FP7 Project 2007- Grant agreement n°: 218575

Project Acronym: **INESS**

Project Title: **INtegrated European Signalling System**

Instrument: Large-scale integrating project
Thematic Priority: Transport

Document Title: **INESS_WSB_D-B-1.2_Development-and-validation-of-life-cycle-model_Draft_Ver2010-01-08**

Due date of deliverable	31.12.2009
Actual submission date	

Deliverable ID:	**D.B.1.2**
Deliverable Title:	Report on Life Cycle based cost model for interlocking
WP related:	B.1
Responsible partner:	DB
Task/Deliverable leader Name:	Karsten Kamps
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Start date of the project: 01-10-2008 Duration: 36 Months

Project coordinator: Paolo De Cicco
Project coordinator organisation: UIC

Revision: 1.1 Dissemination Level[1]: CO

[1] PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services).

Document Information

Document type: Template
Document Name: INESS_WSB_D-B-1.2_Development-and-validation-of-life-cycle-model_Draft_Ver2010-03-19.doc
Revision: 1.1
Revision Date: 19.03.2010
Author: Karsten Kamps
Dissemination level: **CO**

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Document history

Revision	Date	Modification	Author
0.1	18.03.2009	Document created	Karsten Kamps
0.2	22.05.2009	Update due to current progress	Karsten Kamps
0.3	21.09.2009	Update due to current progress	Karsten Kamps
0.4	15.12.2009	Update due to current progress	Karsten Kamps
1.0	08.01.2010	Update due to current progress / Finalisation	Karsten Kamps
1.1	19.03.2010	Update due to TAR comments	Karsten Kamps

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GLOSSARY

IM	Infrastructure Managers
WS B	Workstream B
WS	Workstream
LC	Life Cycle
LCC	Life Cycle Cost
SIL	Safety Integrity Level
ERP	Enterprise Resource Planning
CC	Cost Categories
NoBo	Notified Body
ISA	Independent Safety Assessor
SEU	Signal Equivalent Unit
FAT	Factory Acceptance Test
SAT	Site Acceptance Test

Section 1 Executive Summary

A Life Cycle Model for signalling systems could be developed according to EN60300-3-3. The dimensions of this model are as follows:

- Product Structure
- Life Cycle Phases
- Cost Categories.

Four Market Segments were defined to distinguish different demands (functional requirements). For each project the Market Segment is captured as additional information to analyse cost drivers more specific.

Six railways and four (out of five) participation suppliers provided data for the model. The data provided was taken from real projects.

As the supply industry partners are in direct competition among each other, a special agreement for the suppliers was necessary. Some key points of this agreement were:

- The data collection team for the suppliers only consists of representatives from academic partners (unless otherwise agreed)
- Data gathered will be made anonymous
- No absolute financial values, but the proportion of costs will be provided.

Section 2 Introduction

Today Infrastructure Managers (IM) faces the challenge to survive on the market with road- and air-traffic as competitors. Besides other measures it is essential to exploit cost reduction in all infrastructure fields. This can on the one hand be done by reduced investment costs, but furthermore – especially for products with a life span of more than 20 years – the whole Life Cycle (LC) needs to be considered.

The LC model that will be developed in Workstream B (WS B) has to cover all relevant components of the interlocking that might be affected by the work of other workstreams. On the one hand it can be used to see how different contracting models, risk sharing and requirements affect the costs of a signalling system; on the other hand it will be used to validate the effects of other workstreams.

Due to these needs the Life Cycle Cost (LCC) model has to be established in the first year of the INESS project. Furthermore the data for the status quo is necessary for the evaluation of other WS's effects. All partners were expected to provide the necessary data for the model and their knowledge about processes and cost drivers.

Section 3 Development and validation of Life Cycle Model

Development of LCC Model

The LCC Model used within this WS is based on EN 60300-3-3. Using this norm leads to a very formalized and precise development process.

The model can be visualised as a three dimensional cube (Figure 1).

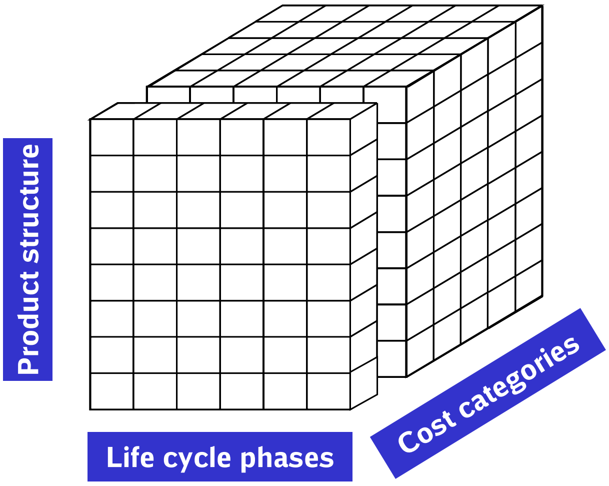

Figure 1: LCC Model according to EN 60300-3-3

Due to the fact that the three dimensions can be regarded as independent, three expert groups consisting of experts from railways, research institutes and suppliers were set up to work on these topics.

Life Cycle Phases

The involvement of railways and suppliers differs for the LC phases**Fehler! Verweisquelle konnte nicht gefunden werden.**. In general the contribution of the suppliers is higher in the early phases, whereas the railways (usually) take over more responsibility at the later stages.

The supplier usually develops his product on his own and starts preparations for his project. The vehicle that is used to bring the supplier and the Infrastructure Managers together is both the request for tender and the contract.

From this point of view suppliers and Infrastructure Managers work together to construct and commission a new signalling system.

After commissioning the Infrastructure Managers operate and maintain the product until it has to be decommissioned. During this phase the supplier (depending on the type of contract) could be deeply involved on an ad hoc basis or according to existing maintenance contracts.

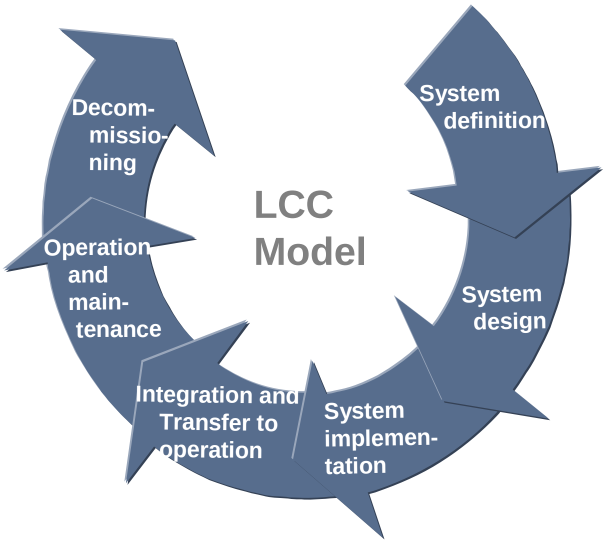

Figure 2: Life Cycle Phases

A supplier develops and produces products which the Infrastructure Managers purchases.

In a lot of cases Infrastructure Managers buy developed and market ready products. This means that a supplier must have the right product for the right application at the right time.

When a supplier decides to develop a product, he of course has to make investigations regarding user and market requirements. On the basis of these findings the supplier starts an internal development project, which could take a few years.

The product life cycle (Figure 2) starts with the phases “System Definition” and “System Design”.

System Definition (1)

In this phase the supplier prepares the development and does investigations, business cases, risk analyses, feasibility studies, etc. to determine whether the development of a new product is feasible or not and if there is a special need by the customers (like ETCS).

System Design (2)

After having decided to work on a new product, a full scale development project is started by the supplier.

All required specifications have to be evaluated, hard- and software has to be developed, tests and assessments have to be done as well as all necessary certifications and approvals.

At this step, the development of a product and the life cycle phase ends. Afterwards, the supplier has a product and the marketing campaign starts.

The involvement of the railways in this phase differs according to the national market.

The Infrastructure Managers have a special need for a new Interlocking system, delivering certain functionalities, availabilities and performance. This means that they start an acquisition project to obtain an product / system which meets their requirements best.

The acquisition project is following life cycle phases, too, but different ones compared to the product development. The Infrastructure Managers mainly perform project preparation activities and they are in general not involved in the product development with the same intensity as the supplier is.

This means that Infrastructure Managers have to do separate activities at the beginning of the LC of a new project compared to the supplier's workload.

Joint activities of railways and suppliers usually start with the "System Implementation" phase, where an already developed product is adapted for the use within a given environment (i. e. track layout, traffic density).

System Implementation (3)

At this point the system has been developed, tested and approved. This means that it can be purchased by the client and is ready to be installed.

The railways start with preparations for a project. For some railways this phase is very short and for others it involves the following activities:

- Feasibility study
- LCC model
- Business Case
- Investment proposal and approval.

At this stage, the railways have the approval and budget for the project and they are able to start with the required engineering.

The supplier starts to prepare his product for a specific application. This basically includes the configuration of hard- and software, the performance of all tests (FAT, SAT, data, installation, etc.), the system installation at the location and performance integration as well as operational tests. Afterwards, he supplies logistic products (training, documentation, spare parts, etc.) and hands the system over to the Infrastructure Managers.

The Infrastructure Managers monitor the contract, attend the FAT, SAT etc., do all necessary activities to prepare the site, sub contract field element suppliers, monitor progress, and take the system and logistics into service.

The result of this phase is at least a scheme plan. This plan shows how the layout must be, informs about the different requirements as well as the complete technical design for the new project.

During this phase the following sub phases and tasks will be necessary:

Contracting (3.01)

- Interlocking Contract (3.01.01)
  The client addresses a request for quotation (RFQ) to the suppliers with detailed project specifications. After negotiations a contract with the winning supplier(s) is fixed.

- Bid (3.01.02)
  This is a supplier document to inform about the own capability, the project process and the arising costs.

- Contract (3.01.03)
  This is a formalized agreement between the supplier and client to agree upon each party’s responsibilities, deliverables, activities, planning and penalty clauses over the project lifespan.

- Construction Contract (3.01.04)
  This is a special contract in terms of special constructing issues.

- Engineering Contract (3.01.05)
  This is a contract focusing on project engineering activities, such as the design work for the signalling systems.

Project specific planning (3.02)

- Scheme Plan (3.02.01)
  This is a final plan of all project engineering activities which contains the layout as well as all technical and functional project requirements (new track section). This is the input for the

suppliers in order to dimension their systems, to specify and define the entire field elements in the projection software.

- Planning (3.02.02)
  A schedule in order to meet the client's required delivery/commissioning date.

- Planning Assessment (3.02.03)
  This is an evaluation of the planning to judge if it is feasible and to estimate possible problems.

- System Requirements Specification (3.02.04)
  These are documents which specify all system requirements.

- System Architecture (3.02.05)
  This is the design of the mandatory components, sub systems and systems.

- Prepare Basic Plans (3.02.06)
  Basic plan to test and advance the necessary steps required in order to deliver a satisfactory project (or system).

- Prepare Documentation for Test, Installation, Commissioning (3.02.07)
  Theses are documents which describe the activities and planning to perform installation, testing and commissioning. They provide an overview about tests that have to be done and about the mode and time span of the tests.

System Integration (4)

During this phase the following sub phases and tasks will be necessary:

System Configuration (4.01)

- Product Adaptation (4.01.01)
  In this phase, the supplier has to decide which of his products will best meet the requirements.

- System Configuration (4.01.02)
  Regarding the system architecture, it has to be decided which versions of HW and which issues of SW will best meet the requirements. Furthermore, it has to be clarified where every single item will be placed.

- Configure Indoor Equipment (4.01.03)
  This is the system configuration designed for the indoor equipment.

- Configure Outdoor Equipment (4.01.04)
  This is the system configuration designed for the outdoor equipment.

- Configure Data for System (4.01.05)
  This is the configuration of the data as projected in the scheme plan.

Installation & Construction (4.02)

- Transfer System to Destination (4.02.01)
  This is the transportation of the equipment from the supplier's factory to the specific locations.

- Installation (4.02.02)
  The installation contains all activities that have to be done in order to install, place, integrate, switch on, and connect etc. the system in its intended environment and location.

- Construction (4.02.03)
  These are all required activities that prepare and empower the system for processes like the installation, housing, connection etc. That includes things such as air-conditioned rooms, containers, gullies etc.

Transfer to Operation (5)

During this phase the following sub phases and tasks will be necessary:

Testing & Approval (5.01)

- Data Integration Test (5.01.01)
  This is an activity which is performed in the factory and at the site, to determine respectively test whether the correct data is transferred in the correct manner between the applicable units (sub-systems, systems etc.). This is important for the operability of the project.

- Provide Infrastructure for Test (5.01.02)
  Within this phase, the supplier has to test his system in its intended environment. Therefore, the system has to be linked to certain interfaces and has to be able to communicate with other technical entities. Only by providing such a test procedure the supplier can assert that his system meets the project's requirements.

- Prepare Process Simulation (5.01.03)
  The way that trains run according to a timetable is an important process. A new project or system must ensure that this process can run correctly. It is difficult and dangerous to test this in the actual installation. Hence, it is better to test this in a laboratory. However, this requires a complex preparation because the current timetable for the specific project has to be emulated. Via simulations, the supplier can prove that his system can meet the required process.

- Factory Acceptance Tests (5.01.04)
  These are tests, which help the supplier to prove that his system performs and functions operates, as the client requires it. In general, this method is operated for testing the shipment and the installation.

- Commissioning and Tests (5.01.05)
  This is the final phase of a construction and installation process. It describes the point where all components and functions are tested in order to meet the client's requirements. It describes also the process (phase) where the safety of a system is proven.

- Validation (5.01.06)
  Before the system goes into operation the client's inspector determine whether the system and its installation can be accepted. This describes also the point where the supplier verifies that he has supplied a good system. Therefore, the approval by an independent evaluator is required as well (NoBo, ISA).

- Assessment and Approval (5.01.07)
  These are the two steps of the validation phase which have to be performed by an inspector. He has to assess all the documents, reports, results, certificates etc. in order to approve the system respectively its installation.

- Site Acceptance (5.01.08)
  Within this phase, all checking activities regarding the acceptance of the site have to be done. The railways and a regulatory authority check the installation regarding the conformity to the planning and the national requirements

- Integration Test / Commissioning (5.01.09)
  Comparable to "Site Acceptance"; here the supplier's view is focused.

Documentation (5.02)

- Archiving of Documents (5.02.01)
  All project specific documents regarding the operation and maintenance phase are created and afterwards given to the railway.

- Deliverables (5.02.02)
  These are the extras which the client needs in order to operate and maintain the installed equipment. This includes training for operation and maintenance, spare parts, documentation, special tools, test equipment, consumables etc.

Additional (5.03)

- Handover (5.03.01)
  Within this formal process, the client takes the system into operation. Henceforward the client is responsible for the operation of the system.

- Provide Warranty Phase (5.03.02)
  The supplier has to issue a guarantee on his delivered/installed equipment. For the conversion of this warranty adjustment, the supplier needs to set up an organization that will solve the client’s problems and repair equipment. On the other side, the client has to install a system whereby he can monitor, report and manage the warranty claims.

- Provide Spare Parts (5.03.03)
  Within this phase, the supplier is asked to guarantee the delivery of all spare parts.

- Remove Failures (5.03.04)
  The supplier is asked to ensure that his system works according to the declared expectations. If the system does not meet the contracted RAMS criteria all failures need to be fixed by the supplier. Furthermore, he has to accept the originated costs with regards to his contracted responsibilities.

Operation and maintenance (6)

Depending on the type of contract and needs of the Infrastructure Managers the supplier plays a more active or passive role in this phase.

In this phase, the Infrastructure Managers play the major role. Now, the system is in operation and has to be operated and maintained by the Infrastructure Managers. The supplier is playing an important role in the maintenance of the system. Depending on the contract model the supplier could perform different support levels.

This phase can extend for a period of 25 years (for an electronic interlocking system).

During this period and due to changing needs it will become necessary to upgrade, modify or renew the hard- and or software. This is usually done in cooperation with the supplier.

During this phase the following tasks occur:

- Operations (6.01.01)
  The system has just been commissioned and taken into service by the client. The operational workforce has been practiced and the system has been integrated into all the relevant operational systems.

- Maintenance and Contract Phase (6.01.02)
  Once the system is in operation it requires maintenance. Aspects such as the maintenance training, logistics, maintenance contracts (if required) are in operation. The system has been incorporated into the client's maintenance organization, maintenance control and monitoring systems etc.

- Renewals (6.01.03)
  Within this phase, the system has to be replaced because of its technical age, new functional requirements, obsolescence etc. This means that new equipment has to be installed. If necessary engineering, design and/ or development activities have to be done.

- Upgrades (6.01.04)
  During the life cycle of a system, certain hardware and/or software components/versions do not meet the requirements anymore (such as capacity, speed etc.) so that they have to be upgraded.

- Modifications (6.01.05)
  Within this phase, the client requires modifications that have to be made in order to enlarge the system or to integrate new functional requirements, new tracks, extra field elements etc. This means that the suppliers have to expedite the necessary changes regarding hardware and software.

Decommissioning (7)

In the expert group none of the members regard this stage as a separate phase in their contracting and replacement models.

The removal and disposal of an old system is contracted as part of the installation contract and is performed while the new system is installed or put into service.

While some IM require a complete removal of the old equipment, other railways only decommission hazardous materials and those elements that cannot co-exist with the new system (i. e. signals or point machines).

All Life Cycle Phases, Sub-Phases and Tasks used in the model can be seen in Table 1.

Phase	Sub-Phase	Task
1 System Definition		
	1.01 System Definition	
		1.01.01 User Requirement Specification
		1.01.02 Risk Analysis
		1.01.03 Rules & Regulations
		1.01.04 Business Case
		1.01.05 Feasability Study
2 System Design		
	2.01 System Specification & Description	
		2.01.01 Requirement Specification
		2.01.02 Safety Requirements Specification
		2.01.03 Architecture Description
		2.01.04 Integration Test Specification
	2.02 Safety Analysis	
		2.02.01 Hazard Analysis
		2.02.02 Safety Case Concept
		2.02.03 Technical Safety and RAM Reports
	2.03 System Development	
		2.03.01 HW-Development
		2.03.02 SW-Development
	2.04 Testing, Validation & Acceptance	
		2.04.01 SW-Validation
		2.04.02 SW-HW Integration Test
		2.04.03 Demonstration of Conformity
		2.04.04 Validation
		2.04.05 Assessment
		2.04.06 Acceptance
		2.04.07 Product Application Documentation
3 System Implementation		
	3.01 Contracting	
		3.01.01 Interlocking contract
		3.01.02 Bid
		3.01.03 Contract
		3.01.04 Construction contract
		3.01.05 Engineering contract
	3.02 Project specific planning	
		3.02.01 Scheme Plan
		3.02.02 Planning
		3.02.03 Planning Assessment
		3.02.04 System Requirement Specification
		3.02.05 System Architecture
		3.02.06 Prepare Basic Plans
		3.02.07 Prepare documentation for Test, Installation, Commissioning
4 Integration		
	4.01 System configuration	
		4.01.01 Product adaption (see Siemens Product)
		4.01.02 System Configuration
		4.01.03 Configure indoor equipment
		4.01.04 Configure outdoor equipment
		4.01.05 Configure data for system
	4.02 Installation & Construction	
		4.02.01 Transfer System to destination
		4.02.02 Installation
		4.02.03 Construction
5 Transfer to Operation		
	5.01 Testing & Approval	
		5.01.01 Data integration test
		5.01.02 Provide Infrastructure for Tests
		5.01.03 Prepare Process Simulation
		5.01.04 Factory Acceptance Tests
		5.01.05 Commissioning & Tests
		5.01.06 Validation
		5.01.07 Assessment and Approval
		5.01.08 Site acceptance
		5.01.09 Integration test/commissioning
	5.02 Documentation	
		5.02.01 Archiving of documents
		5.02.02 Deliverables
	5.03 Additional	
		5.03.01 Handover
		5.03.02 Provide warranty phase
		5.03.03 Provide spare parts
		5.03.04 Remove failures
6 Operation and Maintenance		
	6.01 Operation and Maintenance	
		6.01.01 Operation
		6.01.02 Maintenance/contract phase
		6.01.03 Renewals
		6.01.04 Upgrades
		6.01.05 Modifications
7 Decommissioning		

Table 1: Life Cylce Phases, Sub-Phases and Tasks with numbering scheme

Product Structure

The product structure for the evaluation of cost reduction potential generated by other WS's activities is shown in Figure 3:

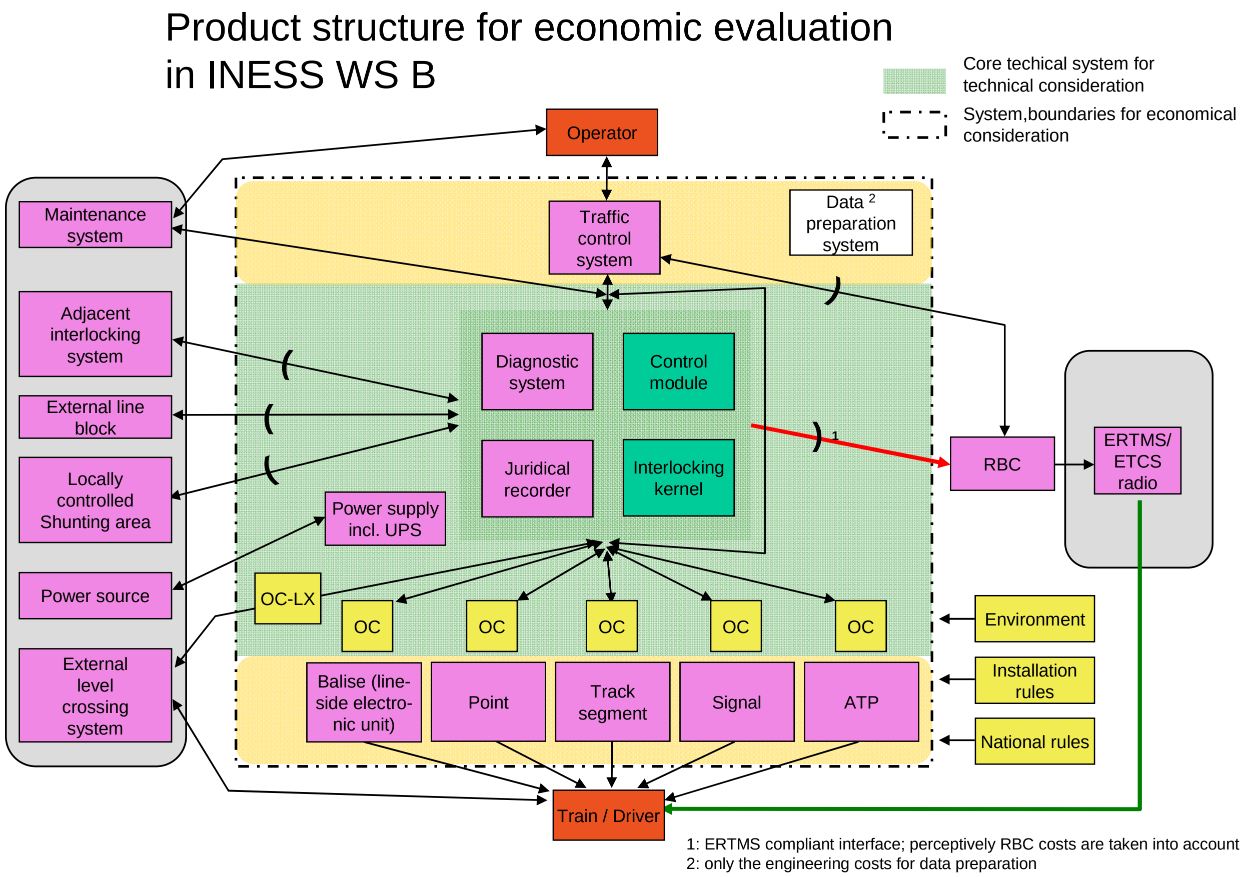

Figure 3: Generic product structure for economic evaluation in WS B

The actual core of the interlocking components may be defined as follows:

- Interlocking kernel: is the heart of the system. This computer ensures that all operations along the line are carried out in a safety manner.
- Control module: these are the modules utilized to interface the interlocking kernel with the wayside equipment, so that signals, point machines and track circuits will automatically operate in line with the commands.
- Diagnostic system: is a monitoring system which detects malfunction within the operation of the interlocking. It can be both, an embedded system or a separate sophisticated application. It is included in the scope, but there is also a separate maintenance system which is outside the scope of WS B.
- Juridical recorder: is a device that logs the operations of the interlocking in a way that the data are juridically exploitable in case of an accident.

The further components of the core are:

- Operation controllers (OC) which control the field elements (points, signals etc., also: level crossings)
- Power supply incl. UPS (uninterrupted power supply): The term power supply / UPS comprises everything to generate the supply specifically required for the applications of the railway system and to provide an uninterrupted power supply. This includes e.g. the transformation of the current to the required amperage, voltage and frequency or the availability of battery backup or emergency power supply. This has to be differentiated from the term power source which is referred to as the current source which delivers electricity. This can be e.g. a public supplier / network operator or the traction power of a railway company.
- Interface to the RBC: at present the RBC is not part of the interlocking, but this may change in future. Therefore the interface to the RBC will be inside the scope, whereas the RBC itself will not be part of it. In contrast to the protocol from the ETCS radio (green line), the protocol between interlocking kernel and RBC is not standardized (red line).
- Interfaces to adjacent interlocking systems, external line blocks and locally controlled shunting areas are also regarded to belong to the core of the interlocking.

As explained the scope of WS B will be extended for the purpose of economic evaluation. The extended scope for these investigations will also comprise:

- Traffic control system (TCS): The TCS is a device that supervises the trains' activities on a line with more than one station (and 1 interlocking). The apparatus send "commands" and receive "controls" to/from the field equipment such as signals, point machines and track circuits. This device is not a "safe" equipment, but exchanges the information with the field (or way side) equipment through the Interlocking (IXL) that is a "safe" device, therefore the overall command and control of the line is done in a "safe" environment.
- In some solution (Interlocking multi-station) the TCS is embedded in the Interlocking. Such a solution is utilized for lines with low traffic or regional lines.
- Data preparation system: here only the engineering costs for data preparation will be regarded, not the evaluation of the tool itself.
- Field units: these are the technical components of the line-side equipment like line-side electronic units (LEU), track segments, points, signals and automatic train protection (ATP).
- The other components in Figure 3 which are arranged outside the dotted line interact with the components inside the extended interlocking described above, but will not be inside the consideration of WS B.

Cost Categories

The Cost Categories (CC) used by different partners varies according to different accounting systems and legal obligations. In general there are CC that are more important for the suppliers while others are essential for the IM.

As there is no need to find CC which every partner can identify in his Enterprise Resource Planning (ERP) systems, the first step was to create a collection of all available CC used by at least one partner (see supplier example in Table 2).

I.	Development costs	
I.1	Material costs	Includes direct and indirect material costs, e. g. needed material needed for the system itself and material, machinery and tools needed for the process of
I.2	Personnel costs	Includes all personel costs needed for all involved development anctivities and the development process
I.3	Energy	Includes all energy costs needed for all involved development activities and the development process
I.4	Financing costs	Costs for financing (bank loan costs, etc.).
I.5	Certification costs	Includes all costs related to certification of the product, e.g. Certification fees, trial operation costs, etc.

II.	Manufacturing and installation costs	
II.1	Material costs	Includes direct and indirect material costs, e.g. material needed for the manufactured equipment itself and material, machinery and tools needed for the process of manufacturing and its management. Also includes all costs of material needed for installati
II.2	Design costs	Includes all costs related to design activities.
II.3	Personnel costs	Includes all personel costs needed for all involved manufacturing activities and their management. Also includes all personel costs for installation, training, testing and commissioning of the equipment.
II.4	Energy	Includes all energy costs needed for all involved manufacturing activities and the development process
II.5	Financing costs	Costs for financing (bank loan interests, charges, fees, insurance, material transport costs etc.).

Table 2: Cost categories used by supplier (excerpt)

It was found, that the whole list contains several duplicate items (i. e. Personnel costs, Energy, Financing costs) since the list was created with the LC phase in mind. All duplicates were removed from the list, resulting in a list of 27 cost categories (see Table 2).

1	Material costs	Includes direct and indirect material costs, e.g. material needed for the manufactured equipment itself and material, machinery and tools needed for the process of manufacturing and its management. Also includes all costs of material needed for installation.
2	Personnel costs	Includes all personnel costs needed for all involved development and manufacturing activities and their management. Also includes all personnel costs for installation, training, testing and commissioning of the equipment. Includes all personnel costs needed.
3	Energy costs	Includes all energy costs needed for all involved development and manufacturing activities and the development process management. Includes all energy costs needed for service of the equipment and maintenance activities.
4	Financing costs	Costs for financing (bank loan interests, charges, fees, insurance, material transport costs etc.).
5	Certification costs	Includes all costs related to certification of the product, e.g. Certification fees, trial operation costs, etc.
6	Design costs	Includes all costs related to design activities.
7	End of life and disassembling costs	Includes all costs related to end of life, disassembling and material disposal.
8	Life time product support costs	Includes all costs related to product support within entire product life time. This should cover activities such as HW and SW updates and modifications due to electronic elements development (when production of some elemements is terminated, some further
9	Future updates/upgrades/modification costs	**This is an optional cost category only**. It is supposed to somehow indicate how costly would be updating, upgrading or modification of the equipment if needed.
10	Bidding costs	Includes all costs related to bidding, such as costs of bonds, tender offer preparation costs, etc.).
11	Preparation recurring / project-related (single product)	Costs for basic evaluation, preliminary planning, blueprint planning and approval planning.
12	Investment	All construction costs as well as planning costs for implementation planning and documentation. Costs for deconstruction are part of "Decommissioning / Marketing / Deconstruction" (I.5).
13	Declining balance	Book value of (interlocking) components that are replaced within the new project.
14	Decommissioning / Marketing / Deconstruction (action)	Costs for deconstruction.
15	Disposal / Reclamation (material)	Disposal costs (DB approach: 0,7 % of signalling costs + 0,3 % of costs for telekommunications).
16	Insurances	All insurances necessary by law (i. e. fire insurance).
17	Charges / Fees	All charges and fees required by law.
18	Communication	Costs for communiction between interlocking and traffic control system as well as between different parts of the interlocking.
19	Preparation unique	Costs for all equipment for messuring and testing needed by maintenance personal and costs for training maintenance personal on specific technology.
20	Inspection / Diagnostics / Attendance	Costs for planned inspections according to maintenance plan.
21	Maintenance preventive	Costs of preventive maintenance, i. e. those costs necessary to keep the interlocking in operation.
22	Maintenance corrective	Costs for corrective maintenance, i. e. those costs necessary to recover full operating ability.
23	Disposal / Reclamation (material)	Costs for disposal of replaced components.
24	Model- and system support	Costs for personel working in the field of model- and system support.
25	Operating materials	Costs for spare parts.
26	Delays	Penalties for delays caused by product failure of the interlocking.
27	Restrictions	Costs for additional personel necessary to operate during periods of product failure.

Table 3: List of all proposed cost categories

A proposal has been discussed resulting in a further aggregation towards six cost categories.

- Material
- Equipment
- Labour
- Energy
- Capital
- Service Disruption

Partners agreed that this segmentation can be used for the data collection, while the 27 CC can be used as additional input to the "Data Collection Guideline" (Handbook).

Due to different ways of managing a project and operating a signalling system for some partners a need for even more aggregation might be necessary. If a partner for example sub-contracts his maintenance he might not be able to separate the costs for Material and Labour. Furthermore he might also not be able to analyse how maintenance costs are split up according to the product structure.

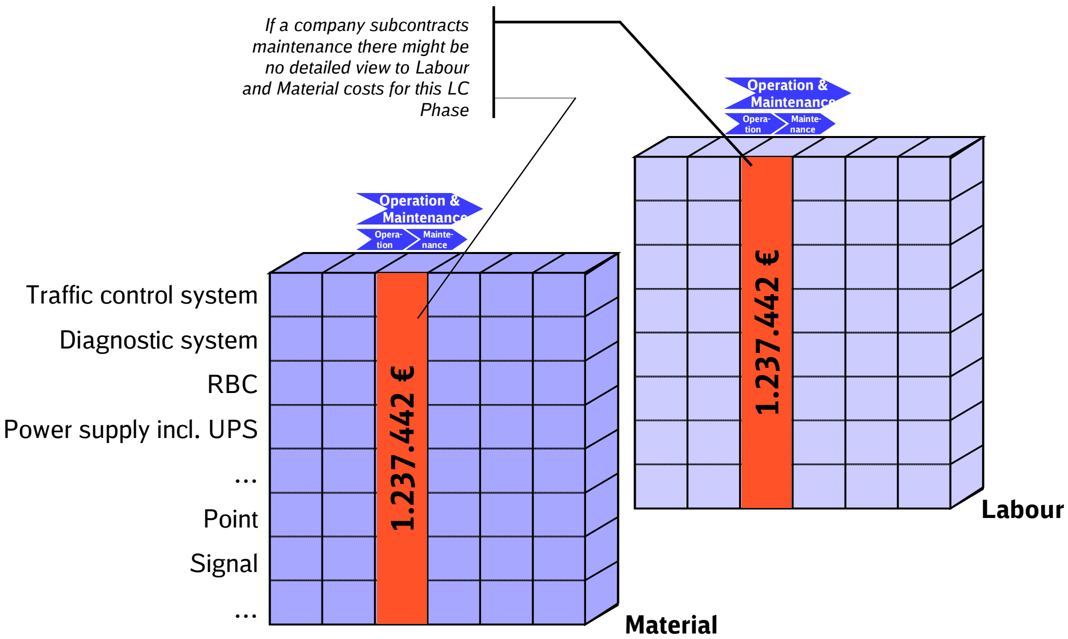

Figure 4: Cost calculation example for sub-contracted maintenance

The example in Figure 4 illustrates the situation of an IM that has sub-contracted maintenance (at a price of 1.237.442 Euro) and thus cannot provide more detailed information.

A cost breakdown according the Product Structure does not make sense for every cost item. For example there is no need to split up operational costs (i. e. costs for the signaller) to the product components.

Figure 5 illustrates how data for Operation (one value for the whole system) and Maintenance (detailed view on the efforts for each product component) can be addressed using the model.

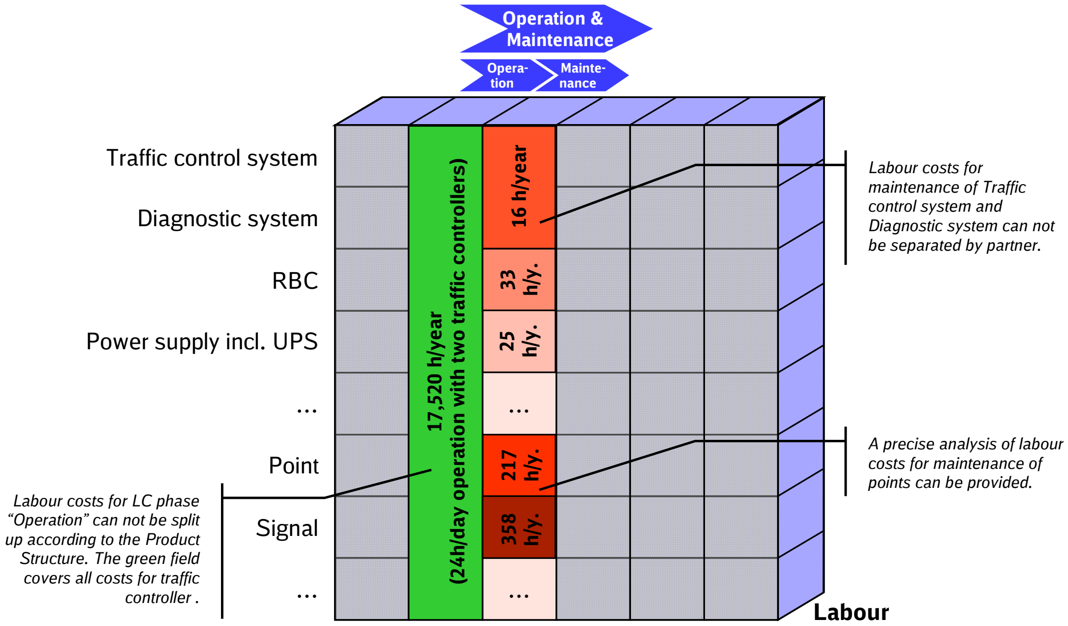

Figure 5: Cost calculation example for Operation & Maintenance (Labour costs)

Market Segments

Railway infrastructure managers use different criteria to distinguish lines within their network. To come to common segmentation criteria for the interlocking market, relevant criteria had to be found to describe requirements of the lines that have to be handled by different types of signalling systems. These requirements can be divided into operational and technical requirements:

Operational requirements

- Speed:
  Maximum speed which the line is designed for. The Parameter is used to identify HS TEN, but not so much for distinction between high and middle demand conventional interlockings.

- No of train movements per day per track:
  Expresses the ability of the interlocking system in terms of average workload of the lines to be operated (permanent load).

- No of train movements within hour of maximum traffic per track:
  Expresses the ability of the interlocking system in terms of peak value of the workload of the lines to be operated (peak load).

- Mixed passenger and freight traffic:
  Interlocking operates lines and junctions with homogeneous traffic or mixed traffic.

Technical requirements

- ETCS (perspectively to be installed):
  Level of ETCS which is installed or is intended to be installed at the infrastructure.

- Level of safety:
  Level of safety according to CENELEC. For the TEN lines Safety Integrity Level (SIL) 4 is required. As WS B will also take the domestic lines of the railway companies into account, SIL 4 is not necessarily mandated. According to CENELEC it depends on the risk analysis and the tolerable hazard rate (THR). The question which level of safety is required is a cost-effective issue and it might turn out during the project that it is worth looking at this. The question is also if the technology is SIL 3, but by the way it is operated, the result is SIL 4. This has to be described together with specific projects.

- SEU per km:
  Parameter to express the complexity of the lines and junctions to be operated by the interlocking by a kind of “density of signalling elements “.
  Distinction between stations and free track is necessary. Depending on the specific project, it might be adequate to describe the complexity by absolute No of SEU, without division by km. This is part of the description of the projects. The definition of the SEU will be taken from the UIC ERTMS Benchmark Group (not yet finalized).

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

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

The market segmentation according to the requirements described above is shown in Figure 6. With regards to the aim of INESS it is proposed to focus on segments I to III of the four segments since these are the segment where harmonization is required as ETCS will have to be applied thereon.

Since this would mean to ignore the domestic railways which form the large part of the railways, it might be taken into consideration to also include this segment into the further analysis because of the important economic relevance.

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

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

[1)] Homogeneity of traffic operated on one line

Figure 6: Market segments for signalling systems

Section 4 CONCLUSIONS

A Life Cycle Model for the INESS project could be developed within the foreseen time and budget of the project.

Experts from railways and suppliers, supported by research institutes, managed to develop a model for the economic evaluations of the INESS project in the next step.

Different national aspects have been discussed and implemented into the model as good as possible. Certain aspects of individual markets are also captured as side information and will help to deepen the understanding of cost drivers in the next step of the project.

For the upcoming discussion on the effects coming out of the “technical” Workstreams, it might be possible to make some amendments to the model. The model was created to allow this flexibility, which might lead to an iterative process, thus finding the right balance between applicableness and complexity.

Section 5 BIBLIOGRAPHY

Dependability management – Part 3-3: Application guide – Life cycle costing (IEC 60300-3-3:2004); EN 60300-3-3:2004