DLR

IFS Institut für Verkehrsführung und Fahrzeugsteuerung

Requirements for the use of Galileo in Railway Applications

Dr. Michael Meyer zu Hörste and Prof. Karsten Lemmer

German Aerospace Centre, Institute of Transportation Systems

13. April 2005, Cergal 2005, Braunschweig, Germany

Structure of the presentation

- **Introduction**
- **Classification of GNSS-based applications in railways**
  - Information applications
  - Assistance application
  - Safety-relevant control applications
- **Resulting requirements on GNSS**
  - functional requirements
  - technical requirements
  - operational requirements
- **Conclusion and Perspective**

Introduction

- GALILEO enables the on board localisation in real time of the trains.
- The topologic location and the precise time of the trains is a basic information for different railway applications like operations control or scheduling of trains.
- The new ERTMS/ETCS requires the train to know his own position.

ERTMS: European Rail Management System, ETCS: European Train Control System

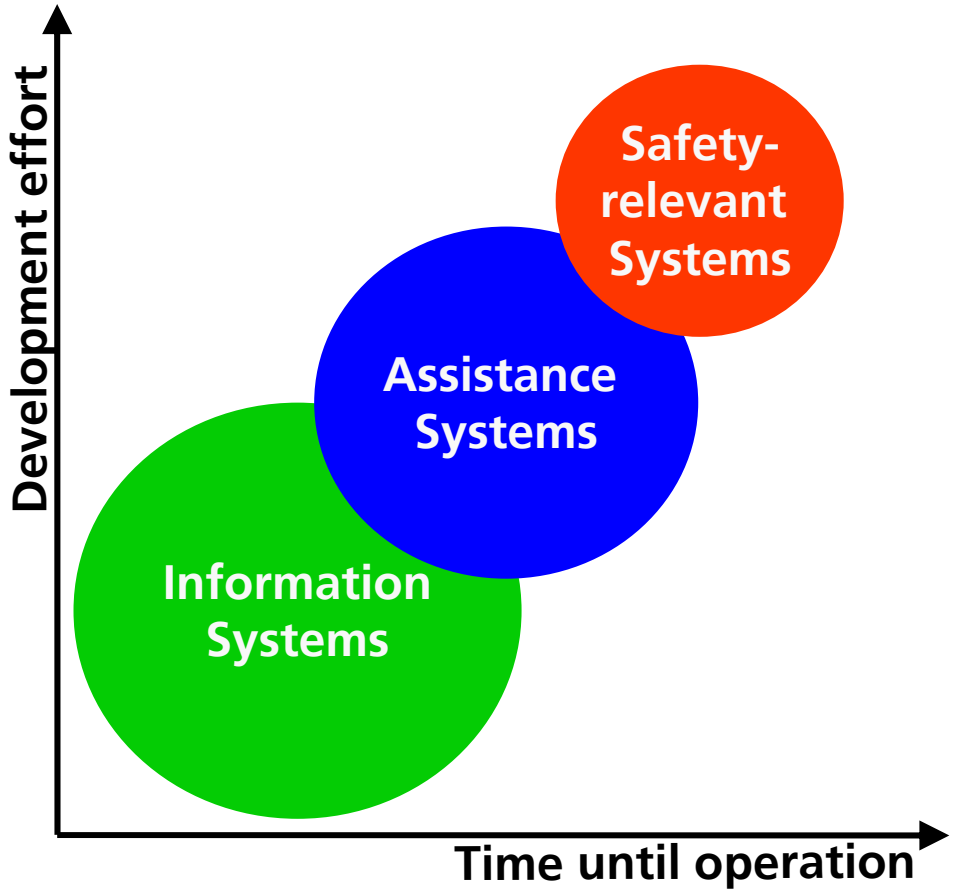
Introduction
GALILEO Characteristics

	Open Service		SOL Service		Public Regulated Service
Frequencies	Single	Dual	Triple		Dual
Time Criticality	-	-	Yes	No	-
Regional Availability	Global		Global		Global
Precision (95%)	H: 15 m V: 35 m	H: 4 m V: 8 m	H: 4 m V: 8 m		H: 6.5 m V: 12 m
Integrity					
Alarm limit	Not		H: 12 m V: 20 m	H: 556 m	H: 12 m V: 20 m
Alarm time	Available !		6 s	10 s	10 s
Integrity risk			1.5e-7/150s	1e-7/1h	3.5e-7/150s
Continuity	8e-6 pro 15 s		8e-6 pro 15 s	1e-4…1e-8 pro h	1e-5 pro 15 s
Time Precision UTC/TAI	Not defined	50 ns	50 ns		100 ns
Certification	No	No	Yes		?
Availability	99.5 %		99.8 %		99 – 99.9 %

Classification of GNSS-based applications in railways

3 Basic Classes:

- Information applications
- Assistance application
- Safety-relevant control systems



Classification of GNSS-based applications in railways – Information applications

Definition:

Applications used to acquire, collect or distribute information about dynamic or static status information of the railway system. They must not interfere with the safety relevant part of the system.

Examples:

- Goods tracking and tracing
- Railway vehicle identification systems
- Network use fees and toll collection
- Service fee collection
- Collection of geo-referenced environmental data
- Etc.

Classification of GNSS-based applications in railways – Assistance applications

Definition:

Applications used to assist a human being by performing the operation of the railway. They can perform safety-related tasks and interact with the safety-relevant part of the system, without being safety-critical by their own.

Examples:

- Advanced Alarm, Search and Rescue (ASAR)
- Support of overhauling whilst in motion in mixed operation
- Energy-optimal driving (locally or network-wide)
- Support of power-optimal driving by wireless intra-train communication
- Telemetry of dangerous goods
- Performance-optimal scheduling
- Etc.

Classification of GNSS-based applications in railways – Safety-relevant applications

Definition:

Applications which are in charge to ensure safe operation of the railways with or without interaction with a human being. To reach the safety target a system with two independent measurement principles is needed.

Examples:

- Railway Operations Control
  - Train Separation
  - Speed and Distance Supervision
  - Route Supervision
  - Train integrity
- Support of time-optimal braking by wireless intra-train communication
- Automatic warning at platforms
- Etc.

Resulting requirements on GNSS

- **The exact requirements are depending on a multitude of parameters:**
  - Type of application
  - Operational characteristics
  - Safety case
  - Etc.
- **Only a first estimation can be given here.**
- **Globally the requirements can be grouped in:**

Functional requirements as:

- Precision
- Performance
- Signal-Integrity
- Data Format

Non-Functional requirements as:

- Safety
- Reliability
- Availability
- Maintainability
- Costs

Resulting requirements on GNSS –
Examples for Information applications

		Generic information application	Goods tracking and tracing	Railway vehicle identification systems	Network use fees and toll collection	Service fee collection	Alarm, Search and Rescue	Collection of geo-referenced environmental data
Precision	X	*100m-1km*	100m	100m	1km	1km	100m	100m
	Y							
	Z	-	-	-	-	-	-	?
	track selectivity	*no (yes)*	no (yes)	yes	no (yes)	no (yes)	no	no
	Performance	*low - medium*	low	low - medium	low	low	medium	low
RAMS	Safety	-	-	-	-	-	-	-
	Reliability	*medium*	medium	medium	medium	medium	medium	low
	Availability	*medium*	medium	medium	medium	medium	medium	low
	Maintainability	*?*	?	?	?	?	?	?
	Cost	*low*	low-medium	low	low	low	low	low

Resulting requirements on GNSS –
Examples for Assistance applications

		Generic assistance application	Advanced Alarm, Search and Rescue (ASAR)	Support of overhauling whilst in motion	Energy-optimal driving (locally or network-wide)	Support of power-optimal driving	Telemetry of dangerous goods	Performance-optimal scheduling
Precision	X	*10-100 m*	10-100 m	10m	10-100 m	10m	100m	100m
	Y	-	10-100 m					
	Z	-	-	-	-	-	-	-
	track selectivity	*yes (no)*	yes	yes (no)	no	no	no	yes
	Performance	*medium - high*	high	high	medium	high	medium	medium
RAMS	Safety	*SIL 1-2*	?	SIL 2	SIL 2	SIL 2	SIL 2	-
	Reliability	*medium*	medium	medium	medium	medium	high	medium
	Availability	*medium*	high	medium	medium	medium	high	medium
	Maintainability	*medium*	medium	medium	medium	medium	medium	?
	Cost	*low-medium*	?	low	medium	low	medium	low-medium

Resulting requirements on GNSS –
Examples for Safety-relevant applications

		Generic safety-critical application	ERTMS/ETCS	Railway Operations Control	Train Separation	Speed and Distance Supervision	Route Supervision	Train integrity	Support of time-optimal braking	Automatic warning at platforms
Precision	X	*10-100 m*	10-100 m	10-100 m	100m	10-100 m	100m	10m	10m	100m
	Y	*(1m)*	1m	1m	1m	1m	1m	-	-	-
	Z	-	-	-	-	-	-	-	-	-
	track selectivity	*yes*	yes	yes	yes	yes	yes	no	no	no
	Performance	*high*	high	high	high	high	high	high	high	medium
RAMS	Safety	*SIL 3-4*	SIL 4	SIL 4	SIL 4	SIL 4	SIL 4	SIL 4	SIL 4	SIL 4
	Reliability	*high*	high	high	high	high	high	high	high	high
	Availability	*high*	high	high	high	high	high	high	high	high
	Maintainability	*high*	high	high	high	high	high	high	high	high
	Cost	*high*	high	high	high	high	high	medium	medium	medium

Conclusion and Perspective

Conclusion

- GNSS can help the railways to become more competitive.
- The different possible applications can be grouped in information, assistance and safety-critical applications.
- Information applications can use GALILEO as the only source of localisation.
- Safety-relevant applications will need a second independent source of localisation.

Perspective

- The certification of GNSS must show the applicable level of safety.
- GALILEO will enable a lot of new or improved applications for railways.

Thank you for your attention!

Questions?