Localisation in the railways

- Passenger information, freight customers information…
- Fleet management
- Traffic management (control-command, signaling)
- Level crossings management
- Protection of workers on tracks
- Infrastructure monitoring (defaults localisation)
- …
Pos. requirements

- Train protection
- Track protection
- Train tilting
- Train integrity
- Power supply
- Infra. inspection
- Maintenance
- Tracking and tracing
- Passenger info.

Accuracy

- Time to Alarm:
  - < 1s
  - 1s < Alarm < 10s
  - > 10s

Discrete pos. req.
Cont. pos. req.

Today

Equipment placed on the infrastructure

Example of a track circuit

⇒ Large maintenance costs!
GNSS Benefits for rail. Ex1

- European harmonization

GNSS Benefits for rail. Ex2

⇒ From fix block to moving block

Continuous positioning, variable speed, variable speed profile…
Promising applications

- GNSS contribution to rail
  - More flexibility with the object to localise (train or wagon)
  - Moving block = traffic enhancement
  
- Costs reduction (permit to save low traffic density lines from closure)

GNSS existing applications in Europe (ex.)

Gédéon, SNCF tool for the tracking of freight

Tr@in-MD, SNCF project, dangerous goods wagons traceability
GNSS existing applications – in the USA

- Use of the NDGPS by the « federal Railroad Administration »
- The DGPS is an essential component of the PTC, *Positive Train Control*.
- Elimination of wayside block signal systems

Safety policy

- A new equipment has to be certified according to railway safety standards
- For safety applications, the solution shall prove it is « GAME » (*Globalement au moins équivalent* – as good as the previous one)
How to guarantee the safety?

By using a risk management process

1. Identification of dangerous failures
2. Estimation using RAMS methods
3. Control

Safety integrity

- Safety objectives are defined by SIL (Safety Integrity Level)
  - SIL1 to SIL4
  - ex.: a SIL 3 is affected when a risk of injury exists
  - a SIL 4 for a risk of death

- SIL requirements are often defined by limit values called THR Tolerable Hazard Rate (dangerous failure probabilities/hour)
From the railway function to GNSS requirements

- SIL affected to a system or function, distributed in the subsystems

A THR (1.0*10^-9 failure/hour) is defined in the specifications of the « control command and signalling » subsystem ➔ ex. SIL4

The GNSS sub-system

For the localisation function: a failure occur when the position is considered « incorrect »

AT USER LEVEL

Accuracy limit (ex.: 10 meters)

Degradations too large

Degradations acceptable
Unacceptable event (ex)

Integrity in the GNSS

- The integrity concept in the GNSS community (close to OACI def.)

“Integrity is a measure of the trust which can be placed in the correctness of the information supplied by the total system. Integrity includes the ability of a system to provide timely and valid warnings to the user (alerts) when the system must not be used for the intended operation (or phase of flight)”

No integrity with GPS!
Integrity data in GNSS

⇒ The EGNOS added-value

Integrity flag

- Use
- Don’t use

• Failure identified by the (spatial) system
• Exclude satellites

Protection level

- Born common mode errors
  - Compute a protection level around the estimated position

- At the receiver level
- Alert the user

Protection level

AL has to be defined in specifications (ex: 20m)

- If PL > AL: non usable position
- If PL < AL: position OK

Always associated to a residual risk
SIL vs GNSS

- GNSS specifications ≠ SIL def.
- GNSS spec. are defined for “free of obstacles” areas. Local propagation phenomena are not taken into account by actual integrity processes.
- GNSS is not certified and will have to be validated according railway standards for safety use.

Challenges

- How to take into account of the GNSS integrity process in the RAMS study?
- How to integer the local propagation effects in RAMS studies?
Past projects in Europe

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Start</th>
<th>End</th>
<th>Funding</th>
<th>Comments</th>
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<tbody>
<tr>
<td>APOLO</td>
<td>1999</td>
<td>2001</td>
<td>5th FP</td>
<td>Low density traffic, ERTMS compatibility</td>
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<td>GADEROS</td>
<td>2001</td>
<td>2004</td>
<td>ESA</td>
<td>EGNOS in ERTMS, multisensor system</td>
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<td>INTEGRAIL</td>
<td>2001</td>
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<td>LOCOPROL</td>
<td>2001</td>
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<td>Low density traffic, ERTMS compatibility, dedicated GPS algorithm</td>
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<td>LOCOPLOC</td>
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<td>Complementing LOCOPROL</td>
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<td>ECORAIL</td>
<td>2001</td>
<td>2005</td>
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<td>Level crossing management with EGNOS</td>
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<tr>
<td>RUNE</td>
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<td>2006</td>
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<td>GNSS as a virtual balise, safety application with EGNOS</td>
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<td>GEORAIL</td>
<td>2004</td>
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<td>UIC</td>
<td>Requirements for a unique Reference System, data structure and standard interfaces.</td>
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<tr>
<td>GIRASOLE</td>
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<td>Use of SoL Receiver</td>
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<td>GPS-LOC</td>
<td>2005</td>
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<td>SNCF internal project</td>
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<tr>
<td>GRAIL</td>
<td>2005</td>
<td>2007</td>
<td>6th FP</td>
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<td>2006</td>
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<td>France, ANR</td>
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<td>TR@IN-MD</td>
<td>2006</td>
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<td>LOCASYS</td>
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<td>Combined transport demo</td>
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<td>TransLogisTIC</td>
<td>2007</td>
<td>2009</td>
<td></td>
<td>Non exhaustive list…</td>
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</tbody>
</table>

Research in progress

- Analogy between GNSS spec. and RAMS criteria [ETRR2010]
- Modelling the receiver behaviour in a Petri Network to evaluate the effects by simulation [ENC-GNSS2008].
- Real measurement analyses.
Conclusion

- GNSS are certainly a powerful tool for railways!
- Some technical challenges remain (proofs, performances to reach…)
- Some convincing messages to deliver
- A long way…

References:

More…
- George Raymond, Juliette Marais, Marion Berbineau, Innovations Bring Satellite Control within Reach, Railway Gazette International, Déc. 2004, p835-837