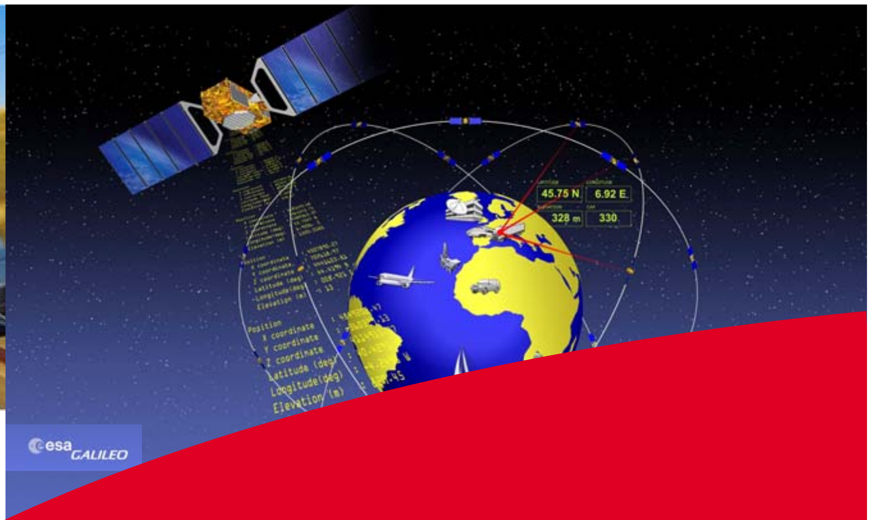

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GNSS and integrity positioning for railway applications

Juliette Marais, INRETS-LEOST
NAVIGARE 30.06.2010, Lausanne

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)
- …

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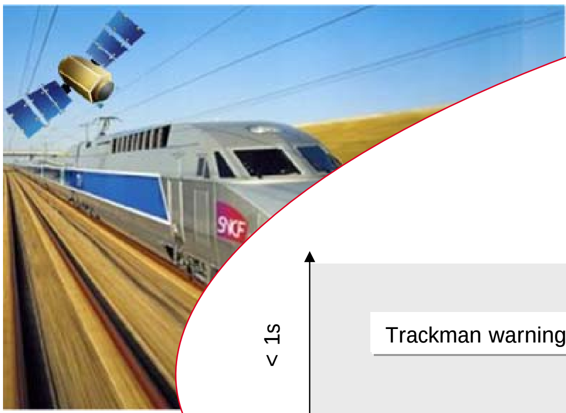
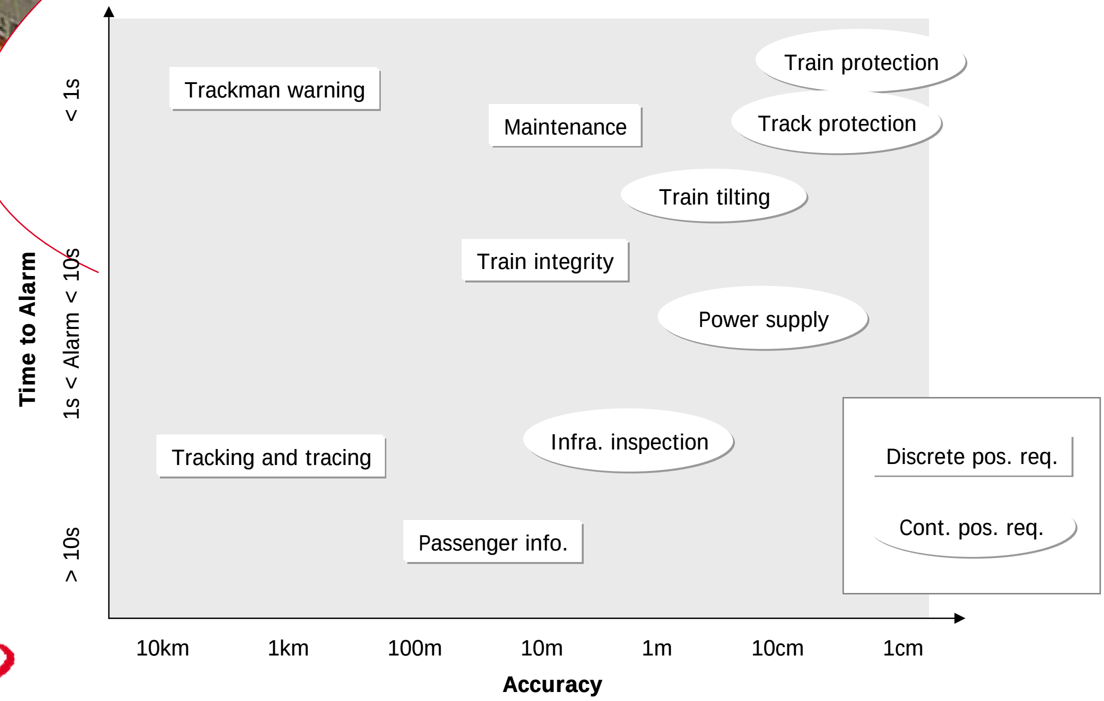


Pos. requirements



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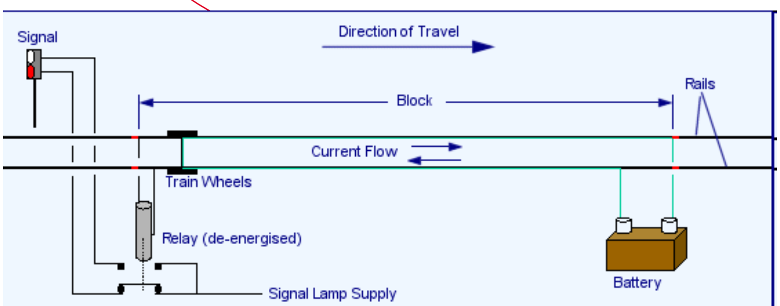
Today

Equipment placed on the infrastructure



Example of a track circuit

⇒ Large maintenance costs!

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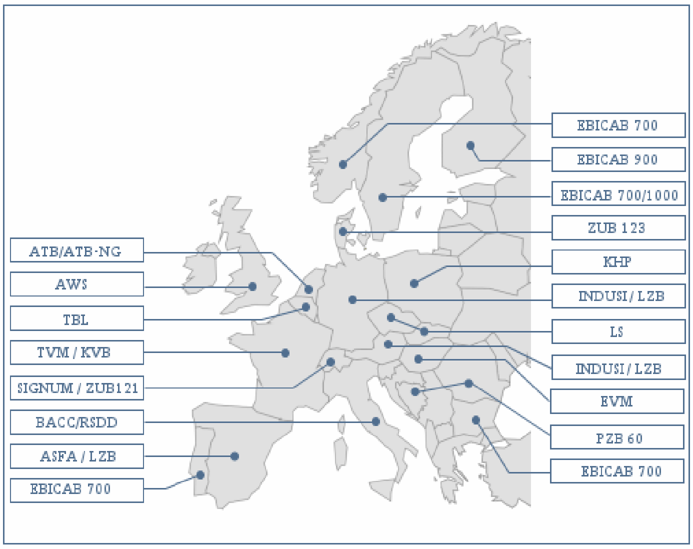
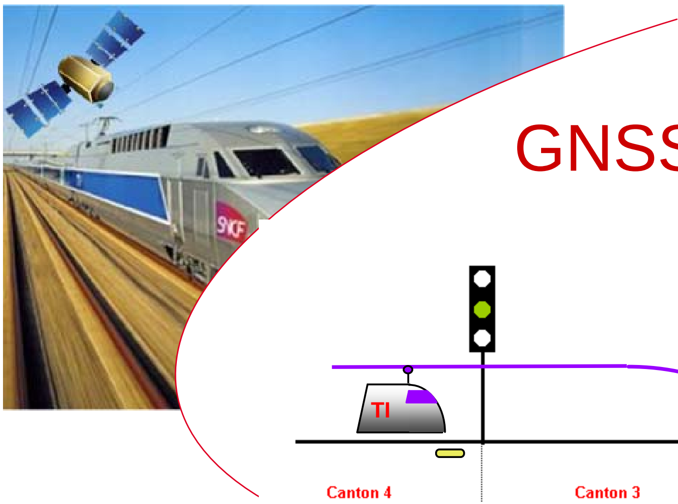
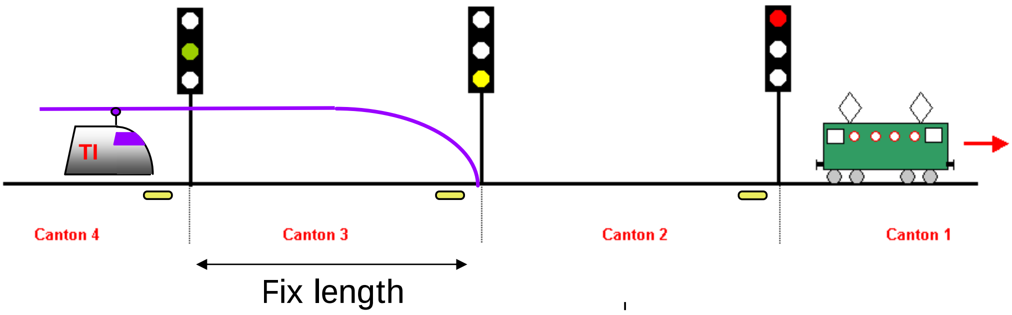
GNSS Benefits for rail. Ex1

- European harmonization

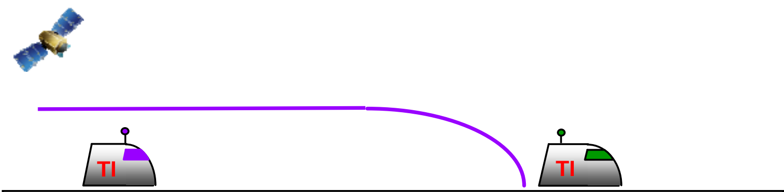




GNSS Benefits for rail. Ex2



⇨From fix block to moving block

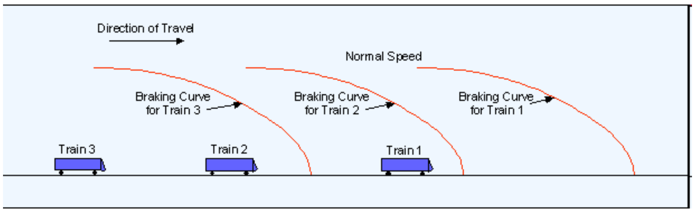


Continous positioning, variable speed, variable speed profile…

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)

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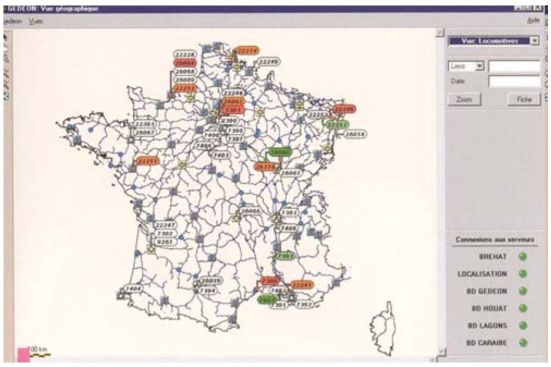
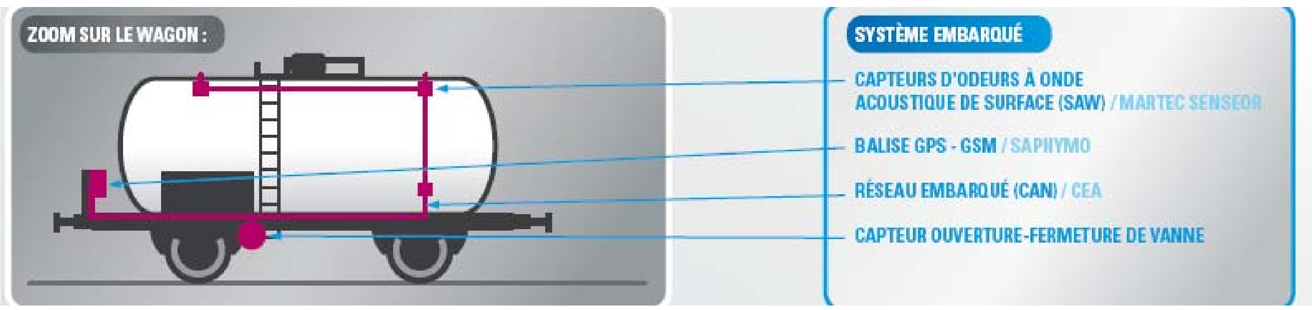
GNSS existing applications in Europe (ex.)

Gédéon, SNCF tool for the tracking of freight

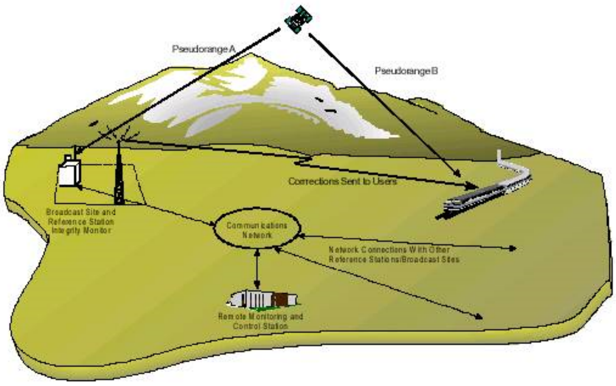


Tr@in-MD, SNCF project, dangerous goods wagons traceability



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



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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)

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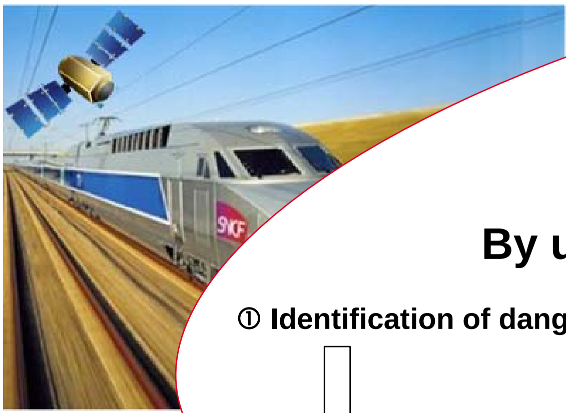


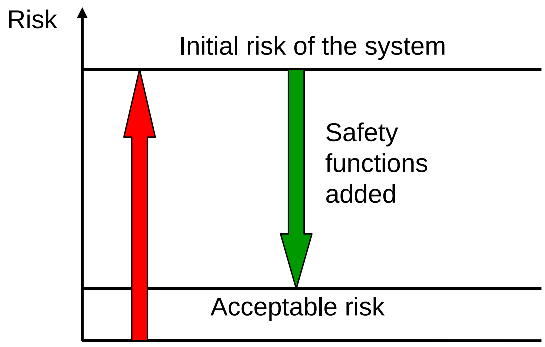
How to guarantee the safety?

By using a risk management process

① Identification of dangerous failures

② Estimation
RAMS methods

③ Control



➔ Safety objectives

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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)

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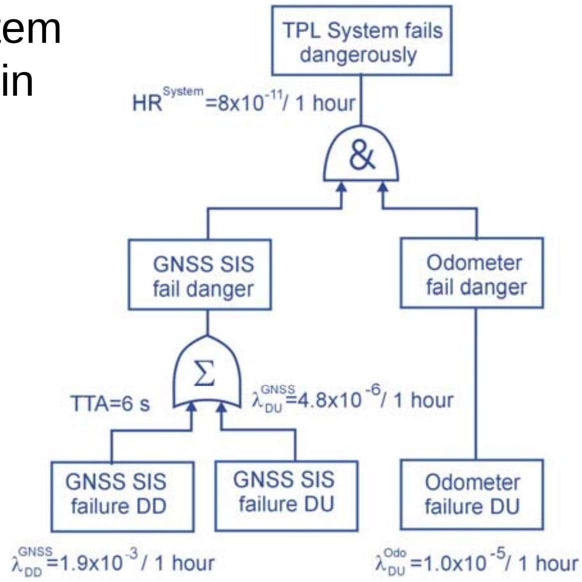
From the railway function to GNSS requirements

- 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



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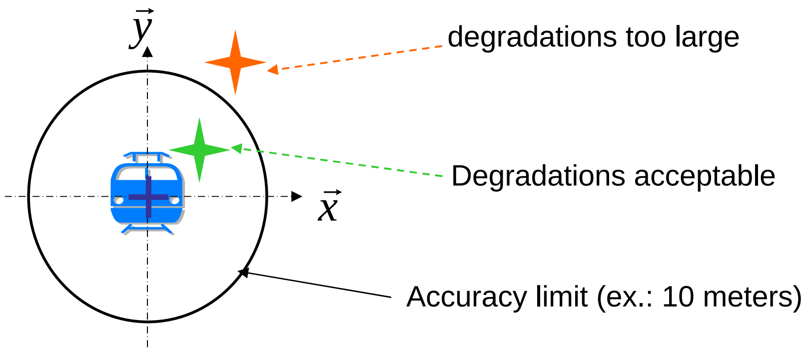
The GNSS sub-system

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

AT USER LEVEL



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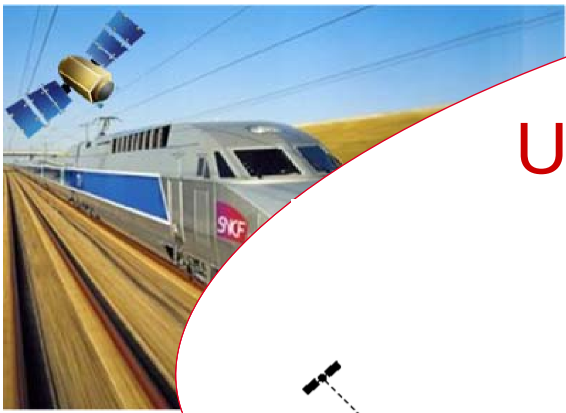
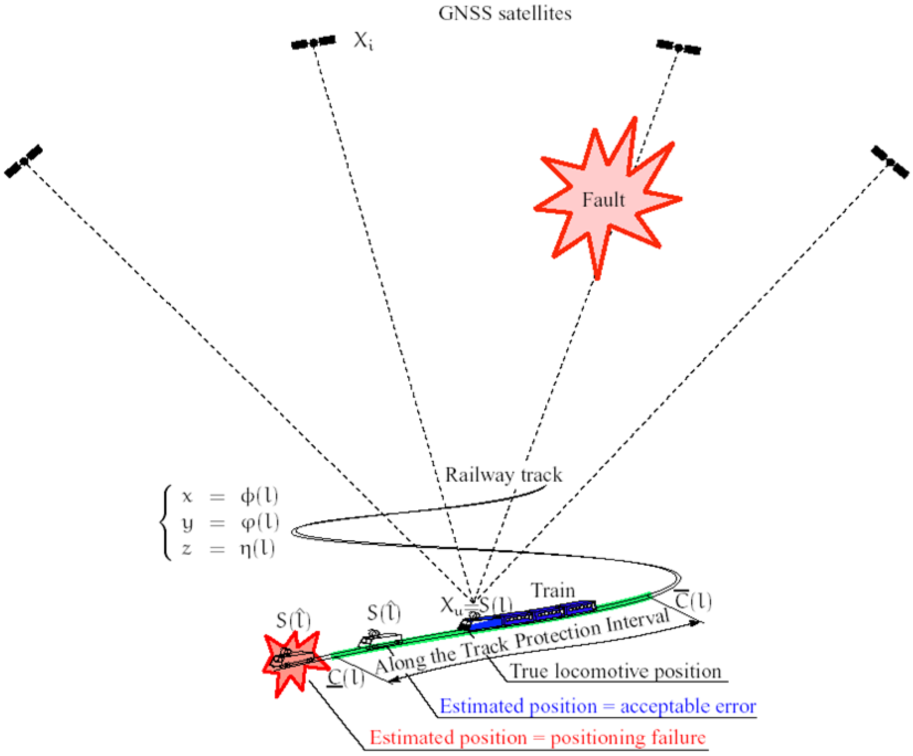


Unacceptable event (ex)



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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!

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Integrity data in GNSS

⇒ The EGNOS added-value

Integrity flag

- Use
- Don't use

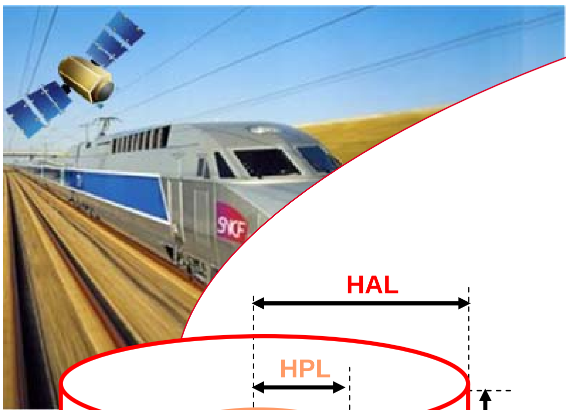
• *Failure identified by the (spatial) system*
• *Exclude satellites*

Protection level

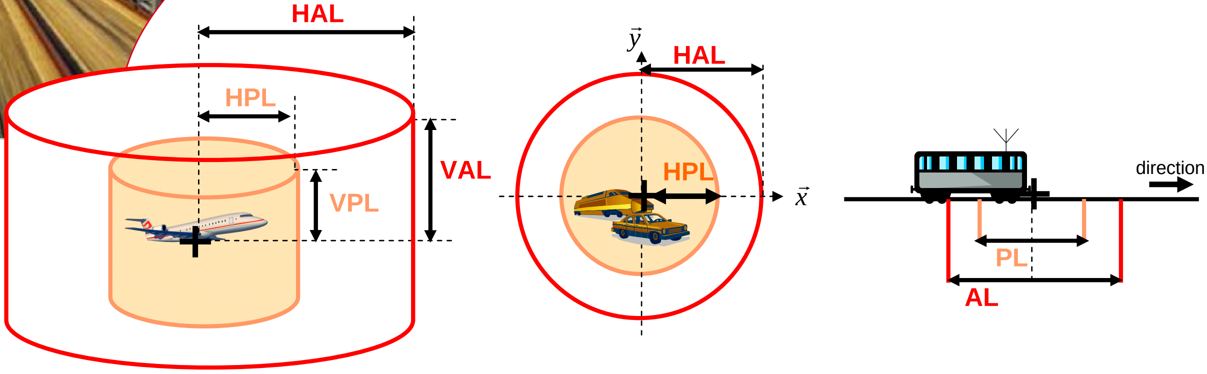
↓ Born common mode errors

↓ 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

Project Name	Start	End	Funding	Comments
APOLO	1999	2001		
GADEROS	2001	2004	5th FP	Low density traffic, ERTMS compatibility
INTEGRAIL	2001	2004	ESA	EGNOS in ERTMS, multisensor system
LOCOPROL	2001	2004	5th FP	Low density traffic, ERTMS compatibility , dedicated GPS algorithm
LOCOLOC			Belgium	Complementing LOCOPROL
ECORAIL	2001	2005	ESA	Level crossing management with EGNOS
RUNE		2006	ESA	GNSS as a virtual balise, safety application with EGNOS
GEORAIL	2004		UIC	Requirements for a unique Reference System, data structure and standard interfaces.
GIRASOLE			6th FP /GJU	Use of SoL Receiver
GPS-LOC				SNCF internal project
GRAIL	2005	2007	6th FP /GJU	
M-TRADE	2005	2007	6th FP	Multimodal transportation
TR@IN-MD	2006	2009	France, ANR	Dangerous goods transportation
LOCASYS	2006	2009	England	« Dependability » study
TransLogisTIC	2007	2009	Belgium	Combined transport demo

Non exhaustive list…

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…

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• **[ENC-GNSS2008]** Julie Beugin, Juliette Marais, Jean-Philippe Lozac'h, A dependability analysis for integrating a satellite positioning system in a rail freight application, ENC-GNSS 2008, Avril 2008, Toulouse

More…

• Ales Filip, Julie Beugin, Juliette Marais, Hynec Mocek, Interpretation of the Galileo Safety-Of-Life Service by Means of Railway RAMS Terminology. International scientific journal Transactions on Transport Sciences, Ministère des transports Tchèques, Vol 1, n°2, p61-68, 2008.

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