Field Tests of INTEGRAIL

Final Presentation on 21/04/2004
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Overview of Field Tests

- **Main tests at LogServ in Austria**
  - Long term test from end of February until beginning of November 2003 with some maintenance interruptions
  - EGNOS was not always available (in mountain area and sometime no broadcast via AOE-O due to ESTB tests)
  - Digital route map as virtual true reference for validation of INTEGRAIL performance
  - DGPS reference measurements undertaken in May and in November 2003 for updating digital route map

- **Additional tests at SNCB in Belgium**
  - Long term test from end of August until end of November 2003 with some maintenance interruptions at SNCB
  - Reference for evaluation: Crocodile (similar to balise but without ID)
Test Vehicle at LogServ
Installation (outside)

- GSM Antenna
- GNSS Antenna for Mobile Unit
- GNSS Antenna for reference measurement
- Odometer
Installation (inside)
Test Site at LogServ in Linz

- Combination of different areas (work premises, city, mountain, ...)
- Regular operation (two journeys Linz<->Styrling per day)
Test Area of the Steelwork Premises

Rough environment
with multi-path and shadowing

Complex rail routes
with many parallel tracks and switches

Data base (provided by LogServ)
with high relative accuracy

Data base update
eliminating the offset to WGS 84
by measurement of the existing reference point
Accuracy of the updated Route Data Base confirmed by Carrier DGPS Tests

Novatel results of 21/05/2003 on the updated map
Route Data Base for the Outside Area

- **Commercial digital map**
  - not all tracks in the data base
  - accuracy of 10-30 m
  - some track construction changes not recorded in the commercial digital map

- **Update by the reference measurements using carrier DGPS in May and November 2003**
  - estimated accuracy of the tracks measured: 20 cm
  - not all tracks and points could be covered by the reference measurements
Validation of GNSS I based Train Location

- **GNSS I**
  - positioning accuracy mostly less than 3 m if no multi-path and serious shadowing
  - EGNOS signal may be unavailable in mountain area
  - EGNOS signal may be lost by slanting antenna at curves

- **Aiding sensors**
  - Odometer used: good relative accuracy (no significant slip/slide under normal conditions)
  - Accelerometer: good short term relative accuracy, no slip/slide but drift on speed and distance measurement
  - Angular Rate Sensor: good mid-term relative accuracy

- **Sensor fusion**
  - improvement of availability, accuracy and integrity of train location with respect to the individual sensors
Example of GNSS I Accuracy (8 journeys from different days)

multi-path influence
Distance Accuracy measured by Aiding Sensors

- **Odometer**
  - 300-500 m inaccuracy over 140 km (observed at return journeys with start and end at the same position)
  - relative accuracy better than 1% under normal conditions

- **Accelerometer**
  - quite constant drift within 1 minute
  - distance measurement of accelerometer (calibrated by GNSS) vs. distance measured by odometer: < 2% (generally < 1%)
Example of Angular Rate Sensor Drift
Example of Sensor Fusion Improvement

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Wrong position after shadowing due to memory effect

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Position of sensor fusion

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True trace

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High way bridge
Example for Difficult Track Detection (1)

Initialization phase in areas with parallel tracks:

- multi-path error may be great in standstill phase

- aiding sensors can only provide support after initialization
Example for Difficult Track Detection (2)

Shunting area with high accuracy requirement on both

- angular measurement.
- distance measurement.

Very difficult for reliable track detection
Additional Tests at SNCB

- E-locomotive
- Analog odometer signals
- Crocodile brush under each cabin
- Mainly operating between Brussels and Luxembourg

- Commercial map with accuracy of about 30 m (mainly limited in area Brussels – Luxembourg)
- Not all tracks available in the data base
- No geographical position data for crocodile available
Evaluation using Crocodile Events

▪ Event generated when passing crocodile
  • no ID but different voltage levels indicating advance signal
  • GNSS positions calculated to the events considering synchronization and lever arm

▪ Identification of the events belonging to the same crocodile
  • classification of GNSS positions to the crocodile events
  • determination of crocodile positions by statistical evaluation

▪ Evaluation of along track location performance
Conclusion

- **GNSS I**
  - Positioning accuracy with EGNOS without serious multi-path and shadowing
    => sufficient for rural line (single line as most part)
    => insufficient for areas with many parallel tracks
  - EGNOS should be augmented by terrestrial communication in mountain area

- **Aiding sensor for distance is necessary**

- **Aiding sensor for direction is recommended for supervision.**
  For reliable track detection, other information like points status may be needed.

- **Initialization phase of train location shall be treated carefully**

- **Accurate route date base: key component of integrity performance**