Which positioning terminal for which application ? The Sensitivity Analysis

High Quality Positioning: a Key to Success for Autonomous Driving

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Introduction

- The main objective was to test how the errors of the positioning terminal influence the performance of the ITS application using it

- Two ITS applications were selected, considered to be particularly sensitive to errors in the positioning terminal:
  - eCall
  - Road User Charging

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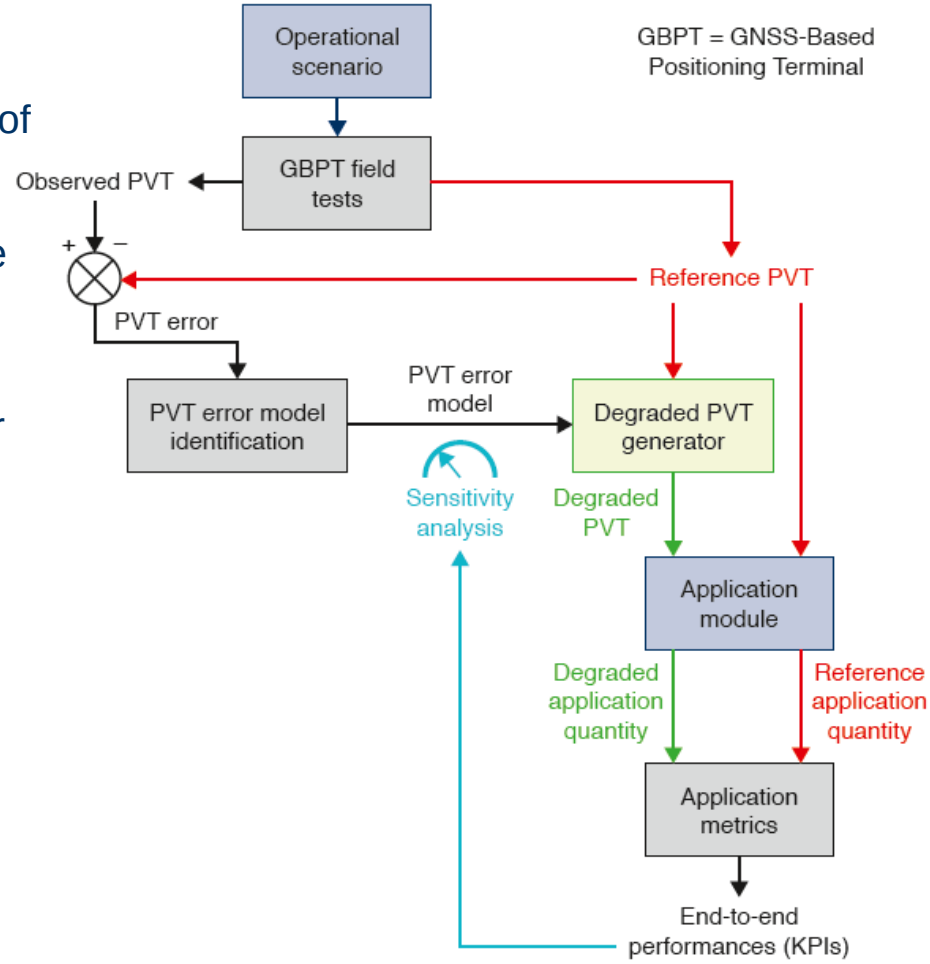
Methodology

- The PVT error model developed as part of SaPPART activities was used
- Several degradations of positioning were created for a set of reference points acquired during a SaPPART STSM
- Software simulations were developed for each application to replicate their behaviour either at a global level or for certain sub-modules
- KPIs were defined for each application
- The simulations were fed with the reference points and with the degraded points and the KPIs were measured



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eCall application

- Map-matching at the Public Safety Answering Point – PSAP was simulated
- Two positioning scenarios were analysed: road junctions and parallel streets
- The most important KPIs:
  - Integrity: percentage of correct road positioning (KPI2)

  This KPI measures whether or not the position of the cloned point is matched to the correct road/street, regardless of the longitudinal distance (along the road) from the matched position of the reference point on that road

  - Average absolute error of the longitudinal positioning along the road (KPI3)

  For the cases with correct road positioning, the longitudinal error in metres with respect to the matched position of the reference point is calculated. The arithmetic mean of the values is then calculated.

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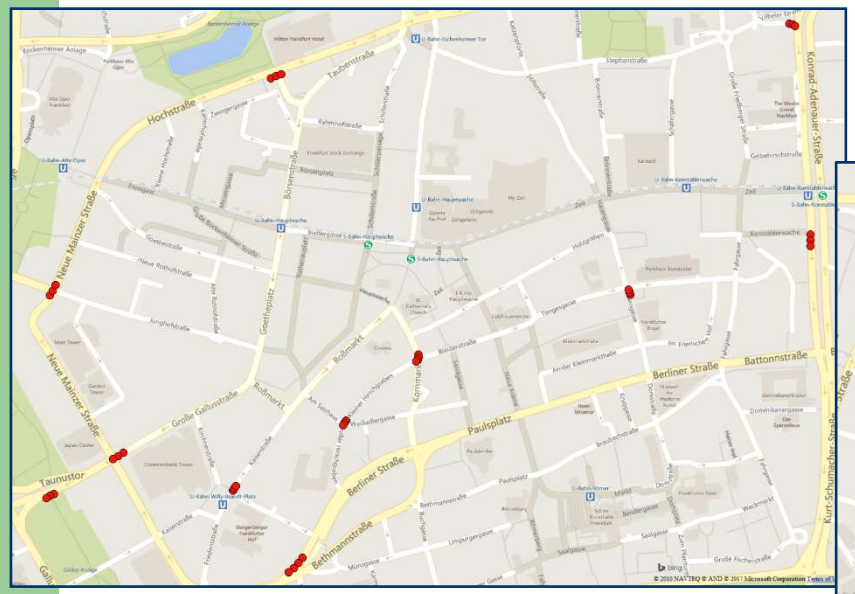
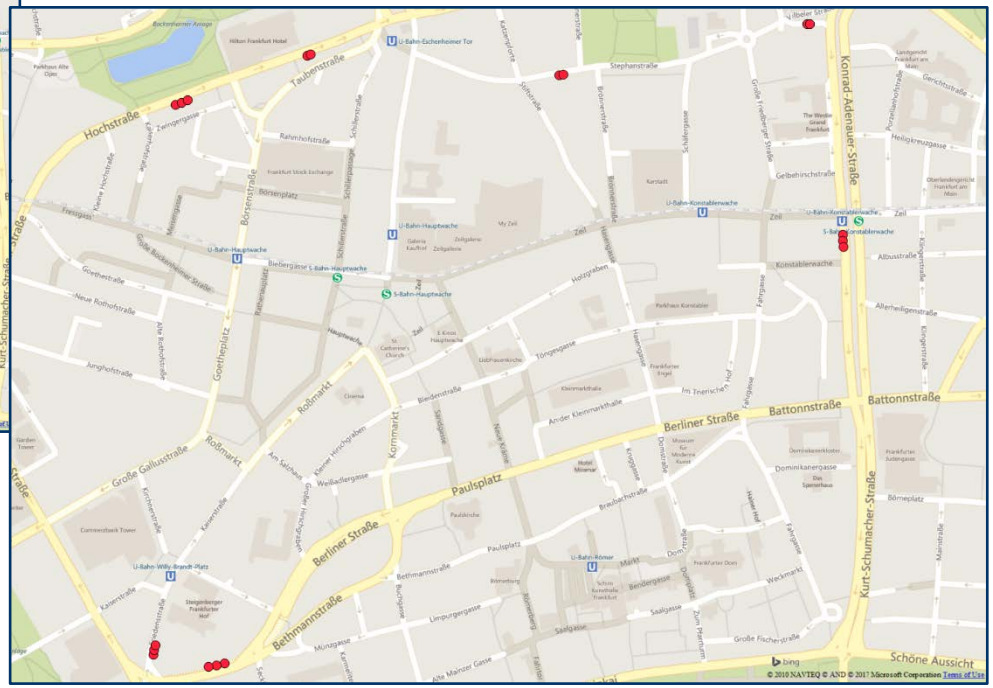
eCall application



Reference points for the junctions scenario



Reference points for the parallel streets scenario

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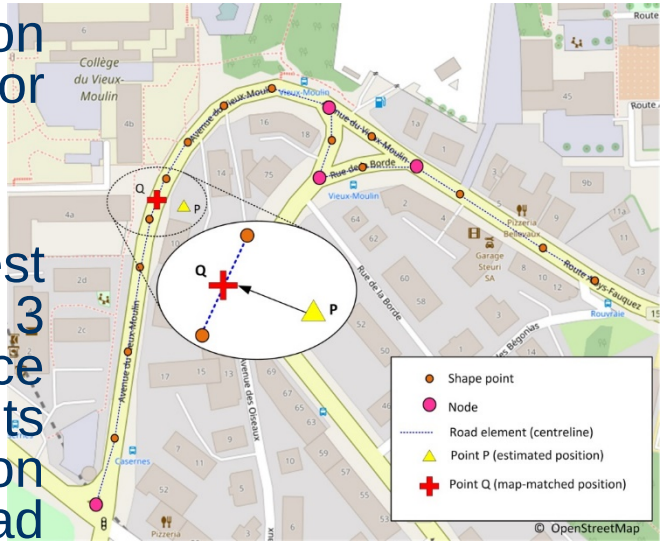
eCall application

- The performance depends significantly on the configuration of the site, especially for the junctions scenario.
- The ratio between the worst and best scenario varies between a factor of 2 to 3 for integrity (KPI2). Also, the performance of KPI2 is globally quite poor, the results being as bad as 32% for the worst junction case and 60% for the worst parallel road case, at the 1st level of degradation.
- The values of KPI3 (longitudinal error) are far more acceptable, varying between 7m and 35m. These numbers are totally acceptable for a rescue team arriving in the correct street



The principle of map-matching

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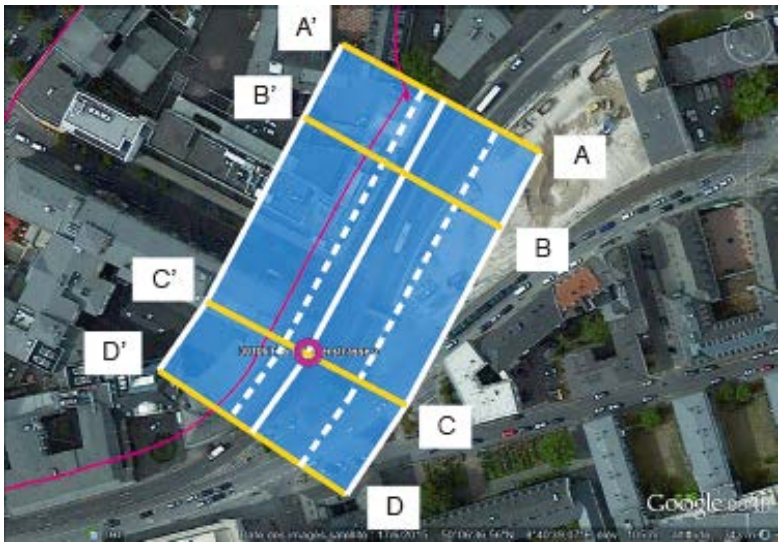
RUC application

- The behaviour of geo-fencing virtual gantries was simulated. The gantries detect entry/exit in/out of the charging area
- The following KPIs were measured:
  - Correct Charging Rate (CCR)

$$CCR = \frac{\text{Total Nb Correct Detections}}{N \times \text{Ref Nb Correct Detection}}$$

  - Over Charging Rate (OCR)

$$OCR = \frac{\text{TotalNbFalseDetections}}{\text{TotalNbChargingEvents}}$$



Defining virtual gantries

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RUC application

- The Correct Charging Rate remains high and stable for the first two levels of degradation but follows a negative exponential curve from the third
- For the Over Charging Rate, the same negative exponential trend is observed, but it is inverted this time, right from the first level of degradation
- The two KPIs converge towards the asymptotic values of 76% and 7.5% respectively when the level of degradation is artificially increased to extreme levels that will never be observed in reality. This tends to prove that the whole system achieves the minimum performance level, whatever the receiver.

Example of false detection

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Which positioning terminal to choose ?

- The sensitivity analysis showed that all applications were influenced by the positioning errors
- The performance of the ITS applications can be highly degraded in certain cases. Therefore in the design phase the specifications of the positioning terminal should be well understood and analysed
- It is not straightforward to define required positioning performance for a given application without performing this kind of study before. Further work can be done to get more precise results by:
  - Developing more accurate application simulations
  - Developing more complex GNSS error modelling

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THANK YOU FOR YOUR ATTENTION !

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