UIC B 169/RP 44 (April 2015)

LCC GUIDELINE

Axles, wheels and axle boxes reliability / safety - Implementation of EN 50126

Rail System Forum Rolling Stock SET 6, "Running gear".

INTERNATIONAL UNION
OF RAILWAYS

ISBN 978-2-7461-2432-5
ISBN 978-2-7461-2430-1 (French Version)
ISBN 978-2-7461-2431-8 (German Version)

Warning

DOCUMENT DATA SHEET

Designation	This version
UIC B 169/RP 44	**April 2015**

Title of document

Axles, wheels and axle boxes reliability / safety - Implementation of EN 50126

Languages					
Original			Translation		
Fr	De	En	Fr	De	En
☐	☒	☐	☒	☐	☒

Author(s)

UIC "Axles Wheels EN 50126" group of experts

Pages	Figures	Tables
32	**1**	**6**

(Excluding annexes)

Project

LCC Guideline

Contractor	Customer
International Union of Railways (UIC) **Rail System Department** **16 rue Jean Rey** **F – 75015 PARIS**	**International Union of Railways (UIC)** **Rail System Department** **16 rue Jean Rey** **F – 75015 PARIS**
Contractor Project No.	Customer Project No.
P000319	**P000319**

Abstract

The aim of the project is to make it possible to calculate characteristic RAMS values on the basis of EN 50126 to determine the reliability and safety of railway rolling stock running gear. The project is to draw upon the results of work by the "Joint Sector Group for the ERA Task Force on wagon/axle maintenance" (JSG), findings from the EURAXLES projects and the results of the UIC SOR project. These characteristic values are necessary to safely analyse changes in the running gear and their effects.

……..……..

……..……..

……..……..

As a result of the project, it will be possible to calculate characteristic LCC values. Upon completion, the project will have provided a procedure for determining these characteristic LCC values.

Keywords

LCC, Life Cycle Costing, LCC-Calculator_UIC, LCC-presentation-charts

Contents

List of appendices

List of illustrations

List of tables

Amendments

Amendment number	Amendment made by (in CAPITALS)	Date made (YYYY-MM-DD)

Abbreviations

EFA	External Functional Analysis
IFA	Internal Functional Analysis
LCC	Life Cycle Cost
PBS	Product Breakdown Structure
RAMS	Reliability, Availability, Maintainability, Safety
UIC	International Union of Railways

1. Purpose

The impetus for performing an LCC calculation on a production resource is the need either to take a decision or to establish the economic bases for said decision.

The starting point for an LCC calculation may be the result of a RAMS analysis.

The “LCC-presentation-charts_UIC.ppt” standard slideshow is recommended for use in presenting and documenting the results of individual process steps and the overall result.

The LCC presentation slideshow has two essential tasks:

- Systematically guide the person in charge of the task to the result and the formulation of an objective recommendation.
- Support the user by supplying a complete audit trail of
  - the underlying data basis,
  - the data preparation, and
  - the presentation of results.

The internal functional analysis (IFA) conducted for the RAMS analysis (EFA_AFE___IFA_AFI.xls) is used to structure the production resource. This is also known as the Product Breakdown Structure.

As well as the LCC Calculator (LCC-Calculator_UIC.xls), other basic tools are available to conduct a LCC calculation from the initial idea onwards.

The application of the LCC methodology is not restricted to rail vehicles or their components. The method is universal and may also be used for other applications in other lines of business.

The LCC methodology is described by means of the example of purchasing a container wagon.

The description in this LCC Guideline follows the sequence of the slides in the “LCC-presentation-charts_UIC.ppt” slideshow.

2. Defining the task

At the end of the “defining the task” phase all those involved in the application case will have a firm grasp of the size of the task and will have clearly documented the task with regard to its substance, purpose and delimitation.

2.1. Title slide

The project title, date of last modification, person in charge and file name must be contained in the title slide.

Furthermore it is recommended to insert a meaningful picture or graphic.

2.2. Characteristics

Why:

The application case is to be described in terms of:

- the original intention or starting point,
- the LCC task derived from the above, specifying the required number of calculation variants,
- the contextual financial conditions surrounding the project,
- the timescale and milestones, and
- the makeup of the team defined for the project. When assembling the team, it is suggested that an interdisciplinary approach be taken, mixing technical and operational experts and financial controllers.

How:

Status logic:

After completing the slides (LCC-presentation-charts_UIC.ppt), the user defines the status of the LCC calculation by marking with a cross in the “Characteristics” slide:

I = Identified: the measure is adequately described as regards its content; the estimated potential savings are described.

A = Agreed: the measure is agreed with the customer. Implementation of the measure is agreed and the potential savings are recognised. There is a detailed implementation plan.

D = Decided: in principle, achieving “A” also achieves “D”, assuming no further decision makers have to be consulted (e.g. executive board, supervisory authority).

P = Preconditions in place: the preconditions for the implementation of the measure are met (e.g. the contracts signed are available). Any other organisational measures needed have been taken (instructions for use, guidelines, communication, etc.).

Initial situation:

This section describes the overall task giving rise to the LCC task.

LCC task:

All LCC management activities must be seen against the backdrop of defined contextual conditions and a specific question. This section therefore details the specific LCC task, which is generally a sub-task deriving from the initial situation (e.g. choice of the cheapest railway control center according to LCC criteria).

Originator of the LCC calculation, dates:

The team leader takes responsibility for handling the LCC task. Team members are appointed and the deadline by which the final result is to be presented is entered here.

Tools:

- None

Output documents:

- Completed “Characteristics” slide, including customer’s agreement

2.3. IN / OUT Framework

Why:

The IN / OUT framework is completed:

- In order to identify and document those aspects considered in the LCC calculation (inside) and those not considered in the LCC calculation (outside) (by analogy to a picture-frame). The external functional analysis (EFA) conducted for the RAMS analysis offers a good basis.
- In order to avoid endless debate during the further course of the process, and to clarify what has to be considered and what does not. Moreover, this creates transparency as to the contextual conditions in which the final result was arrived at and is to be interpreted.
- In order to define the components of the object under consideration. These may represent a part or all of the technical structure (c.f. internal functional analysis (IFA)).

How:

- Contained in the calculation (inside the red box): this lists those components / contextual conditions covered by the measure.
- Not contained in the calculation (outside the red box): this lists all components / contextual conditions not covered by the measure.

- Still to be resolved: topics which are still to be resolved (e.g. with the customer) during the processing of the LCC calculation are placed in the red box. At the end of the process (i.e. the LCC calculation), there should be no more topics in the box.
- Determined on (date): documents the date on which the details contained in the IN/OUT framework were determined and indicates the persons involved.

Examples of questions to help with completion of the IN / OUT framework:

- Which components are considered and which are not? The components considered by the LCC calculation can be seen in the subsequent slide, “Product Breakdown Structure/System Environment”.
- What is the overall size of the production resource considered (e.g. route length, vehicle fleet)?
- Is allowance made for a migration period in the LCC calculation? Migration here means the staggered execution of the same measures, e.g. the procurement of 100 vehicles of the same type over a three-year period.

Tools:

- None

Output documents:

- Completed IN / OUT framework

3. Laying the groundwork

Before collecting and processing the data, the necessary contextual conditions must be defined.

3.1. Product Breakdown Structure / System Environment

Why:

- In order to create clarity about the individual components of the production resource or the system limits of the analysis.
- Product Breakdown Structure: the technical or functional structure of the production resource is shown in order to visualise and sort the individual elements (components / modules) comprising it. This is particularly helpful in delimiting one component from another in cases where only some of the production resource's components/modules are considered, e.g. the power train.
- System environment: in order to clarify causal effects, the interaction of the production resource concerned with its environment can be shown using a degree-of-influence/impact diagram.
- Visualising things in this way facilitates a discussion of which components / modules are to be considered in the LCC calculation and which components / modules are unaffected.

The user is also free to apply other methods.

How:

- Technical / functional structure: the production resources concerned are divided into their constituent components in top-down fashion. See the internal functional analysis (IFA) list for RAMS analyses.

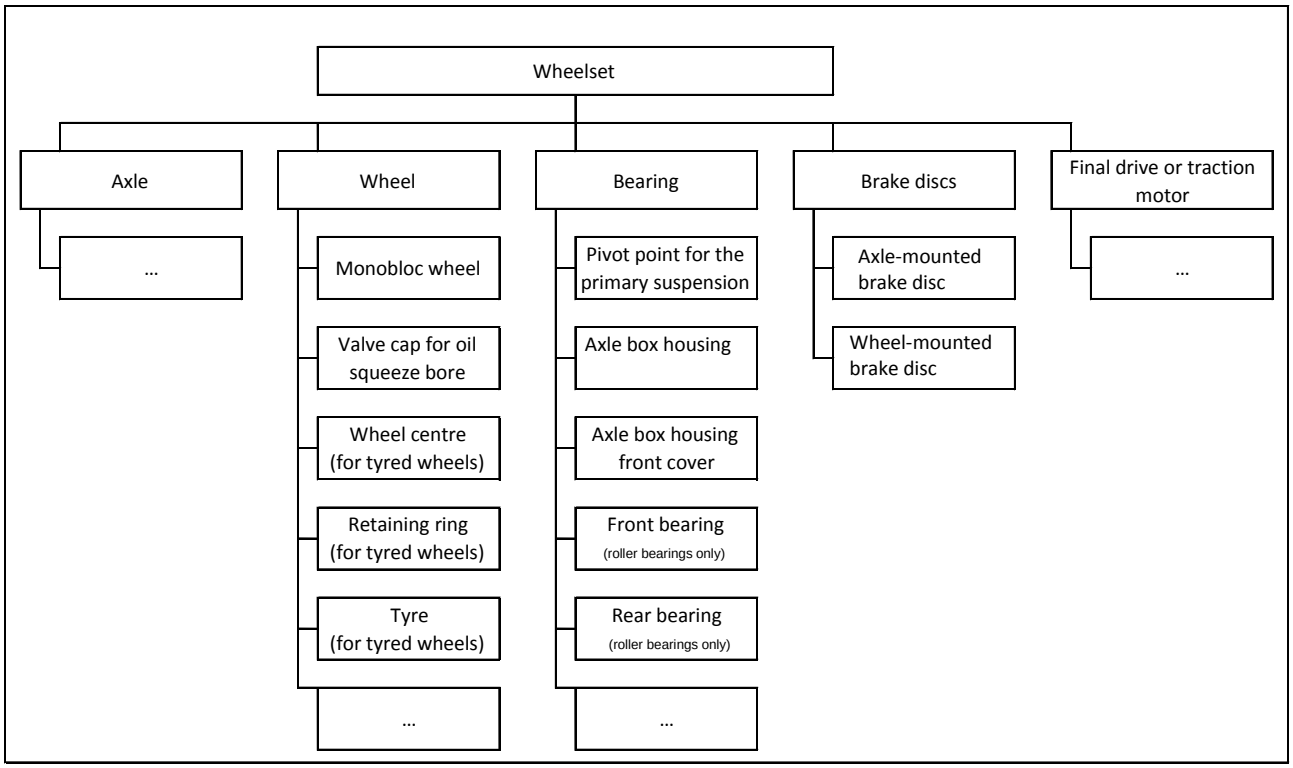


Figure 1: Example of the technical structure of a wheelset

Tools:

- Internal Functional Analysis (IFA), see file EFA_AFE___IFA_AFI.xls.
- Standards (EN, ISO, etc.), specifications, list of items.

Output documents:

- Technical or functional structure of the production resource or degree-of-influence/impact diagram in the “Product Breakdown Structure / System Environment” slide.

3.2. LCC cost blocks used for the calculation

Why:

The choice of cost blocks has the following aims:

- Specify the cost structure of the LCC calculation model.
- Document and justify the cost blocks chosen for the cost structure.

How:

- In selecting the cost blocks the team is to ask itself the following question: “Which cost blocks are impacted by the object under consideration throughout its lifespan?” In principle, all costs arising in the work processes in which the object is involved and which can be ascertained with acceptable effort are to be taken into account.

- The cost blocks involved will be marked with a coloured (red) outline in the “LCC cost blocks used for the calculation” slide of the LCC presentation.

Tools:

- None

Output documents:

- Completed “LCC cost blocks used for the calculation” slide

3.3. Purpose & brief description of each option

Why:

In order to present the various aims and backgrounds for the variants chosen, including the basic option,, also called ‘alternative A’.

How:

- Formulate aim (no more than 256 characters).
- Provide a brief description (no more than 256 characters).

Tools:

- None

Output documents:

- Completed “Purpose & brief description of each option” slide

Note: if the slides provided do not offer enough space to present all the variants, additional slides may be created by copying the original slide.

3.4. Variants: list of principal differences

Why:

In order to specify the variants under consideration by identifying 1) those essential parameters whereby the variants differ and 2) those essential parameters which are the same for all variants and which are relevant for the LCC calculation.

How:

- Variants are defined based on the task and the combination of possible parameter values (also see cost block structure and IN/OUT framework).
- The period under consideration is defined and documented uniformly for all variants. In case the period under consideration is not the same as the period of use, residual values must be considered in the costing table.

- One possibility is to conduct a sensitivity analysis by using the extreme values of a parameter to determine different variants.
- More variants may also be defined if there are multiple migration scenarios. The transition of a group of production resources (e.g. vehicles of a certain type) from the current situation to the new normally takes a period of several years.
- The variants and the relevant cost blocks are copied into the “Composition of Cost and Cycle Data” slide of the presentation.
- Any other useful parameters not otherwise considered, or able to be considered, in any of the variants are to be dealt with using the IN / OUT framework and / or the "Overview of results and comments" slide.
- Currently valid calculated interest rates and inflation rate.

Tools:

- None

Output documents:

- Completed “Variants: list of principal differences” slide.

Note: if the slides provided do not offer enough space to present all the variants, additional slides are to be created by copying the original slide.

4. Data acquisition

Calculating the LCC requires the underlying data basis to be sufficient. For this the data must be

- drawn from available data systems,
- reacquired if current data is necessary,
- estimated if necessary,

and analysed.

The following questions are helpful in assessing the required scope of data:

- Is this data accessible for me as a user?
- Do I have the correct data for my question?
- Do I have sufficient data for my question?
- Is the estimated data comprehensible and plausible?
- Is the effort required to obtain the data in reasonable proportion to the estimated benefit of the measure?

4.1. Composition of Cost and Cycle Data

Why:

- Process data stock in order to complete the LCC task.
- Guarantee data quality and data content (informative value).
- Obtain an idea of the other data necessary to increase the accuracy of the final outcome.

How:

- Check data for completeness and plausibility.
- Document share of incorrect, incomplete and implausible data.
- Process data for transfer to the costing table. Any secondary calculations required are to be documented, detailing the data source, time reference and any other relevant contextual conditions.
- Assign data to cost blocks.
- Decide on the “correct” units [km, h, tkm, performance ton etc.] to be used for each cost block as a basis for determining the moment at which this cost data is to be entered in the costing table.
- Determine investment and follow-up cost cycles (maintenance, operating costs, product failure costs). The cycles can, for instance, be derived from reliability data and maintenance instructions.

- For presentation purposes, the data are to be transferred to the “Composition of Cost and Cycle Data” slide, indicating the “Euros per unit”, “Cycle [unit]”, “Source” and "Robustness" for each cost block and variant. The robustness expresses the accuracy of the LCC result.

  Estimate: Personal estimate (“rough guess”)

  Expert: Estimate based on an expert interview

  Analysis: Data analysis of the same or comparable objects or simulation results

Tools:

- Databases, data acquisition and analysis tools

Output documents:

- Files prepared by the user with the data collected and processed.
- Completed “Composition of Cost and Cycle Data” slide.

If the slides provided do not offer enough space to present all the variants, additional slides may be created by copying the original slide.

5. Determining the LCC values

This step in the process serves to determine the LCC result for each variant. The general term “LCC value” stands for the net present value, the break-even time and key financial indicators, e.g. the annuity (average annual costs) or annuity/performance unit (e.g. "annuity/km"), generated from the net present value.

The net present value is the primary decision-making criterion (for or against variant X); the break-even time is the secondary decision-making criterion (for or against variant X). To calculate these two criteria, all the costs listed in the costing table are discounted in relation to the reference point in time (decision-making point).

To calculate the LCC values, it is recommended to use the LCC-Calculator_UIC tool. Any other calculation tool may also be applied if it is also able to calculate the net present value.

5.1. Table of values and net present value of variant A

Why:

In order to calculate decision-making criteria “net present value” and “break-even time”.

How:

- Complete the two costing tables in the “LCC_CalculationSheet”.
- The “AuxiliaryCalculation” sheet serves to perform any simple secondary calculations required.

Tools:

- LCC-Calculator_UIC

Output documents:

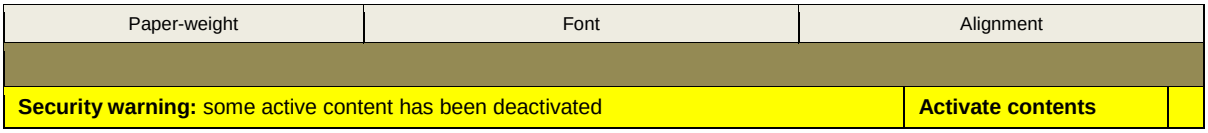
- Completed “Table of values and net present value of variant A” slide.

The same method is used for the alternative option or variant B (= second costing table in the “LCC_CalculationSheet”).

6. Application of the LCC-Calculator_UIC

6.1. Notes for the application of the LCC-Calculator_UIC

- The LCC-Calculator_UIC is an MS Excel file with several sheets.
- The user has a choice of three languages: German, English, or French.
- Only two variants can ever be compared using a single calculation: the Basic option (variant A) and the Alternative option (variant B).
- Some functions are realised by means of the programming language VBA (Visual BASIC for Applications):



Therefore, click the “Activate contents” button.

The user works exclusively in the “LCC_CalculationSheet”.

Users can carry out any secondary calculations necessary in the “AuxiliaryCalculation” sheet.

Functions are assigned to cells using a colour marking:

- Grey cells: Heading of the two costing tables for each variant
- Dark blue cells: Headings
- Light blue cells: Input cells. In these cells, the user can enter, delete or modify values.
- White/light yellow cells: Result cells. The user cannot change the cell contents manually.

6.2. General data input in the “LCC_CalculationSheet”

The general data is inputted in the first three lines.

The language can be selected in the options display in cell AA3.

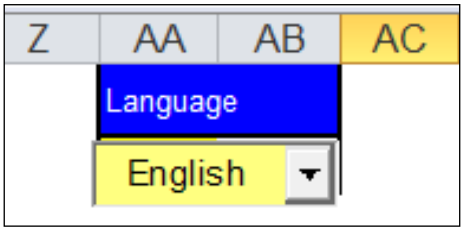


Table 1 - Screenshot, language selection

Note: the language is selected in the options display highlighted in yellow.

Changing the language does not influence the calculation.

Names of the two variants and number of units per variant:

	A	B	C	D	E	F	G
1	Comparison: Container wagon, Company A with Container wagon, Company						
2	Basic option		Container wagon, Company A				
3	Alternative option		Container wagon, Company B				

Table 2 - Screenshot, names of the two variants

Defining the values valid for the two variants:

G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W			
		activatable			Product type		Wagon				Imputed interest rate				10,00%				
	Amortisation period [years]			25	Cycle unit				km		Rate of inflation				3,00%				
	Reference year (= year 0)			2010	Planned days of operation p. a.				290										

Table 3 - Screenshot, general values

- The options displayed are “activatable/not activatable”: If the object is activatable, an amortisation period is suggested. Only activatable assets must be amortised.
- Note: the choice of “activatable/not activatable” is made in the options display highlighted in yellow.
- Amortisation period [years]: (withdrawal for wear and tear): linear deduction, i.e. amortisation value/year = purchase costs/amortisation period.

The amortisation period is not needed for the LCC calculation: all payments are included and discounted in full at the time of the financial transfer. This value only impacts on the results planning.

- Reference year: the reference year corresponding to the year of the first version, generally the year of purchase, is indicated here.
- Product type: once a product type is selected, a default value is recommended for the amortisation period and the characteristic cycle unit, e.g. “km” for a vehicle.
- Cycle unit: recommended cycle unit for the product type
- Planned days of operation p.a: this parameter has an impact on the “annuity/day”
- Imputed interest rate: this value represents the desired return on the invested capital and is a calculation parameter for the net present value.
- Rate of inflation: calculation parameter for the net present value.

6.3. Input for the Basic option in the “LCC_CalculationSheet”

Lines 5 to 28 represent the Basic option.

- Cell C6: determines the period under consideration (= time span for the calculation), generally the utilisation time of the item under consideration.

Completing the costing table:

- Cells A 12 to A 23: choice of the main cost blocks.
- Cells B 12 to B 23: free-text description of the cost blocks.
- Cells C 12 to C 23: result (net present value) per cost line (=result of this cost block)
- Cells D 12 to D 23: input of the cost values in the current year (= year 0); the investment is generally made in year 0.
- Cells G8 12 to BN 23: input of the costs as of year 1.

Note: the cost values may be written in the costing table manually (time-consuming) or automatically (simple and more precise).

Completing the costing table automatically:

- Cell K6: input of the planned annual performance, e.g. planned mileage p. a. [km], planned operating hours p. a., [h], planned service load p. a. [million performance tonnes].
- Cells E 12 to E 23: input of the unit costs for the cost block
- Cells F 12 to F 23: input of the cycle to calculate the unit costs in the costing table based on the planned annual performance.
- Pressing the “Costs in table” button assigns the unit costs to the costing table in line with the ratio between the cycle details provided and the planned annual performance.

Further possible specifications:

- Failure days/failure: the planned annual performance is reduced by an amount corresponding to the number of failures multiplied by the number of days per failure. The achievable annual use corresponds to the actual performance. The costs per performance unit increase correspondingly (e.g. annuity/million performance tonnes). The planned operation and actual operation are expressed in terms of the performance unit (e.g. actual distance run p.a., actual performance tonnes p. a.).
- Failures/year: the number of planned days of operation is reduced by the number of failures (see failure days/failure).

6.4. Input for the Alternative option in “LCC_CalculationSheet”

Lines 32 to 55 represent the Alternative option (=variant B).

The period under consideration and the cost blocks have already been defined for the Basic option (= variant A). The costing table is completed as for the Basic option.

6.5. Result in “LCC_CalculationSheet”

57	Break-even point of alternative option	13 years
58	Max. target costs of alternative option	71.935 EUR

60 Result

		1 Unit			
62		Net present value (NPV) [EUR]	Annuity	Annuity / km	Annuity / day
65	Basic option	-96.079 EUR	-10.585 EUR	-0,092 EUR	-36,499 EUR
66	Alternative option	-93.644 EUR	-10.317 EUR	-0,090 EUR	-35,574 EUR
67	Delta (Alternative - Basic)	2.435 EUR	268 EUR	0,00 EUR	0,93 EUR
68	% (Delta / Alternative)	2,53%	2,53%	2,53%	2,53%

70 LCC-Calculator_UIC.xls
71 Version-Nr.: 150409

LCC_CalculationSheet | AuxiliaryCalculation | NPV_chart | BreakEven_chart | PL_statement | ReportFormat

Table 4 - Screenshot, result in “LCC_CalculationSheet”

- Break-even point of alternative option: this is the time as of which the alternative optionis advantageous compared to the basic option (see “BreakEven_chart” sheet). The break-even point corresponds to the zero crossing of the graph (the delta between the alternative option relative to the basic option is shown relative to the zero line).
- ! Due to occasional occurrences of high costs (e.g. vehicle overhaul), there may be several zero crossings (in which case the curve follows a zigzag course). The break-even point is always represented by the last of the zero crossings.
- Max. target costs of alternative option: here the difference between the net present values of the two variants is set at 0 by adjusting the purchase cost of the alternative option. This theoretical purchase cost represents the maximum possible upper limit up to which the alternative option remains advantageous.
- Net present value: sum of all discounted costs over the reference year.
- Annuity: average annual costs, taking account of the interest rate and inflation.
- Annuity / performance unit: average costs per performance_unit
- Annuity / day: average costs per performance_unit

6.6. Result in “BreakEven-chart” sheet

Pressing the “P/L, Break-Even, ReportFormat” button updates the “BreakEven_chart” and “PL_statement” graphs and copies the tabular values across into the “ReportFormat” sheet for further processing.

The “BreakEven_chart” sheet determines the time at which the net present value of the payments reaches the value "0". As of this time, the variant with the positive value is advantageous.

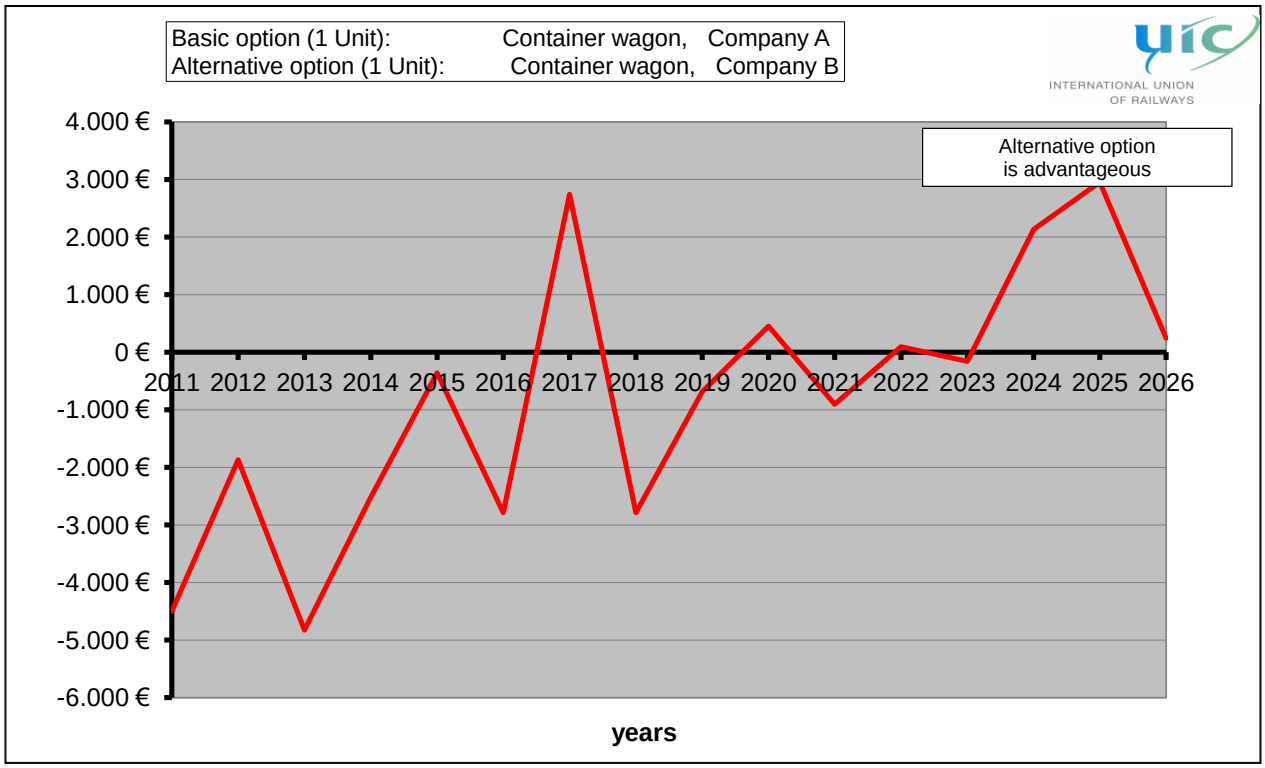


Table 5 - Screenshot, result in “BreakEven_chart”

6.7. Result in “PL_statement” sheet

- The profit and loss graph (“PL_statement” sheet) shows the potential cost reduction (positive values) and the additional cost burden (negative values) for each main cost block for the alternative option relative to the basic option.
- The cost values shown are nominal values, i.e. costs inclusive of increases due to inflation but not interest payments.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Saldo P/L:	0 €	0 €	3.183 €	-3.934 €	3.377 €	3.478 €	-4.299 €	10.774 €	-11.857 €	4.958 €	2.957 €	-3.876 €	3.137 €

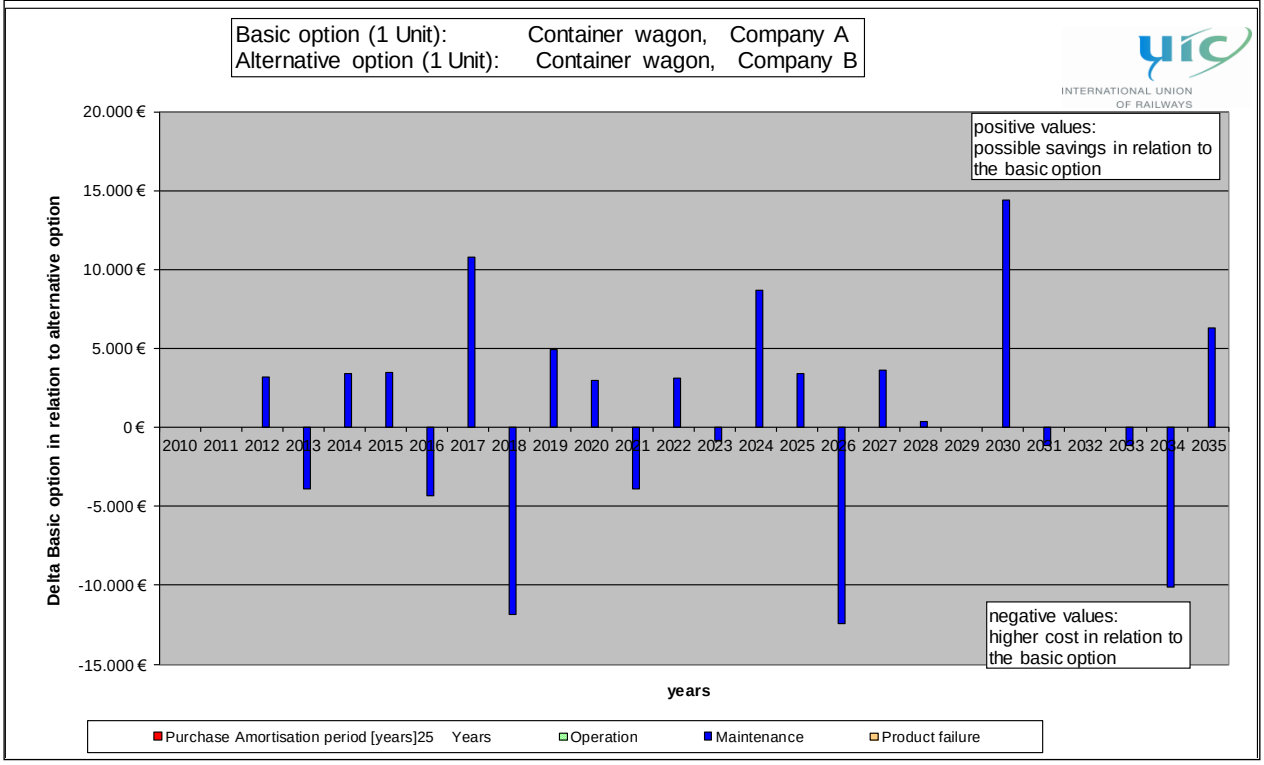


Table 6 - Screenshot, result in "PL_statement" sheet

7. Result

7.1. Overview of results and comments

Why:

- The results of the individual variants must be processed and interpreted in order to serve as a basis for decision-making. The contextual conditions (e.g. operational use parameters) with a substantial impact on the result are to be appraised as to their effect.
- The determination of the net present value is the primary decision-making criterion. The second important criterion is the break-even time. The break-even time represents the time as of which the accumulated sum of all discounted payments for the alternative option is smaller than the accumulated sum of all discounted payments for the basic option.

How:

- Assign the result parameters "net present value", "break-even time" and "annuity" to the "Overview of results and comments" slide.
- Interpret the result; make reference to any sensitivities (e.g. if the result changes suddenly when the price of steel products rises by 5 % annually instead of 3 %); assess any changes in the result once allowance is made for factors which are presently unable to be quantified with sufficient accuracy and which were not considered in the LCC calculation. This can include national or European legislation expected in the medium term.

Tools:

- LCC-Calculator_UIC

Output documents:

- Completed “Overview of results and comments” slide.

7.2. Key Performance Indicators

Why:

- The benefit of the measure must be proved using the customer’s existing KPI system.

How:

- User chooses suitable key financial indicators and explains the respective effect of each.

Tools:

- None

Output documents:

- Completed “Key Performance Indicators” slide.

7.3. Profit-and-loss chart

Why:

For medium-term planning, the difference between the payment streams for the two variants is important in answering the question “How will the medium-term planning of the affected cost centres need to be adjusted if the alternative option is adopted?” The difference between the payment streams is shown based on the four main cost blocks in the profit-and-loss chart.

How:

- Copy the chart from the LCC-Calculator_UIC, “PL_statement” sheet

Tools:

- LCC-Calculator_UIC

Output documents:

- Completed “Profit and Loss chart” slide.

7.4. Break-even chart

Why:

- The break-even time shows the time as of which the alternative option (variant B) becomes cost-effective. Until this time, the costs of the alternative option outweigh the costs of the basic option.
- The progression of the break-even curve over time gives an important clue as to the certainty of the result. If the break-even time curve remains close to the zero line, this indicates that the measure will be barely advantageous. In representing the break-even curve, the costs for one variant are set at 0 and the costs of the variant being compared mirrored against this.

How:

- Copy the chart from the LCC-Calculator_UIC, “BreakEven_chart” sheet

Tools:

- None

Output documents:

- Completed “Break-even chart” slide.

7.5. Recommendation

Why:

- Reach a final verdict as a basis for decision-making.
- Summarise the key results for the LCC calculation.
- List the further steps needed to implement the recommendation.

How:

- Complete the "Recommendation" slide.
- Chosen variant/recommendation: formulation of the recommendation.
- Reason: list the qualitative and quantitative reasons, also taking into account company-wide cost effects.
- Prerequisite for implementation: list all the contextual conditions necessary to the implementation of the recommendation.
- Further procedure: list the steps necessary, with deadlines and responsibilities. Examples: specifications, technical notifications, type of tender, terms of contract, data collection, etc.

Tools:

- None

Output documents:

- Completed “Recommendation” slide.

7.6. Approval status

Why:

The implementation of a measure must be validated by the customer and other individuals with the requisite approval authority.

Output documents:

- Completed “Approval status” slide.
- Completed "LCC-presentation-charts_UIC" slideshow.