Welcome to the INESS training

7,8 & 9 March 2012

Day 2

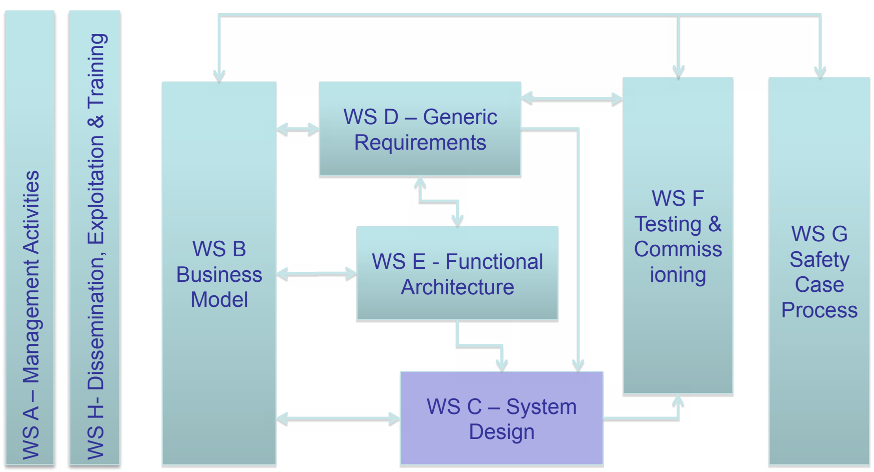
Welcome

- Please wear your badge at all times
  - Internet access info is on your badge!
- Please: No Food & Bevarage in meeting rooms
- Presentations available via:
  - Hardcopy of sheets available in lobby
  - Download via the www.INESS.eu webpage (Training)
  - The USB you got at registration
- Questions?...ask the people with GRAY banner on badges

WP H.3: Training (Day two)

Agenda Item	Speaker	Time
1. Unified European Railway Infrastructures data model (EUDRI); Status of activities • Explanation of work done in the WS • Overview of the Data Model requirements	WS C Tom Stein	09:00 – 09:45
• Q&A		09:45 – 10:00
• Challenges & Path forward • Identify challenges in the present data model • Needed actions to be able to implement the data model in your own organisation	Tom Stein + TBC	10:00 – 10:40
Coffee break		10:40 – 11:10
• Discussion about how to make the Data Model work in your organisation		11:10 – 11:45
LUNCH BREAK		12:00 – 13:00
2. Testing and Commissioning • Presentation cost efficient methods for testing and commissioning of interlockings + Handbook	WS F Neil Barnatt	13:00 – 14:00
• General Discussion about testing & commissioning		14:00 – 14:30
Coffee break		14:30 – 15:00
Conformity Testing / Data Reduction	Jorge Gason	15:00- 16:00
3. **General Discussion and Closing day two**		16:00 – 16:30

INESS System Design (EURDI) WS-C



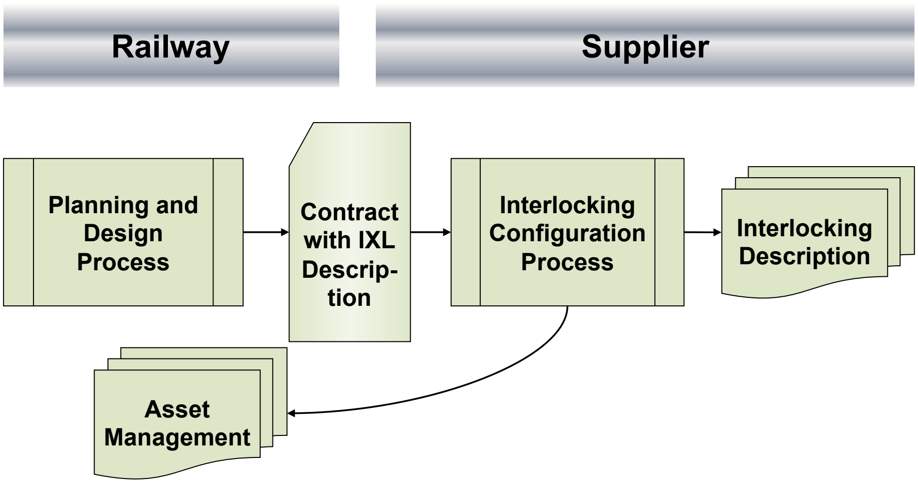
Explanation of Work Done

Main Objective of Workstream C

System Design

- Define the necessary inputs and outputs of a design tool environment in order to be able to develop tools to support the application of new systems.
- Enable secure transfer of scheme knowledge between user and supplier in line with the associated work packages within this work stream. To extract all relevant information that can be used to support asset management of the final delivered system.

Purpose of the Data Model

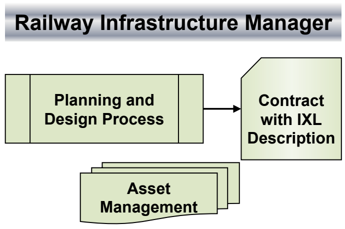


Why Should Anyone Use a Standardised Data Model?

Planning & Design Process

Why Should a Railway Use a Standardised Data Model?

- There is a process used by the railway infrastructure manager to describe an interlocking
- There is data exchange in that process between different departments
- There are tools used during this process that currently are proprietary



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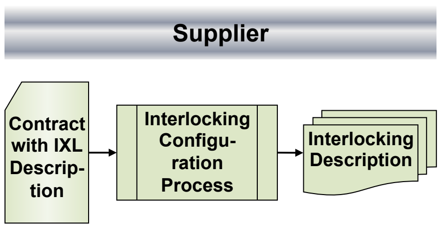
Interlocking Configuration Process

Why Should a Supplier Use a Standardised Data Model?

- There is a process used by the supplier to implement and configure an interlocking
- There is data exchange in that process between different departments
- There are tools used during this process that currently are proprietary



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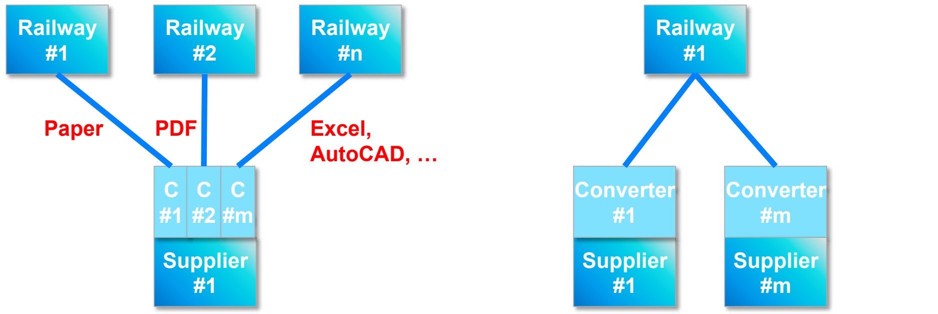
Individual Conversions of Interlocking Descriptions



- n railways = n converters, 1 paid by each railway
- m suppliers = m converters, each paid by a railway

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Why Should Anyone Use a Standardised Data Model?

Optimisation

- Different railway infrastructure manager pay for the development of different tools doing similar things
- Often even internal steps are linked via paperwork only
- Each supplier needs to (often manually) import data in different formats
- Each manual step may produce unpredictable mistakes
- Each manual step takes additional time
- Every railway infrastructure manager has to (often manually) import the list of new assets
- ➔Optimisation is possible

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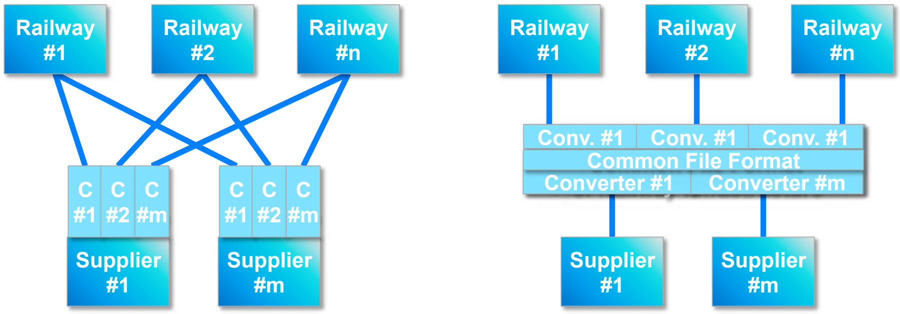
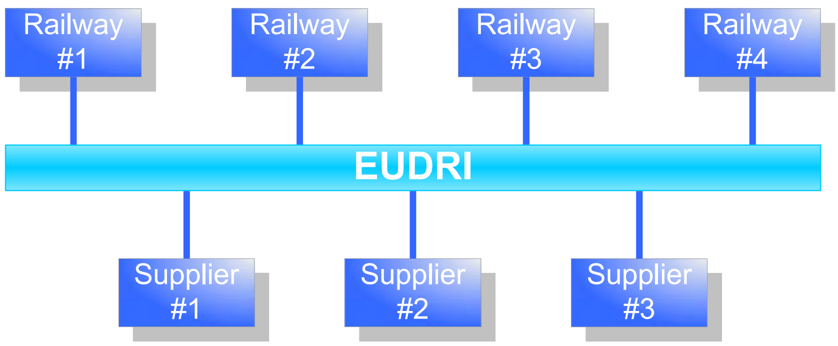
Combining Conversions of Interlocking Descriptions



- n * m converters, m paid by each railway
- m + n converters = 1 + m/n paid by each railway, break even at m+n=**4**

European Unified Description of Railways Infrastructures



What is EUDRI?

EUDRI

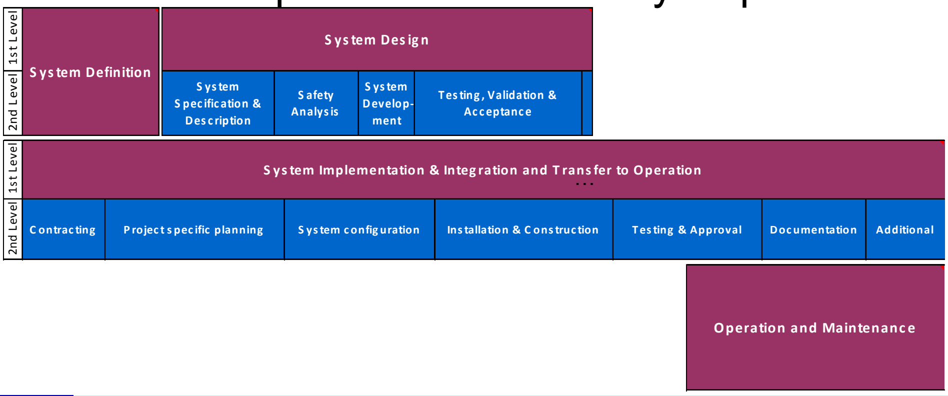
- European Unified Description of Railways Infrastructures
- EUDRI describes a specific INESS compliant interlocking (an interlocking that may include ETCS)
- EUDRI can be used to exchange interlocking descriptions between a railway infrastructure manager and a supplier
- EUDRI is an interface and a data model

Why to use EUDRI:
Because it can save money.

And speed things up.

Effect Evaluation Between Workstreams B and C

- With the help of workstream B the costs reduction potential in the life cycle phases



Cost reduction potential towards INESS cost drivers

- The overall cost reduction potential differs largely due to current status of data usage and expectations of different suppliers (no figures from railways given), average was considered to be app. 2%:

Characterization of cost reduction potential: -Labour costs to maintain the field elements -Labour costs for field elements during system implementation	Impact [%]: **-1 to -10%**

Why Design a New Data Model?

Why Design a Data Model?

What is WS C good for?

- There are many different data models in use now, like EuroInterlocking, RailML, DB Modell, Stamp, Unisig 112, PoE
- All were designed for a special purpose, which was not the same purpose INESS has
- ➔Therefore, the gap must be filled with a “new” model

A New Data Model?

What is WS C good for?

- As some (or many) aspects already are part of existing data models, it is never useful to re-invent the wheel
- Instead, state of the art models where evaluated, ranked, and the best one was selected as a basis
- In a second step, this basis was analysed in detail and the gaps were described

How to Select a Data Model

What is WS C good for?

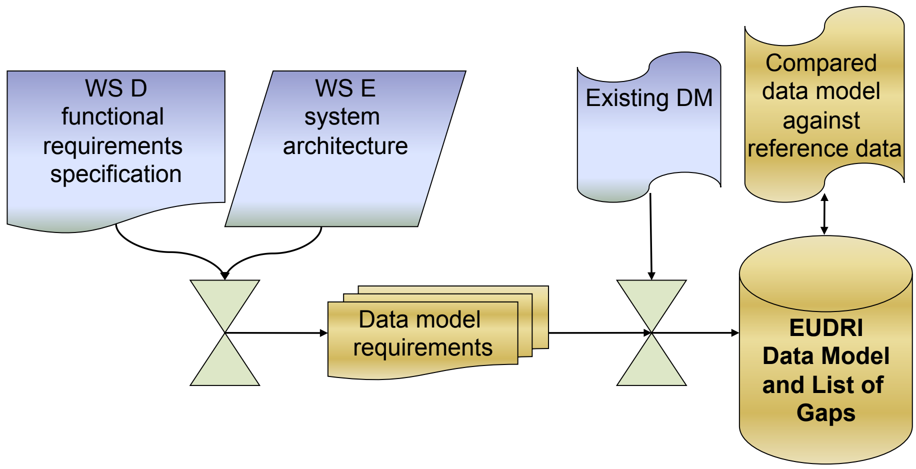
- In a first step, requirements for data models were derived from the knowledge of the workstream members and on the basis of the requirements defined by WS D
- In a second step, the data models were evaluated and then ranked according to the fulfilment of requirements

How to Select the Best Data Model

What is WS C good for

- The requirements are not weighted according to their importance – range of "important" parameters differs between users
- Therefore, first ranking does not reflect a balanced, but purely technical ranking
- ➔Second ranking on users opinions reflects their individual balance
- 3 data models were almost equally in first and second ranking, the best one was chosen to be the basis for EUDRI

Tasks and Results of WS C



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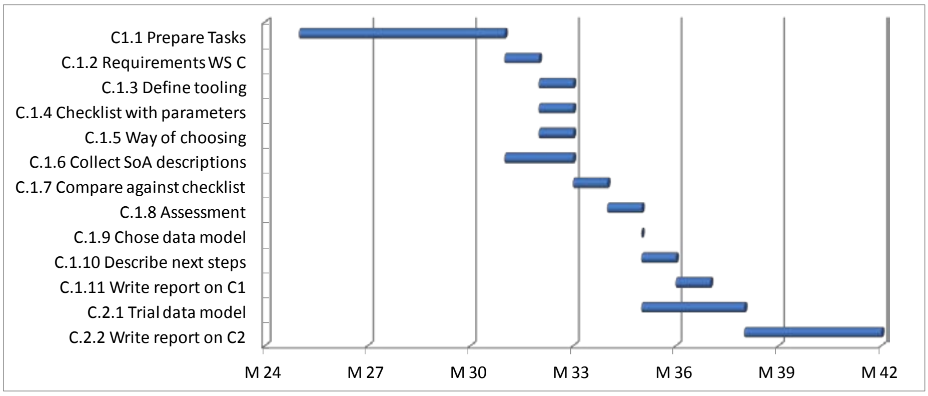
Work Stream C: „System Design“

Who needs EUDRI? How to find an European Unified Description of Railway Infrastructures

Tasks and timeline to find the best data model



Task C.1.2: Requirements WS C

- Requirements for data models were derived
  - from the knowledge of the workstream members, based on the system architecture given by workstream E, and
  - based on the requirements defined by WS D

Do Safety and Security affect the data model?

Safety & Security

- How can a supplier make sure he received the data right?
- How can a railway make sure it received the data right?
- How about updates of parts of the data?
- How can a tester make shure he uses the right data (including updates)?
- Can this be part of the process or must it be part of the data?
- ➔ It was decided that safety and security shall (partly must) be part of the surrounding process, not of the data

Example from the requirements

Checklist for Data Model: Example

Req. Unique ID	Req. Description	Measurable	Knock-out req.	Importance from 1 to 3	Ful-filment from 0 to 4	Covered in	Comments
DM_001	The Data Model (DM) shall be extendable with easy evolution for introducing (removing) new objects to the model and new attributes to existing objects						
DM_001-1	The DM structure shall allow the definition/removal of objects and their attributes.	X	X	3			
DM_001-2	The DM structure shall allow the definition/removal of new/ existing objects without impacting the existing (already defined) objects.	X	X	3			
DM_001-3	The DM structure shall allow the definition/removal of new/ existing attributes within an existing object without impacting the existing (already defined) attributes for that object	X	X	3			
DM_005	The DM shall ensure the retro-compatibility with previous (old) versions	X		3			
DM_005-1	The DM shall include a dedicated object for version management for the complete DM	X		2			
DM_007	The version management shall handle with one version for the data structure and one version for the data itself	X		2			
DM_008	The DM shall be free and available within the INESS partners This topic will be discussed later on (in a second step) for new comers in the market.	X	X	3			

Task C.1.3: Define tooling

Two areas for tools:

- Tools for the data model
- Development of DM
- Versioning of DM
- Drawings of maps
- Signal aspects
- Users

- Tools for the data
- Using of DM (e.g. writing XML)
- Versioning of Data
- Test of the file
  - well-formed, validation
  - all needed objects, attributes
  - links between objects
  - compliance technical rules
- Management of planning
- Viewer for the data

Task C.1.4: Checklist with parameters

- Find checkable requirements
  - from users experience
  - from all objects and attributes mentioned in the extended core requirements of WS D

Comparison process

Calculation of fulfillment

- To compare the data models in an objective way the results are calculated in marks. As all data models did not fulfill at least one so called know out criteria, the following formula was used to express the fulfillment of requirements in marks and as a percentage

$$R_{ik} = W_i \cdot FD_{ik}$$

$$TM = \sum_{i=1}^{n}(W_i \cdot 5)$$

$$DMM_k = \frac{\sum_{i=1}^{n}(R_{ik})}{TM} \cdot 100$$

R_{ik} = Result (or Mark) of the Requirement "i" in the Data model "k".
W_i= Weight (Importance) of the Requirement "i". Range= [1,3].
FD_{ik}= Fulfillment Degree of the Requirement "i" in the Data Model "k". Range =[0,5]
TM = Top Mark of any Data Model
KO_{ik}= Knock Out Factor
DMM_k= Data Model Mark of the Data Model "k".

Task C.1.5: Way of choosing

- An objective, reproducable way to choose the data model had to be found and described.

Task C.1.6: Collect SoA descriptions

- To be able to compare the data models, the description of each model was collected.
- A team consisting of one specialist (someone already knowing the data model), a railways and a suppliers representative was formed for each data model

Task C.1.7: Compare against checklist

- Each data models' team compared the requirements to their data model
- The data models were evaluated and then ranked according to the fulfilment of requirements

Results of the technical ranking (Overview)

Results for checking	RailML DM	EuroIXL	Stamp	DB Model	PoE Siemens	UNISIG 112
Overall fulfilment	346	263	349	321	270	290
Overall fulfilment Formula 1	85%	64%	86%	79%	66%	71%
STRUCTURE	141	111	158	126	111	119
GENERAL_REQ	28	24	25	28	24	21
FIELD_ELEMENTS	85	94	95	103	57	74
ERTMS	46	2	31	16	38	36
TRACK_LAYOUT	46	32	40	48	40	40
KNOCKOUT REQ. FULFILED	96	93	105	84	87	105
Number req. fulfiled degree 4	32	21	29	32	25	26
Number req. fulfiled degree 3	6	3	8	3	2	3
Number req. fulfiled degree 2	3	3	6	0	1	3
Number req. fulfiled degree 1	1	1	2	0	1	1
Number req. not fulfiled	6	18	4	12	18	13
Knock-out requirements						
Fulfilment	**96**	**93**	**105**	**84**	**87**	**105**
Number req. fulfiled degree 4	7	5	8	7	7	8
Number req. fulfiled degree 3	0	3	1	0	0	1
Number req. fulfiled degree 2	2	1	0	0	0	0
Number req. fulfiled degree 1	0	0	0	0	1	0
Number req. not fulfiled	0	0	0	2	1	0
Requirements of importance 3						
Fulfilment	**222**	**207**	**231**	**213**	**192**	**204**
Number req. fulfiled degree 4	16	14	17	17	15	15
Number req. fulfiled degree 3	2	3	3	1	1	2
Number req. fulfiled degree 2	2	2	0	0	0	1
Number req. fulfiled degree 1	0	0	0	0	1	0
Number req. not fulfiled	0	1	0	2	3	2
Requirements of importance 2						
Fulfilment	**104**	**50**	**102**	**92**	**74**	**68**
Number req. fulfiled degree 4	11	6	8	10	8	7
Number req. fulfiled degree 3	2	0	4	2	1	1
Number req. fulfiled degree 2	1	0	3	0	1	1
Number req. fulfiled degree 1	0	1	1	0	0	1
Number req. not fulfiled	2	9	0	4	6	6
Requirements of importance 1						
Fulfilment	**20**	**6**	**16**	**16**	**4**	**18**
Number req. fulfiled degree 4	4	1	2	4	1	4
Number req. fulfiled degree 3	1	0	1	0	0	0
Number req. fulfiled degree 2	0	1	2	0	0	1
Number req. fulfiled degree 1	1	0	1	0	0	0
Number req. not fulfiled	4	8	4	6	9	5

Legend:
- ≥ 80% of maximum
- ≥ 60% of maximum
- ≥ 40% of maximum
- ≥ 20% of maximum
- < 20% of maximum

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Results of the technical ranking

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STRUCTURE	141	111	158	126	111	119
GENERAL_REQ	28	24	25	28	24	21
FIELD_ELEMENTS	85	94	95	103	57	74
ERTMS	46	2	31	16	38	36
TRACK_LAYOUT	46	32	40	48	40	40

Task C.1.8: Assessment

Technical and personal ranking

- The requirements are not ranked according to their importance – range of "important" parameters differs between users
- Therefore, first ranking does not reflect a balanced, but purely technical ranking
- ➔Second ranking on users opinions reflects their individual balance

Results of final ranking

	ADIF	Alstom	Ansaldo	AZD	Bombardier	DB	Invensys	Network Rail	Pro Rail	RFI	Siemens	Thales	Funkwerk	Eliop	*Average*	***Ranking***	*Expected #1*
Stamp (349 Points)	2	2	4	1	2	3	1	1	2	2	3	2	3	2	*2,14*	***2***	*3*
RailML (346 Points)	1	1	1	3	3	2	2	2	1	4	1	4	2	1	*2,00*	***1***	*6*
DB Model (321 Points)	4	3	5	2	1	1	3	3	3	1	2	1	1	3	*2,36*	***3***	*5*
Unisig 112 (290 Points)	3	4	3	4	4	5	4	4	5	5	5	4	4	4	*4,14*	***4***	*0*
PoE Siemens (270 Points)	5	5	6	6	6	6	5	5	6	6	4	6	6	6	*5,57*	***6***	*0*
EuroIXL (263 Points)	6	6	2	5	5	4	6	6	4	3	6	5	5	5	*4,86*	***5***	*0*

Task C.1.9: Chose data model

- The ranking showed the same 3 data model being "top class" in technical and personal ranking.
- Based on the technical ranking the personal ranking selected RailML as the best data model for all partners
- ➔ It for sure is not the best data model for every single partner, if he already uses a specialised model!

What is RailML?

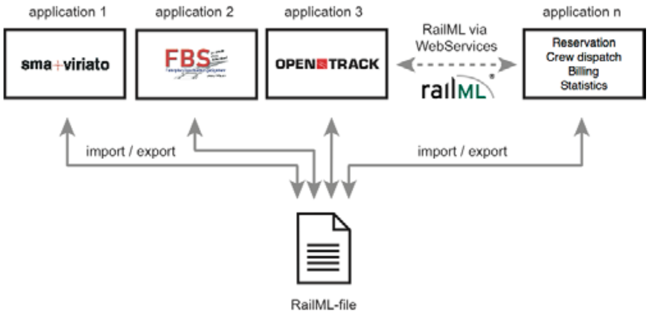
What is RailML

www.railml.org

- RailML is XML-based
- It is developed by an open source working group (including DB, SBB, ÖBB, …) having a strong scientific background but focusing on industrial usability.
- RailML (www.railml.org) is Open Source, licensed under "Creative Commons License 2.0"

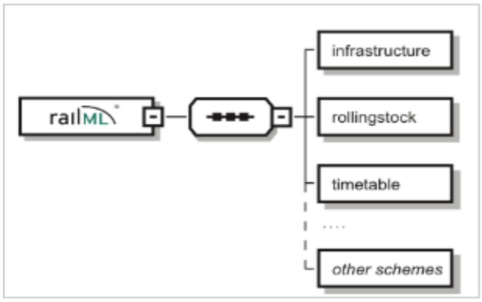
The Purpose of RailML

- The railML.org Initiative was founded in early 2001 against the background of the chronic difficulty of connecting different railway IT applications. Its main objective is to enable heterogeneous railway applications to communicate with each other.



Format of RailML

- RailML is a generic language that can be used to describe railway-related data.
- The language has been divided into sub-formats (or schemes) for particular types of railway data.



```xml
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with OpenTrack (http://www.opentrack.ch) -->
<railmlxmlns:xsi="http://www.w3.org/2000/10/XMLSchem
a-instance"
xsi:noNamespaceSchemaLocation="timetable.xsd">
<timetable version="0.95" scheduleformat="hh:mm:ss"
periodformat="s">
<train trainID="RX 100.2" type="planned"
source="opentrack">
<timetableentries>
<entry posID="ZU" departure="06:08:00" type="begin">
</entry>
<entry posID="ZWI" departure="06:10:30" type="pass">
</entry>
<entry posID="ZOER" arrival="06:16:00"
departure="06:17:00" minStopTime="9" type="stop">
</entry>
<entry posID="WS" departure="06:21:00" type="pass">
</entry>
<entry posID="DUE" departure="06:23:00" type="pass">
</entry>
<entry posID="SCW" departure="06:27:00" type="pass">
</entry>
<entry posID="NAE" departure="06:29:00" type="pass">
</entry>
<entry posID="UST" arrival="06:34:30" type="stop">
</entry>
</timetableentries>
</train>
</timetable>
</railml>
```


RailML-Beispiel-Daten

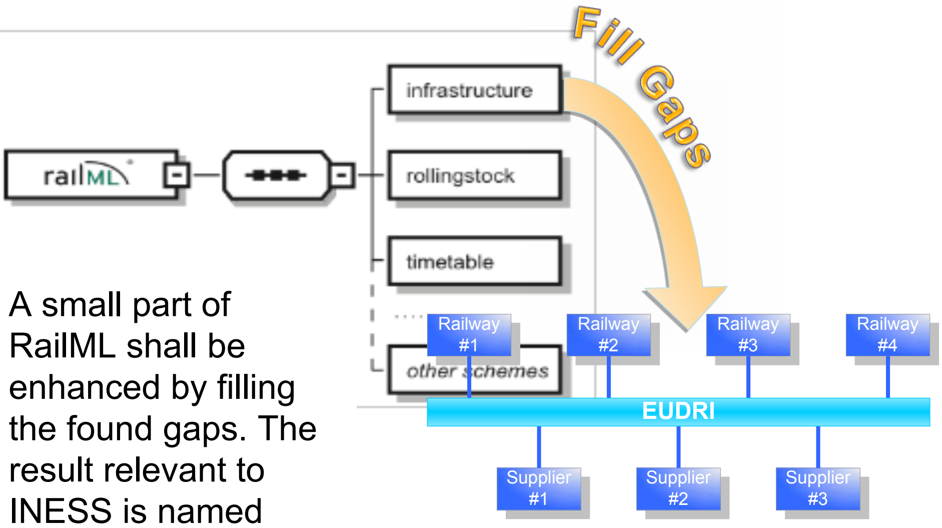
Task C.2.1: Trial of the Data Model

- It was planned to put the data model to trial
- But as this would have needed high efforts in adapting existing tools and finalising at least some gaps of the data model, this was replaced:
- Instead, engineers of workstream members compared the data model and the requirements to reference data of proprietary data models
- ➔ A detailed list of gaps was build

Task C.2.2: Write Report on C2

- The delivery DC.2.1 is a publicly available report on the work and results of workstream C
- It includes a list of gaps in RailML that need to be filled for the purpose of EUDRI
- For addressing the "new" data model compliant to INESS purposes, that part of **RailML** was given the name **EUDRI**

Will RailML become EUDRI?



A small part of RailML shall be enhanced by filling the found gaps. The result relevant to INESS is named **EUDRI**

Overview of the Data Model Requirements

Groups of Requirements

#	Group
1	Route
2	Powered Moveable Element: Point
3	Powered Moveable Element: Derailer
4	Powered Moveable Element: Moveable switch diamond crossing
5	Lockable and detection device: Detector
6	Lockable and detection device: Lockable device
7	Signal
8	Local Shunting Area
9	Working Area
10	Temporary Speed Restriction
11	Level Crossings
12	TVP Section
13	Track segment
14	Platform
15	Catenary Group
16	Line Block
17	Group of points
18	Group of signals
19	Emergency local panel
20	Balise group
21	Loop
22	Addresses
23	Interlocking
24	RBC
25	General configuration

Example: Requirements for a Route

Object	Attribute No.	Attribute(s)	Value(s)	Comments
Route	1.1	ID		
	1.2	route name		The route name (including overlap) as string
	1.3	route type	values defined in ETCS, can be extented for national needs	
	1.4	route signalling type	ETCS L2; L1; conventional	Further attribute to distinguish between different routes for L2, L1 or conventional operation
	1.5	route body		Parent attribute for other attributes in the list
	1.6	flank protection for route body		Parent attribute for other attributes in the list
	1.7	overlap		Parent attribute for other attributes in the list
	1.8	flank protection for overlap		Parent attribute for other attributes in the list
	1.9	route entry signal		
	1.10	route exit signal		
	1.11	sub-route signal		
	1.12	signals for flank protection to the route body		
	1.13	TVP sections in route body		TVP sections must be free by default, exeptions can be put in here
	1.14	TVP sections in overlap		TVP sections must be free by default, exeptions can be put in here
	1.15	TVP sections in flank protection		TVP sections must be free by default, exeptions can be put in here
	1.16	moveable elements in route body		
	1.17	moveable elements in overlap		

Requirements

- As the complete list of requirements is far to long and to complex to be discussed here, it can be obtained with the final report of the workstream.

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Challenges and Path Forward

Optimisation of costs, speed and quality

Why use EUDRI

- No single optimisation can reduce the overall costs of an interlocking in a significant way. This is one of the important results of workstream B. As an interlocking is a complex system surrounded by hundreds of processes, only the significant optimisation of every process will reduce the overall costs significantly.
- EUDRI is a method to reduce those costs driven by describing the interlocking, either driven by (existing or future) tools on a railway infrastructure managers side or by reading the description on a suppliers side.

Getting things into production

Who might use EUDRI

- As shown by workstream B, it is up to the railway infrastructure managers to drive the change
- As a first step they might add resources to the RailML consortium to fill the gaps that are described by this workstream.
- That will result in RailML being useful as EUDRI: An harmonised interface that can be used by design tools.

Open tasks

Maintenance of the data model

- There is a detailed list of gaps that needs to be turned into an enhanced version of RailML
- Who is responsible for defining new reference versions after INESS stops?
- Who will start using EUDRI, and how?
- Converters could be replaced by direct processing of the data model

Thank you!

How to Make the Data Model Work

How to Make the Data Model Work

- What Data Model are you using in your company?
- How Could the EUDRI (INESS Data Model) be implemented in your company?
- What are the benefits of using EUDRI?
- How can EUDRI be maintained?

Thank you!

Discussion

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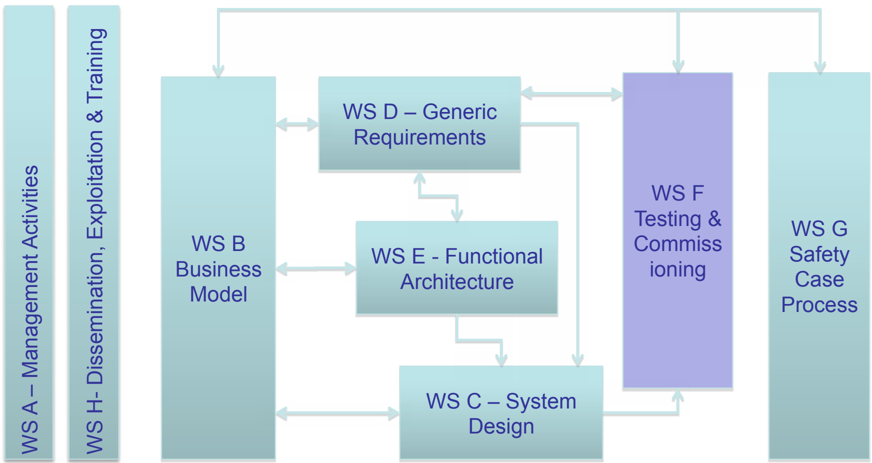
INESS Test & Commissioning WS-F



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Part 1:

Possible Approaches for optimised testing

Possible Approaches for optimised testing

Using laboratories for time efficient testing

KEY INFLUENCES

The selection of testing techniques is influenced by the way in which application requirements are defined.

A railway defines the requirements in the form of a set of business requirements to move passengers/freight from one point to another. The requirements mainly have to follow the operational needs.

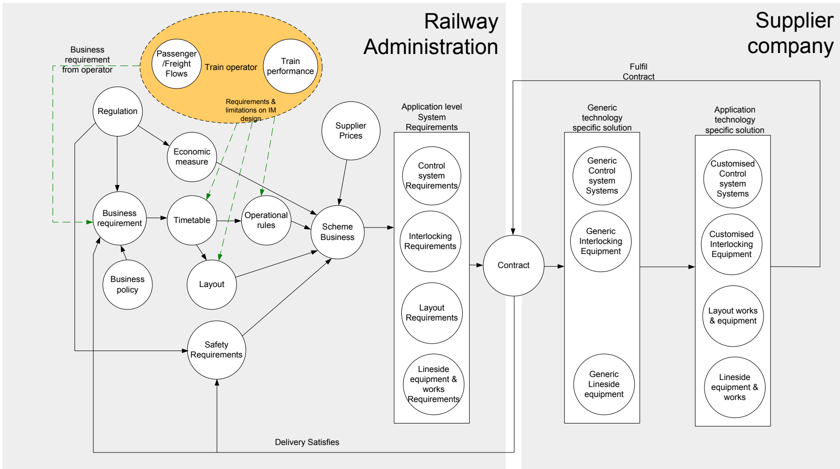
These then are decomposed eventually into a set of requirements for a signaling system to provide the operational movements required.

It can be assumed that the technical requirements are derived from the operational requirements. Therefore the operational requirements can be used as a basis of testing.

An optimisation of the operational requirements will have a direct influence on the complexity of the technical requirements and by this on the testing efforts.

Possible Approaches for optimised testing

Using laboratories for time efficient testing



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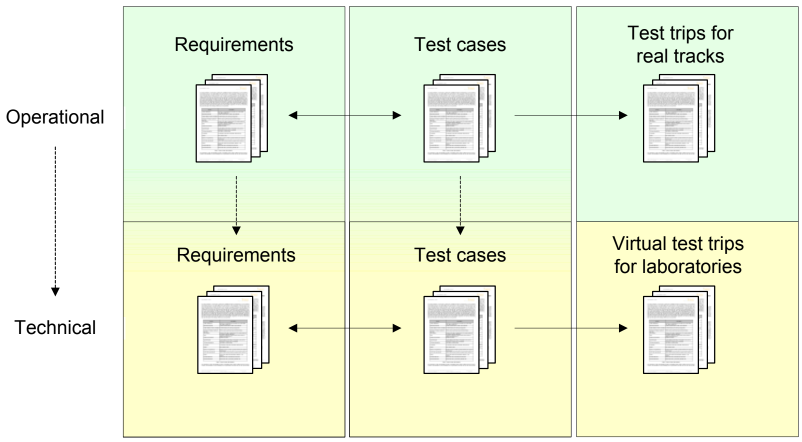
Possible Approaches for optimised testing

Using laboratories for time efficient testing



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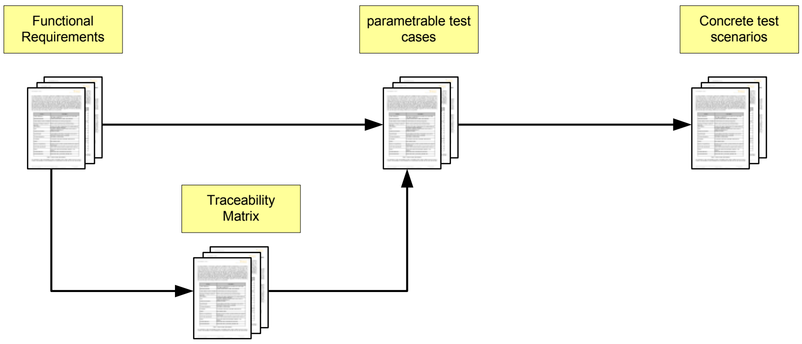
Possible Approaches for optimised testing
Using laboratories for time efficient testing

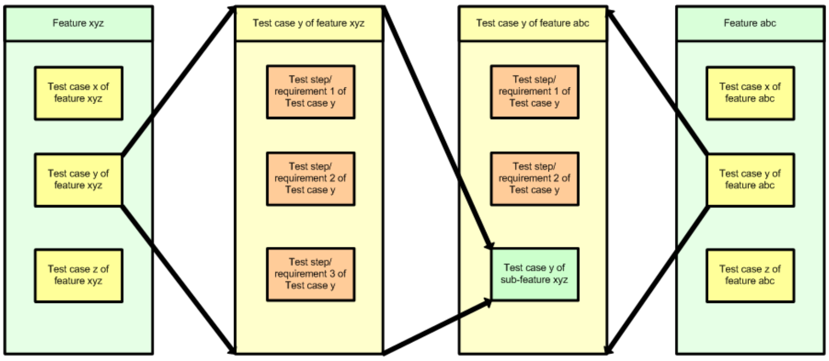
- To increase efficiency a testing method should be set up that avoids repetition of tasks and reuses things that have been produced before.
- To that end the creation of templated test cases is seen as key.
- These can then be reused time and time again by inserting the appropriate test parameters.
- Another key item in the schemata is a traceability matrix that provides verification against the requirements that tests actually verify a requirement.
- By adopting this process tests can be quickly constructed to carryout scenarios as part of the testing and commissioning process.
- Utilizing the method will reduce the number of overall tests required to test the application.

Possible Approaches for optimised testing
Using laboratories for time efficient testing



Possible Approaches for optimised testing

Using laboritories for time efficient testing



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Possible Approaches for optimised testing

Modularisation for reducing interlocking interfaces

- The design of the interlocking has a bearing on the testing requirements for an interlocking.
- Traditional interlocking developments have tended to define separate interfaces for the field equipment rather than standard interfaces.
- As a result it has been necessary to test each interface in turn leading to an inefficient test regime.
- By taking account of the needs of testing during the design the effort required to test an application can be significantly reduced.

Note: This feeds back into the design process of the product. The design not only affects the product performance but also the application configuration performance

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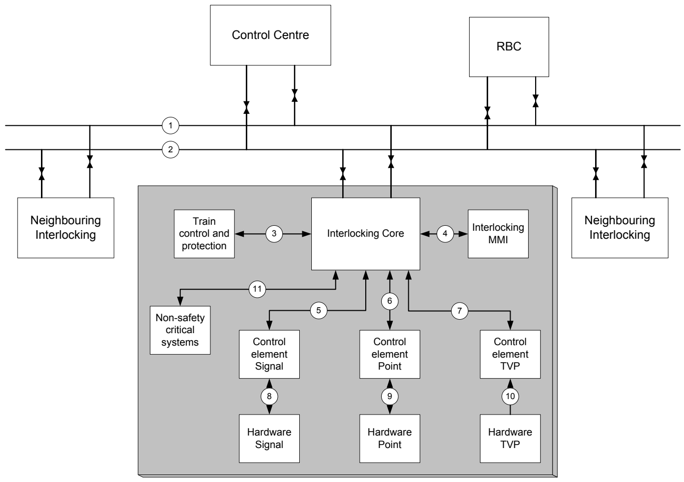
Possible Approaches for optimised testing

Modularisation for reducing interlocking interfaces



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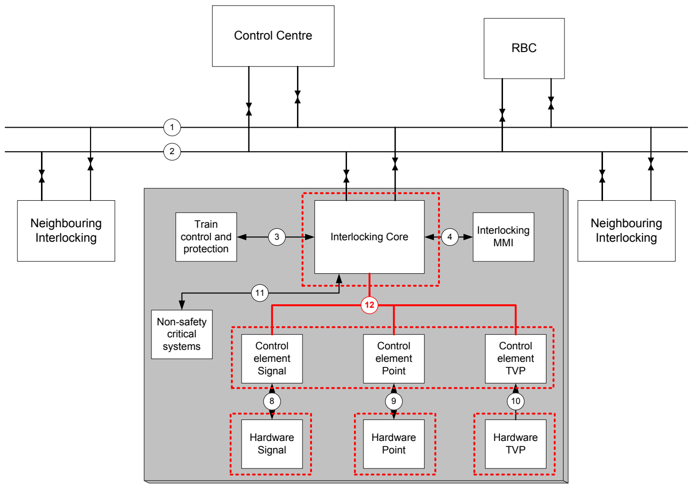
Possible Approaches for optimised testing

Modularisation for reducing interlocking interfaces



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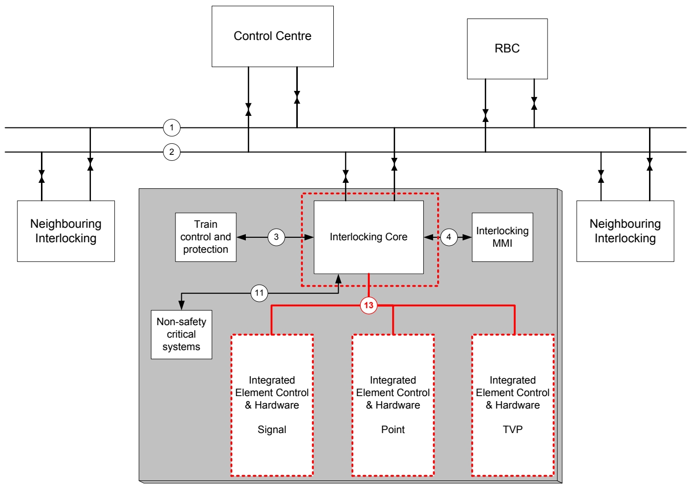
Possible Approaches for optimised testing

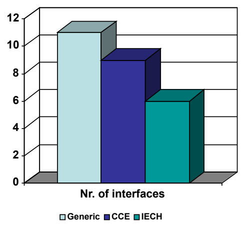
Modularisation for reducing interlocking interfaces



Possible Approaches for optimised testing

Modularisation for reducing interlocking interfaces

- Modularisation will lead to a minimised set of interfaces and consequently to less testing effort.
- In the example this will bring a saving potential of
  - about 20% for the standardisation of interfaces and
  - about 40% for the combination of elements in addition to the stardardisation of interfaces



Interface number	Generic	CCE	IECH
1	x	x	x
2	x	x	x
3	x	x	x
4	x	x	x
5	x		
6	x		
7	x		
8	x	x	
9	x	x	
10	x	x	
11	x	x	x
12		x	
13			x
Number of interfaces to be tested	11	9	6

Possible Approaches for optimised testing

Industrial Engineering for optimising number of elements

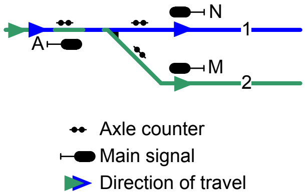
- The effort reduction for testing of interlocking modules can be achieved by identifying frequently recurring combinations of components of control centre and subject them to a development pre-test as combinations to create large modules to avoid further repetitive testing for the particular application.
- After having tested the combinations of modules successfully with the positive and the negative tests, they can be used for the design and development of the interlocking application on project level.
- Furthermore, those pre-tested module combinations can be integrated in any other project, in which these functionalities are needed. This can decrease the effort for future interlocking applications.
- In the field only the correct connection of the wiring has to be tested (correspondence testing) to be sure that the interlocking will work correctly. Further functional field tests are not needed.

Possible Approaches for optimised testing

Industrial Engineering for optimising number of elements

I. Positive testing:
- Signal A only shall show a proceed aspect, when the signals N and M showing a stopping aspect, the point is locked in the end position and the point is not blocked (valid for the blue and the green travelling connection).
- The signals N and M have to show a stopping aspect as long as signal A shows the green aspect.
- The point must not be turned as long as signal A shows the proceed aspect.
- The point must not be unlocked as long as signal A shows the proceed aspect.

I. Negative testing:
- Signal A must immediately switch to a stopping aspect, when one of the following events occur:
  - i. Signal N and/or M does not show the stop aspect any longer
  - ii. Signal N and/or M reports a degraded mode to the interlocking
  - iii. The point is no longer locked
  - iv. The point reports a degraded mode to the interlocking
  - v. The TVP section of the point is no longer reported as free.
  - vi. The TVP section or one of the axle counters reports a degraded mode to the interlocking



Possible Approaches for optimised testing

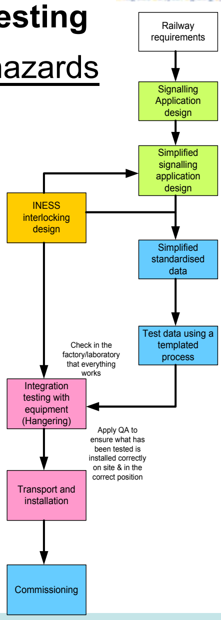
Safe by design approach to eliminate hazards

This methods goes in line with the philosophy

„*What is not there, can not fail*“

therefore the main idea is to reduce the functionality and/ or the complexity of the system in a way that errors or failures do not occur. This removes latent hazards from the application

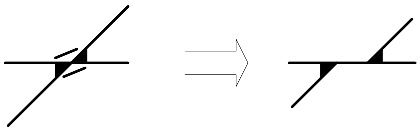
The approach starts during the transformation of the requirements into the application ‘s design with an objective of simplification of the design.



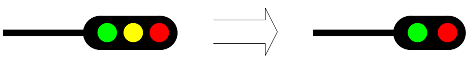
Possible Approaches for optimised testing

Safe by design approach to eliminate hazards

Example: Diamond crossing can be replaced by two single points, which are much easier to test



Example: Replace a three-aspect signal by a two-aspect signal when the „slow approach“ aspect (yellow) is not essential.



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Possible Approaches for optimised testing

Conclusion

The methodical evaluation of the different methods paints the picture that

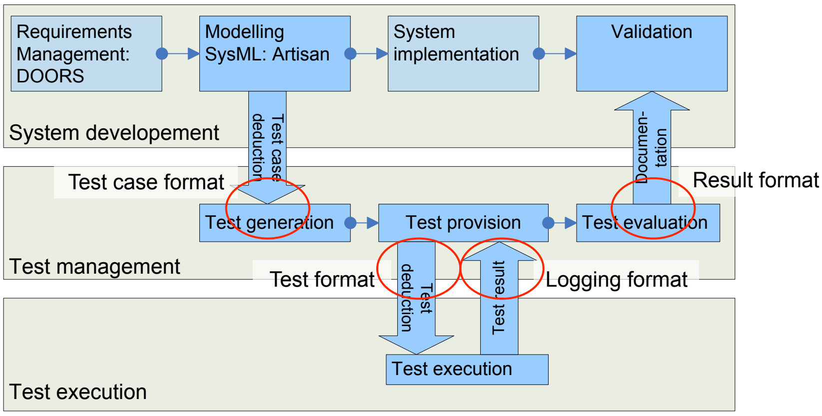
- the modularisation and standardisation can produce a significant saving by eliminating different interfaces, which need to be tested each one by one
- the safe by design approach can in parallel lead so some effort saving due to the simplification of elements and in the process making testing easier. Also can this approach decrease the testing effort by minimising the catalogue of functions of the elements to an operational needed level, which will end directly in a decrease of testing.
- the implementation of Industrial Engineering and especially the definition of standard element units will bring the highest effort saving potential due to scaling effects – an element unit needs to be tested once but can be installed several times without being tested again.

Part 2:

Optimised Testing by using laboratories

Optimised Testing by using laboratories

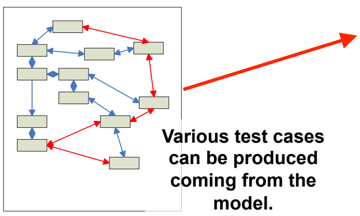
Example for a Tool-Chain



Optimised Testing by using laboratories

Test case format for the example OBU

- Great number of tools available
- Easy-to-understand structure, human readable
- Easy to handle (PDF, DOC, etc.)



Various test cases can be produced coming from the model.

OBU: Onboard Unit

Optimised Testing by using laboratories
Test management: Administration of tests

- Generic tool for versioning to administrate the test cases:
  - Subversion (SVN)
    - Parallel changes from different user can be traced and administrated
    - Usage of any number of versioning branches and updates
    - Ideal for the administration of XML- and MySQL-data
    - Available and OS independent

Optimised Testing by using laboratories
Test management: Administration of tests

- Generic tool for the administration of change requests -> BugTracking
  - Mantis
    - Errors can be reported by any kind of user to a defined position
    - Correlation of errors and changes of versions
    - Generation of documentation

Quelle: Mantis Demo

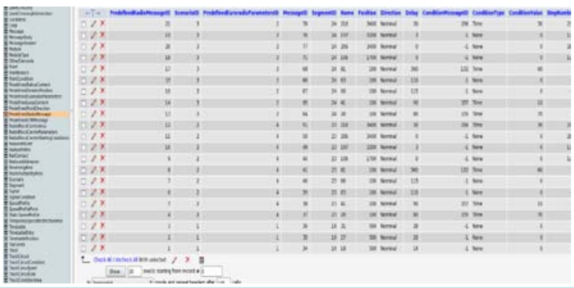
Optimised Testing by using laboratories
Test execution: Test format

Requirements for the test format:

- Additionally to the test case format:
  - Combination of test cases to test sequences
    - Usage of existing parameters and starting requirements
    - Sorting requirements orientated, to make checking of requirements groups possible
  - High timing requirements for the availability of the data
  - Data volume will be higher than for single test cases

Optimised Testing by using laboratories
Test execution: Test format

- Many implementation are available
- Independent from the operation system
- Developed for huge amounts of data
- In an adopted structure the saving of test descriptions and logging data in the same format and/or data base is possible
- Can be implemented in also in other data bases



Source: DLR RailSiTe®

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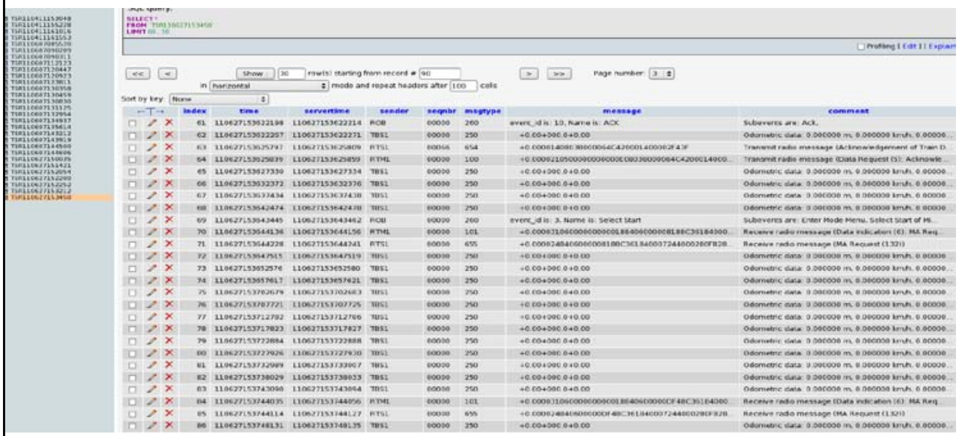
Test execution: Logging format



Source: DLR RailSiTe®

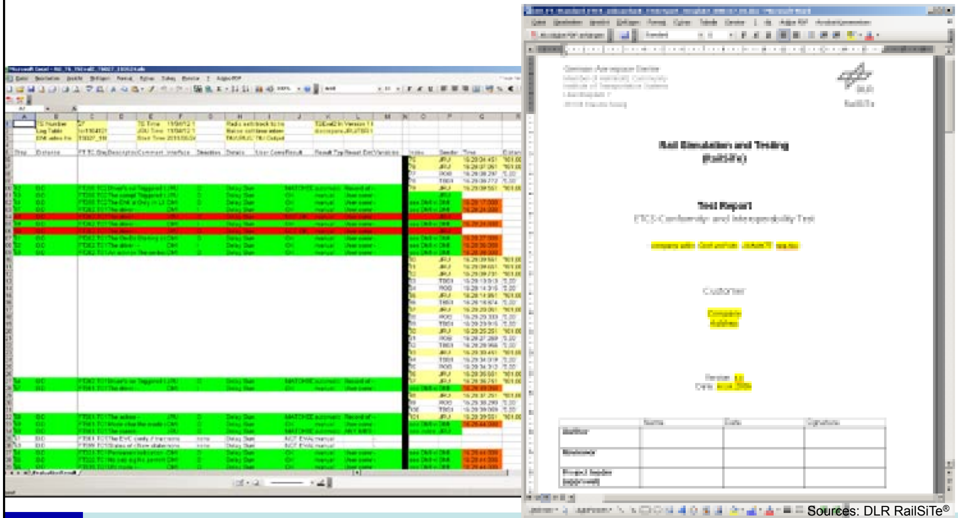
Optimised Testing by using laboratories

Test evaluation: Format of results

- Results of the tests need to be documented
- Format of the test reports is selectable, since no further handling necessary
- But a kind of Meta format is recommended to make the usage easier (Ideally MS Excel after version 2008: XML format)
- Using MS Excel up to 70% of a report can be generated automated, the other 30% have to be done manually

Optimised Testing by using laboratories

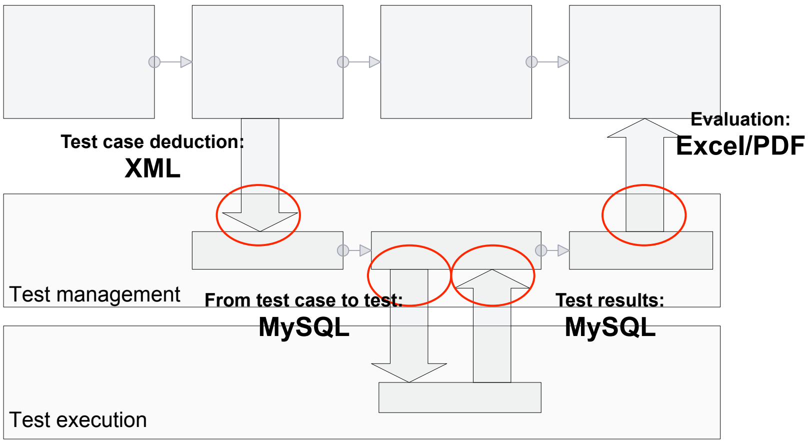
Test evaluation: Format of results



Sources: DLR RailSiTe®

Optimised Testing by using laboratories

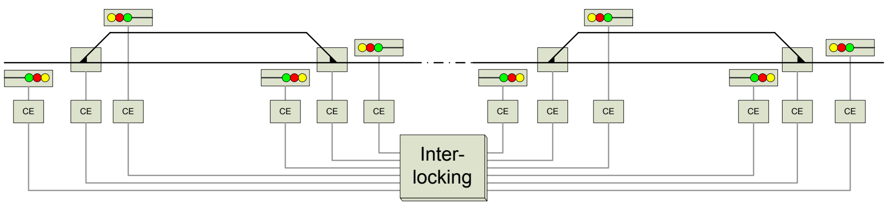
Conclusion



Part 3:

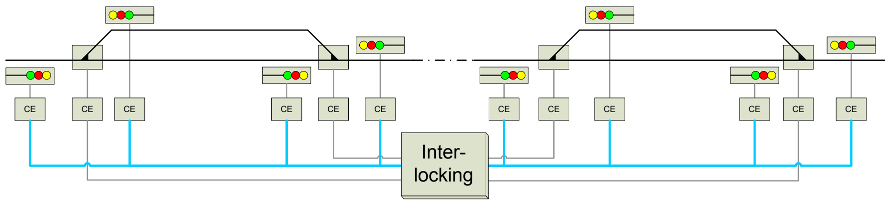
Savings through the design approach

Savings through the design approach
Modularisation methods



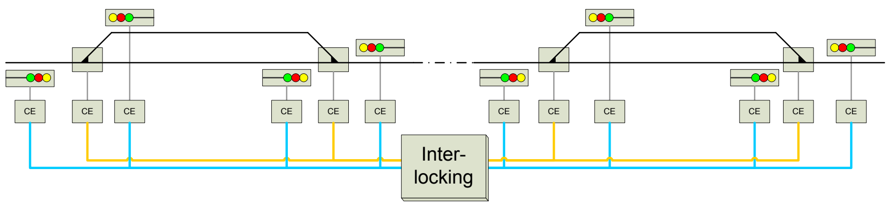
- Basic design: Sample track layout of a single track line with two double track stations controlled by one interlocking
  - 4 points
  - 8 three aspect signals
  - 12 Element controller (4 controller for points, 8 controller for signals)
  - 24 interfaces
    - 12 interfaces between interlocking and element controller
    - 12 interfaces between element controller and field element hardware
  - 32 functions (8 points functions, 24 signal functions)
  - 48 functional tests (positive & negative tests), 24 interface tests

Savings through the design approach
Modularisation methods



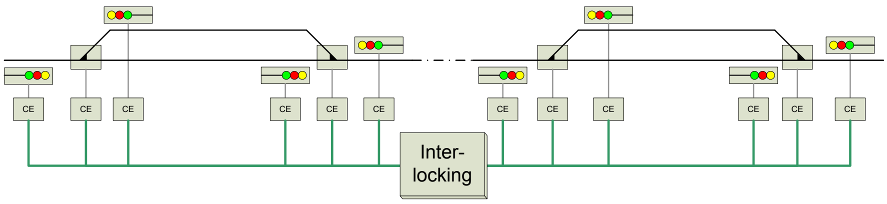
- Step 1: standardising and combining interfaces between interlocking and signal control element
  - 4 points
  - 8 three aspect signals
  - 12 Element controller (4 controller for points, 8 controller for signals)
  - **18** interfaces
    - **6** interfaces between interlocking and element controller
    - 12 interfaces between element controller and field element hardware
  - 32 functions (8 points functions, 24 signal functions)
  - 48 functional tests (positive & negative tests), 18 interface tests

Savings through the design approach
Modularisation methods



- Step 2: standardising and combining interfaces between interlocking and point control element
  - 4 points
  - 8 three aspect signals
  - 12 Element controller (4 controller for points, 8 controller for signals)
  - **16** interfaces
    - **4** interfaces between interlocking and element controller
    - 12 interfaces between element controller and field element hardware
  - 32 functions (8 points functions, 24 signal functions)
  - 48 functional tests (positive & negative tests), 16 interface tests

Savings through the design approach
Modularisation methods



- Step 3: standardising and combining interfaces between interlocking and control elements
  - 4 points
  - 8 three aspect signals
  - 12 Element controller (4 controller for points, 8 controller for signals)
  - **14** interfaces
    - **2** interfaces between interlocking and element controller
    - 12 interfaces between element controller and field element hardware
  - 32 functions (8 points functions, 24 signal functions)
  - 48 functional tests (positive & negative tests), 14 interface tests

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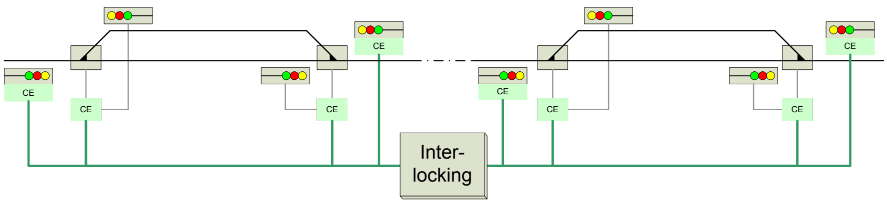
Savings through the design approach
Modularisation methods



- Step 4: standardising and combining control elements
  - 4 points
  - 8 three aspect signals
  - 8 Element controller (4 combined controller for point and signal, 4 controller for signals)
  - **10** interfaces
    - **2** interfaces between interlocking and element controller
    - **8** interfaces between element controller and field element hardware
  - 32 functions (8 points functions, 24 signal functions)
  - 48 functional tests (positive & negative tests), 10 interface tests

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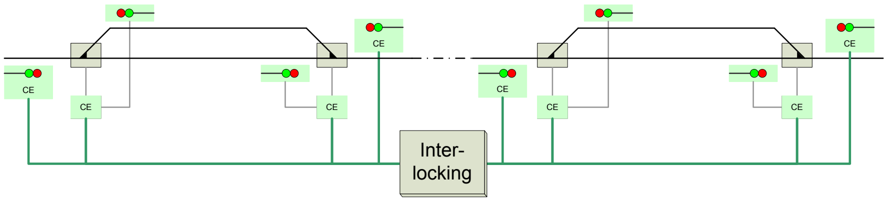
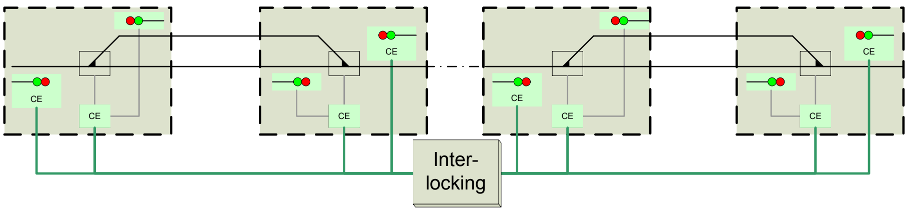
Savings through the design approach
Safe by design methods



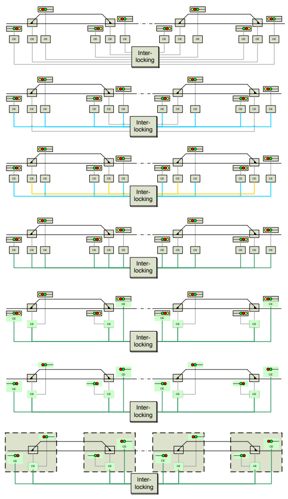
- Step 5: reducing functions
  - 4 points
  - 8 two aspect signals
  - 8 Element controller (4 combined controller for point and signal, 4 controller for signals)
  - 10 interfaces
    - 2 interfaces between interlocking and element controller
    - 8 interfaces between element controller and field element hardware
  - 24 functions (8 points functions, 16 signal functions)
  - 32 functional tests (positive & negative tests), 10 interface tests

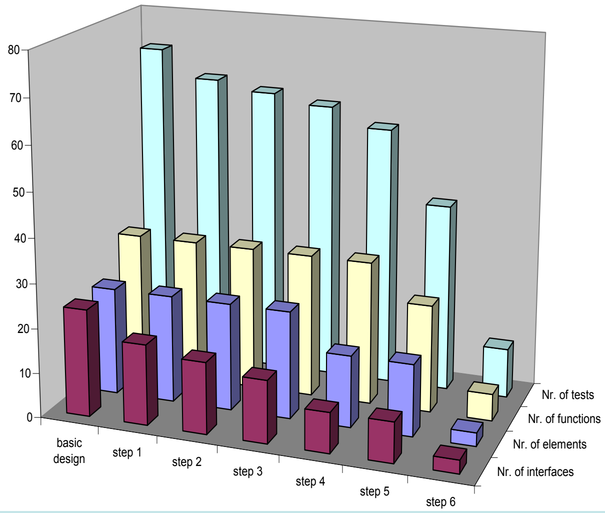
Savings through the design approach
Industrial Engineering methods



- Step 6: generating pre-testable unit (which can be used four times in this layout)
  - 1 point
  - 2 two aspect signals
  - 2 Element controller (4 combined controller for point and signal, 4 controller for signals)
  - 3 interfaces
    - 1 interface between interlocking and element controller
    - 2 interfaces between element controller and field element hardware
  - 6 functions (2 points functions, 4 signal functions)
  - 8 functional tests (positive & negative tests), 3 interface tests

Savings through the design approach
Overview of possible saving potentials





Savings through the design approach
Overview of possible saving potentials

- The implementation of modularisation approaches can save about 20% of tests which need to be performed for the shown sample layout (steps 2 to 4).
- Further savings of about 20% can be reached by reducing the functionality by using safe by design methods (step 5).
- Additional saving of about 40% of the testing effort for the sample layout can be reached by using pre-testable element units (step 6).
- Combining all three methods as shown previously can produce a total saving potential of about 80%, especially driven by the definition of pre-testable element units.

Savings through the design approach
Overview of possible saving potentials

- **But**
  - the effects may be smaller due to higher complexities of the new combined interfaces and field elements.
  - the effects also vary with respect to the state of the art each player in the railway market is currently working with. The potentials will be less for a railway or a supplier who is developing its systems already in a more or less modularised and/or standardised way.

Savings through the design approach
Summary and recommendations

- The evaluation of the savings by design approaches shows that
  - a standardisation of interfaces and elements is the basis for further effort saving steps
  - even with only a few standardised interfaces large savings are achievable by creating a catalogue of several standard element units, which will be applicable to as many operational and infrastructural situations as possible. Only special cases shall be designed separately
  - by using such an element unit catalogue in combination with standardised interfaces saving potentials of 50% - 60% are possible.

Discussion

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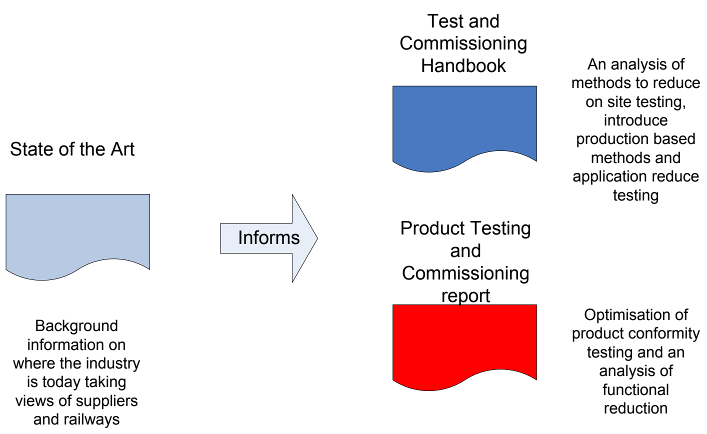
WS F

Conformity Testing / Data Reduction

Content

- WS F Structure
- Task F.3M.2
- Task F.3M.2.1
- Reduction of the Functional subset
- Estimation of cost reduction
- Task F.3M.2.2
- Black Box Testing
- Good Practises in Testing
- Minimize the data set
- Optimal Test Procedures
- Conclusions
- Next Steps

WS F – Deliverable Roadmap



Task F.3M.2

- First we are going to give a glimpse of the first task.
- Sub Task 1
  - WSD defined an extended common kernel of requirements that was used as a starting point for this tasks. New documents with requirements have been provided by this WS, but not in time for us to use them in our analysis.
  - This sub task looks at ways to reduce the amount of data used in an application

Task F.3M.2.1

- These functional requirements were divided into:
  - Route general requirements
  - Route initiation completion
  - Route locking proving
  - Route used cancelled
  - Monitoring
  - Signal
  - Local shunting area
  - Powered point
  - Lockable devices
  - Level crossing
  - TVP section
  - Interlocking system general
  - Commands
  - Statuses
  - Driving values
  - Detected values

Task F.3M.2.1

- A classification was performed by the members of the group regarding how difficult it was to test each one of the requirements: Easy, medium, difficult.
  - **Easy** : can be perform by non specialised personnel and/or does require small amount of time.
  - **Medium** : trained personnel/specialised is needed and/or requires more amount of time.
  - **Difficult** : requires specialised personnel and/or greater amounts of time.
- The analysis was performed by group participants from ANSALDO, NR, DLR, AZD, ADIF and UPM.

Reduction of the Functional subset

- As a result we obtained the following weight scale:

Difficulty to be tested	Evaluation
Difficult	3
Difficult- Medium	2.5
Medium	2
Medium- Easy	1.5
Easy	1

Reduction of the Functional subset

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- With that information, a reduced subset with less functional requirements that can be applied to the most common track layout configurations was defined to proceed with our work.
- Most interlockings do not need all the requirements to be implemented to provide the desired functionality. A limited subset can be enough for a lot of scenarios and complete INESS core can be used for large stations or complex scenarios.
- It is foreseeable that a reduction in the functionality will provoke a reduction in functional testing effort.
- This reduction was done according to expert's criteria selecting the set of functions more commonly used.

Reduction of the Functional subset

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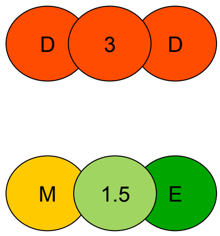
- An example of analysed requirements:

Mon14-Com	**2 Monitoring**		
Mon15-Com	***2.1 General***		
Mon16-Req	The interlocking system shall continuously supervise the conditions in a route.		Germany Italy Netherlands Spain Sweden U.K.
Mon244-Req	If a main signal with an associated shunting signal is in position to provide flank protection or opposing movement protection, the protection shall be provided by:		Germany Spain Sweden
Mon308-Req	•*the 'stop' aspect displayed on the main signal*		Germany Spain Sweden



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Reduction of the Functional subset

- Other weights can be chosen and even a one by one analysis of testing effort for each element would lead to a finer approach, but in order to quantify the cost saving this can be a fair approach.
- Savings are expected to come from two main sources:
  - Reducing the number of elements to be tested.
  - Using functional elements that are easier to test.
- Other savings:
  - Easier to test interlockings applicable to the most usual railway environments (small and medium stations).

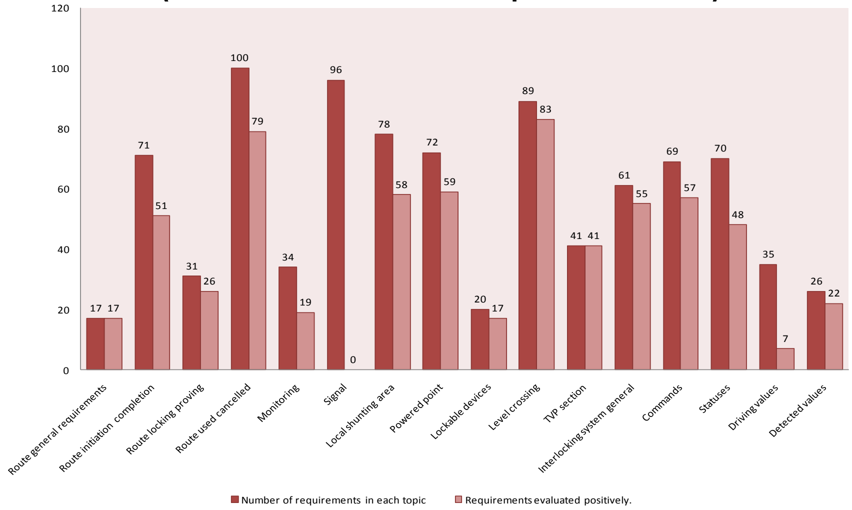
Estimation of Cost Reduction

- Let's present some figures relating to the test reduction:

			Valuation of the requirements in the INESS extended kernel	Valuation of the requirements in the reduced subset	Percentage of reduction in terms of testing effort	Number of requirements in each topic	Requirements evaluated positively.	Percentage of reduction in terms of functional elements
1	RGR	Route general requirements	18	18	0%	17	17	0%
2	RIC	Route initiation completion	117	82.5	29%	71	51	28%
3	RLP	Route locking proving	65	52.5	19%	31	26	16%
4	RUC	Route used cancelled	170.5	137	20%	100	79	21%
5	Mon	Monitoring	65.5	41.5	37%	34	19	44%
6	Sig	Signal	138	0	100%	96	0	100%
7	LSA	Local shunting area	149	114.5	23%	78	58	26%
8	PPt	Powered point	121	101	17%	72	59	18%
9	LDv	Lockable devices	40.5	31.5	22%	20	17	15%
10	LCr	Level crossing	173	160	8%	89	83	7%
11	TVP	TVP section	71.5	71.5	0%	41	41	0%
12	ISG	Interlocking system general	108	101.5	6%	61	55	10%
13	Cmd	Commands	109	91.5	16%	69	57	17%
14	Stat	Statuses	135	99.5	26%	70	48	31%
15	DrV	Driving values	40.5	11.5	72%	35	7	80%
16	DeV	Detected values	50.5	44	13%	26	22	15%
		TOTAL	1572	1158	26%	910	639	30%

Estimation of Cost Reduction (number of test requirements)

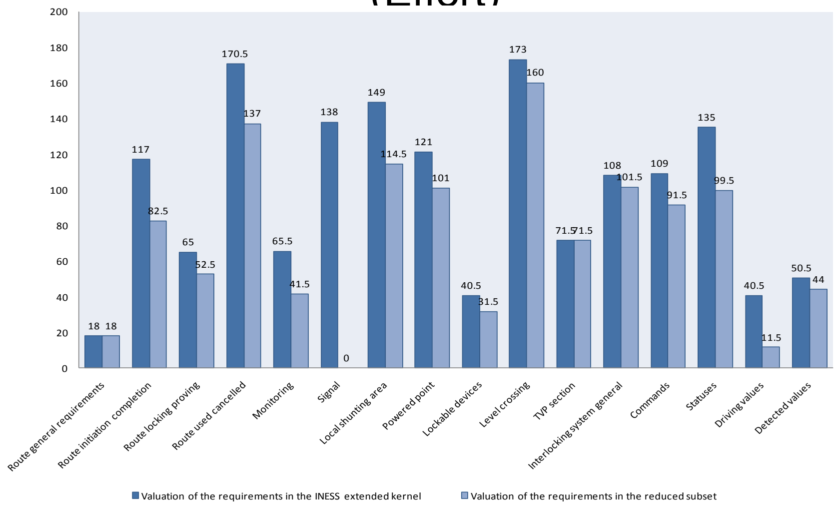
iness



Comparison between the global number of requirements and the requirements included into the reduced subset after the evaluation

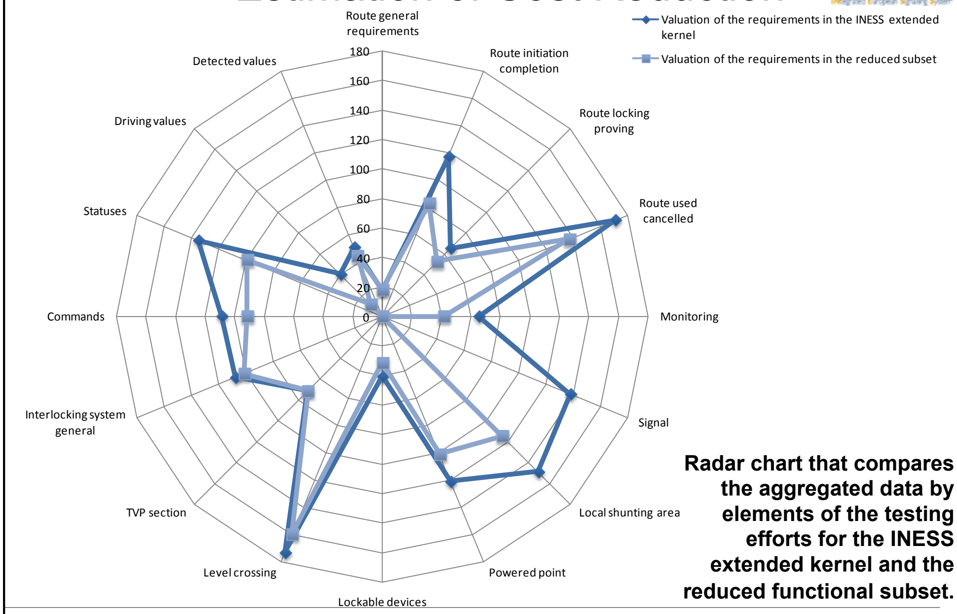
Estimation of Cost Reduction (Effort)

iness



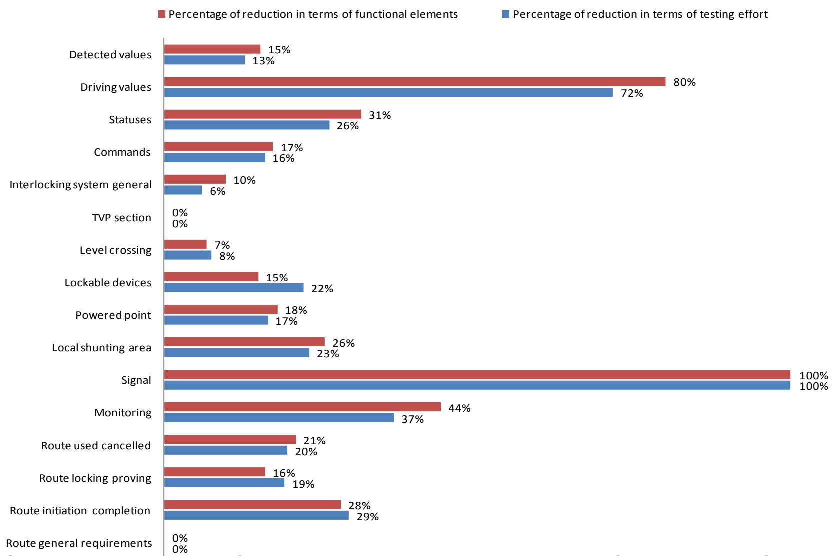
Comparison between the global valuation of the total requirements and the value of the requirements that are present in the reduced subset of functionalities.

Estimation of Cost Reduction



Radar chart that compares the aggregated data by elements of the testing efforts for the INESS extended kernel and the reduced functional subset.

Estimation of Cost Reduction



Comparison in terms of percentage between the reduction of the number of requirements and the reduction valuated.

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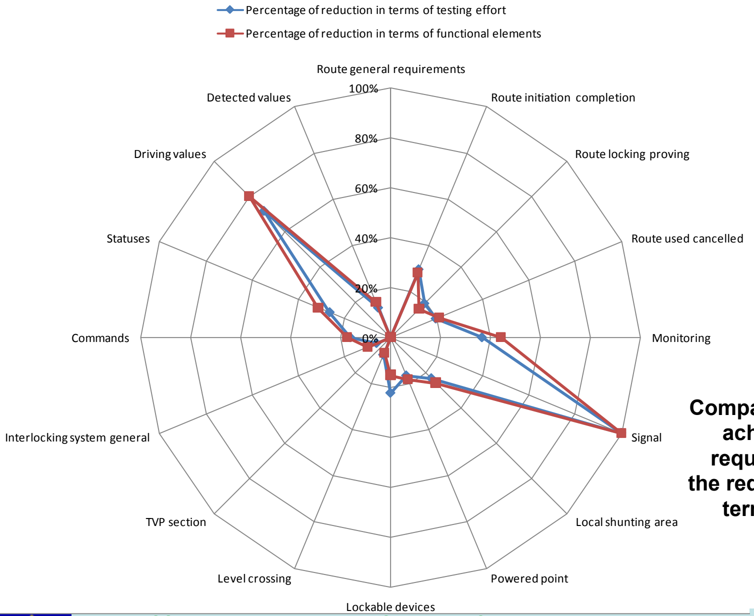
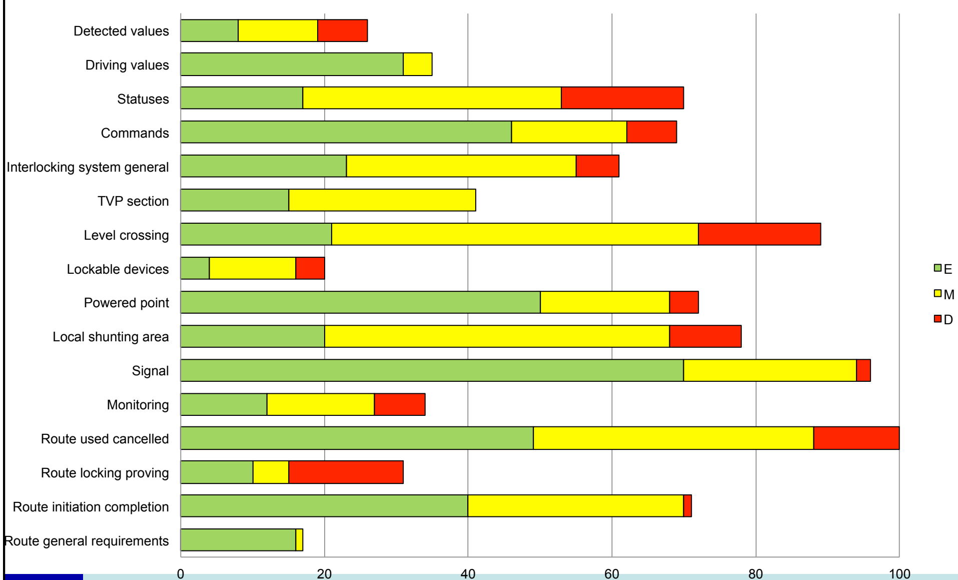
Estimation of Cost Reduction



Comparison between the achieved reduction of requirements (red) and the reduction obtained in terms of testing effort (blue)

Estimation of Cost Reduction

INESS Extended Core



Estimation of Cost Reduction

Reduced Subset

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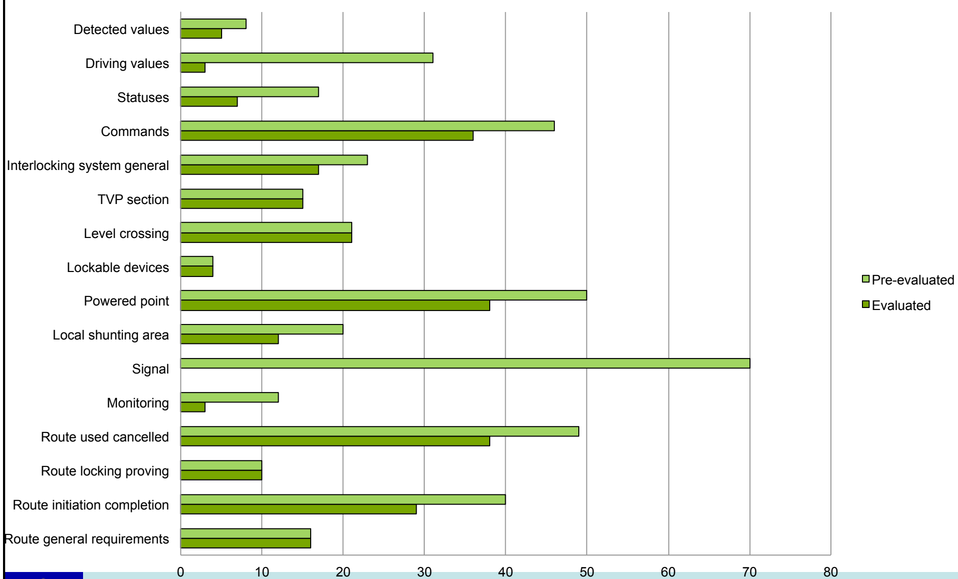
Estimation of Cost Reduction

Easy



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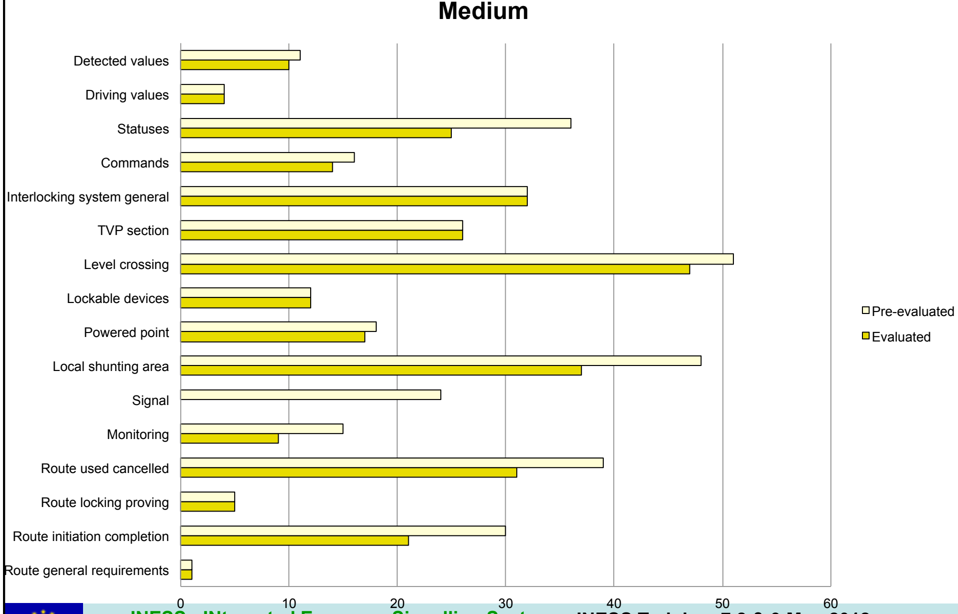
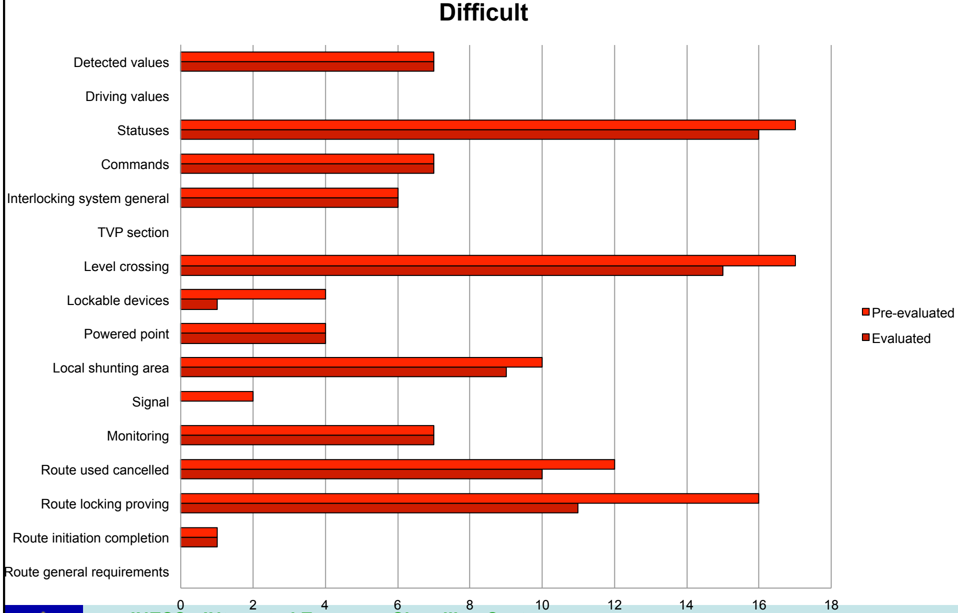
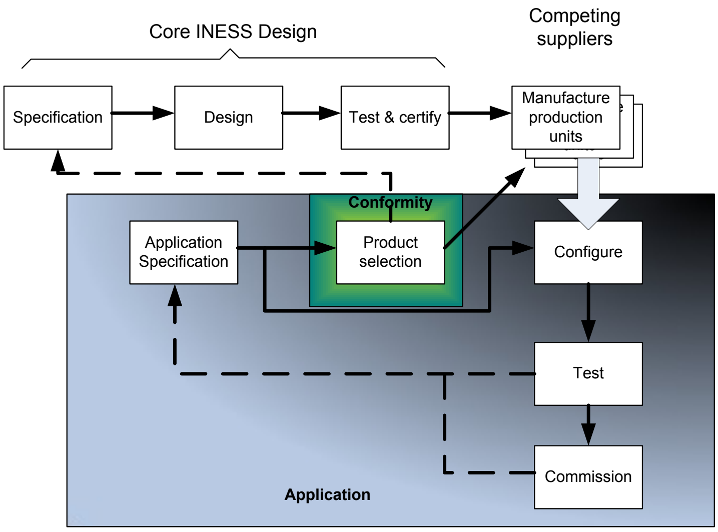
Estimation of Cost Reduction



Estimation of Cost Reduction



WS F Structure



Task 3M.2.2

- Conformity tests are the first step in order to acquire a system by the Railway Administration. It is a way to assure that the functional specifications are correctly implemented in the product.

- Almost all Administrations have signed a contract with a supplier that assured that its product complies with the specifications and later the product delivered differs from the specification.

- This task deals with describing and proposing ways for obtaining a more cost effective tests procedures for conformity.

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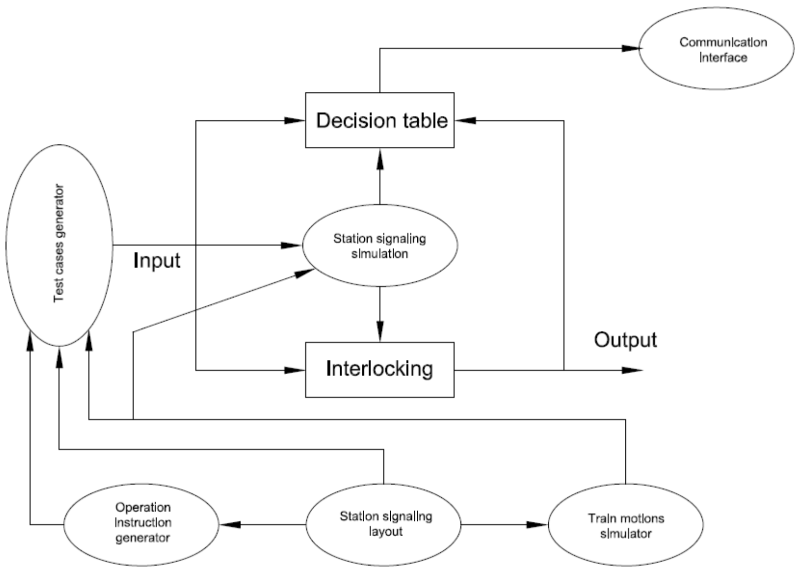
Conformity

- A conformity test is used to test compliance with a specification
- In INESS this is taken as a test to establish that a suppliers product is fully compliant with the INESS functional specification

Black Box Testing

- Black Box Testing:
  - It is a way of testing only looking at the inputs and outputs of the system without inner knowledge of the system.
  - Testing through interfaces requires those interfaces to be standard or at least agreed by the Administration and the supplier.
  - Testing through interfaces is easy to implement into scripts for automate testing.

Black Box Testing



Black Box Testing

- Inputs:
  - The main inputs come from the routes of the control table that states the relation for establishing routes and field elements statuses.
  - To fully test the interlocking track layout, an enormous input domain is needed, although for conformity testing it is not needed to test the whole interlocking but the whole functionality implemented on it.

Black Box Testing

- Outputs and decision table:
  - This process can be done automatically then all the outputs are compared with the cases contained in the decision table.
  - If this is tested in a simulated environment, then the question about the validity of the testing environment comes into scene.
  - The classical decision table used in the Black Box method must fit the complexity of an interlocking. Because of the dynamicity of scenarios to be managed and the complexity of the state machine, the decision table must be dynamic.

Black Box Testing

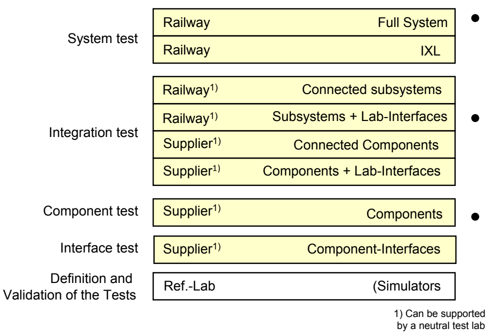
- In order to fully test an interlocking according to the functional specifications, a catalogue of testing scenarios would ease the process.
- These different scenarios should address every specified function.
- These scenarios have a direct impact in testing efficiency.

Good Practises in Testing

- Good Practises in testing:
  - ERTMS/ETCS testing approach:
    - These good practices are obtained from current state of testing interlocking and from similar approaches carried out in similar systems like, for example, ERTMS/ETCS conformity testing of equipment as defined in the ETCS subset 076.
    - The defined target of the ETCS subset 076 test sequences is to test each requirement of the SRS at least once to show the conformity with the specification.

Good Practises in Testing

- There are some interesting aspects:



- It gives hints about testing through interfaces (RBC – OBU).
- It gives experience about testing in a controlled environment.
- It gives information about testing against the specifications.

Minimize the data set

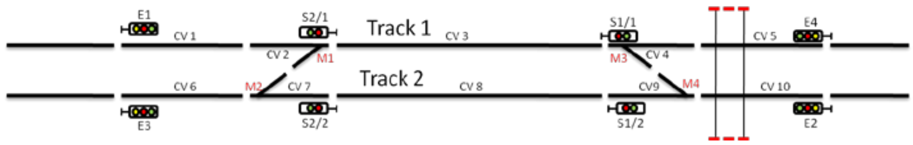
- Minimize the data set for testing functionality:
  - As said before, there is no need to test the whole track layout or control table in order to test the functionality of a certain testing scenario.
  - There's only need to test identical functional elements once.
  - In order to perform tests in a cost efficient way, operational research methods can be applied.
  - One method is proposed in the deliverable for obtaining an optimised testing procedure for a given track layout.

Minimize the data set

- The stages of the proposed method are:
  1. To identify the track circuits or sections belonging to the interlocking.
  2. To list all the possible routes in the interlocking system.
  3. To categorize each different part or component of the interlocking system.
  4. To list the specification sheets of each different element in order to define the functionalities of each one.
  5. To identify the functionalities that could be checked directly in each route or scenario.
  6. To define the relationships between routes.
  7. With these restrictions an operation research method, like the minimal spanning tree algorithm, could resolve the problem of checking all the functionalities of all the parts in the least number of steps possible.

Minimize the data set

- One example:



Minimize the data set

Nº	Description	Nº	Description
M1	→1 → 2 → 3 → 4 → 5→	M12	→5→ 4 → 3 → 2 → 1→
M2	→1 → 2→ 3 → 4 → 9 →10→	M13	→5 → 4→ 3 → 2 → 7 → 6→
M3	→6 → 7→ 2 → 3 → 4 → 5→	M14	→10 → 9→ 4 → 3 → 2 → 1→
M4	→6 → 7→ 8 → 9 → 10→	M15	→10 → 9→ 8 → 7 → 6→
M5	→6 → 7→ 2 →3 → 4 → 9 → 10→	M16	→10 → 9→ 4 → 3 → 2 → 7 → 6 →
M6	→ 1 → 2 → 3	M17	→ 5 → 4 → 3
M7	→ 6 → 7→ 2 → 3	M18	→ 10 → 9→ 4 → 3
M8	→ 6 → 7→ 8	M19	→ 10 → 9→ 8
M9	3 → 4 → 5→	M20	3 → 2 → 1→
M10	3 → 4 → 9 →10→	M21	3 → 2 → 7 →6→
M11	8 → 9 → 10→	M22	8 → 7 → 6→

Minimize the data set

Element	Functionalities		
Entry signals	Green aspect	Red aspect	Yellow aspect
Exit signals	Green aspect	Red aspect	
Right-hand switch	Move to straight track	Move to diverging track	
Left-hand switch	Move to straight track	Move to diverging track	
Level crossing	Closed	Opened	

Nº	Description	Entry S.			Exit S.		R-h S.		L-h S.		L.C.	
							+	-	+	-	O	C
M1	→1 → 2 → 3 → 4 → 5→											
M2	→1 → 2→ 3 → 4 → 9 →10→											
M3	→6 → 7→ 2 → 3 → 4 → 5→											
M4	→6 → 7→ 8 → 9 → 10→											
M5	→6 → 7→ 2 →3 → 4 → 9 → 10→											
M6	→ 1 → 2 → 3								-	-		
M7	→ 6 → 7→ 2 → 3								-	-		
M8	→ 6 → 7→ 8								-	-		
M9	3 → 4 → 5→						-	-				
M10	3 → 4 → 9 →10→						-	-				
M11	8 → 9 → 10→						-	-				
M12	→5→ 4 → 3 → 2 → 1→											
M13	→5 → 4→ 3 → 2 → 7 → 6→											
M14	→10 → 9→ 4 → 3 → 2 → 1→											
M15	→10 → 9→ 8 → 7 → 6→											
M16	→10 → 9→ 4 → 3 → 2 → 7 → 6 →											
M17	→ 5 → 4 → 3						-	-				
M18	→ 10 → 9→ 4 → 3						-	-				
M19	→ 10 → 9→ 8						-	-				
M20	3 → 2 → 1→								-	-		
M21	3 → 2 → 7 →6→								-	-		
M22	8 → 7 → 6→								-	-		

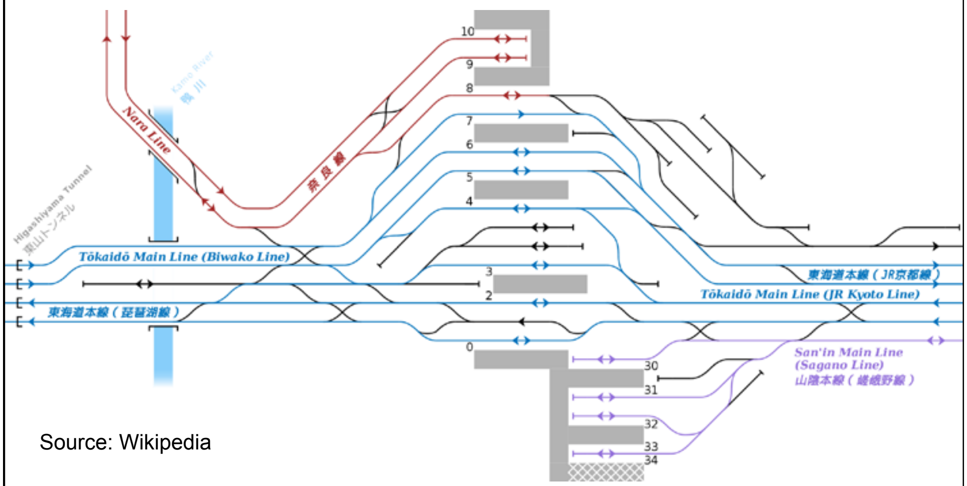
Minimize the data set

Nº	Possible routes that could be done after each one.						Entry S.			Exit S.		R - h S.		L-h S.		L.C.	
												+	-	+	-	O	C
M8	M11	M22												-	-		
M11	M14	M15	M16	M18	M19							-	-				
M16	M3	M4	M5	M8													

Optimised Test Procedures

- Optimised test procedures:
  - Functional equivalence: this concept merges different sets of functionality that are equivalent from the point of view of testing.
    - For example, in a station with a level crossing, the complexity of tracks layout does not affect the functionality and the possible failures of each one of them will only add complexity for the conformity testing.
    - Another case can be route conformity test, since more repeated identical functional elements add unnecessary testing complexity.
    - To test the core product conformity it is equally valid to test one unique element of the interlocking, as to check and validate a complex system with several identical functional components.
    - In order to test a route, whether the interlocking needs to monitor several equal functioning track circuits or just one does not matter from the point of view of functional testing, but it does have an effect from the point of view of making sure that each one of the elements that are monitored cannot change their state, or that if they are changed, the interlocking detects that change and closes the route signal if needed.

Optimised Test Procedures



Source: Wikipedia

Optimised Test Procedures

- Simpler testing scenarios are easier to test.
- A compromise between testing difficulty and the number of functional elements needs to be achieved.
- A method for repeating as less as possible has been showed.
- Obtaining optimised and standardised testing scenarios will allow Administrations to spend less time performing conformity tests and will facilitate easier ways for different tenders to opt to installation processes.

Conclusions

- **Reduced functional subset for applications**
- A reduced functional subset has been proposed and analysed based on application needs.
  - This reduction leads to a reduction in testing effort.
  - This reduction has been quantified using some arbitrary weights.
- The intended objective of reducing difficult to test functional elements when possible was not totally realized in this case. Both reductions are similar being a bit higher the reduction of functionality (30%) that the reduction of efforts (26%).

Conclusions

- **Conformity testing**
- An analysis of different ways of performing cost efficient conformity tests has been undertaken.
- Definition of standard interfaces will ease the testing processes and open the road for full automated black box functional testing.
- Valuable lessons can be learned from testing performed in ERTMS/ETCS.
- Ways for optimal test scenarios will lessen the testing effort.
- Functional equivalence points toward simpler testing scenarios.

Next Steps

- As has been shown in the previous slides, an indicative analysis of effort reduction has been performed. Further accuracy can be obtained by used precise data and analysis.
- The proposed reduction is for a line equipped only with ERTMS / ETCS Level 2 and no backup system. Other configurations will lead to other outcomes.
- Definition of optimal testing scenarios for conformity will ease the process of assuring that the required specifications are met..

Discussion