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TABLE OF CONTENTS

List of abbreviations

ATP	Automatic Train Protection
ATC	Automatic Train Control
DOORS	Distributed Object Oriented Requirements Specification
DoW	Description of Work
ERTMS	European Rail Traffic Management System
ETCS	European Traffic Control System
FIS	Functional Interface Specification
FFFIS	Form Fit Function Interface Specification
INESS	Integrated European Signalling System
IXL	Interlocking
MA	Movement Authority

RBC	Radio Block Centre
UML	Unified Modelling Language
WP	Work Package
WS	Work Stream

Section 1 – Executive Summary

1 Section 1 – Executive summary

In the INESS DoW Part B “Concept and Project Objectives” a way for migration from traditional national interlockings towards standardized European interoperable ERTMS compliant interlockings is quested. Interoperable in this context means interchangeable, that is for making ERTMS more cost-effective by choosing a common and agreed system architecture for future interlocking systems. This aiming IXL to be suitable for integration in ERTMS level 2 and 3 systems. Cost-effective also means having the capability of migration, taking under account existing European (ERTMS ready) interlocking systems.

This document gives advice for WP E.3 defining a standardized functional Interface between IXL and ERTMS. It is build upon information from WS-D (existing extended functional common kernel of IXL and harmonized future ERTMS related functions) as well as on European ERTMS experiences like RBC related information in questionnaire of WP E.1.

The work of WP E.2 is to provide a system architecture picture. Coming from that, input information is allocated to ERTMS relevant functions distributed over the IXL- / ERTMS system leading to FIS which is input information for WP E.3. This is done by defining a functional apportionment of IXL/ERTMS functions. Out of the functional apportionment WP E.3 will be able to define the FFFIS. This documents proposes a harmonised (system) structure together with a FIS covering a future resistant system architecture combined with the capability of migration.

Section 2 – INTRODUCTION

2 Section 2 – INTRODUCTION

This document is focused on the aspect of designing future interlockings to be suitably and cost effectively integrated in ERTMS systems. It proposes a harmonized structure as precondition for standardization of ERTMS relevant IXL interfaces.

The understanding of a harmonized structure is a common and agreed picture of functional entities. This picture must have the ability to decompose all ERTMS related functions and allocate the functional parts to functional entities of the picture provided. This picture represents the overall system view. Doing the functional decomposition on a abstract level over (national defined) IXL functionality and (European defined) ERTMS functionality, it is possible to derive common ERTMS related IXL functions.

Creating this architecture it is a natural process to get requirements for system interaction, which is essential for the work of WP E.3.

This document proposes a harmonized structure of future European interlockings and their adjacent subsystems. The continuing task of WPE.3 is to define out of this work a FFFIS which represents a future European standard.

The quested information of D.E.2.1 is to propose a “harmonized structure” (regarded as system architecture) in order to be able to break down operational (overall) functions in parts and assign them to functional entities. This is a precondition to build a common understanding of system structure and the necessary interaction between functional entities. The technical definition of this harmonized Interaction later on will be work of WP E.3.

The intention of D.E.2.1 originally was to provide information about all relevant interfaces of the interlocking and the adjacent subsystems. This overall and common approach is focused by an process described in D.E.2.2. Result of this process is to focus on Interlocking functions related to ERTMS functions. In order to get a convenient proposal for a harmonized functional structure the WPE.2 team chooses a double track approach.

First look is on already harmonized functions and already common interfaces using information extended common core (D.D.2.4) and results of the questionnaire analysed in D.E.1.2.

Second, to have a look into the future, IXL-ERTMS spanning functions are analysed in order to get a stable base for the functional harmonization.

Because of planning constraints the necessary Input from D.D.3.2.2 for doing that is not available in time. In coordination with work stream leaders the input information is at first substituted by ERTMS experiences contributed by WP E.2 team. In a later step this information will be an additional Input for WP-D. A close collaboration between WP-D and WP-E therefore is established.

All together main part of D.E.2.1 is a list of IXL functions (related to ETCS) with short description and functional apportionment. Derived of this analysis the document closes with some findings and conclusions.

Section 3 – Main Part

3 Section 3 – Main Part

3.1 Approach

Topic of work package E.2 is to provide a harmonised functional structure (or structures) of interlockings and their adjacent sub-systems. In order to analyse the functional structure it is indispensable to know about European interlocking functions. This knowledge is composed of IXL basic function (D.D.2.4) and enhanced IXL functions regarding ERTMS (from D.E.1.2 questionnaire) completed by experience of WP E.2 team members.

3.1.1 Preconditions

The former European research project Euro Interlocking aimed to have a common understanding of interlocking functionalities and derived out of that a common definition of Interlocking functionalities agreed in Europe. This project collected functional requirements from participating railways. This functional requirements where classified in

- COMMON CORE, meaning all European railways have a common understanding and definition of a certain function
- EXTENDED CORE, meaning to have a common understanding, but despite of that a national railway specific implementation (e.g. because of national rules or laws).

Unfortunately not all the railways participated in this research project.

In INESS, which is a kind of "Euro Interlocking successor research project", this issue is handled in WP D.2. Based on existing EURO Interlocking information and structure, the functional requirements are completed and harmonized but still now under consideration of some of the railways.

WS-D found that spanning functional requirements over more railway partners the common core melts like snow in the sun. Because of that WS-D concentrates on the extended core. WS-D took big effort on a common understanding and grouping similar, but different functional requirements and assigning them to the using railways. This is a big step forward, because the railways reduced the number of specific national functions to fewer analogue functions. This agreement comprehends the commitment to implement those functions in a national context, even if these functions are not the same, but only similar to the existing national ones. This process is documented in D.D.2.3.

A disadvantage of this approach is, that this now called Extended Functional Core is sometimes contradictorily.

Please, have in mind, the Extended Functional Core in WS-D is not the intersection of functions (like EURO-Interlocking understood), but the set union of functions (new INESS understanding).

The approach of WP E.2 chosen to achieve a functional structure of interlockings and their adjacent sub-systems is shown in chapter 3.3

During the run time of INESS the steering board was afraid a possible gap between tasks, understanding and results of the different work streams. As a contingency measure a task force and out of that a comprehensive workgroup WS B/D/E was implemented.

This workgroup gave advice to WP E.2 how to proceed. The following issues were addressed:

- WP E2 continuous work as planned and committed, thus considering all ERTMS levels (including L1 and LS) and focusing on high level ERTMS functions (see D.E.2.2).
- INESS may progress on the way of using the Extended Core to the WP E.2 presented system conception. Actual method to group functions and allocate to subsystem constituents should be used (MS Excel) (see 3.3.2). In addition it was advised, while investigating the Extended Core, to concentrate on IXL-ERTMS spanning functions (which will use the external functional interface).

- Further translation to UML and export to DOORS could be useful, but is not part of WP E.2
- ETCS functionality added on by WP E.2 team experiences is ok, but do not require sophisticate new functions, which goes over given WS-D Extended Core.
- Further this workgroup gave advice for the collaboration of WS-D and WS-E
- Methodology may be important but results should be the first target
- Partners are encouraged to document the interaction between WS-D and WS-E (which is the authors motivation for this section)
- INESS should refer to the future conception of interlocking for interoperability (means interchangeability) and keep the implementation and migration aspects in eye. Greenfield approach is not retained.

3.1.2 IXL Core Functions

The requirements, which are collected by WS-D, are classified as follows. For the work of WS-E only functional requirements are assessed:

- route modules:
- route general requirements
- route initiation completion
- route locking proving
- route use cancelled
- monitoring
- element modules:
- signal
- local shunting area
- powered point
- key-locked point
- lockable devices
- level crossing
- line block
- tvp section
- interlocking system general
- functional interfaces
- commands
- statuses
- driving values
- detected values
- engineering configuration requirements

The Extended Core was created neglecting ERTMS functionality. The Extended Core is documented in D.D.2.4. WS-E uses as input data from D.D.2.4. chapter 5 (Annex) Section “Complete Extended Core of Requirements“. WS-D commits this data as complete. No effort was taken within WS-E for further completion.

3.1.3 Enhanced IXL Functions regarding ERTMS (by Experience)

Even neglecting ERTMS functionality the Extended Common Core is treated as complete. This includes that some ERTMS functions are implicit part of Extended Core. This is mandatory, because the base of IXLs used for IXL function assessment were ERTMS ready that mean state of the art (ERTMS supporting) IXL systems. The WSB/D/E workgroup stated a low expectation of very new functionality can be found in WP D.3. Otherwise round the collected experience from WP E.2 will be helpful Input for work of WS-D. This is one more argument for a close collaboration between WS-D and WS-E.

Additional input is given by WS-E in D.E.1.2 with the questionnaire section about usage of RBC

Questionnaire input is completed by WP E.2 team experience about comprehensive functions between IXL and ERTMS. The advice given by work group is not to introduce sophisticate new functions, which goes over given WS-D Extended Core Input. The collected functions are analysed in chapter 6.1.

3.1.4 Architecture

The request for a harmonized structure is seen as a basic “system picture” enabling system engineers to navigate, in order to allocate functions or part of functions to certain blocks (entities). This functional architecture leads then in consequence to a basic system architecture.

Architecture is a word coming from Greek “Archi” (from the beginning) and Latin “tectum” ((house / roof). That means: architecture sets the bases (and is something very essential). Architecture answers the question where is what located in order to assure future functionality.

To find this common harmonized picture WP E.2 looked at first on the entity diagram introduced by Euro interlocking. This seemed to be common sense and well introduced. But the experience from WP E.1 (questionnaire) was a confusion about a common understanding as long as no definition of functionality and apportionment of functionality is done. Furthermore all ERTMS level can not be shown convenient with this diagram. WP E.2 proposed a extended picture. WP E.2 agreed this picture lives only together with functions and functional apportionment in order to have a clear understanding, in sense of architecture, which sub function is located in which entity. The introduced picture is not contradictorily to Euro Interlocking entity diagram, but extends that for better use in INESS context.

For better understanding of the proposed architecture see D.E.2.2

3.2 IXL Functions about ERTMS

The ERTMS system functions are distributed over different subsystems like interlocking or ETCS trackside. All sub functions together are leading to the required ERTMS function. Here only the functions, which require sub functions within IXL are mentioned.

The list of IXL functions in annex chapter 6.1 is a collaboration of ERTMS functions derived out of Extended Common Core (WS-D), IXL-RBC feed back given by suppliers and railways from ERTMS reference projects in questionnaire of WP E.1 and last but not least from WP E.2 team members experiences working with ERTMS over years.

The described functions are shown in an operational view. In order to get a common understanding of what this function is intended to be, the definition is structured in the sections “abstract”, “function” and “what happens if function is omitted”.

3.3 Functional Apportionment

The functional apportionment is part of architecture. Functional Apportionment splits an operational overall function in parts in order to allocate the created sub functions to function or system entities fitting best to a system architecture. This process interacts with a given architecture. It may be that functional apportionment impacts the system architecture in order to have a better logical allocation of function (e.g. minimizing information traffic). Splitting functions and coupling them by interaction are leading directly to FIS definition. This is part of WP E.2 and provides the necessary input information for WP E.3.

Beside functional apportionment are non functional requirements also affecting system architecture (e. g. the request for capability of migration or interchangeability). WP E.2 accounts this information in the proposal of harmonised structure. This Information only influences indirectly the FIS definition.

Definition of FFFIS is intended work of WP E.3

Please note: neither FIS nor FFFIS is a well defined term. Advice for defining a FFFIS Interface is given in D.E.2.2.

3.3.1 Criteria for the Apportionment

This section is regarded to provide criteria for doing functional apportionment. The criteria are essential and were agreed by WP E.2 or by work group B/D/E. Some consequences are derived from those considerations.

3.3.1.1 Capability of Migration

To be able to roll out new components, products, systems or function it is essential to respect the existing situation. At some point every new part has a interface to an already existing part. To have a green field situation is untypical in Europe. To respect existing situation is crucial for cost effective roll out, even for future systems. The proposed harmonized structure must reflect this explicit advice from work group B/D/E (“Greenfield approach is not retained”).

Bad Example

While route setting IXL has to pass in advance additional signalling information, in order to compensate RBC route initiation lead time. This design would request a European common understanding of logical states while route setting within IXL. Defining this IXL internals are contradictional to the requirement of interchangeability and migration. Rejecting of routes in early stages within IXL additional brings up the need of handling in RBC and would increase complexity of FIS.

Good Example

Central-Leu provides a subset of RBC functionality. Some railway might migrate ATP sections equipped with Central-Leu (Level 1) to RBC (Level 2). To keep IXL communication consistent it might be a good advice to keep communication of these sub set functionalities the same for central LEU and RBC.

3.3.1.2 Avoid unnecessary time constraints or data mix-up

Do not split functions in that way, that dynamic behaviour interacts functionality. Time constraints, if possible, shall not be mixed with functionality.

Bad Example

RBC and IXL interacts occupation information. IXL talks about track occupation, RBC in location information transmitted from EVC. EVC has to deal with confidence intervals and transmission time EVC, RBC, IXL (at about 6 sec. typically). In addition kilometre information has to be mapped to track circuit, discontinuity in topographical survey data has to be regarded.

Good Example

Route release shall be performed only by using closed loop (no route release after timeout). IXL sends route release information to RBC. RBC informs IXL about affected train and shortens ETCS Onboard MA. EVC informs RBC about acceptance of shortened MA (either it is able to brake to new stop location or it must come to standstill). RBC informs IXL that route is allowed to be released. IXL releases route.

3.3.1.3 Keep Interfaces small

Minimize addressed partners and transmitted information, if possible. Small interface gives clear responsibility, supports migration, minimizes functional interferences. D.D.2.4 shows impressive how small a proven in use IXL/ERTMS interface can be.

Good Example

Typical RBC regions are spanning more IXL regions. In case of RBC border synchronize borders of RBC region and IXL region in order to have a clear operational interface and responsibility.

Good Example

IXL and RBC communicating about signal aspects in order to generate MA for EVC, reduce communication to signal and points. Transmit route information as property of these elements. Do not introduce unnecessarily IXL route entities.

3.3.2 Process of Apportion Functions

WP E.2 started to work with definition of a “system picture” (see chapter 3.1.4). Treated as a map where WP E.2 is and where WP E.2 is intended to go to, this picture was refined by a process described in chapter 3.3 leading to a functional (system) structure.

This structure is described in D.E.2.2 and is reflected in an Excel table containing the functional apportionment. This Excel file is structured as follows:

Tabs

- Administrative information (Cover-Sheet, History, Sources)
- IXL Core Functions (like chapter 3.1.2)
- ERTMS_Experience (like chapter 3.1.3)

Columns

- One function per line

Rows

- Index to input source
- Function group
- Function headline
- ETCS-level (L1LS, L1, L1-centralised, L2, L3 (regional))
- Affected system entity (CTC-IXL…ETC-Onboard (EVC))
- Sub function of affected system entity
- Sequence-Number
- Sub function

The allocation table is populated with IXL functions (see 3.2). All functions are assessed about their relevance about ERTMS (also see 3.2). If the listed function affects the external functional interface the allocation to the operational ERTMS level is done by setting a cross. Filtering these functions shows clearly laid out the function which has to be apportioned.

The final step is to allocate per every function the system entity and subsequent the sequence of sub functions. The functional apportionment is reviewed by WP E.2 team. This leads to functional interface information, treated as FIS, according to chapter 3.3 .

WP E.2 is encouraged to follow this process by work group B/D/E together with the advices of not to introduce sophisticate new functions, which goes over given WS-D Extended Core and not to retain a “Greenfield” approach.

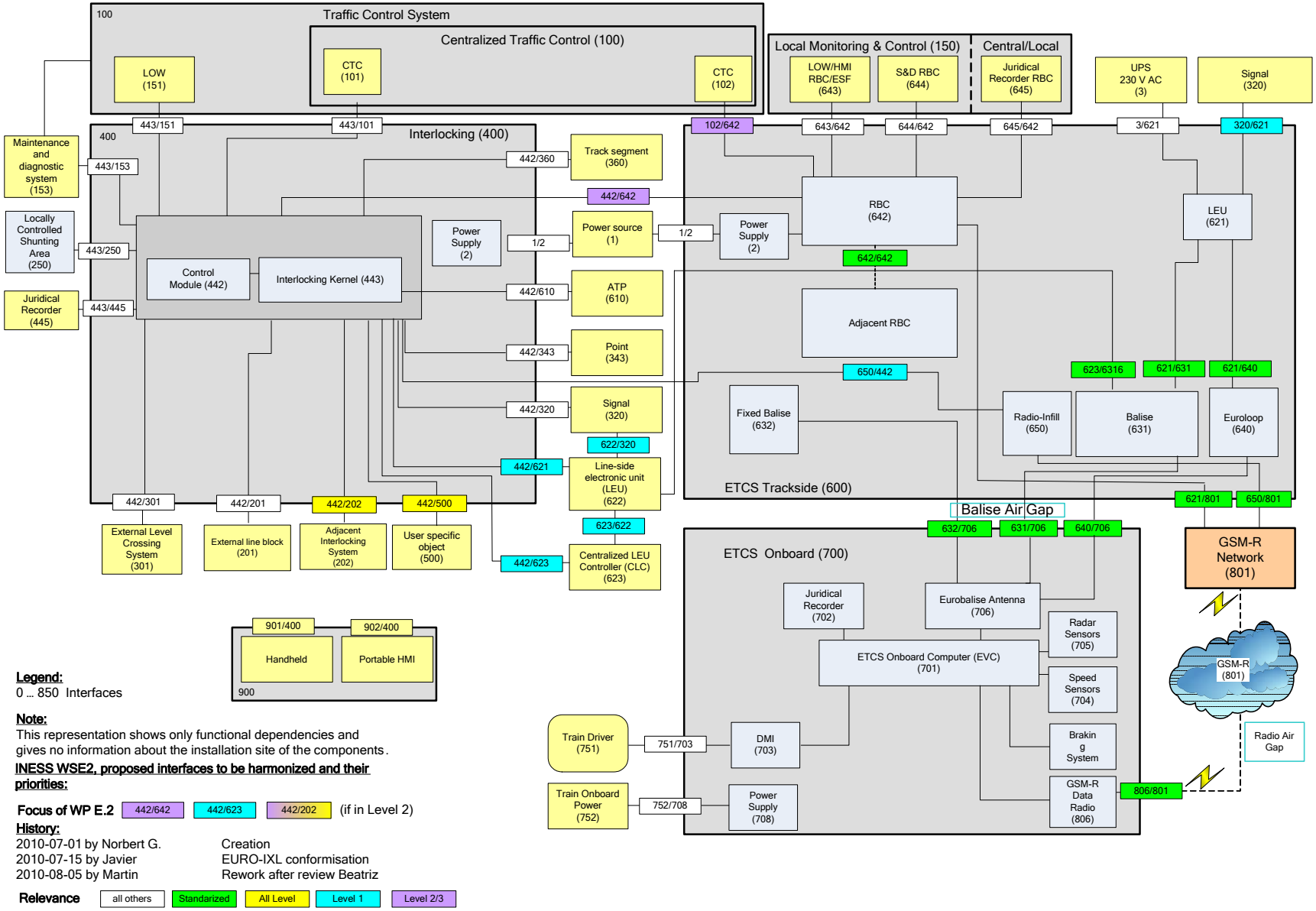
3.4 Proposal of a Harmonised Structure

The proposal of a harmonised structure is a collaboration of a functional (system) picture (see 3.1.4) , an abstract of the functional building blocks (described in D.E.2.2) the functional apportionment (see 3.3) resulting in FIS. The FIS section is recorded in annex chapter 6.1 .

WP E.2 put ambition to be aligned with European requirements. The proposed harmonised structure is coherent to

- EURO Interlocking picture, which is well known and agreed to,
- Extended Common Kernel of WS-D (D.D.2.4)
- long year lasting experience of ERTMS experts (involved in WP E.1 and WP E.2)
- advices of work group B/D/E and requirements of chapter 3.3.1

The proposed functional (system) architecture below spans over all known IXL Interfaces. The WP E.2 work is focused to interfaces 442/623, 442/621 and 442/642. Please be aware of that.



Picture 1 Proposal of a harmonised structure of IXL and adjacent subsystems

Section 4 – CONCLUSIONS

4 Section 4 – CONCLUSIONS

The proposed harmonized structure (Picture 1) covers the IXL with its adjacent sub-systems. This structure is conform to EURO-IXL approach, but refined. The hereby shown (sub-functional) entities are allocated to European well known blocks. That means the structure fits organically to the existing world and is at the same time fit for future. It is evolutionary and not revolutionary. For referencing all blocks are numbered. Interfaces consists of number pairing.

Use of this structure as FIS and therefore as input for WS E.3 (creating FFFIS), is only possible together with a functional apportionment. This apportionment is done within WP E.2 with the focus on IXL ERTMS issues.

Beside the structure of Picture 1 and the functional apportionment (chapter 6.1) follows now some advices and findings coming up while analysing the harmonised structure.

4.1 Advices

- Capability of migration is essential for system rollout and cost effectiveness. It is fundamental to respect existing interfaces and the potency to derive and transmit logical information. Minimize if ever possible transmitted data (see chapter 3.3.1.1).
- Avoid unnecessary time constraints or data mix-up. For safe use of systems and sub-systems it is necessary to have a safety concept and a safety architecture. To show the correctness and completion of this method it is good practice to have at least for safety critical functions (e. g. such as signal stop / route release) a clear procedure that is e. g. hand shake driven and not e.g. time based (see chapter 0).
- Keep interfaces small- Minimize addressed partners and transmitted information, if possible. Small interface gives clear responsibility, supports migration, minimizes functional interferences. D.D.2.4 shows impressive how small a proven in use IXL/ERTMS interface can be (see chapter 3.3.1.3 for examples).
- When designing FIS and FFFIS keep IXL and RBC separated of different control areas of ATP and IXL sub systems. But also keep the possibility to combine these sub- systems (with same FIS) to create low ended systems like TCC in ERTMS regional.
- While collecting experiences some experts claimed to provide advantages to IXL/ERTMS systems by:
  - introducing centralized CTC for IXL and ERTMS
  - introducing handheld / Mobile HMI for flexible service concepts
  - introducing European harmonised Icons for CTC

4.2 Findings

- Work and content of WP E.2 is to propose one or several harmonised structures of interlockings and their adjacent sub-systems. This work is focused to ERTMS and should be continued in order to be completed.
- Another issue is that this proposed structure is treated as FIS input for the work of WP E.3. It does make sense to have a commitment process to proceed from the proposed structure to a committed structure in order to minimise risk in the following WP E.3.
- Assure the loop back activity to plug in the ERTMS experience part of WP E.2 in WP D.3. This is important, because input for WP E.3 must be committed by railways and be defined and agreed on by an “ERTMS enhanced” Extended Common Core. This might also contain the big chance of having a harmonisation of operational procedures of (national) IXL / (European) ERTMS related functions (see chapter 3.1.3).
- Looping back it is necessary to import WP E.2 FIS (Excel) in DOORS e.g. by WS-D. That in order to have one functional requirement source and to be able to baseline and to do configuration management.
- Findings regarding the Extended Common Core are
- Positive: The defined and proposed Extended Common Core contains best common European IXL function description ever had
- Negative: still national systems have to be completed by national functions.
- Negative: to be Extended Core compliant more functionality has to be implemented, than a special national implementation will require
- Negative: some functions within the Extended Functional Core are contradictory

Section 5 – BIBLIOGRAPHY

5 Section 5 – BIBLIOGRAPHY

[D.D.2.3]	100726	Harmonized set of requirements
[D.D.2.4]	100726	Definition of a common kernel
[D.D.3.2.2]	open	Defining requirements (exclusive to ERTMS level 2 and 3)
[D.E.1.2]	100208	Report on information collected from various railways and/or suppliers about the ETCS
[D.E.2.1]		Propose one or several harmonized structures (this Document)
[D.E.2.2]	open	List of relevant Interfaces to be harmonized
[LFA]	100727	WP E.2 List of Functional Apportionment

Section 6 – ANNEXES

6 Section 6 – ANNEXES

6.1 Listed IXL Functions about ERTMS

Information shown in these sections are derived out of [LFA].

6.1.1 IXL Functions from Extended Common Core

Function	Sub Function	ETCS-Level				
		L1LS	L1	L1-centralised	L2	L3 (Regional)
IXL Functions from Extended Common Core						
	· Receive route request from ATC (RBC)				x	x
	· Receive level crossing activation request from ATC (RBC)			x	x	x
	· Send signal stop aspect (dark, light) to ATC (LEU, C-LEU, RBC)	x	x	x	x	x
	· Send signal proceed aspect (dark, light, velocity) to ATC (LEU, C-LEU, RBC)	x	x	x	x	x
	· Send signal substitute aspect (dark, light) to ATC (LEU, C-LEU, RBC)	x	x	x	x	x
	· Send stop command (dark, light) to ATC (C-LEU, RBC)	x	x	x	x	x
	· Send element status (Points) to ATC (RBC)			x	x	x

6.1.2 IXL Functions from Experience

6.1.2.1 Questionnaire

Function	Sub Function	ETCS-Level				
		L1LS	L1	L1-centralised	L2	L3 (Regional)
IXL Functions from Experience						
Questionnaire						
	· IXL has to drive more than one RBC (adjoining, overlapping)– some does				x	x
	· Send TSR command to ATC (C-LEU) – some does			x		
	· Send route setting to ATC (RBC) – many do				x	x
	· Send route cancelling to ATC (RBC) – many do				x	x
	· Send cooperative MA revocation to ATC (RBC) – some does				x	x
	· Send emergency stop command (dark, light) to ATC (RBC) – many do				x	x
	· Send train aspect (train speed / position / issued MA) from ATC (RBC) – some does				x	x
	· Send element status (track, route occupation) to ATC (RBC) – many do				x	x
	· Send element status (other elements in route) to ATC (RBC) – many do				x	x

6.1.2.2 WP E.2 team member experience

Function	Sub Function	ETCS-Level				
		L1LS	L1	L1-centralised	L2	L3 (Regional)
WP E.2 team member experience						
	· Route shorting request (Cooperative)				x	x
	· Initialise Reversing				x	x
	· Operator Emergency Stop Request triggers sending of Unconditional Emergency Stop to one train, identified by OBU Id.				x	x
	· "System Approval Request commands approval of the RBC."				x	x
	· "System Approval Revocation Request commands revocation of RBC approval."				x	x
	· "Shutdown Request commands shutdown of the RBC."				x	x
	· an IXL has to handle more than one RBC. Nevertheless it is strongly adviced to match IXL and RBC boundaries, in order to avoid operational mismatching				x	x
	· "to assure migration operational function driven by the interface shall be restricted · e.g. If possible IXL-RBC Interface must be able to drive conventional ATP-Systems (e. g. LZB)"				x	
	· operational compatibility with legacy ATP systems				x	
	· "future IXL/RBC distributed function shall be able scaleable, in order while migration to fullfill conventional functions also as future ones · (shall be flexible in order to assure connectivity from older and newer generations)"				x	
	· Route release shall be performed only by using closed loop. No route release after timeout (except IXL-RBC connection disturbance).				x	x
	· integrated CTC for IXL / RBC				x	x
	· train shall be protected by LC by (safe) transmission of arival train time at LC				x	
	· Transmission of train numbers / train category from RBC to IxL (proceed information to CTC) with route/ darkening request				x	x
	· in case of IXL acknowledgement requests a RBC shall generate acknowledgement for status report from IXL				x	x
	· Set a Temporary Speed Restriction (TSR) <-- DB AG				x	x
	· Set a Temporary Speed Restriction (TSR) <-- ProRAil, RFI				x	x
	· Set a Temporary Speed Restriction (TSR) <-- BDK				x	x
	· Set a Temporary Speed Restriction (TSR) <-- Trafikverket ; ProRail				x	x
	· Set a Temporary Speed Restriction (TSR) <-- Future 1				x	x
	· Set a Temporary Speed Restriction (TSR) <-- Future 2				x	x
	· Set a Temporary Speed Restriction (TSR) <-- Future 3				x	x
	· increasing safety level by RBC informing interface in case of critical train actions				x	x
	· tunnel train reversion in case of danger				x	x
	· In case of requested acknowledgement in IXL status reports (from Ixl to RBC) IXL is forced to supervise all acknowledgements of RBC as precondition for putting a signal in proceed				x	x
	· transmit emergency information with destination signal				x	x
	· distinguish between emergency stop and route release				x	x
	· track layout (topology) to internal data model e.g. knotes / edges				x	x
	· Safety Distance after Signal				x	x
	· Upgrade from "staff responsible" to "full supervision" (replace "track ahead free request" TAFR)				x	x

6.2 Functional Apportionment

Information shown in these sections are derived out of [LFA].

6.2.1 Route_General_Requirements_CC

Source	Function		ETCS-Level									Logical		
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LOW.IXL	IXL	new	CTC.IXL	LOW.IXL	IXL
Comp-ID								101	151	400	xxx	101	151	400
[1]	RGR14-Com	**2 General**												
[1]	RGR273-Req	• *a request 'Set main route' is received*	-	-	-	x	x	x	x	x		1.) CTC send command "Set main route" to IXL	1.) LOW send command "Set main route" to IXL	2.) IXL sets the status "part of a main route" at the elements of the route IXL sends this information to RBC

6.2.2 Signal_CC

Source	Function						ETCS-Level									
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC-IXL	LOW-IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSM-R Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[1]	Sig15-Com	**2 Signals**															
[3]	Sig132-Com	**2.2.2.1 Main Aspect - Stop**	x	x						1.) the IXL monitors the conditions and sets the Signal-aspect "Stop". 2.) The IXL switchs the Stop-Aspects at the wayside signal		3.) The signal shows thestop aspect, e.g. the red lamp is burning		4.) the LEU detects the burning red lamp and sends the stop-command to the controlled balises	5.) the balise sends the stop-command	6.) the OBU receives the stop command if passing the balise and brakes the train	
[3]	Sig132-Com	**2.2.2.1 Main Aspect - Stop**			x					1.) The IXL monitors the conditions and sets the Signal-aspect "Stop". 2.) The Ixl sends the Information "Signal number + Stop-aspect" to central - LEU	3.) the central LEU determined the associated controlled balise and sends the stop-command				4.) the balise sends the stop-command	5.) the OBU receives the stop command if passing the balise and brakes the train	
[3]	Sig132-Com	**2.2.2.1 Main Aspect - Stop**				x	x			1.) The IXL monitors the conditions and sets the Signal-aspect "Stop". 2.) The Ixl sends the Information "Signal number + Stop-aspect" to RBC			3.) If the signal aspect changes from proceed to stop: the RBC determined the associated train and sends the stop-command via GSM-R			5.) the OBU receives the stop command if passing the balise and brakes the train	4.) The GSM-R network transports the messages between RBC and trains

Source	Function		ETCS-Level													
Functional Component			LILS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LOW.IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSMR Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[3]	Sig136-Com	**2.2.2.2 Main Aspect - Proceed**	x	x						1.) the IXL monitors the conditions and sets the Signal-aspect "Proceed". 2.) The IXL switchs the		3.) The signal shows the proceed aspect, e.g. the green lamp is burning		4.) the LEU detects the burning green lamp and sends the proceed-command to the controlled balises	5.) the balise sends the proceed-command (MA)	6.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig136-Com	**2.2.2.2 Main Aspect - Proceed**			x					1.) The IXL monitors the conditions and sets the Signal-aspect "Proceed". 2.) The Ixl sends the Information "Signal number + Proceed-aspect" to central - LEU	3.) the central LEU determined the associated controlled balise and proceed-aspect				4.) the balise sends the proceed-command (MA)	5.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig136-Com	**2.2.2.2 Main Aspect - Proceed**				x	x			1.) The IXL monitors the conditions and sets the Signal-aspect "Proceed". 2.) The Ixl sends the Information "Signal number + Proceed-aspect" to RBC			3.) If the signal aspect changes from stop to proceed: the RBC determined the associated train and sends the MA via GSM-R			5.) the OBU receives the MA and monitores the movement of the train	4.) The GSM-R network transports the messages between RBC and trains

Source	Function		ETCS-Level														
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LDW.IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSMR Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[3]	Sig151-Com	**2.2.2.3 Main Aspect - On sight**	x	x						1.) the IXL monitors the conditions and sets the Signal-aspect "on sight". 2.) The IXL switchs the on sight-aspects at the wayside signal		3.) The signal shows the on sight aspect, e.g. the yellow lamp is flashing		4.) the LEU detects the flashing yellow lamp and sends the on sight-command to the controlled balises	5.) the balise sends the on sight-command (MA)	6.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig151-Com	**2.2.2.3 Main Aspect - On sight**			x					1.) The IXL monitors the conditions and sets the Signal-aspect "on sight". 2.) The Ixl sends the Information "Signal number + on sight-aspect"	3.) the central LEU determined the associated controlled balise and on sight-aspect				4.) the balise sends the on sight-command (MA)	5.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig151-Com	**2.2.2.3 Main Aspect - On sight**				x	x			1.) The IXL monitors the conditions and sets the Signal-aspect "on sight". 2.) The Ixl sends the Information "Signal number + on sight-aspect" to RBC			3.) If the signal aspect changes from stop to on sight: the RBC determined the associated train and sends the MA via GSM-R			5.) the OBU receives the MA and monitores the movement of the train	4.) The GSM-R network transports the messages between RBC and trains

Source	Function		ETCS-Level														
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LDW.IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSMR Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[3]	Sig937-Req	**2.2.2.4 Main Aspect - Staff responsible**	x	x	x	x	x	2.) The dispatcher inform the driver vocal "Drive in staff resoncible mode"	2.) The dispatcher inform the driver vocal "Drive in staff resoncible mode"	1.) the IXL monitors the conditions and sets the Signal-aspect "staff responcible".						3.) the driver change the OBU in the staff responcible mode. The OBU monitores the movement of the train	

Source	Function		ETCS-Level												
Functional Component			LILS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LDW.IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSMR Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[3]	Sig277-Com	**2.4.2.1 Aspect - Stop**	x	x								1.) the block system monitors the conditions and sets the Signal-aspect "Stop". 2.) The wayside signal shows the stop aspect, e.g. the red lamp is burning		3.) the LEU detects the burning red lamp and sends the stop-command to the controlled balises	4.) the balise sends the stop-command	5.) the OBU receives the stop command if passing the balise and brakes the train	
[3]	Sig277-Com	**2.4.2.1 Aspect - Stop**			x					1.) The IXL monitors also the block signals and sets the Signal-aspect "Stop". 2.) The Ixl sends the Information "Signal number + Stop-aspect" to central - LEU	3.) the central LEU determined the associated controlled balise and sends the stop-command				4.) the balise sends the stop-command	5.) the OBU receives the stop command if passing the balise and brakes the train	
[3]	Sig277-Com	**2.4.2.1 Aspect - Stop**				x	x			1.) The IXL monitors also the block signals and sets the Signal-aspect "Stop". 2.) The Ixl sends the Information "Signal number + Stop-aspect" to RBC			3.) If the signal aspect changes from proceed to stop: the RBC determined the associated train and sends the stop-command via GSM-R			5.) the OBU receives the stop command if passing the balise and brakes the train	4.) The GSM-R network transports the messages between RBC and trains

Source	Function		ETCS-Level													
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LDW.IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSMR Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[3]	Sig280-Com	**2.4.2.2 Aspect - Proceed**	x	x								1.) the block system monitors the conditions and sets the Signal-aspect "proceed". 2.) The wayside signal shows the stop aspect, e.g. the green lamp is burning		3.) the LEU detects the burning green lamp and sends the proceed-command to the controlled balises	4.) the balise sends the proceed-command (MA)	6.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig280-Com	**2.4.2.2 Aspect - Proceed**			x					1.) The IXL monitors also the blocksignals and sets the Signal-aspect "Proceed". 2.) The Ixl sends the Information "Signal number + Proceed-aspect" to central - LEU	3.) the central LEU determined the associated controlled balise and proceed-aspect				4.) the balise sends the proceed-command (MA)	5.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig280-Com	**2.4.2.2 Aspect - Proceed**				x	x			1.) The IXL monitors also the blocksignals and sets the Signal-aspect "Proceed". 2.) The Ixl sends the Information "Signal number + Proceed-aspect" to RBC			3.) If the signal aspect changes from stop to proceed: the RBC determined the associated train and sends the MA via GSM-R			5.) the OBU receives the MA and monitores the movement of the train	4.) The GSM-R network transports the messages between RBC and trains

Source	Function		ETCS-Level												
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LDW.IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSMR Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[3]	Sig151-Com	**2.2.2.3 Main Aspect - On sight**	x	x								1.) the block system monitors the conditions and sets the Signal-aspect "on sight". 2.) The wayside signal shows the on sight aspect, e.g. the yellow lamp is flashing		3.) the LEU detects the flashing yellow lamp and sends the on sight-command to the controlled balises	4.) the balise sends the on sight-command (MA)	5.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig151-Com	**2.2.2.3 Main Aspect - On sight**			x					1.) The IXL monitors also the blocksignals and sets the Signal-aspect "on sight". 2.) The Ixl sends the Information "Signal number + on sight-aspect" to central - LEU	3.) the central LEU determined the associated controlled balise and on sight-aspect				4.) the balise sends the on sight-command (MA)	5.) the OBU receives the MA if passing the balise and monitores the movement of the train	
[3]	Sig151-Com	**2.2.2.3 Main Aspect - On sight**				x	x			1.) The IXL monitors also the blocksignals and sets the Signal-aspect "on sight". 2.) The Ixl sends the Information "Signal number + on sight-aspect" to RBC			3.) If the signal aspect changes from stop to on sight: the RBC determined the associated train and sends the MA via GSM-R			5.) the OBU receives the MA and monitores the movement of the train	4.) The GSM-R network transports the messages between RBC and trains

Source	Function		ETCS-Level												
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	LOW.IXL	IXL	central-LEU	Wayside Signal	RBC	LEU	Controlled Balise	ETCS Onboard	GSM-R Network
Comp-ID								101	151	400	623	320	642	621	631	700	801
[3]	Sig72-Com	**6 Setting Signals to 'Stop' Aspect by Request**	x	x						1.) the IXL monitors the conditions and sets the Signal-aspect "Stop". 2.) The IXL switchs the Stop-Aspects at the wayside signal		3.) The signal shows thestop aspect, e.g. the red lamp is burning		4.) the LEU detects the burning red lamp and sends the stop-command to the controlled balises	5.) the balise sends the stop-command	6.) the OBU receives the stop command if passing the balise and brakes the train	
[3]	Sig72-Com	**6 Setting Signals to 'Stop' Aspect by Request**			x					1.) The IXL monitors the conditions and sets the Signal-aspect "Stop". 2.) The Ixl sends the Information "Signal number + Stop-aspect" to central - LEU	3.) the central LEU determined the associated controlled balise and sends the stop-command				4.) the balise sends the stop-command	5.) the OBU receives the stop command if passing the balise and brakes the train	
[3]	Sig72-Com	**6 Setting Signals to 'Stop' Aspect by Request**				x	x			1.) The IXL monitors the conditions and sets the Signal-aspect "Stop". 2.) The Ixl sends the Information "Signal number + Stop-aspect" to RBC			3.) If the signal aspect changes from proceed to stop: the RBC determined the associated train and sends the stop-command via GSM-R			5.) the OBU receives the stop command if passing the balise and brakes the train	4.) The GSM-R network transports the messages between RBC and trains

6.2.3 Level_Crossing_CC

Source	Function													ETCS-Level						
Functional Component		L1LS	L1	L1-centralised	L2	L3 (Regional)	IXL	LC	central-LEU	Wayside Signal	LEU	Controlled Balise	ETCS Onboard	new	IXL	LC	central-LEU	Wayside Signal	LEU	Controlled Balise	ETCS Onboard
Comp-ID							400	301	623	320	621	631	700	xxx	400	301	623	320	621	631	700
[2]	LCr296-Com	x	x				x	x		x	x	x	x		1.) the IXL activates the level crossing 2a.) the IXL monitors the conditions and sets the Signal-aspect "Stop". 2b.) the IXL switchs the Stop-Aspects at the wayside signal 4.) the IXL works like descripte in requirment Sig136-Com	2.) The LC is activated 3.) if the LC is detected as "secured" he will inform the IXL		3.) The signal shows thestop aspect, e.g. the red lamp is burning	4.) the LEU detects the burning red lamp and sends the stop-command to the controlled balises	5.) the balise sends the stop-command	6.) the OBU receives the stop command if passing the balise and brakes the train
[2]	LCr296-Com			x			x	x	x			x	x		1.) the IXL activates the level crossing 2a.) The IXL monitors the conditions and sets the Signal-aspect "Stop". 2b.) The Ixl sends the Information "Signal number + Stop-aspect" to central - LEU 4.) the IXL works like descripte in requirment Sig136-Com	2.) The LC is activated 3.) if the LC is detected as "secured" he will inform the IXL	2c.) the central LEU determined the associated controlled balise and sends the stop-command			2d.) the balise sends the stop-command	2e.) the OBU receives the stop command if passing the balise and brakes the train
2	LCr296-Com				x	x	x	x							1.) The IXL monitors the conditions and sets the Signal-aspect "Stop". 2.) The Ixl sends the Information "Signal number + Stop-aspect" to RBC 4.) the IXL works like descripte in requirment Sig136-Com	2.) The LC is activated 3.) if the LC is detected as "secured" he will inform the IXL					

6.2.4 Interlocking_System_Gen_CC

Source	Function		ETCS-Level												Logical						
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	CTC.RBC	LOW.IXL	LOW.RBC	IXL	central-LEU	RBC	new	CTC.IXL	CTC.RBC	LOW.IXL	LOW.RBC	IXL	central-LEU	RBC
Comp-ID								101	102	151	643	400	623	642	xxx	101	102	151	643	400	623	642
[1]	ISG13-Com	**2 Interlocking System Operation**	-	-	-	-	-															
[3]	ISG201-Req	• *the detected values of all elements shall be updated to the actual status*	-	-	x	x	x	x	x	x	x	x	x	x		3.) receive information from IXL 4.) Display the values at the monitors	3.) receive information from RBC 4.) Display the values at the monitors	3.) receive information from IXL 4.) Display the values at the monitors	3.) receive information from RBC 4.) Display the values at the monitors	1.) all values of the elements will be detected from the interlocking 2.) The Ixl sends the information to central - LEU and RBC 2.) The Ixl sends the information to CTC-IXL, LOW-IXL	3.) the central LEU will receive the values	3.) The RBC will receive all this values 4.) The RBC sends the Information to CTC-RBC and LOW-RBC
[3]	ISG206-Req	• *set all signals to display a 'stop' aspect*	-	-	x	x	x	x	x	x	x	x	x	x		3.) receive stop aspect from IXL 4.) Display the signal in stop at the monitors	4.) receive stop aspect from RBC 5.) display the signal in stop at the monitors	3.) receive stop aspect from IXL 4.)Display the signal in stop at the monitors	4.) receive stop aspect from RBC 5.) display the signal in stop at the monitors	1.) set all signals to "stop" aspect 2.) The Ixl sends the Information "Signal number + Stop-aspect" to central - LEU and RBC 2.) The Ixl sends the Information "Signal number + Stop-aspect" to CTC-IXL, LOW-IXL	3.) receive stop aspect and set all signals to "stop"	3.) receive stop aspect and set all signals to "stop" 4.) The RBC sends the Information "Signal number + Stop-aspect" to CTC-RBC and LOW-RBC

6.2.5 Commands_CC

Source	Function		ETCS-Level									Logical	
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	IXL	new		CTC.IXL	IXL
Comp-ID								101	400	xxx		101	400
[1]	Cmd17-Com	**2 General**											
[3]	Cmd27-Com	**3.1.1 Main route setting**	-	-	-	x	x	x	x			1.) CTC send command "Set main route" to IXL	2.) IXL sets the status "part of a main route" at the elements of the route IXL sends this information to RBC

6.2.6 Statuses_CC

Source												ETCS-Level				
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	IXL	RBC	LEU	ETCS Onboard	new	IXL	RBC	LEU	ETCS Onboard	new
Comp-ID								400	642	621	700	xxx	400	642	621	700	xxx
[1]	Stat362-Req	**2 General**															
[1]	Stat55-Req	'Detected' right	-	x	-	x	x	X	X	X		X	The IXL receives from the point the status "right" and forwards this information to the RBC/LEU.	The RBC receives the status of the point from the IXL	The LEU receives the status of the point from the IXL		Point sends its status to IXL
[1]	Stat56-Req	'Detected' left	-	x	-	x	x	X	X	X		X	The IXL receives from the point the status "left" and forwards this information to the RBC/LEU.	The RBC receives the status of the point from the IXL	The LEU receives the status of the point from the IXL		Point sends its status to IXL
[1]	Stat57-Req	Not 'detected'	-	x	-	x	x	X				X	1. The IXL receives a "not detected" status from a point. 2. The IXL requests the point status again. 3. If the new status received is "left" or "right" see above. If the new status received is "not detected" the IXL would not authorise any route that goe				Point sends its status to IXL

Source												ETCS-Level				
Functional Component			LILS	L1	L1-centralised	L2	L3 (Regional)	IXL	RBC	LEU	ETCS Onboard	new	IXL	RBC	LEU	ETCS Onboard	new
Comp-ID								400	642	621	700	xxx	400	642	621	700	xxx
[1]	Stat80-Req	'Failed'	-	x	-	x	x	X				X	1. The IXL receives a "failed" status from a point. 2. The IXL would not authorise any route that goes through that point.				Point sends its status to IXL
[1]	Stat322-Req	'Failed'	-	x	-	x	x	X			X		The IXL receives info from signal with status "failed".The IXL informs the RBC / LEU / TCC system of the status of the signal (failed)			Signal sends its status to IXL	
[1]	Stat303-Req	'Dark'	-	x	-	x	x	X			X		The IXL receives info from signal with status "dark". The IXL will informs the RBC / LEU / TCC system of the status of the signal (indicates the aspect that the siganl shows in the field. If because of the lamp fuse the signal aspect changes from an aspec			Signal sends its status to IXL	

Source												ETCS-Level				
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	IXL	RBC	LEU	ETCS Onboard	new	IXL	RBC	LEU	ETCS Onboard	new
Comp-ID								400	642	621	700	xxx	400	642	621	700	xxx
[1]	Stat298-Req	Proceed aspect	x	x	x	x	x	X			X		The IXL informs the RBC / LEU / TCC system that the main signal status is "PROCEED"			Main signal sends its status to IXL	
[1]	Stat299-Req	Stop aspect	x	x	x	x	x	X			X		The IXL informs the RBC / LEU / TCC system that the main signal status is "STOP"			Main signal sends its status to IXL	
[1]	Stat300-Req	On sight aspect	x	x	x	x	x	X			X		The IXL informs the RBC / LEU / TCC system that the main signal status is "ON SIGHT"			Main signal sends its status to IXL	
[1]	Stat475-Req	Staff responsible aspect	x	x	x	x	x				X		The IXL informa the RBC / LEU / TCC system of the status of the main signal			Main signal sends its status to IXL	

Theses statuses are the information that the IXL gives to another supervisory system in order to inform of the condition of the railway.
With the info the LEUs is able to choose the correct telegram that should be sent by the balises they control. In case of ERTMS N2, with this information and the state of the points the RBC will send the appropriate MA to the ERTMS L2 trains.
Most of the statuses should be transmitted to ERTMS (RBC or LEU), not only the ones marked with an X here
The way the information is given has to be defined. It can send the status of points and signals or the list of possible routes, etc.

I think that Staff Responsible does not correspond to an aspect that needs to be transmitted to ERTMS
Stat57-Req and Stat80-Req might be transmitted to RBC /LEU as "point not supervised" or might not be transmitted at all. (depending on the implementation of the interface)

6.2.7 Driving_Values_CC

Source	Function								ETCS-Level			
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	IXL	new	IXL	new
Comp-ID								400	xxx	400	xxx
[1]	DrV362-Req	2 General									
[1]	DrV298-Req	Display proceed aspect	x	x	x	x	x	x	x	1. output value from the IXL to signal	2. Value received from IXL. For example in Spain this value corresponds to different aspects of the signal: green, green-yellow, yellow, red blue flashing (for ERTMS trains) and Red Blue (for ERTMS L2 trains). This means that the proceed aspect should be
[1]	DrV299-Req	Display stop aspect	x	x	x	x	x				
[1]	DrV300-Req	Display on sight aspect	x	x	x	x	x				
[1]	DrV463-Req	Display staff responsible aspect	x	x	x	x	x				
End of Da	End of Data	End of Data						End of .	End of .	End of Data	End of Data
		The interlocking transmits the value to the signals that then will display an aspect									
		Display means: action describing a driving value form the IXL to a signal with the intention to display a signal aspect on the signal.									

6.2.8 Detected_Values_CC

Source	Function							ETCS-Level			
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	IXL	new	IXL	new
Comp-ID								400	xxx	400	xxx
[1]	DeV362-Req	**2 General**									
[1]	DeV55-Req	Detected right	-	X	-	x	x	x	x	The IXL receives from the point the status "right"	Point sends its status to IXL
[1]	DeV56-Req	Detected left	-	X	-	x	x	x	x	The IXL receives from the point the status "left"	Point sends its status to IXL
[1]	DeV60-Req	Trailed	-	X	-	x	x	x	x	The IXL receives from the point the status "trailed"	Point sends its status to IXL
End of Da	End of Data	End of Data						End of .	End of .	End of Data	End of Data
		The process for this functionality is the same, no matter the value detected. The interlocking receives the value form the point. This value can be:									
		1. right									
		2. left									
		3. trailed									
		The IXL will then send the status to RBC /LEU... see tab statuses									

6.2.9 ERTMS_Experience

6.2.9.1 Commands

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component								ETCS-Level							
Comp-ID								101	102	400	202	623	642	621	700
	Commands														
[2]	**Route inhibition**														
[2]		Input route Inhibition Area Activition of temporary Exit Signal	-	-	-	X	X	in case of integrated CTC for IXL and RBC CTC-Ixl must be able to drive RBC commands/indicators	handle commands and indications				handle commands and indications		
[2]	**TSR**		-	-	X	X	X	see below	see below				see below		
[2]	**Route shorting request (Cooperative)**		-	-	-	X	X	see below	see below				see below		
[2]	**Initialise Reversing**		-	-	-	X	X	see below	see below				see below		
[2]	**Operator Emergency Stop Request**							see below	see below				see below		
[2]		Operator Emergency Stop Request triggers sending of Unconditional Emergency Stop to one train, identified by OBU Id.	-	-	-	X	X	see below	see below				see below		
[2]	**Modify RBC Operational State**							see below	see below				see below		
[2]		System Approval Request commands approval of the RBC.	-	-	-	X	X	see below	see below				see below		
[2]		System Approval Revocation Request commands revocation of RBC approval.	-	-	-	X	X	see below	see below				see below		
[2]		Shutdown Request commands shutdown of the RBC.	-	-	-	X	X	see below	see below				see below		

Source	Function	Sub Function	ETCS-Level											
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Comp-ID								101	102	400	202	623	642	621	700
[6]	**Entering in ERTMS L2 area. Transition from National Signalling System (STM**		-	-	-	x	-	3. Automatic route setting for IXL of ERTMS L2 system (ERTMS line), afterwards called "**PJ1-IXL**"		4. Route setting by **PJ1-IXL** 10. **PJ1-IXL** forwards the informations about the consensus (CCON and CMA) to **PJ2-IXL**	2. Route setting by IXL of national signalling system (traditional line), afterwards called "**PJ2-IXL**" 11. **PJ2-IXL** moves both STM-L2 area boundary signal and PJ2 route entry signal to proceed aspect		7. If the path in front of the train is free for a fixed number of block sections in advance to the boundary signal in ERTMS L2 area RBC sends MA to OBU 9. After ACK to MA receiving RBC sends " Radio Connection Consensus" (CCON) and "MA Consensus" (CMA) to **PJ1-IXL**		5. Train is in STM mode and passes on a specific fixed BG that order to OBU to set up a communicattion session with RBC. 6. Train with an open EVC-RBC communication session passes over specific commutable BG (announcement BG) and request to RBC the generation of two signals (consensus) to IXL-PJ1 8. OBU ack MA sent by RBC 13. Train pass the boundary signal and OBU entry in FS mode

6.2.9.2 Detected Values

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Detected Values														
[2]	**Train positioning as substitute of TVP**		-	-	-	-	x			**(sophisticated new function?)** 3.) IXL evaluates RBC information about free / occupied sections for route setting / release			2.) RBC shall inform IXL about occupied / released route sections evaluating the ETCS Onboard position report		1.) ETCS Onboard reports ist position on request from RBC
	Hot Wheel Detection														
[6]		Hot wheel detector (RTB = Rilevamento Temperatura Boccole) functionality	-	-	-	x				2. IXL sends the information about hot wheel alarm status to RBC			4. When train pass over a Balise Group well-known in RBC configuration, RBC sends a TSR to the train. If the alarm is "Hot" TSR's value is 150 km/h. If alarm is "Very Hot" TSR's value is 0 km/h (train stopping). The beginning of TSR is the next "hot wheel inspection location" (PVB) after the sensor location		1. Train running in FS or OS mode passes over a hot wheel sensor that detect an alarm 5. OBU receives TSR by RBC and set the braking curve to respect it
[6]		Train restart after detection of "Very Hot" alarm	-	-	-	x				3. IXL sends the information of the command to RBC			4. RBC sends a TSR revocation (pkt 66 of subset 026) and an informative text message to the driver (pkt 76 of subset 026)		1. Train is standstill in FS mode with EoA in front of it, and after driver inspection can be start again 5. OBU receives TSR revocation by RBC, and after driver acknowledgement the train can be re-start

6.2.9.3 Interlocking System General

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Interlocking_System_General														
[2]	**an IXL has to handle more than one RBC. Nevertheless it is strongly adviced**		-	-	x	x	x			IXL must be able to coordinate more than one RBC (even if the RBC-Boarder is located within one route)			RBC must support IXL handshake function, even if a route is distributed over more than one RBC		
[2]	**Migration**														
[2]		to assure migration operational function driven by the interface shall be restricted e.g. If possible IXL-RBC Interface must be able to drive conventional ATP-Systems (e. g. LZB)	x	x	x	x	-			it is forbidde to define functions, that afford communication between legacy ATP Systems and RBC			it is forbidde to define functions, that afford communication between legacy ATP Systems and RBC		
[2]		operational compatibility witw legacy ATP systems	x	x	x	x	-			it is forbidden to use operational function in RBC, which are contradictionary to legacy ATP-systems			it is forbidden to use operational function in RBC, which are contradictionary to legacy ATP-systems		
[2]		future IXL/RBC distributed function shall be able scaleable, in order while migration to fullfill conventional functions also as future ones (shall be flexible in order to assure connectivity from older and newer generations)	x	x	x	x	x			function must be defined in classes in order to handle migration issues			function must be defined in classes in order to handle migration issues		

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
[2]	**Reduced timer Funtions**														
[2]		Route release shall be performed only by using closed loop. No route release after timeout (except IXL-RBC connection disturbance).	-	-	-	x	x			**(sophisticated new function?)** 1.) IXL sends route relase information to RBC 5.) IXL releases route			2.) RBC informs IXL about affected train and shortens ETCS Onboard MA 4.) RBC informs IXL that route is allowed to be released		3.) ETCS Onboard informs RBC about acceptance of shortened MA (either it is able to brake to new stop location or it must come to standstill)
[2]	**CTC**														
[2]		integrated CTC for IXL / RBC	-	-	x	x	x	CTC must drive commands and indicators from different subsystems	CTC must drive commands and indicators from different subsystems						
[2]		common normalized Icons for CTC													
[2]	**Mobile HMI / Handheld**														
[2]		Operating Permission Management	-	-	-	-	-			permission management must not be distributed in ERTMS functioanlity					

6.2.9.4 Level Crossing

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Level Crossing														
[2]	**train shall be protected by LC by (safe) transmission of arival train time at LC**		-	-	-	x	x			**(sophisticated new function?)** 4. IXL has to pass LC close request to LC 7. IXL informs RBC about LC status			1. RBC informes OBU about LC together with lead time (MA-request parameter) in order to save LC 3. RBC evaluates MA request and informs IXL 8. Extends MA to OBU across closed LC		2. OBU generates MA request with position report in time

6.2.9.5 Monitoring

Source	Function	Sub Function	ETCS-Level											
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC-IXL	CTC-RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Comp-ID								101	102	400	202	623	642	621	700
	Monitoring														
[2]	**RBC driven functions**														
[2]		Transmission of train numbers / train category from RBC to IxL (proceed information to CTC) with route/ darkening request	-	-	-	x	x	3.) CTC-IXL uses train information to send request for train specific route to IXL		**(sophisticated new function?)** 2.) IXL transmitts train information and request to CTC-IXL			1.) RBC sends train number / train category to IXL together with request to IXL		
[2]		in case of Ixl aknowledgement requests a RBC shall generate acknowledgement for status report from IXL	-	-	-	x	x			**(sophisticated new function?)** IXL requests acknowledgement of element status report			acknowledgement for IXL element status is sent to IXL		

6.2.9.6 Route General Requirements

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Route General Requirements														
[3]	**TSR**														
[3]		Set a Temporary Speed Restriction (TSR) <-- DB AG	-	-	x	x	x		1a.) TSR submission to RBC 3.) Indicate TSR (even if not submitted here)				2.) store TSR in Track Image send TSR to GSM-R		4.) Monitor the speed
[3]		Set a Temporary Speed Restriction (TSR) <-- ProRail, RFI	-	-	x	x	x		3.) Indicate TSR				2.) store TSR in Track Image send TSR to GSM-R		4.) Monitor the speed
[3]		Set a Temporary Speed Restriction (TSR) <-- BDK	-	-	x	x	x			**(sophisticated new function?)** hold Signal Speedaspect			2.) store TSR in Track Image send TSR to GSM-R		4.) Monitor the speed
[3]		Set a Temporary Speed Restriction (TSR) <-- Trafikverket ; ProRail	-	-	x	x	x		3.) Indicate TSR				2.) store TSR in Track Image send TSR to GSM-R		4.) Monitor the speed
[3]		Set a Temporary Speed Restriction (TSR) <-- Future 1	-	-	x	x	x	1a.) TSR submission to IXL 3.) IndicateTSR (even if not submitted here)		**(sophisticated new function?)** 2.) Transmit Speed - Section to RBC			3.) calculate Section to kilometer store TSR in Track Image send TSR to GSM-R		4.) Monitor the speed
[3]		Set a Temporary Speed Restriction (TSR) <-- Future 2	-	-	x	x	x	1a.) TSR submission to IXL 3.) IndicateTSR (even if not submitted here)		**(sophisticated new function?)** 2.) store TSR, Combine TSR-Info to with signalaspect of the routes, transmit modified aspect to adjacent Wayside Signal				4.) send TSR to controlled Balise	6.) Monitor the speed
[3]		Set a Temporary Speed Restriction (TSR) <-- Future 3	-	-	x	x	x	1a.) TSR submission to IXL 3.) IndicateTSR (even if not submitted here)		**(sophisticated new function?)** 2.) Transmit Speed - Section to central LEU		3. store TSR, send TSR to adjacent controled balises			5.) Monitor the speed

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Shunting in an RBC area														
[3]		Train is driving in shunting area	-	-	-	x	x	1a.) Command submission to IXL 3.) Indicate typ "shunting route" (even if not submitted here)		**(sophisticated new function?)** 2.) set the route into shuntig area monitor the conditions If condition fullfilled, send information to RBC			3.) send the command "change to shunting mode" to GSM-R delete the train inside RBC		5.) Change to Mode shunting. Drive in mode shunting. 6.) If next route is full supervision route - follow the "start of mission " procedure
[4] 4.9.7		Shunting in an RBC area	-	-	-	x	x			**(sophisticated new function?)** 1. When the IXL sets and locks the SH route informs the RBC.			2. the RBC sends the SH authorisation to the EVC 4. the RBC gives the authorisation without any info from the IXL.		3. If SH is selected by driver

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Increasing safety level														
[2]		transmit emergency information with destination signal	-	-	-	x	x			IXL shall send emergency information for the destination signal of a route			RBC is able to affect a train even if the train has passed the start signal of the route if emergency information is reported for the destination signal		
[2]		increasing safety level by RBC informing interface in case of critical train ac	-	-	-	x	x			**(sophisticated new function?)** 3. IXL informs RBC			4. RBC shortens MA 5. RBC sends text information "LC-time out"		6. Proceed in staff responsile
[6]		"MA Cancellation" command: IXL functionality used to prevent a train in FS mode in front of route exit signal with Proceed aspect (green) from moving because suddenly some new critical conditions have come up	-	-	-	x				3. IXL sends the information about "MA cancellation" command to RBC			4. RBC sends an Unconditional Emergency stop to the train		1. Train is standstill in FS mode in front of a route exit signal at proceed aspect 5.OBU receives UES and switch in TRIP mode
[2]	**cross boarder functions**														
[2]	**tunnel train reversion in case of danger**		-	-	-	x	x	1. CTC commands reversing		**(sophisticated new function?)** 2. Set reversing rout			4. RBC commands Reversing MA to OBU		5. OBU moves according to reversing MA

6.2.9.7 Route Initiation Completion

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Route_Initiation_Completion_CC														
	Route setting														
[4]4.9.1		Route setting request	-	-	-	x	x			2. Set route			1. The RBC requests the IXL to provide a route to be set		
[2]		Avoidance of tunnel encounterance (see also section Monitoring. RBC dri	-	-	-	x	x			2. IXL proves special conditions 3. Set route			1. RBC issues MA together with information train number and train category		

Source	Function	Sub Function	LILS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level							
Functional Component								CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Comp-ID								101	102	400	202	623	642	621	700
	Route Locking Proving														
[3]		>full supervision route – normal operation route with full monitoring conditions, with complete overlap (dynamic) and flank protection						1a.) Command submission to IXL 3.) Indicate typ "normal route" (even if not submitted here)		2.) set the route monitor the conditions If condition fullfilled, send send the informations of the rlevant elements to RBC			3.) generate MA for the route from the Signal, send MA to GSM-R		5.) Monitor the MA
[3]		>on sight route – normal operation route used to send trains to an occupied track, no overlap, normal flank protection						2a.) Command submission to IXL 4.) Indicate typ "on side route" (even if not submitted here)		3.) set the onside route monitor the conditions If condition fullfilled, send on-side aspect with signal-number to RBC			4.) generate MA for the route from the Signal, send MA together with the command "change to Onside-Mode" to GSM-R		5.) Monitor the Change to OS-Mode Monitor the MA
[3]		>staff responsible route – degraded operation route, no overlap is set, all other available route elements are initiated and locked The route indicatea a special aspect subject to some monitoring conditions which would require at least that the path of the train is correct.						1a.) Command submission to IXL 3.) Indicate typ "staff responcible route" (even if not submitted here) via voice-communication inform the driver and give "written order"		2.) set the route monitor the conditions If condition fullfilled, send aspect with signal-number to the MMIs Send RBC signal aspect STOP with signal-number			3.) generate no MA for the route from the Signal		4.) Monitor the Change to staff responcible

Source	Function	Sub Function						ETCS-Level							
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Comp-ID								101	102	400	202	623	642	621	700
[3]		>shunting route – normal operation shunting route						1a.) Command submission to IXL 3.) Indicate typ "shunting route" (even if not submitted here)		3.) set the onside route monitor the conditions If condition fullfilled, send on-side aspect with signal-number to RBC			4.) generate MA for the route from the Signal, send MA together with the command "change to Onside-Mode" to GSM-R		5.) Monitor the Change to OS-Mode Monitor the MA
[3]		>other special routes are set as full supervision route with a parameter (speed reduction, stopping train, freight train, no overlap) **see Item 40**													
[3]		>route oversetting is included Manual oversetting by the signaller is possible. Automatic oversetting (signals in automatic mode) should be replaced by automatic route setting functionality.													
[3]		>route locking harmonised, no route locking exceptions (not needed due to dynamic overlap)													
[3]		>dynamic overlap – new combination of existing functions for overlap extending and overlap swinging													
[3]		>route cancellation by command will release all elements up to an occupied section in the route body													
[3]		>2 cancellation commands Cancel route and Cancel residual route													
[3]		>use of approach zone to evaluate if a release delay timer is required													
[3]		>separate command for cancelling staff responsible routes													
[3]		>staff responsible route would not be released by the train													
[3]		>track blocking harminised to prevent route setting													

Source	Function	Sub Function												
							ETCS-Level							
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC:IXL	CTC:RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Comp-ID								101	102	400	202	623	642	621	700
[2]	**Handshake Procedure**														
[2]		In case of requested acknowledgement in IXL status reports (from Ixl to RBC) IXL is forced to supervise all acknowledgements of RBC as precondition for putting a signal in proceed	-	-	x	x	x			**(sophisticated new function?)** 1.) IXL requests acknowledgement for all elementstatus of the route 4.) IXL sets startsignal to proceed if it has information that RBC has acknowledges all requested element status reports (either from RBC or from adjacent IXL)	3.) adjacent IXL informs IXL about RBC acknowledgment		2.) RBC acknowledgs status report for all requests from IXL		
[4]4.9.2	**Provides confirmation to RBC that the route is set and locked**		-	-	-	x	x			**(sophisticated new function?)** 1. Provides confirmation to RBC that the route is set and locked			2. ???		
	Provides confirmation to CLC that the route is set and locked		-	-	x	-	-			1. IXL sends to the Centralised LEU the information of signal aspects, point positions and border conditions		2. the CLC would be able to select the adequate telegram			

Source	Function	Sub Function	LILS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component								ETCS-Level							
Comp-ID								101	102	400	202	623	642	621	700
	On Sight (OS)														
[6]		Management of OS functionality in case of rack occupancy in line (auto-activation)				x				2. IXL sends the information about track occupancy to RBC			3. RBC generates and sends OS-MA to OBU to proceed to signal		1. Train is standstill in FS mode in front of a signal (EoA) of a line section with an undue occupied track circuit (TVP section) 5. Driver acknowledges the OS mode and OBU switch in this state
[6]		Management of OS functionality in case of drive on sight route in station	-	-	-	x				3. IXL sends the information about drive on sight route with on going TX command to RBC			3. RBC generates and sends OS-MA to OBU to proceed to signal		1. Train is standstill in FS mode (EoA) in front of an entry signal of a station with an undue occupied track circuit (TVP section) 6. Driver acknowledges the OS mode and OBU switch in this state

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC:IXL	CTC:RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	Route Used Cancelled														
	Route Release														
[2]		distinguish between emergency stop and route release	-	-	-	x	x			**(sophisticated new function?)** IXL shall be able to distinguish between emergenca stop and route release information to RBC			If emergency stop and route relase is reported differently, RBC is able to apply varying reactions towards ETCS Onboard		
		Automatic Route Release	-	-	-	x	x			**(sophisticated new function)** 1. IXL indicates to RBC that the signal has been set to stop due to command of the signalman.			2. The RBC shall then shorten the MA of the train or send an emergency stop		3. Emergency stop
[4]4.9.4		Route releasing	-	-	-	x	x			**(sophisticated new function?)** 2. ???			1. when a train has cleared a route the RBC informs the IXL that the route can be released		

[6]		MA Co-operative shortening to improve safety in tunnel: co-operation involves IXL system too				x	x			2. IXL sends the information about "Co-operative revocation" command to RBC 6. If the new EoA has been accepted, IXL block the related signal. 7. Depending on the case (accepting or refusing of new MA) IXL propagates the command to the signal in advance or in rear and the automatic process goes on until the fittest location to stop train haven't been found. In this location a NSA (Non stopping area) is set on the opposing track to protect train running in reverse direction			3. RBC generates and sends MA Co-operative shortening to OBU 5. RBC forwards the information about the decision to IXL		4. OBU can accept or refuse the proposed new EoA and inform RBC about the decision

Source	Function	Sub Function						ETCS-Level							
Functional Component			L1LS	L1	L1-centralised	L2	L3 (Regional)	CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Comp-ID								101	102	400	202	623	642	621	700
	Eng_Conf_Requirements														
[2]	Mapping RBC / Ixl Data														
[2]		track layout (topology) to internal data model e.g. knotes / edges	-	-	-	x	x	Capability to map track layout (topology) to internal data model e.g. knotes / edges	Capability to map track layout (topology) to internal data model e.g. knotes / edges	(sophisticated new function?) Capability to map track layout (topology) to internal data model e.g. knotes / edges			Capability to map track layout (topology) to internal data model e.g. knotes / edges		

Source	Function	Sub Function	L1LS	L1	L1-centralised	L2	L3 (Regional)	ETCS-Level: CTC.IXL	CTC.RBC	IXL	Adjacent IXL	central-LEU	RBC	LEU	ETCS Onboard
Functional Component															
Comp-ID								101	102	400	202	623	642	621	700
	TVP Section (saves axle counter)														
[2]	**Safety Distance behind Signal**		-	-	-	x	x			**(sophisticated new function?)** 1.) IXL reports 'inexist' for a destination signal to RBC in case the route is released (i.e. the train has left the route with its last axle) 3.) IXL is able to set the route again without waiting that the track vacancy detection system beyond the destination signal reports 'free'			2.) RBC waits after reception of 'inexist' until the train has passed the safety distance with ist min safe rear end, evaluating position and speed in the positionreports of ETCS Onboard, and reports to IXL 'safety distance is free'		
	Track Ahaed Free Request														
[5]		TAF	-	-	-	x	x						2. then the RBC can give a FS MA		1. If the driver confirms that the track between the head of the train and the next signal or board marking signal position is free
[2]		Alternative: Upgrade from "staff responsible" to "full supervision" (replace "track ahead free request" TAFR)	-	-	-	x	x			**(sophisticated new function?)** 3. IXL supervises history of track occupation and aknowledges TAFR to RBC			2. RBC request IXL if section(s) between train and signal remain free since occupation by train 4. RBC generates MA to OBU to proceed to signal		1. OBU restart while train is not located direct in front of a signal

End of Document