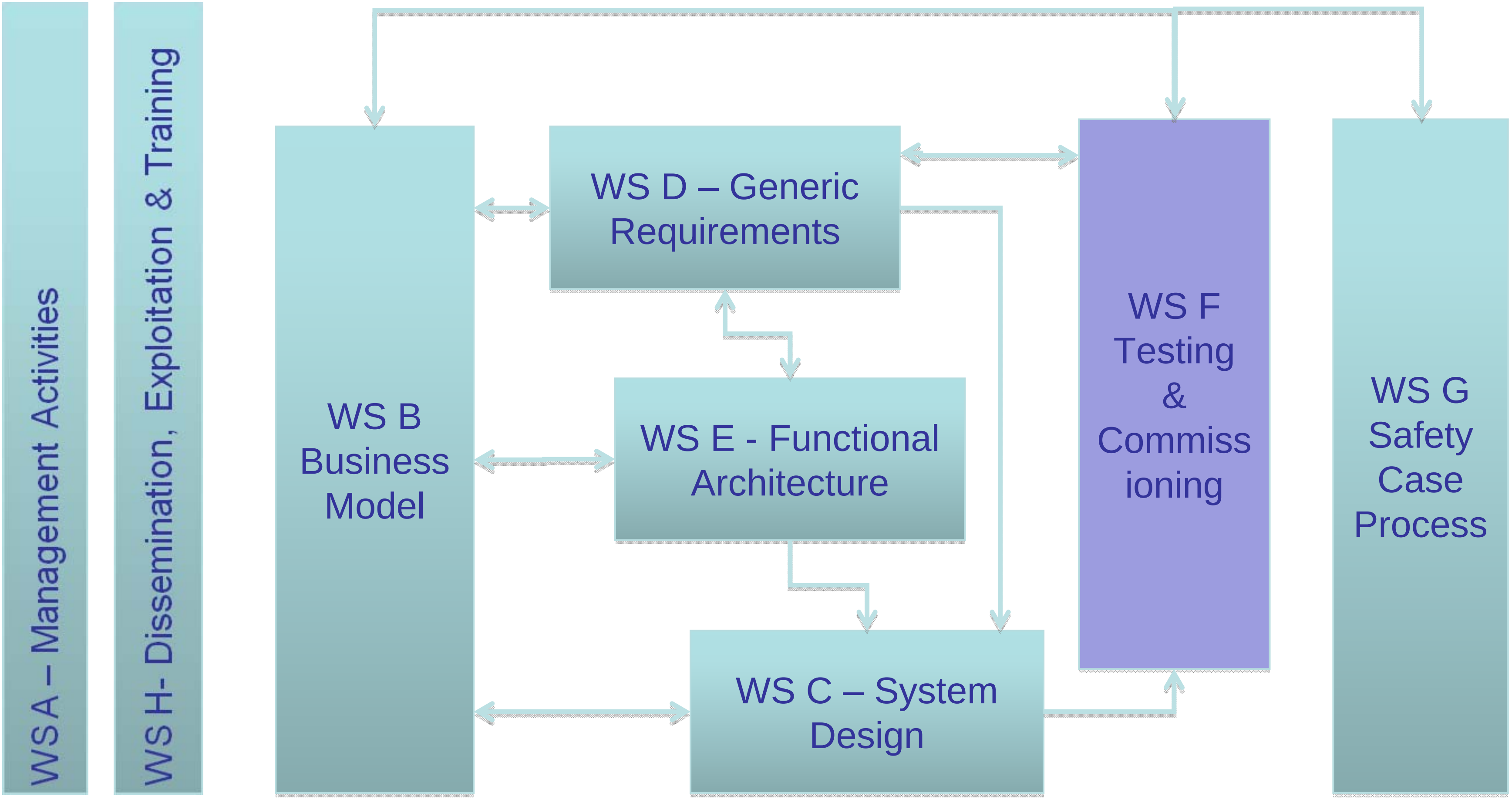
INESS Test & Commissioning WS-F



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.

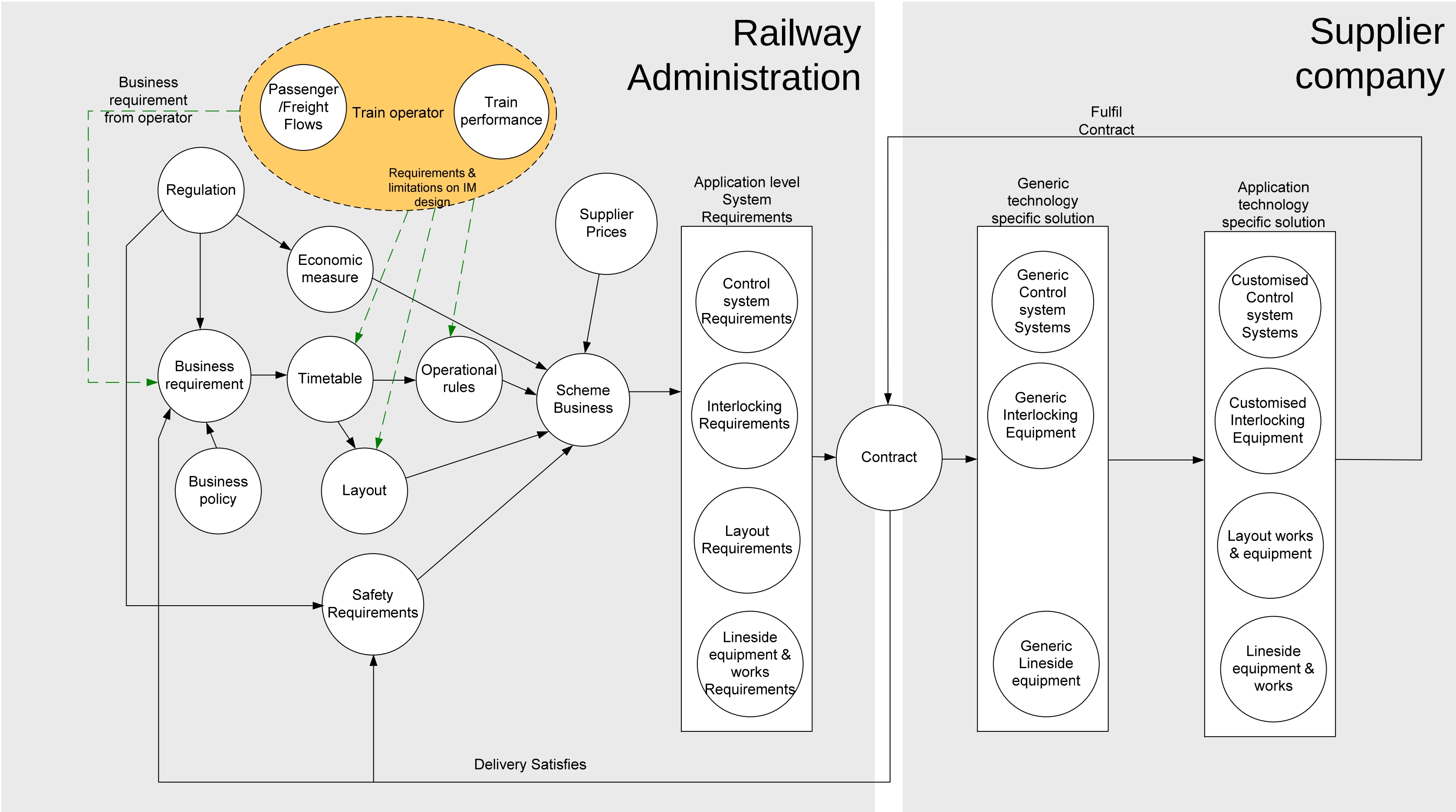
These then are decomposed eventually into a set of requirements for a signaling system to provide the operational movements required.

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.

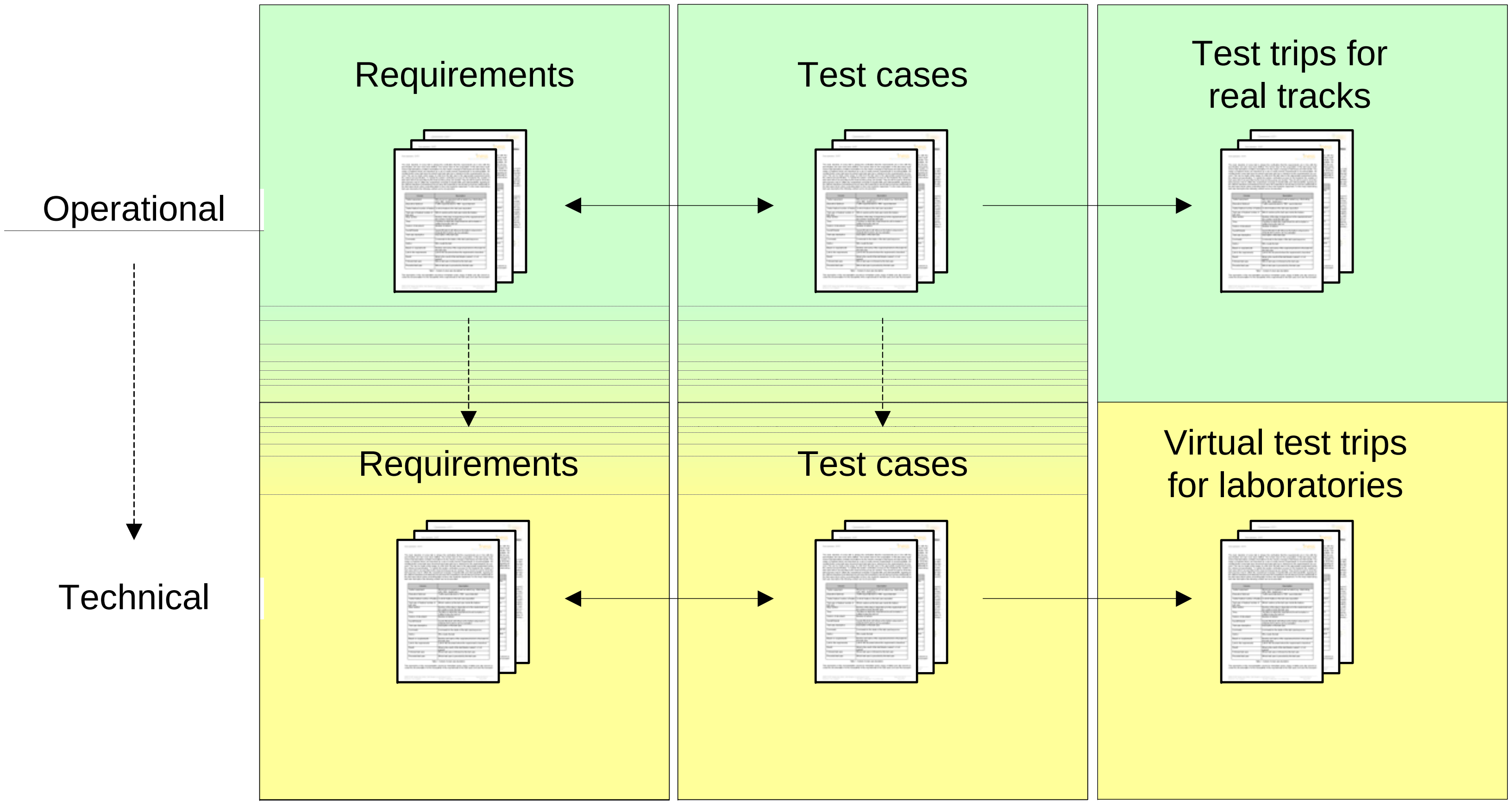
Possible Approaches for optimised testing

Using laboratories for time efficient testing



Possible Approaches for optimised testing

Using laboratories for time efficient testing



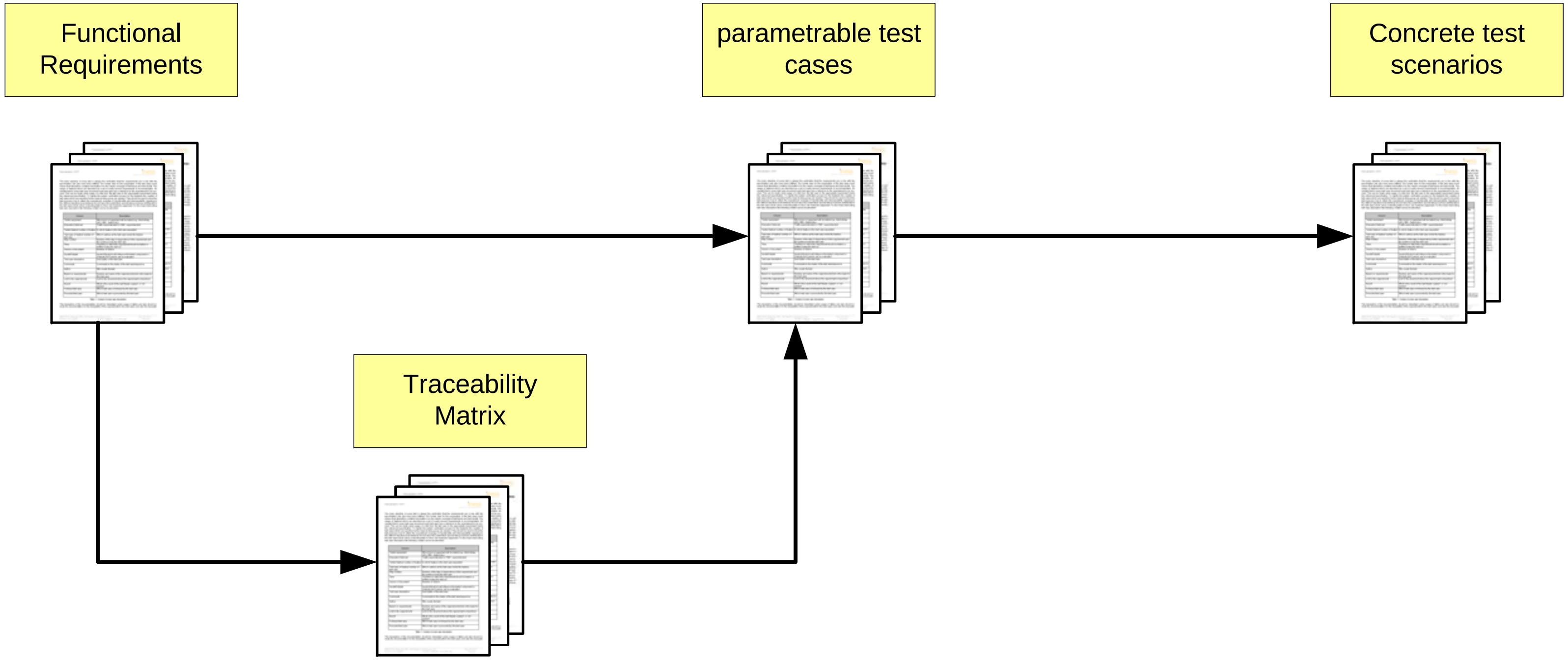
Possible Approaches for optimised testing

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.

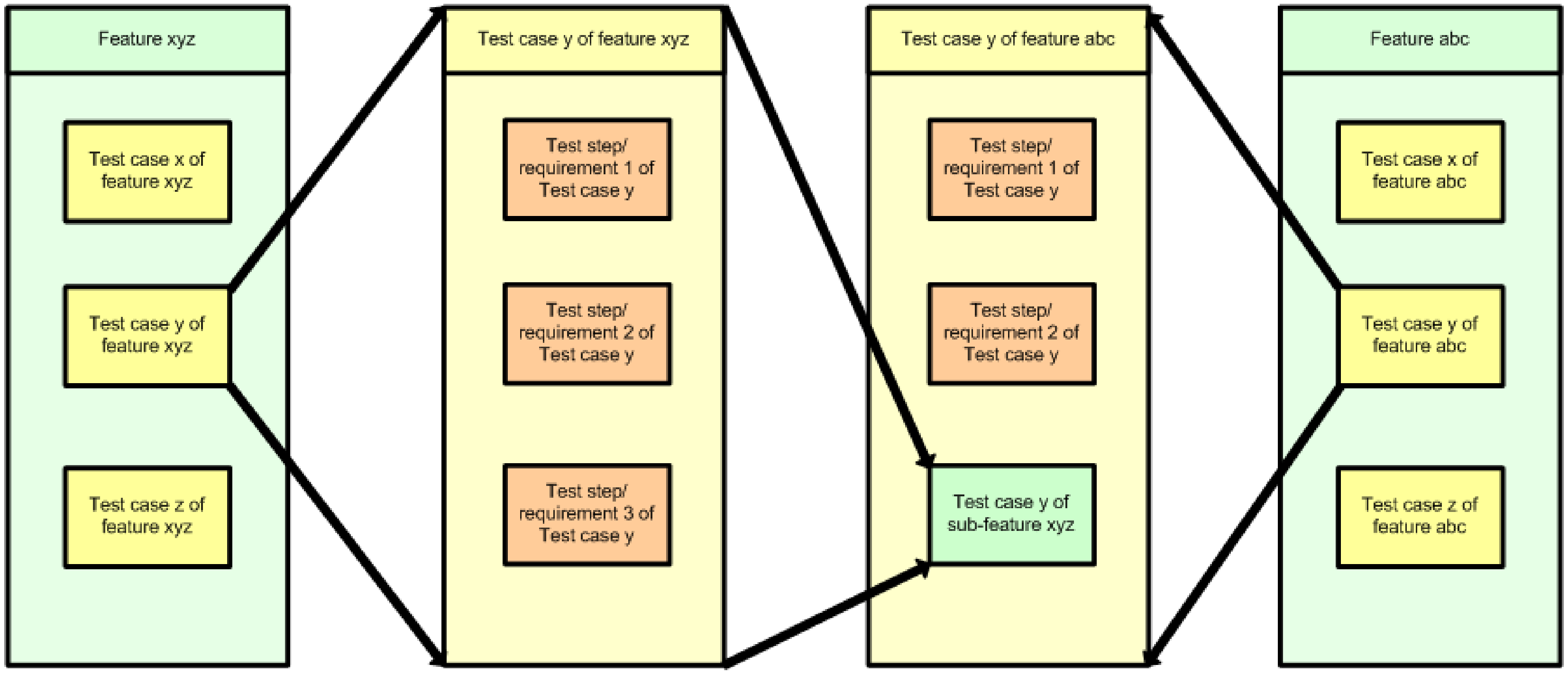
Possible Approaches for optimised testing

Using laboratories for time efficient testing



Possible Approaches for optimised testing

Using laboritories for time efficient testing



Possible Approaches for optimised testing

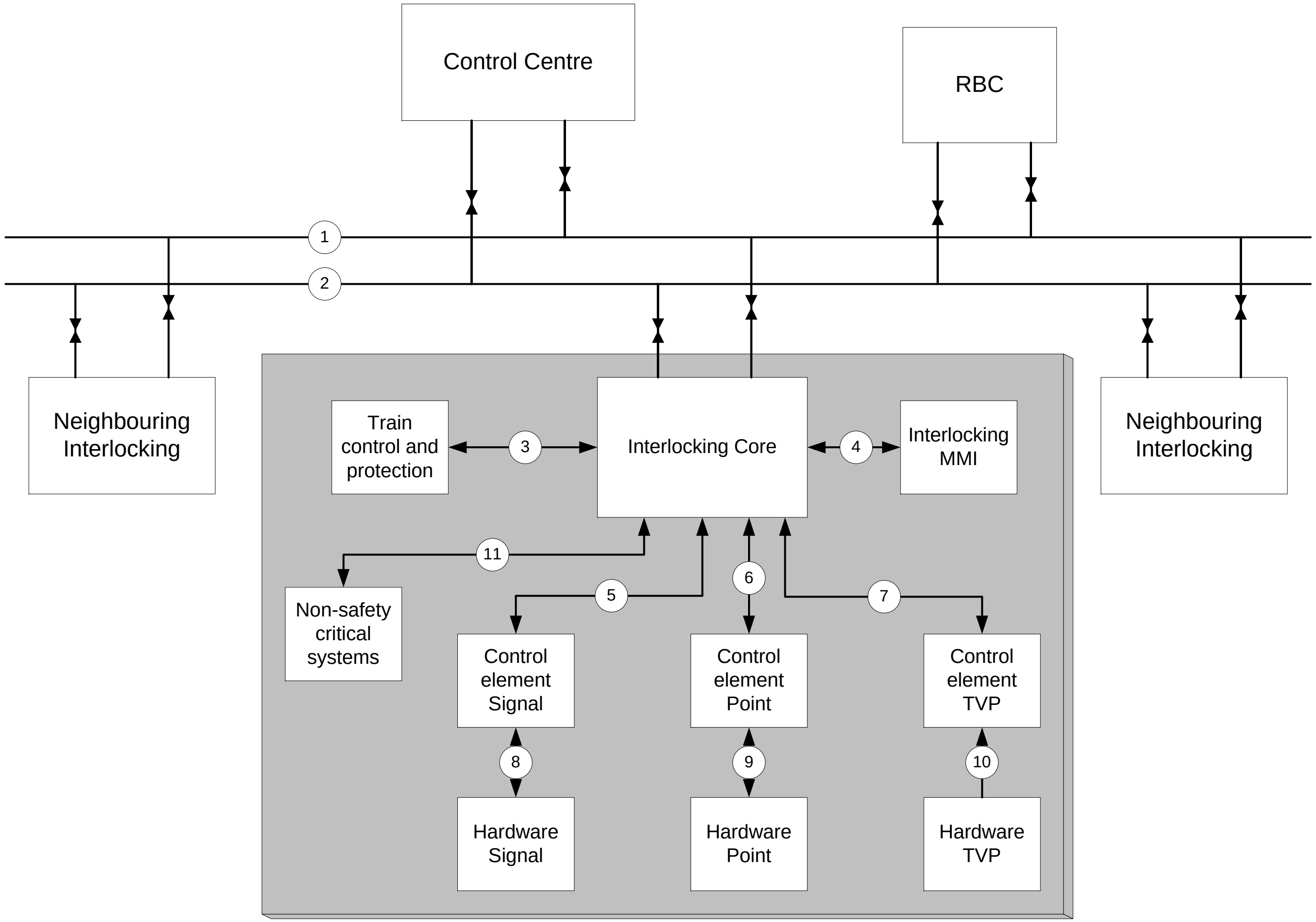
Modularisation for reducing interlocking interfaces

- 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

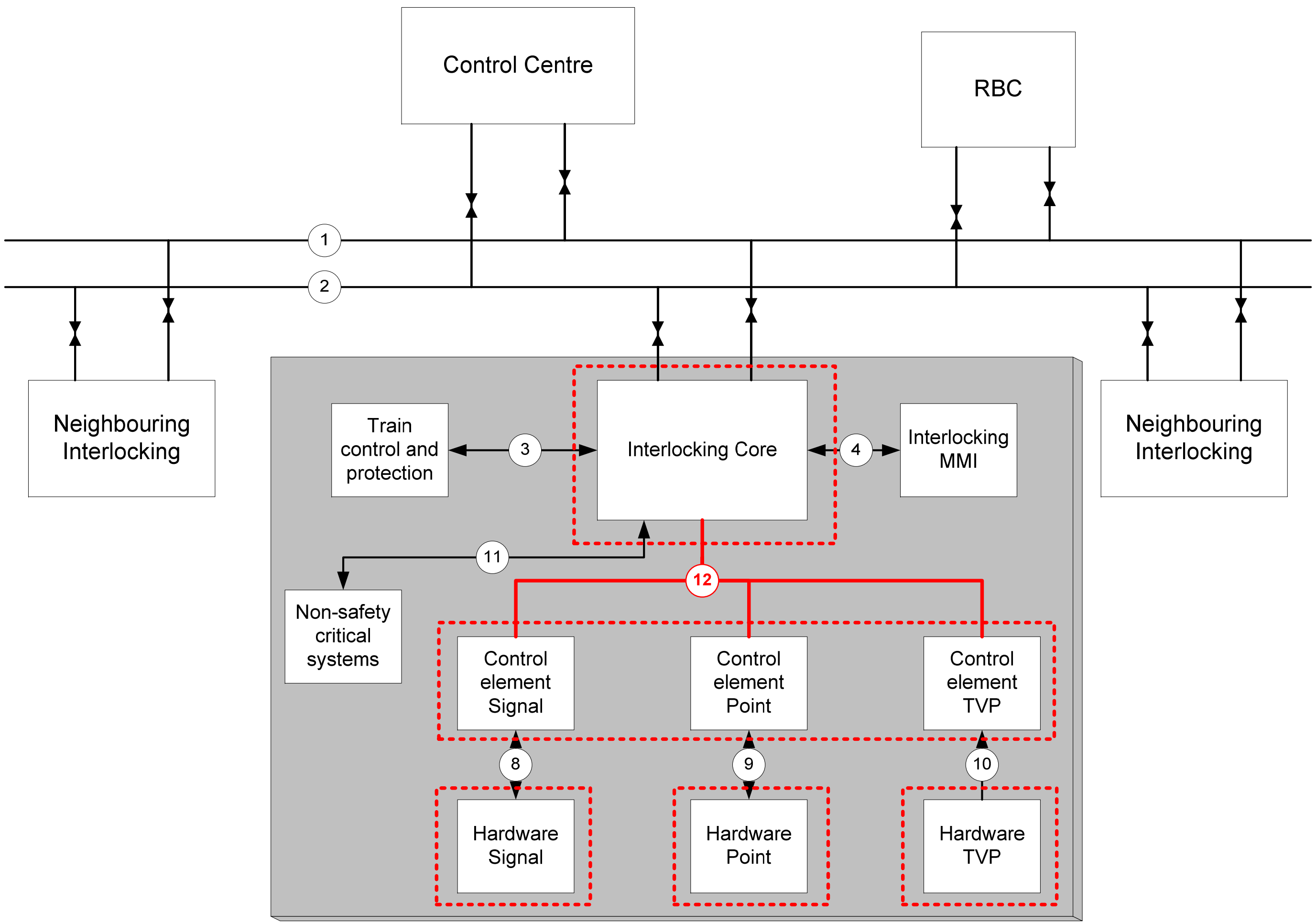
Possible Approaches for optimised testing

Modularisation for reducing interlocking interfaces



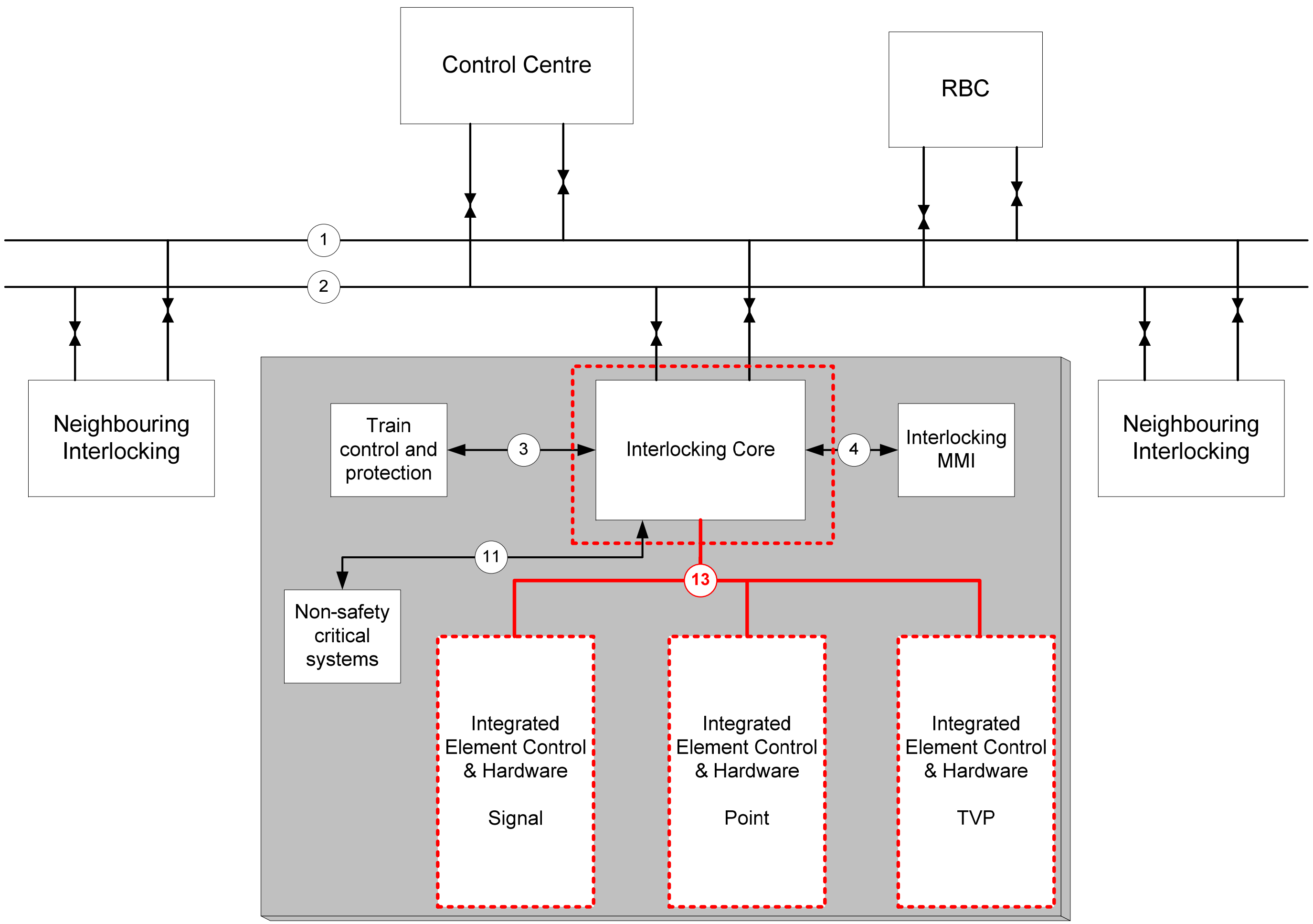
Possible Approaches for optimised testing

Modularisation for reducing interlocking interfaces



Possible Approaches for optimised testing

Modularisation for reducing interlocking interfaces

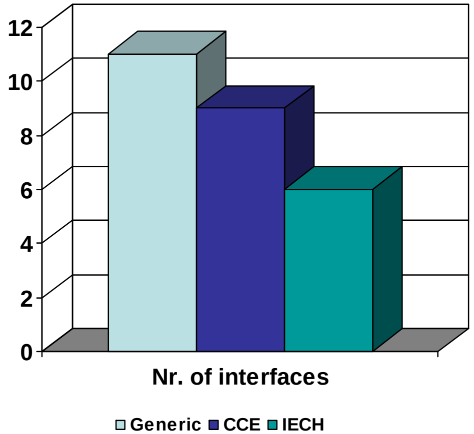


Possible Approaches for optimised testing

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 inter-faces 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

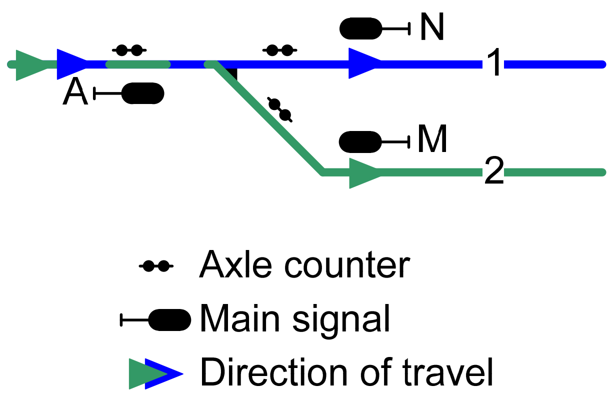
Industrial Engineering for optimising number of elements

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

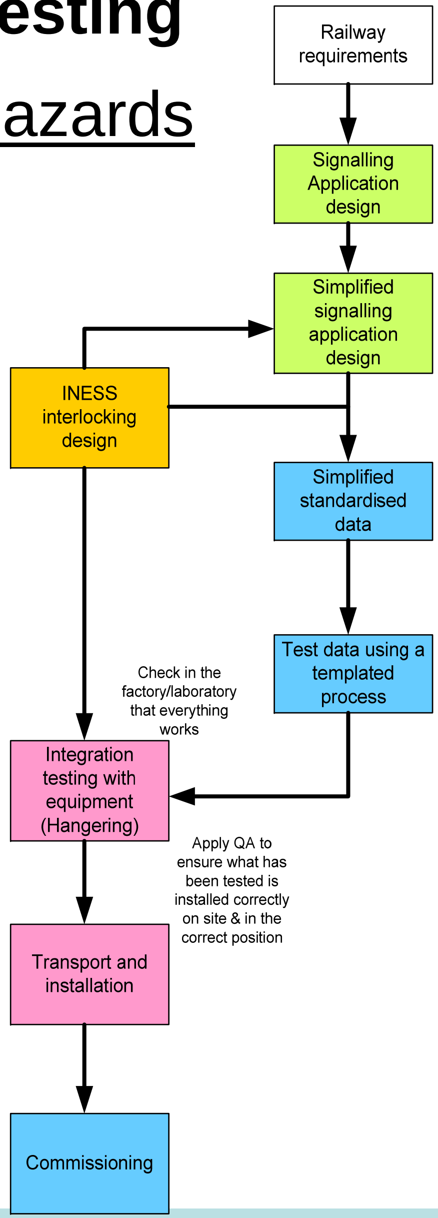
Safe by design approach to eliminate hazards

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

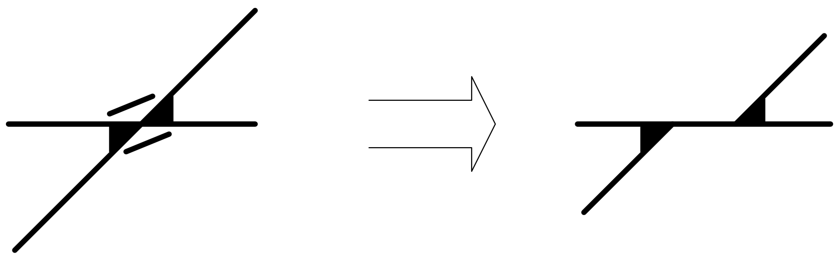
The approach starts during the transformation of the requirements into the application‘s design with an objective of simplification of the design.



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.

INtegrated European Signalling System

Possible Approaches for optimised testing

Conclusion

The methodical evaluation of the different methods paints the picture that

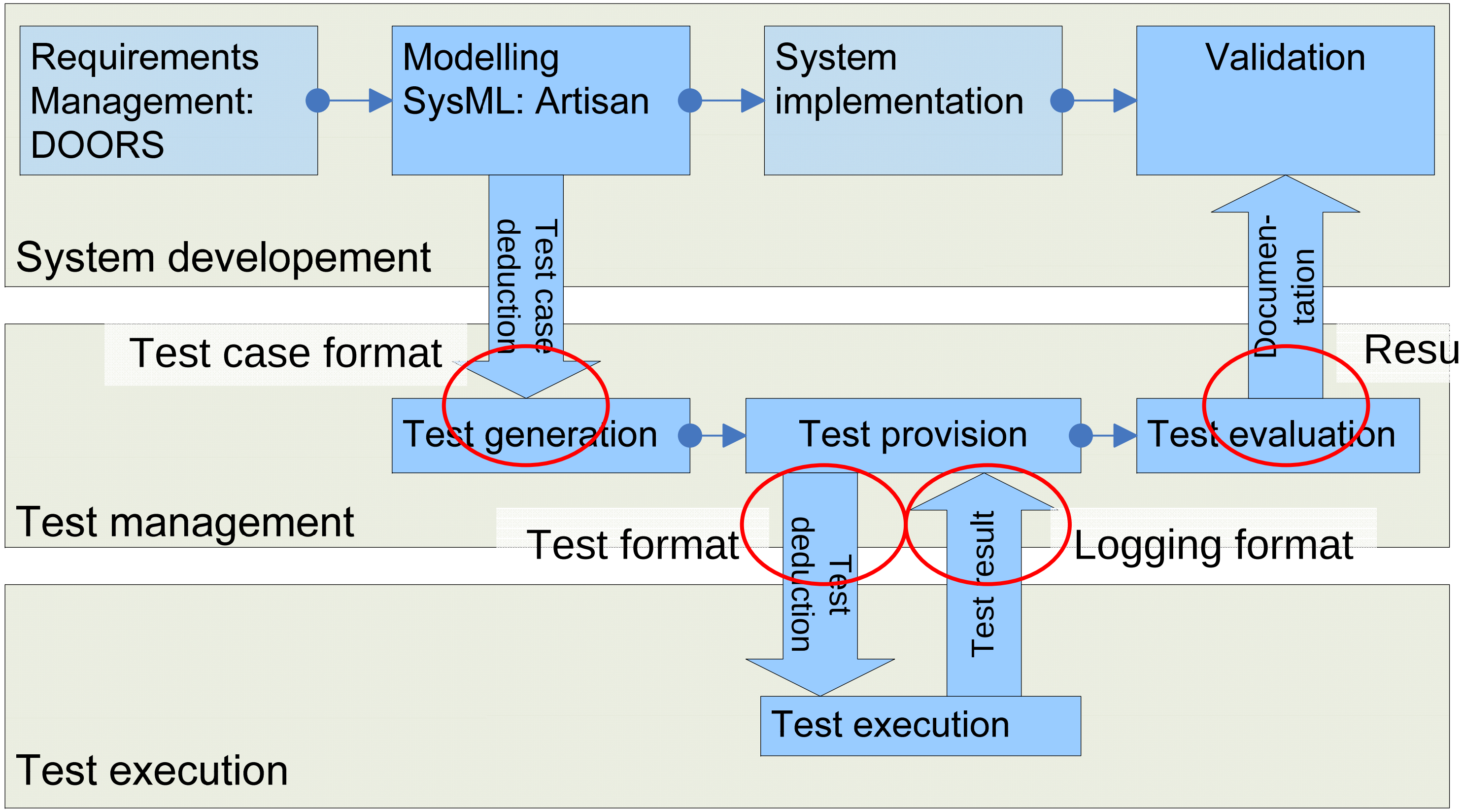
- the modularisation and standardisation can produce a significant saving by eliminating different interfaces, which need to be tested each one by one
- the safe by design approach can in parallel lead so some effort saving due to the simplification of elements and in the process making testing easier. 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

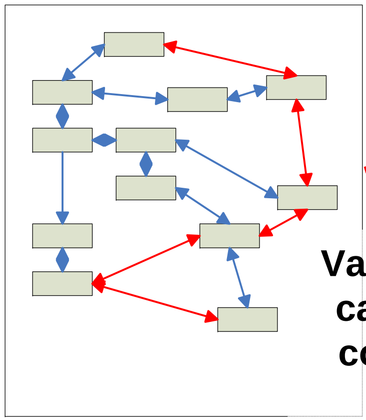
Example for a Tool-Chain



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.)



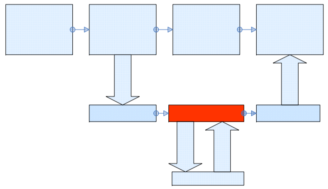
Various test cases can be produced coming from the model.


```
<?xml version="1.0" encoding="UTF-8" ?>
- <CommonEvents xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" ver="1.0" xsi:noNamespaceSchemaLocation="CommonEvents.xsd">
    <test_sequence_number>016</test_sequence_number>
  - <TestSequenceFile>
      <name>sequence_016_0002_TS.xml</name>
      <path>.</path>
      <version>232</version>
    </TestSequenceFile>
    <common_events_version>1.0</common_events_version>
    <common_events_creation_date>2003-03-31T08:56:57</common_events_creation_date>
    <common_events_last_mod_date>2011-06-27T15:30:09</common_events_last_mod_date>
    <device_kind>TIU</device_kind>
  - <CommonEventsList>
    + <CommonEvent direction="I">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    - <CommonEvent direction="O">
        <version>1.0</version>
        <order_in_test_sequence>146</order_in_test_sequence>
      - <Trigger>
          <distance>3000</distance>
        </Trigger>
        <rel_distance>0</rel_distance>
      - <EventDescription>
          <description>The EB is applied No revocation command (for emergency brake) is transmitted as long as in TR mode.</description>
          <event_comments />
          <user_comments />
        </EventDescription>
        <event_id />
        <ParameterList />
      </CommonEvent>
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    + <CommonEvent direction="O">
    </CommonEventsList>
  </CommonEvents>
```


OBU: Onboard Unit

Optimised Testing by using laboratories

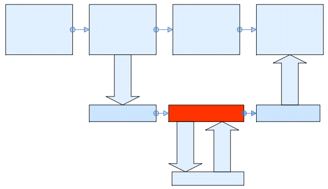
Test management: Administration of tests



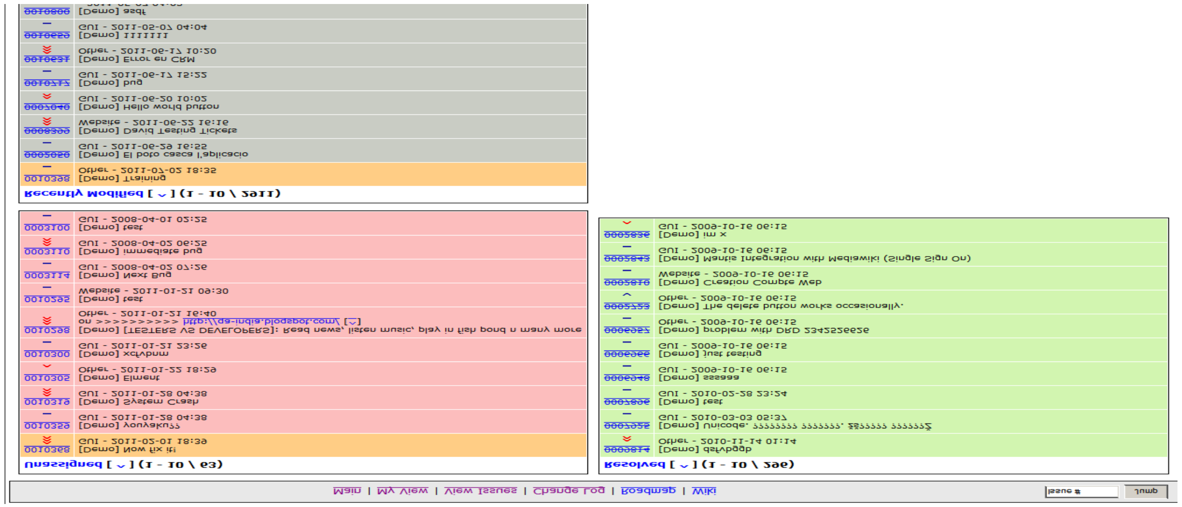
- Generic tool for versioning to administrate the test cases:
  - Subversion (SVN)
    - Parallel changes from different user can be traced and administrated
    - Usage of any number of versioning branches and updates
    - Ideal for the administration of XML- and MySQL-data
    - Available and OS independent

Optimised Testing by using laboratories

Test management: Administration of tests



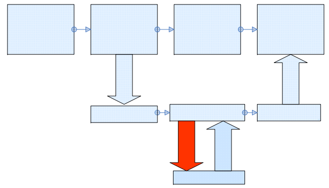
- Generic tool for the administration of change requests
  -> BugTracking
  - Mantis
    - Errors can be reported by any kind of user to a defined position
    - Correlation of errors and changes of versions
    - Generation of documentation



Quelle: Mantis Demo

Optimised Testing by using laboratories

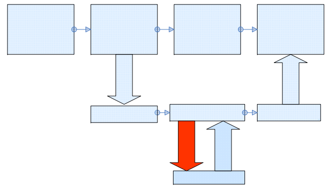
Test execution: Test format



Requirements for the test format:

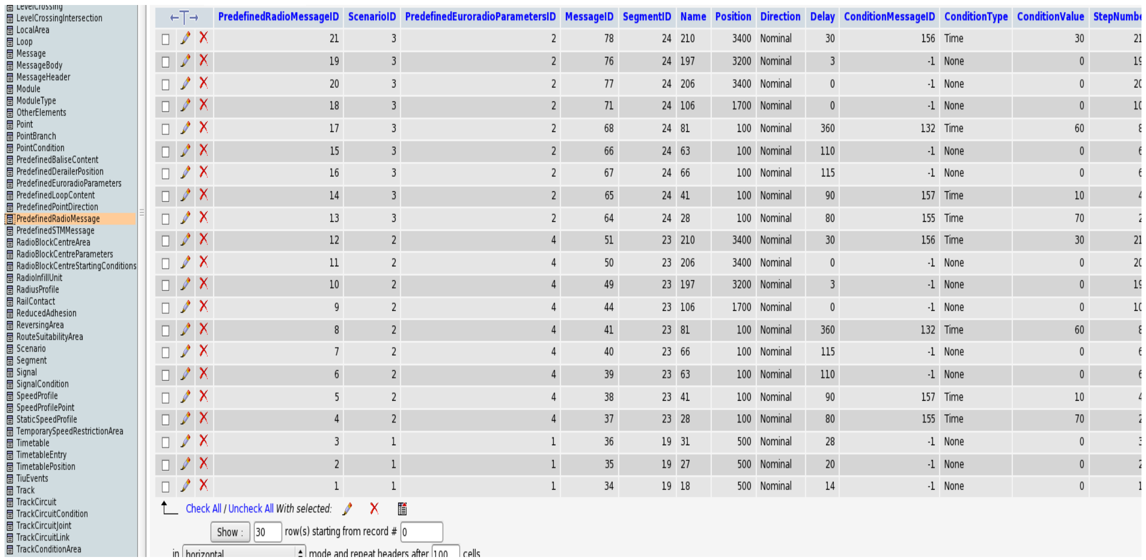
- Additionally to the test case format:
  - Combination of test cases to test sequences
    - Usage of existing parameters and starting requirements
    - Sorting requirements orientated, to make checking of requirements groups possible
  - High timing requirements for the availability of the data
 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

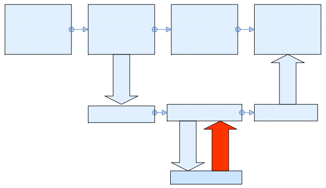


PredefinedRadioMessageID	ScenarioID	PredefinedEuroradioParametersID	MessageID	SegmentID	Name	Position	Direction	Delay	ConditionMessageID	ConditionType	ConditionValue	StepNumbe
21	3	2	78	24	210	3400	Nominal	30	156	Time	30	21
19	3	2	76	24	197	3200	Nominal	3	-1	None	0	19
20	3	2	77	24	206	3400	Nominal	0	-1	None	0	20
18	3	2	71	24	106	1700	Nominal	0	-1	None	0	10
17	3	2	68	24	81	100	Nominal	360	132	Time	60	8
15	3	2	66	24	63	100	Nominal	110	-1	None	0	6
16	3	2	67	24	66	100	Nominal	115	-1	None	0	6
14	3	2	65	24	41	100	Nominal	90	157	Time	10	4
13	3	2	64	24	28	100	Nominal	80	155	Time	70	2
12	2	4	51	23	210	3400	Nominal	30	156	Time	30	21
11	2	4	50	23	206	3400	Nominal	0	-1	None	0	20
10	2	4	49	23	197	3200	Nominal	3	-1	None	0	19
9	2	4	44	23	106	1700	Nominal	0	-1	None	0	10
8	2	4	41	23	81	100	Nominal	360	132	Time	60	8
7	2	4	40	23	66	100	Nominal	115	-1	None	0	6
6	2	4	39	23	63	100	Nominal	110	-1	None	0	6
5	2	4	38	23	41	100	Nominal	90	157	Time	10	4
4	2	4	37	23	28	100	Nominal	80	155	Time	70	2
3	1	1	36	19	31	500	Nominal	28	-1	None	0	3
2	1	1	35	19	27	500	Nominal	20	-1	None	0	2
1	1	1	34	19	18	500	Nominal	14	-1	None	0	1

Source: DLR RailSiTe®

Optimised Testing by using laboratories

Test execution: Logging format



TSR110411153048
TSR110411155228
TSR110411161016
TSR110411161553
TSR110607085520
TSR110607090209
TSR110607090311
TSR110607112123
TSR110607120447
TSR110607120923
TSR110607123811
TSR110607130358
TSR110607130459
TSR110607130830
TSR110607131125
TSR110607132954
TSR110607134937
TSR110607135614
TSR110607143212
TSR110607143919
TSR110607144500
TSR110607144606
TSR110627150035
TSR110627151421
TSR110627152054
TSR110627152200
TSR110627152252
TSR110627153212
TSR110627153450

SQL query:

```
SELECT *
FROM `TSR110627153450`
LIMIT 60 , 30
```

Profiling [Edit] [Explain

<< < Show : 30 row(s) starting from record # 90 > >> Page number: 3

in horizontal mode and repeat headers after 100 cells

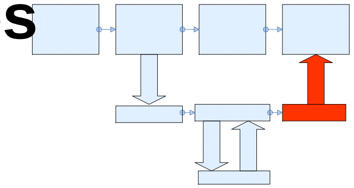
Sort by key: None

index	time	servertime	sender	seqnbr	msgtype	message	comment
61	110627153622198	110627153622214	ROB	00000	260	event_id is: 10, Name is: ACK	Subevents are: Ack,
62	110627153622267	110627153622271	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
63	110627153625797	110627153625809	RTS1	00066	654	+0.00001408038000064C420001400002F43F	Transmit radio message (Acknowledgement of Train D...
64	110627153625839	110627153625859	RTM1	00000	100	+0.0000210500000000000E08038000064C4200014000...	Transmit radio message (Data Request (5): Acknowle...
65	110627153627330	110627153627334	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
66	110627153632372	110627153632376	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
67	110627153637434	110627153637438	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
68	110627153642474	110627153642478	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
69	110627153643445	110627153643462	ROB	00000	260	event_id is: 3, Name is: Select Start	Subevents are: Enter Mode Menu, Select Start of Mi...
70	110627153644136	110627153644156	RTM1	00000	101	+0.000031060000000000188406000008188C36184000...	Receive radio message (Data Indication (6): MA Req...
71	110627153644228	110627153644241	RTS1	00000	655	+0.0000248406000008188C361840007244000280FB28...	Receive radio message (MA Request (132))
72	110627153647515	110627153647519	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
73	110627153652576	110627153652580	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
74	110627153657617	110627153657621	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
75	110627153702679	110627153702683	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
76	110627153707721	110627153707725	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
77	110627153712782	110627153712786	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
78	110627153717823	110627153717827	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
79	110627153722884	110627153722888	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
80	110627153727926	110627153727930	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
81	110627153732989	110627153733007	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
82	110627153738029	110627153738033	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
83	110627153743090	110627153743094	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...
84	110627153744035	110627153744056	RTM1	00000	101	+0.0000310600000000001884060000DF48C36184000...	Receive radio message (Data Indication (6): MA Req...
85	110627153744114	110627153744127	RTS1	00000	655	+0.000024840600000DF48C361840007244000280FB28...	Receive radio message (MA Request (132))
86	110627153748131	110627153748135	TBS1	00000	250	+0.00+000.0+0.00	Odometric data: 0.000000 m, 0.000000 km/h, 0.00000...

Source: DLR RailSiTe®

Optimised Testing by using laboratories

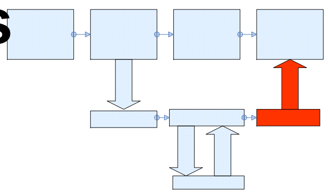
Test evaluation: Format of results

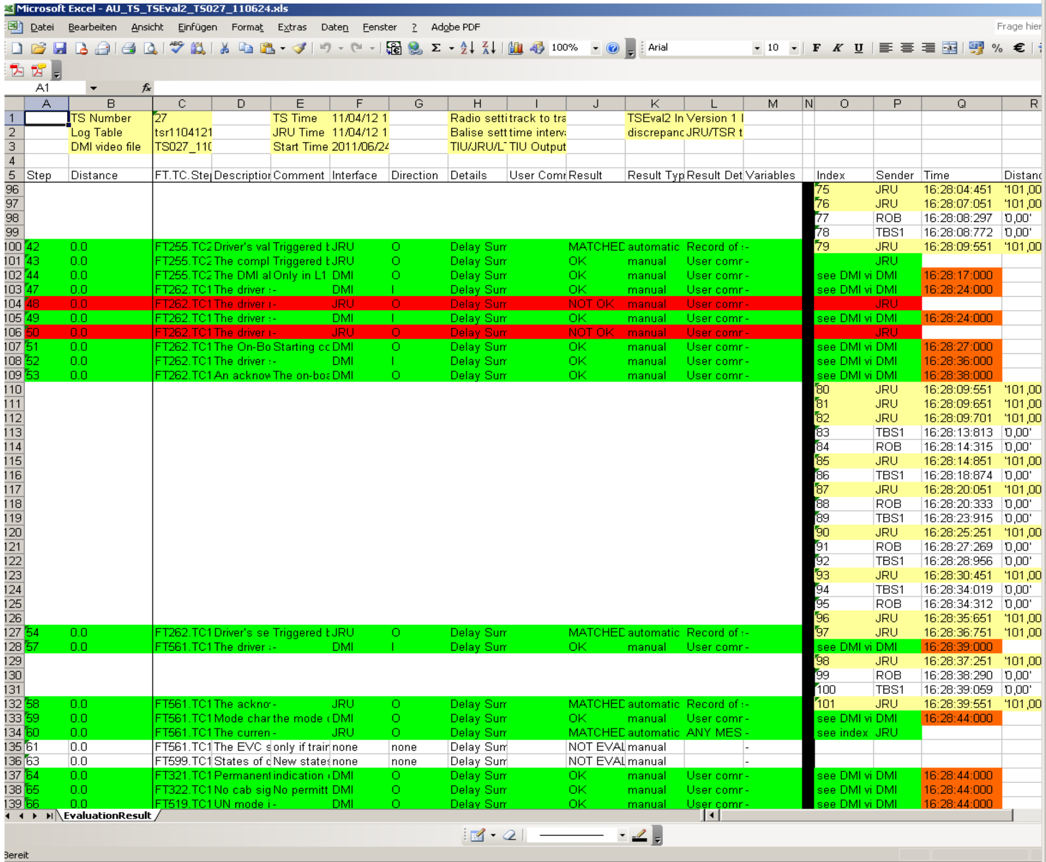


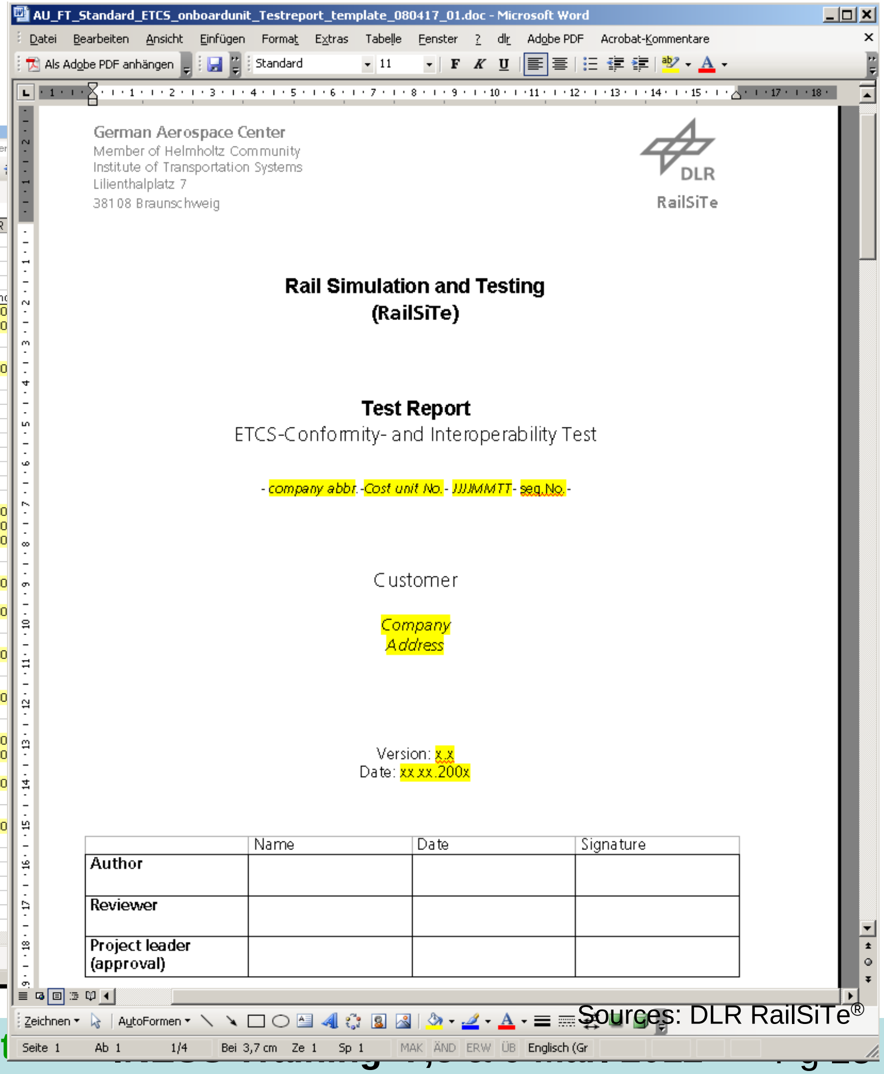
- Results of the tests need to be documented
- Format of the test reports is selectable, since no further handling necessary
- But a kind of Meta format is recommended to make the usage easier (Ideally MS Excel after version 2008: XML format)
- Using MS Excel up to 70% of a report can be generated automated,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

Optimised Testing by using laboratories

Test evaluation: Format of results



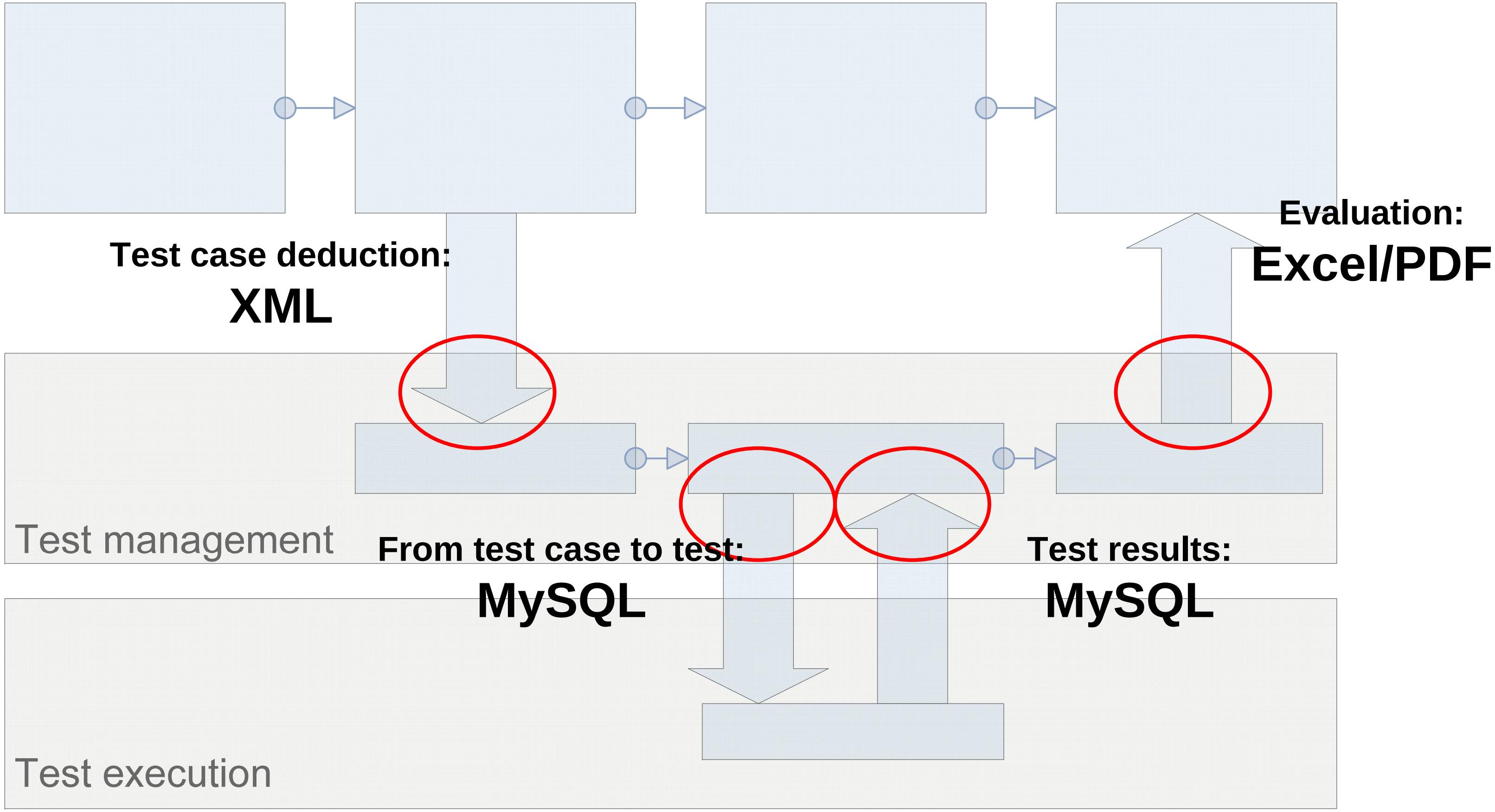




Sources: DLR RailSiTe®

Optimised Testing by using laboratories

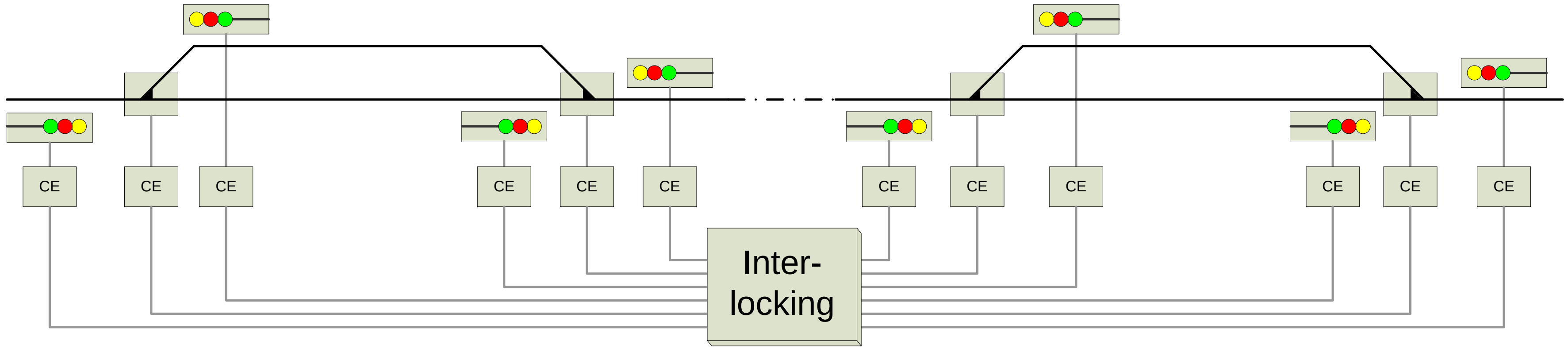
Conclusion



Part 3:

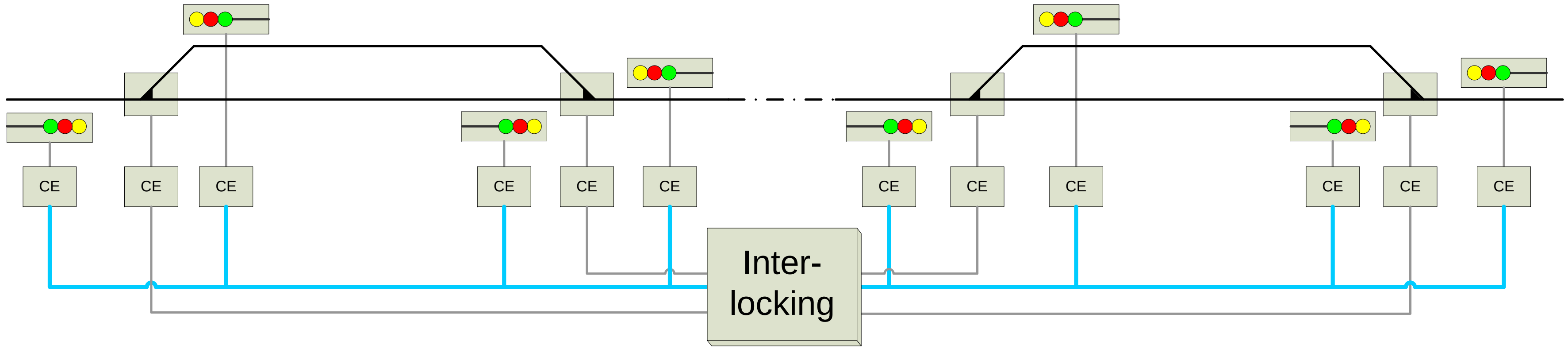
Savings through the design approach

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

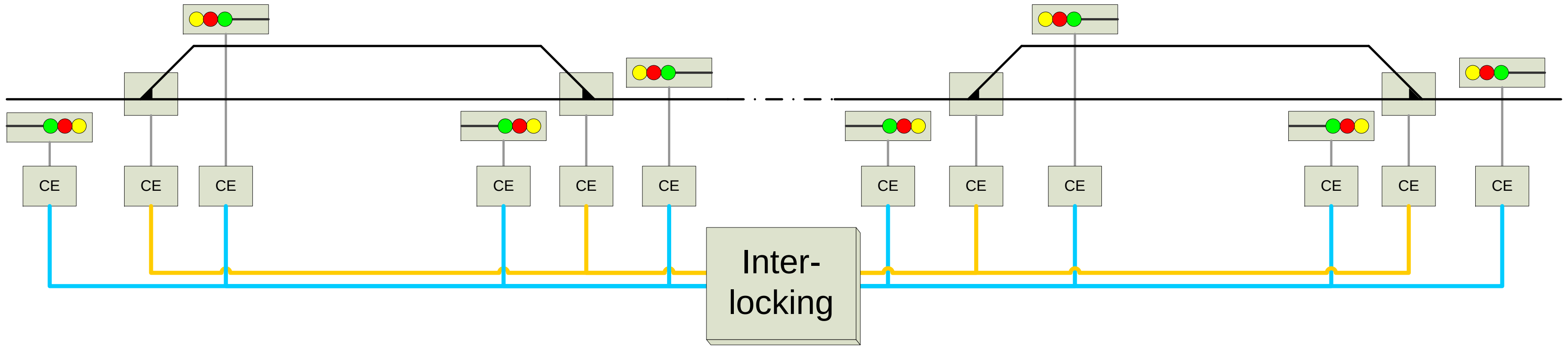
Savings through the design approach
Modularisation methods



- 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

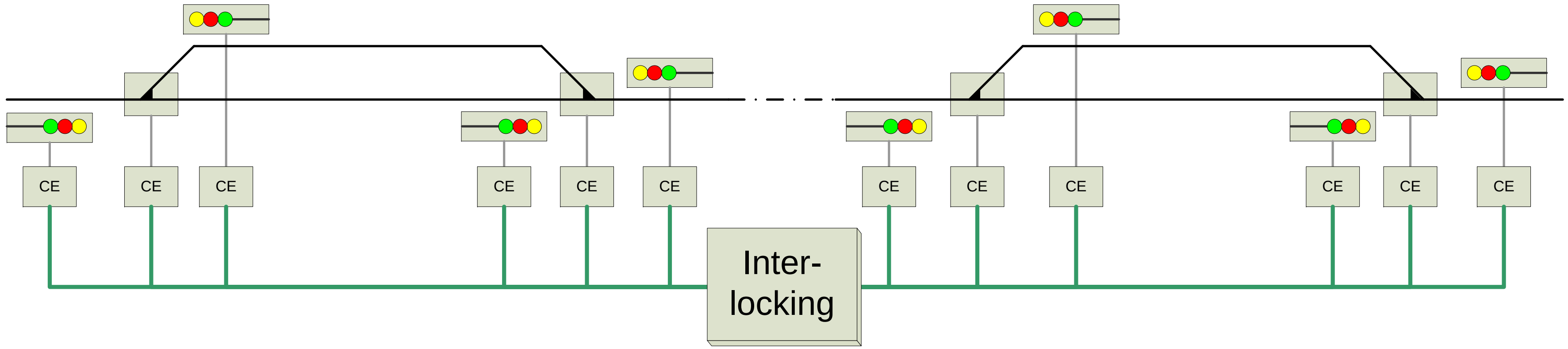
Modularisation methods



- 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

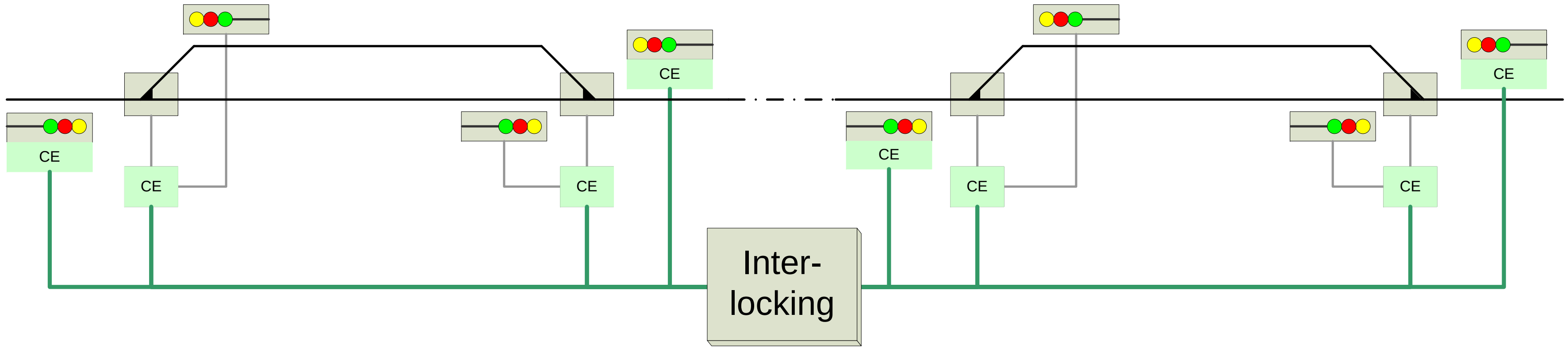
Savings through the design approach

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

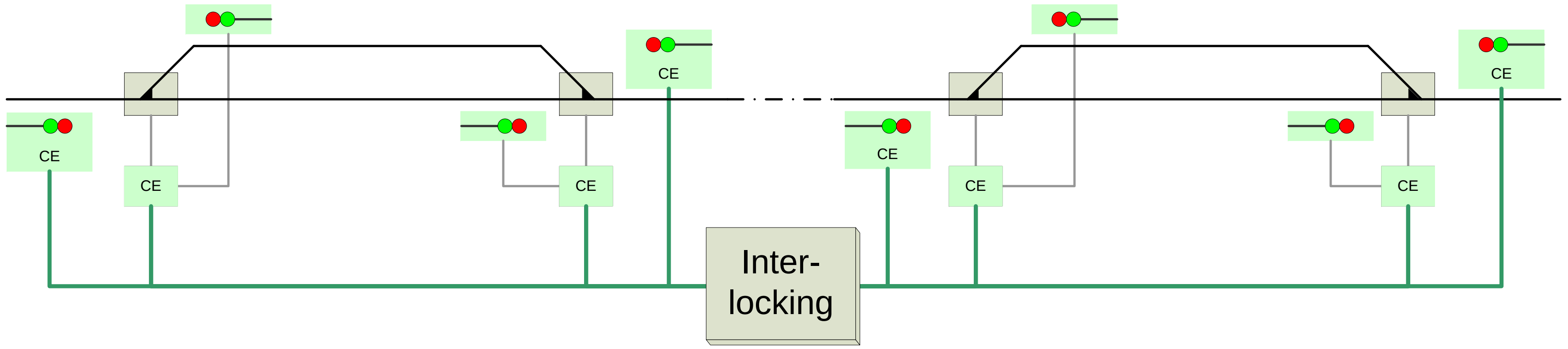
Savings through the design approach
Modularisation methods



- 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

Savings through the design approach

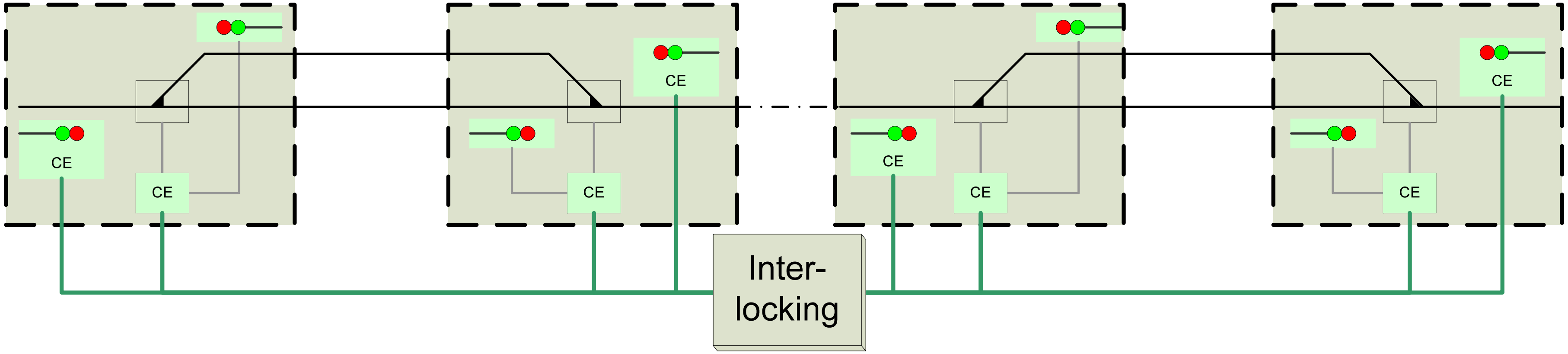
Safe by design methods



- 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

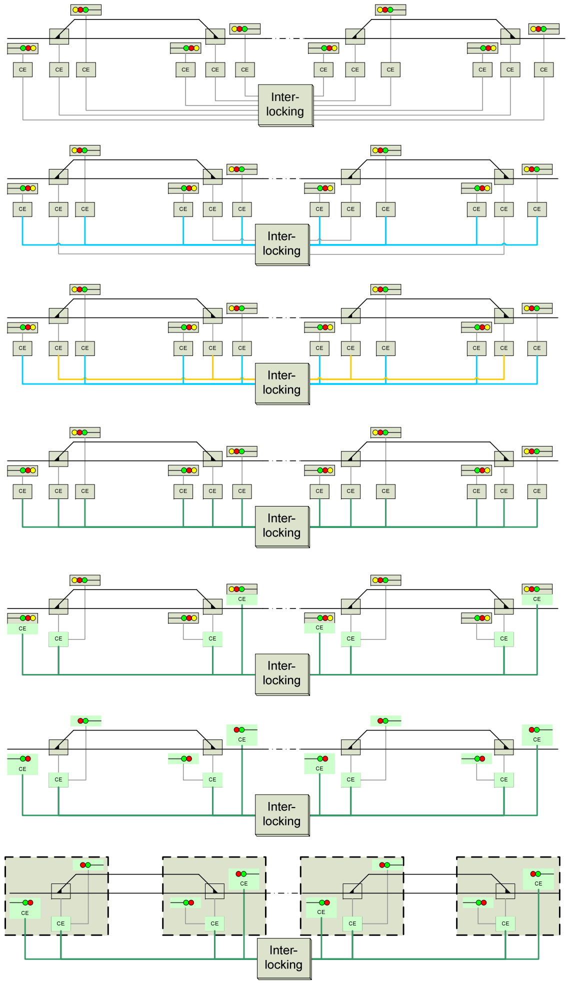
Industrial Engineering methods

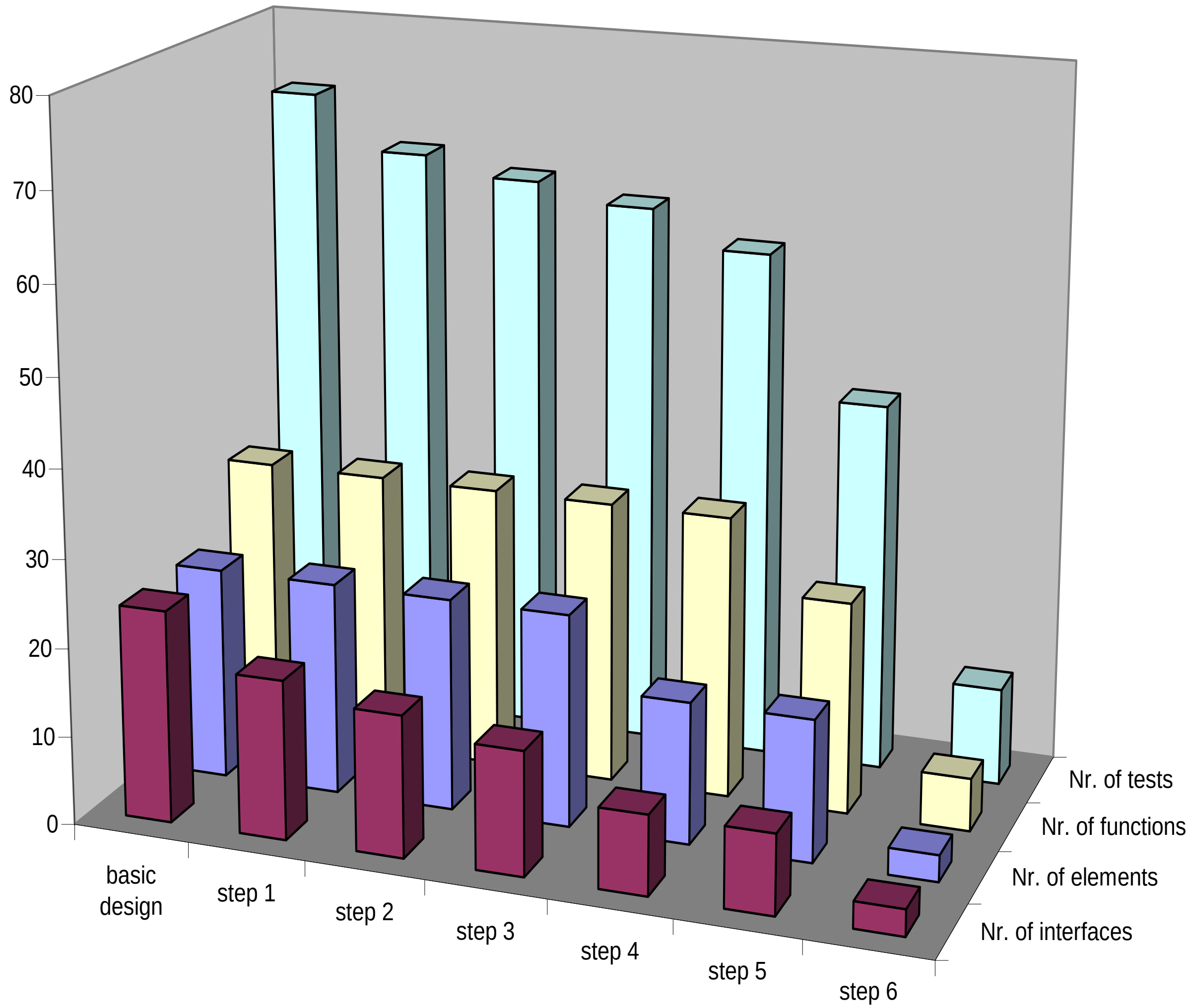


- Step 6: generating pre-testable unit (which can be used four times in this layout)
  - **1** point
  - **2 two** aspect signals
  - **2** Element controller (4 combined controller for point and signal, 4 controller for signals)
  - **3** interfaces
    - **1** interface between interlocking and element 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.