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GLOSSARY

ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
GSM-R	Global System for Mobile Communications - Rail(way)
HS	High Speed
LS	Limited Supervision
MTBF	Mean Time Between Failure
RAM	Reliability, Availability, Maintainability
SEU	Single Equivalent Unit
SIL	Safety Integrity Level
TEN	Trans European Network
THR	Tolerable Hazard Rate
TM	Train Movements
TSI	Technical Specification for Interoperability

Section 1 – EXECUTIVE SUMMARY

The objective of deliverable B 2.1 is the development of a classification scheme for line categories depending on functional and other requirements.
In the context of the INESS project the classification scheme is necessary for the calculation of target costs at a later date. In order to fulfil deliverable B 2.1 different market segments have to be determined since they help to define the specific requirements of an interlocking system.
According to [1] a market segment describes a subgroup of people or organizations sharing one or more characteristics that cause them to have similar product and/or service needs. A market segment meets – according to [2] – the following criteria: it is distinct from other segments (different segments have different needs), it is homogeneous within the segment (exhibits common needs); it responds similarly to a market stimulus, and it can be reached by a market intervention. The term is also used when consumers with identical product and/or service needs are divided up into groups so they can be charged different amounts.
Within the framework of the INESS project market segments are used in order to get a final segmentation of the interlocking market.

Section 2 – INTRODUCTION

According to the description of work, D.B.2.1 should basically sum up the classification scheme for line categories. In a first step different market segments have to be developed since different types of interlocking systems can be found which comply with the requirements of the segments and which have delimitable costs.

To reach that goal, all work stream B members confirmed during the 2nd work stream meeting in Frankfurt, to install an expert group, which concentrates on that issue.

Section 3 – SUMMARY ON CLASSIFICATION SCHEME FOR LINE CATEGORIES

3.1 Market segments – General approach

As explained in abstract two, the line category classification has to be done in relation to the market segmentation of interlocking systems. Therefore, an expert group was founded, which essentially focuses on the different issues in question.

3.1.1 Market segments – Organizational issues to reach Milestone M.B.2.1.

Mr. Brinkmann from DLR/ Germany was in charge of the expert group “Market segments”. His basic task was the coordination of the process development. He had to organize and moderate expert group meetings, telephone conferences etc. and he also had to take care for the final report to the task and work stream leader within the due dates.

“Market segments” expert group members apart from Mr. Brinkmann were Mr. Gosling (Invensys/ Great Britain), Mr. Valerio (Ansaldo STS/ Italy), Mr. Lange (Bombardier/ Germany), Mr. Sagrini (RFI/ Germany). Essentially, all expert group members had to work on the issues in question and they also had to support Mr. Brinkmann regarding any content and organizational issues.

3.1.2 Market segments – Results

In the following, there is a monthly overview of results that are committed by all work stream members:

2009/01/23

The “Market segments” expert group did not work out any results so far.

2009/02/25

1. Result: Status quo
The distinction of market segments for interlocking systems depends on lines and junctions they have to operate. I.e. the segmentation of different types of lines operated by the railway companies, have to be clustered and projected into the market segments of the interlocking. In a first step information of the companies represented in the INESS project were inquired about how the different railway operators distinguish between lines. This was also compared with the classification of lines of the UIC. According to the description of Task B.2.1, the UIC

classification scheme (UIC Code 700) should be used as a basis for a further approach. The purpose of this line classification should lead to load limits for wagons in terms of axle loads of weight per length, which is not a relevant criterion for interlocking systems. Therefore, this classification scheme could not be used for a further approach of the expert working group. Instead of that, a draft proposal was made by DLR which was discussed within the expert group and distributed among all members of WS B to get feedback and to come to a consolidated result.

2. Result: Delimitation of terms

To get a final segmentation of the interlocking market, relevant criteria had to be found in order to describe requirements of lines that have to be handled by different types of interlocking systems. These requirements can be divided into operational and technical requirements:

Operational requirements:

- Speed: regularly driven speed maximum at the line.
- N° of train movements: this figure expresses the ability of the interlocking in terms of TM = N° of time wise concurrent routing + shunting movements in a single interlocking.
- Passenger trains: interlocking operates lines and junctions with passenger traffic.
- Freight train: interlocking operates lines and junctions with freight trains.
- Shunting allowed: interlocking operates lines and junctions where shunting is allowed and supports the appropriate functionalities.

Technical requirements:

- ETCS: The interlocking operates lines which are part of the Trans European Network (TEN). This can be either High Speed TEN or Conventional TEN. Both are subject to ETCS equipment of Level 2 (in future also Level 3) or Level 1 (usually in junctions where the gain of performance is not high enough to justify Level 2 or 3 equipment).
- Level crossings: The interlocking operates lines where level crossing is allowed and supports the appropriate functionalities (e.g. control of adjacent level crossings, refer to product structure).
- Safety: for the TEN lines Safety Integrity Level (SIL) 4 is required. If WS B will only deal with these lines, the safety level is not a criterion to distinguish between market segments. In case that WS B will also take regional lines of railway companies into account, SIL 4 is not necessarily mandated. According to CENELEC it depends on the risk analysis and the tolerable hazard rate (THR). The question which safety level is required is a cost-effective issue and should therefore be taken into account.
- N° of functionalities: The number of functionalities to be fulfilled by the interlocking in a safe manner determines the certification effort according to CENELEC. This is why it is a costs-effective figure.
- Downtime minutes p.a.: The reciprocal value of the Mean Time Between Failure (MTBF) and thus a parameter to express the availability of the interlocking. Since the availability varies according to the requirements of lines / junctions to be operated, it is a criterion for the distinction of market segments.
- Non safety relevant features (new): e.g. centralized traffic control, automation, diagnostic, passenger info etc. are features which are not necessarily, but regularly components of an interlocking system. Therefore they have influence on the costs.

The market segmentation according to the requirements described above is shown in Figure 1. With regards to the aim of INESS it is proposed to focus on segments I to III due to a required harmonization as ETCS will be applied.

Market segments for interlocking systems

		Segment I	Segment II	Segment III	outside INESS
		high speed TEN	conventional TEN		domestic railway
			high demand	mid. demand	low demand
operational requirements	speed	> 200 km/h (acc. to TSI)	relevant? figures?	relevant? figures?	relevant? figures?
	Nº of train movements*)		high figures?	middle figures?	low figures?
	passenger trains	yes	yes	yes	yes
	freight trains	no	yes	yes	yes
	shunting allowed	no	yes	yes	yes
technical requirements	ETCS	L2 (or L3)	L2 (or L3), L1 (junctions)	L1 (or L2)	no
	level crossings	no	yes	yes	yes
	safety	SIL 4	SIL 4	SIL 4	SIL 3 / 4
	Nº of functionalities (complexity?) (= certification effort)	mid figures?	high figures?	mid figures?	low figures?
	downtime [minutes p.a.]	very low figures?	low figures?	mid figures?	high
	non-safe features	which?	which?	which?	which?

*) TM = N° of time wise concurrent routing + shunting movements in a single interlocking

Figure 1: Proposal for the segmentation of the interlocking market (2009/03/10)

2009/03/10

During the 4th work stream meeting in Madrid, Mr. Brinkmann presented the results the expert group worked out so far (see
Figure 1: Proposal for the segmentation of the interlocking market (2009/03/10)
. After an intensive discussion of the preliminary results within the project consortium the following amendment have been made:

- Concerning the requirement “speed” it is important to identify high speed lines. On the other hand conventional lines can be better determined by the number of train movements. Therefore it is less important to distinguish between high and mid demand interlocking systems regarding conventional lines.
- Two figures were developed to express the ability of the interlocking: Firstly the number of train movements per day / per track, secondly the number of train movements within the hour of maximum traffic / track:
  The numbers of train movements per day / per track were derived from guidelines of the DB and are also comparable to those of ProRail. According to that, for conventional lines with a value of more than 100, high demand interlocking systems are required. For high

speed lines this figures can have a wide range.
The Number of train movements within the hour of maximum traffic represents the peak value of traffic which the interlocking has to be designed for. This seems to be an adequate criterion to assess the complexity and demand of the interlocking system.

- The distinction between passenger trains and freight trains was removed and replaced by the term mixed traffic. This figure shall express the (in)homogeneity of traffic concerning passenger and freight trains. Furthermore the requirement to operate mixed traffic can have an influence on the requirements of an interlocking system.
- The expert group tried to express the "complexity" of the lines not by the absolute number of SEU, but by the term SEU/km. The term expresses the remarkable difference in the density of signalling elements especially between Segment I and II.

According to the contributions and amendments of the project partners Mr. Brinkmann integrated the contributions in the market segments scheme (see Figure 2). The red-coloured figures assign the distinction between the segments.

Market segmentation for economical analysis of interlocking projects

		Segment I	Segment II	Segment III	Segment IV
	Criteria	High speed TEN	Conventional TEN		Domestic railway
			High demand	Medium demand	
Operational requirements	Speed	> 190 km/h (acc. to TSI)	Speed not the relevant parameter for distinction between high and medium demand or domestic		
	No of train movements / day / track	40 … 120	> 100	50 … 100	< 50
	No of train movements within hour of maximum traffic / track	6 … 8	> 10	6 … 10	3 … 4
	Mixed passenger & freight traffic [1)]	No	Yes	Yes	Yes
Technical requirements	ETCS (perspectively to be installed)	Level 2 / 3	Level 1 / 2 / 3	Level 1 / 1LS	Optional
	Level of safety	SIL 4	SIL 4	SIL 4	SIL 3 / 4
	SEU / km	1,5 … 4,5	15 … 45	4 … 15	< 6
	R (contractual downtime min / a)	figures gathered from data collection			
	A [%]	figures gathered from data collection			

Non-safe features will be part of textual description of circumstances of the projects.

[1)] Homogeneity of traffic operated on one line

Figure 2: Market segmentation for economical analysis of interlocking projects

2009/05/15

During the 5th workshop meeting in London Mr. Brinkmann presented the results the expert working group “product structure and market segments” worked out. Within his presentation, he

underlined the changes and amendments that have been included in the description of the market segments. The implemented feedback was based on the remarks given by the consortium members of work stream B. The new version of the market segments description have been discussed and afterwards committed by all partners. Subsequently Mr. Brinkmann refined the final results which have been afterwards approved by the work stream leader. In the following, the final results of the expert working group regarding the market segmentation will be summarized:

Requirements to the market segmentation:

- Limited number of segments that cover a large part of the interlocking market in order to reduce complexity.
- Clear distinctions to identify the required extend of the interlocking systems (which will be important for the target costs).
- It must be possible for each of the railway partners to find their interlocking systems within the defined segments.
- Focus on electronic interlocking systems for lines where the TSI is mandatory.
- Therefore, the basis are the TEN (Trans European Network) railway lines (High Speed and Conventional) which are subject to ERTMS (ETCS & GSM-R).

Operational requirements:

- Speed: Maximum speed wherefore the line is designed for. The Parameter is used to identify the High speed TEN (Trans European Network), but not so much for the distinction between high and middle demand conventional interlocking systems.
  N.B.: 190 km/h for High speed is not a hard figure since some infrastructure manager operate their High speed lines with less speed.
- N° of train movements per day per track: Expresses the ability of the interlocking system in terms of average workload of the lines to be operated (permanent load).
- N° of train movements within hour of maximum traffic per track: Expresses the ability of the interlocking system in terms of peak value of the workload of the lines to be operated (peak load).
- Mixed passenger and freight traffic: Interlocking operates lines and junctions with homogeneous traffic or mixed traffic.
  N.B.: In e.g. UK or Sweden also (HS) freight traffic is operated and mixed with High speed passenger trains. Therefore this is not a hard figure.

Technical requirements:

- ETCS (perspectively to be installed): Level of ETCS which is installed at the infrastructure.
- Level of safety: Level of safety according to CENELEC. For the TEN lines Safety Integrity Level (SIL) 4 is required. As WS B will also take the domestic lines of the railway companies into account, SIL 4 is not necessarily mandated. According to CENELEC it depends on the risk analysis and the tolerable hazard rate (THR). The question which level of safety is required is a cost-effective issue and it might turn out during the project that it is worth looking at this. Another question is if the technology is SIL 3, but by the way it is operated, the result is SIL 4. This has to be described in the context of the specific projects.
- SEU or SEU per km: Parameter to express the complexity of the lines and junctions to be operated by the interlocking by a kind of “density of signalling elements “.

Distinction between stations and free track is necessary. Depending on the specific project, it might be adequate to describe the complexity by absolute N° of SEU, without division by km. This is part of the description of the projects.
The definition of the SEU will be taken from the UIC (not yet finalized).

- RAM:
  - Reliability R, e.g. [contractual downtime minutes per year],
  - Availability A, e.g. [%] and
  - Maintainability M, e.g. [% per time].

  These parameters vary depending on the requirements of the lines / junctions to be operated, and are therefore a criterion for the distinction of market segments.
  Reliability and maintainability are values prescribed by the infrastructure manager. The availability depends on the way the infrastructure manager maintains the infrastructure.

2009/08/07

In the following the results of the expert group for “Market segments” are summarised. The description includes the final version of the delimitation of terms regarding operational and technical requirements.

1. Result: Final status

During several discussions, basically 4 segments could be identified. The first distinction could be derived from the guidelines of the Trans-European Network (TEN) corridors where division is made into High Speed (HS) Lines and Conventional Lines. These are the lines across Europe to be realized with ETCS and handle both national and international traffic. They are therefore in a special focus of the standardisation and cost reduction efforts of INESS. The second distinction has been made within the Conventional TEN lines, sub-dividing them further into lines and junctions which require high demand interlockings and medium demand interlockings.

With regards to the aim of INESS it had been proposed to focus on these three segments since these are the segments where harmonization is required as ETCS will have to be applied thereon.

2. Result: Final version of the delimitation of terms

To describe the segmentation of the interlocking market, relevant criteria had to be found which reflect the requirements of the lines that have to be handled by different types of interlockings. These requirements can be divided into operational and technical requirements:
Operational requirements:

- Maximum speed which the line is designed for. The Parameter is used to identify HS TEN, but not so much for distinction between high and middle demand conventional interlockings where the demand can be better determined by the number of train movements to be handled. The value of 190 km/h for high speed was chosen since it is a specification of the EU ("lines equipped for speeds of the order of 200 km/h").
  N.B.: 190 km/h for HS is not a hard figure since some infrastructure manager operate their HS lines with less speed.

- No of train movements per day per track: this figure expresses the ability of the interlocking in terms of average workload of the lines to be operated (permanent load). Figures were derived from guidelines of the DB and are also comparable to those of ProRail. According to that, for conventional lines with a value of more than 100, high demand interlockings are required. For high speed lines this figures can have a wide range (but those lines are mainly determined by the parameter speed, as said above).
- No of train movements within the hour of max. traffic: this figure represents the peak value of traffic which the interlocking has to be designed for (peak load). This seems a good criterion to assess the complexity and demand of the interlocking.
- Mixed traffic: interlocking operates lines and junctions with a mixture of passenger traffic and freight trains. This figure shall express the (in)homogenity of traffic, meaning traffic of both passenger and freight (or fast and slow traffic) at the same time (it does not mean, like e.g. in Germany, pure passenger traffic during daytime and freight trains by night on certain lines). The requirement to operate mixed traffic can have influence on the requirements of an interlocking.
  N.B.: Unlike in most countries, in e.g. UK or Sweden also (HS) freight traffic is operated and mixed with HS passenger trains. Therefore this is not a hard figure.
- In the first approach, also shunting had been considered as a parameter for the operational requirements, but since it is allowed in principle on every kind of lines, it has been abandoned as a criterion for the distinction, although shunting will take place on different kinds of lines to different extend (also refer to the product structure where the component “interface to locally controlled shunting areas” is foreseen).

Technical requirements:

- ETCS (perspectively to be installed): the interlocking operates lines where ETCS is (or will perspectively be) installed. This can be either for the reason that the lines are part of the Trans European Network (TEN) or that they are equipped with ETCS for other reasons, e.g. economical / technical / political considerations. Both High Speed TEN and Conventional TEN are subject to ETCS equipment according to the TIS. High speed and high demand interlockings will operate all kinds of ETCS Levels, in future it might also be Level 3. The conventional TEN lines where L1 or L1-LS will be installed are regarded as mid demand interlockings. Domestic railways do not necessarily require ETCS.
- Level of Safety: is the Level of safety according to CENELEC. For the TEN lines Safety Integrity Level (SIL) 4 is required. As WS B will also take the domestic lines of the railway companies into account, SIL 4 is not necessarily mandated. According to CENELEC it depends on the risk analysis and the tolerable hazard rate (THR). The question which level of safety is required is a cost-effective issue and it might turn out during the project that it is worth looking at this. During the discussion the question was raised how to handle the case that the technology is SIL 3, but by the way it is operated, the result is SIL 4. This has to be described together with specific projects when gathering data from example projects.
- No of SEU/km: the number signalling equivalent unit per km is a parameter to express the “complexity” of the line to be operated by a kind of “density of signalling elements“. The figures in
- Figure 1: Proposal for the segmentation of the interlocking market (2009/03/10)

A distinction between stations and free track is necessary. Depending on the specific project, it might be adequate to describe the complexity by absolute No of SEU, without division by km. This is part of the description of the project.

The consistent definition of the SEU will be taken from the result of UIC ERTMS cost benchmark (the work of the UIC is not yet finished) and has been presented on the workshop in Madrid (ProRail presentation “Value of a Signal Unit”). According to this definition, the value of signal units is determined as described in Table 2:

~~Table 1: Signal Equivalent Units according to UIC ERTMS cost benchmark~~

description	*value*	*comment*
signal / marker board	1	
speed signal / direction indicators	1	repeater signal / shunting signal
dynamic shunting area	1	per area
switch	1	
high speed switch	2	speed > 140 km/h
derailing facility	1	
additional signal	0.5	departure signal
coded track circuit	1	
axle counter per section	0	
train detection (tone freq. circuit)	0	
level crossing	1	only if connected to a signalling system
line block interface	1	per track

Table 2: Signal Equivalent Unit (SEU) definition from UIC ERTMS benchmark group

- RAM:
  - Reliability R, e.g. [contractual downtime minutes per year],
  - Availability A, e.g. $A = \frac{MTBF}{MTBF + MTTR}$ [%] and
  - Maintainability M, e.g. [% per time].

These parameters vary depending on the requirements of the lines / junctions to be operated, and are therefore a criterion for the distinction of market segments. Reliability and Maintainability are values prescribed by the infrastructure manager. The Availability depends on the way the infrastructure manager maintains the infrastructure.

The RAM parameters and the way they are handled (e.g. in the contract) have to be described together with the data collection of the specific example projects.

Furthermore, non safety relevant features like e.g. centralized traffic control, automation, diagnostic, passenger info, etc. can have significant influence on the costs of an interlocking. These are features which are not necessarily, but regularly component parts of an interlocking. It was decided not to describe them as criterion for the market segmentation due to the high diversity of possible solutions. Nevertheless they are important to be recorded and described when gathering cost data from the companies in order not to have falsification in the data analysis.

The final results of the market segmentation according to the parameters described above are summarized in Figure 3.

		Segment I	Segment II	Segment III	Segment IV
	Criteria	High speed TEN	Conventional TEN		Domestic railway
			High demand	Medium demand	
Operational requirements	Speed	> 190 km/h (acc. to TSI)	Speed not the relevant parameter for distinction between high and medium demand or domestic		
	N_0 of train movements / day / track	40 … 120	> 100	50 … 100	< 50
	N_0 of train movements within hour of maximum traffic / track	6 … 8	> 10	6 … 10	3 … 4
	Mixed passenger & freight traffic [1)]	No	Yes	Yes	Yes
Technical requirements	ETCS (perspectively to be installed)	Level 2 / 3	Level 1 / 2 / 3	Level 1 / 1LS / 2	Optional
	Level of safety	SIL 4	SIL 4	SIL 4	SIL 3 / 4
	SEU / km	1,5 … 4,5	15 … 45	4 … 15	< 6
	Reliability R (contractual downtime min / a)	figures gathered from data collection			
	Availability A [%]	figures gathered from data collection			
	Maintainability M [%/time]	figures gathered from data collection			

Non-safe features will be part of textual description of circumstances of the projects.

[1)] Homogeneity of traffic operated on one line

Figure 3: Results of the segmentation of the interlocking market

Section 4 – CONCLUSIONS

In the following, a monthly overview of any new results and further steps is mentioned:

2009/01/23

Results: - The “Market segments” expert group did not work out any results so far.

2009/02/25

Results: - The current status quo was defined.
- A delimitation of terms regarding requirements of the lines which have to be handled by different types of interlocking systems was defined.

Further steps: -The finalization of the “Market segments” is planned to take place at the workshop in Madrid (2009/03/10).

2009/03/23

Results: - Contributions of the consortium partners regarding the pre final version of the classification scheme were collected and afterwards implemented in a new proposal.

Further steps: -The classification scheme for “Market segments” was updated and send to the partners for approval.

2009/05/18

Results: - Work stream B commitment of the established market segmentation.

2009/05/18

Results: - The results of the expert working group for “Market segments” have been approved by WS B members.

2009/09/23

Final conclusions and perspective:

The objective of deliverable B 2.1 is the development of a classification scheme for line categories depending on functional and other requirements. Therefore the expert group identified four market segments. The defined market segments feature different operational respectively technical requirements and thus help to describe the variable line categories. For the further progress of the different tasks and next steps of work stream B the distinction between the four segments provides different opportunities. One potential opportunity is described below:

Each interlocking project regarded during the data collection process can be allocated to one market segment. This allocation could lead to a clustering of different projects per market segment. In a further step it has to be analysed if the projects combined in the clusters feature common cost drivers.

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