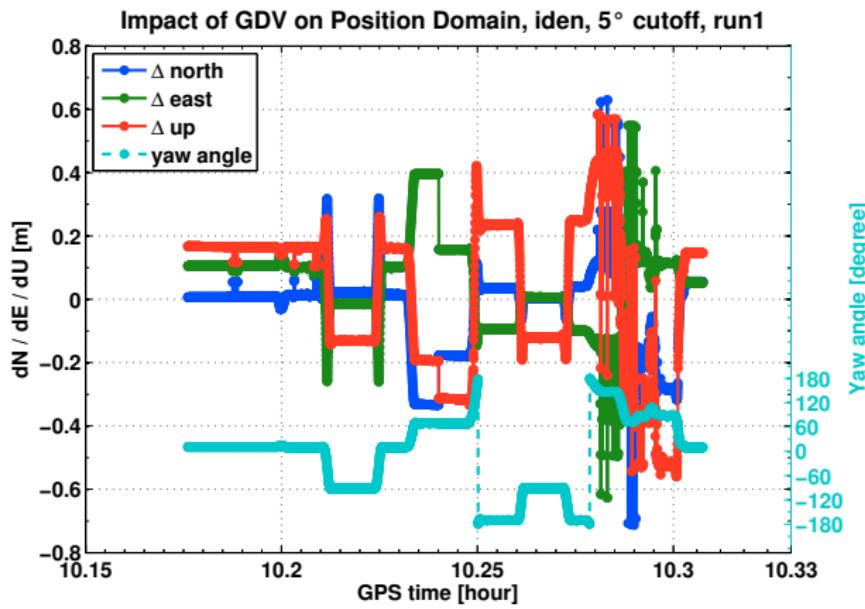
## Application on Kinematic Positioning - Observation Domain



## Application on Kinematic Positioning - GDV Impact on Position Domain

Difference of kinematic trajectories (w/o GDV consideration)

- exemplarily calculated for  $\mu$ Blox antenna



## Conclusions | Outlook

### Conclusions

- ▶ GDV are antenna specific and determinable by the Hannover concept of absolute antenna calibration
  - ▶ azimuthal variations of up to 6 ns can be (repeatable) detected
  - ▶ GDV not only a function of antenna but also of the used receiver
- ▶ consideration of GDV on static SPP improves coordinates
  - ▶ in parts of up to 1.8 m for north and up component
  - ▶ RMS of time series by 0.2 - 0.3 m ( $\approx 20\%$ ) in north and up component
- ▶ improvement for kinematic SPP near below the C/A and P1(Y) code noise (0.3 m)

### Outlook

- ▶ new signal generations (E5a,b AltBOC) will decrease code noise, so GDV will become more important
- ▶ external clocks can improve signal tracking quality and decrease observation noise, e.g. CSAC (chip scaled atomic clocks) for navigation approaches
- ▶ GDV could improve Ambiguity fixing, esp. for Precise Point Positioning (PPP)

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