

**Zusätzliche Informationen zur IEC 60300-3-3:
Zuverlässigkeitsmanagement**
Teil 3-3: Anwendungsleitfaden — Betrachtung der Lebenszykluskosten
(IEC 56/655/CD : 1999)

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Supporting information to IEC 60300-3-3: Dependability management –
Part 3-3: Application guide – Life cycle costing (IEC 56/655/CD : 1999)

Das internationale Schriftstück IEC 56/655/CD:1999-02, „Supporting information to IEC 60300-3-3: Dependability management – Part 3-3: Application guide – Life cycle costing“, ist unverändert in diesen deutschen Norm-Entwurf übernommen worden.

Anwendungswarnvermerk

Dieser Norm-Entwurf wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfes besonders zu vereinbaren.

Stellungnahmen werden erbeten an die Deutsche Elektrotechnische Kommission im DIN und VDE (DKE), Stresemannallee 15, 60596 Frankfurt am Main.

Fortsetzung Seite 2
und 61 Seiten IEC-Original

Deutsche Elektrotechnische Kommission im DIN und VDE (DKE)

Nationales Vorwort

Dieser Norm-Entwurf enthält die englische Originalfassung des Internationalen Norm-Entwurfs [Committee Draft (CD)] IEC 56/655/CD:1999-02 "Supporting information to IEC 60300-3-3: Dependability management - Part 3-3: Application guide - Life cycle costing".

Das Präsidium des DIN hat mit Präsidialbeschuß 1/78 festgelegt, daß deutsche Norm-Entwürfe, deren Inhalt sich auf internationale Arbeitsergebnisse der IEC gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für diesen Norm-Entwurf erfüllt. Er steht nicht unmittelbar in Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen. Es kann davon ausgegangen werden, daß die Anwender über hinreichende englische Sprachkenntnisse verfügen.

Der Internationale Norm-Entwurf wurde vom TC 56 "Dependability" der Internationalen Elektrotechnischen Kommission (IEC) erarbeitet.

Es wird darauf aufmerksam gemacht, daß die Kommentierungsfrist zum internationalen Sekretariats-Entwurf (Committee Draft [CD]) IEC 56/655/CD bereits aufgelaufen ist. Stellungnahmen, die aufgrund des vorliegenden deutschen Norm-Entwurfs bei der DKE abgegeben werden, werden für den nachfolgenden internationalen Entwurf berücksichtigt werden.

Für den vorliegenden Norm-Entwurf ist das nationale Arbeitsgremium K 132 „Zuverlässigkeit“ der Deutschen Elektrotechnischen Kommission im DIN und VDE (DKE) zuständig.

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf eine Norm oder andere Unterlage ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils neueste gültige Ausgabe der in Bezug genommenen Norm oder anderen Unterlage.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe der Norm oder anderen Unterlage.

Der Zusammenhang der zitierten Normen und anderen Unterlagen mit den entsprechenden Deutschen Normen und anderen Unterlagen ist nachstehend wiedergegeben. Zum Zeitpunkt der Veröffentlichung dieser Norm waren die angegebenen Ausgaben gültig.

IEC hat 1997 die Benummerung der IEC-Publikationen geändert. Zu den bisher verwendeten Normnummern wird jeweils 60 000 addiert. So ist zum Beispiel aus IEC 68 nun IEC 60068 geworden.

Europäische Norm	Internationale Norm	Deutsche Norm	Klassifikation im VDE-Vorschriftenwerk
-	IEC 60300-3-9:1995	E DIN IEC 56(Sec)410:1995-03	-
EN ISO 14040:1997	ISO 14040:1997	DIN EN ISO 14040:1997-08	-

Nationaler Anhang NA (informativ)

Literaturhinweise

E DIN IEC 56(Sec)410	Analyse des Risikos technischer Systeme – Leitfaden (IEC 56(Sec)410:1994)
DIN EN ISO 14040	Umweltmanagement – Ökobilanz – Prinzipien und allgemeine Anforderungen (ISO 14040:1997); Deutsche Fassung EN ISO 14040:1997

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**Supporting information to
DEPENDABILITY MANAGEMENT –
Part 3-3: Application guide –
Life cycle costing**

1 General

The IEC 60300 series of standards explain the procedures for implementing a dependability program during all phases of the life cycle of a product in order to achieve specified levels of dependability.

IEC 60300-1 is the top level document which provides guidance on dependability programme management.

IEC 60300-2 is the next level down and defines the tasks/elements that may need to be carried out to achieve dependability objectives and gives guidance on how the tasks should be undertaken.

IEC 60300-3 encompasses a series of Application Guides which develop the tasks in IEC 60300-2 with respect to specific areas of a product. One of these Application Guides is IEC 60300-3-3, Life Cycle Costing.

IEC 60300-3-3 is a generic guideline on life cycle costing and covers all applications.

The material presented in this annex is also intentionally general in nature but more detailed. The examples included illustrate how LCC principles are applied in practice.

It may be advantageous for particular organisations, or industry sectors, to extract those parts of this annex relevant to their LCC needs and produce a rationalised approach to LCC. This could take the form of industry-specific guidelines or customised LCC models as shown in Figure 1.

In this Annex more detailed information is given about:

- development of cost breakdown structure
- LCC model development
- inclusion of dependability costs in LCC models
- treatment of costs including inflation and taxation
- costs associated with risk and life cycle assessment and LCC.

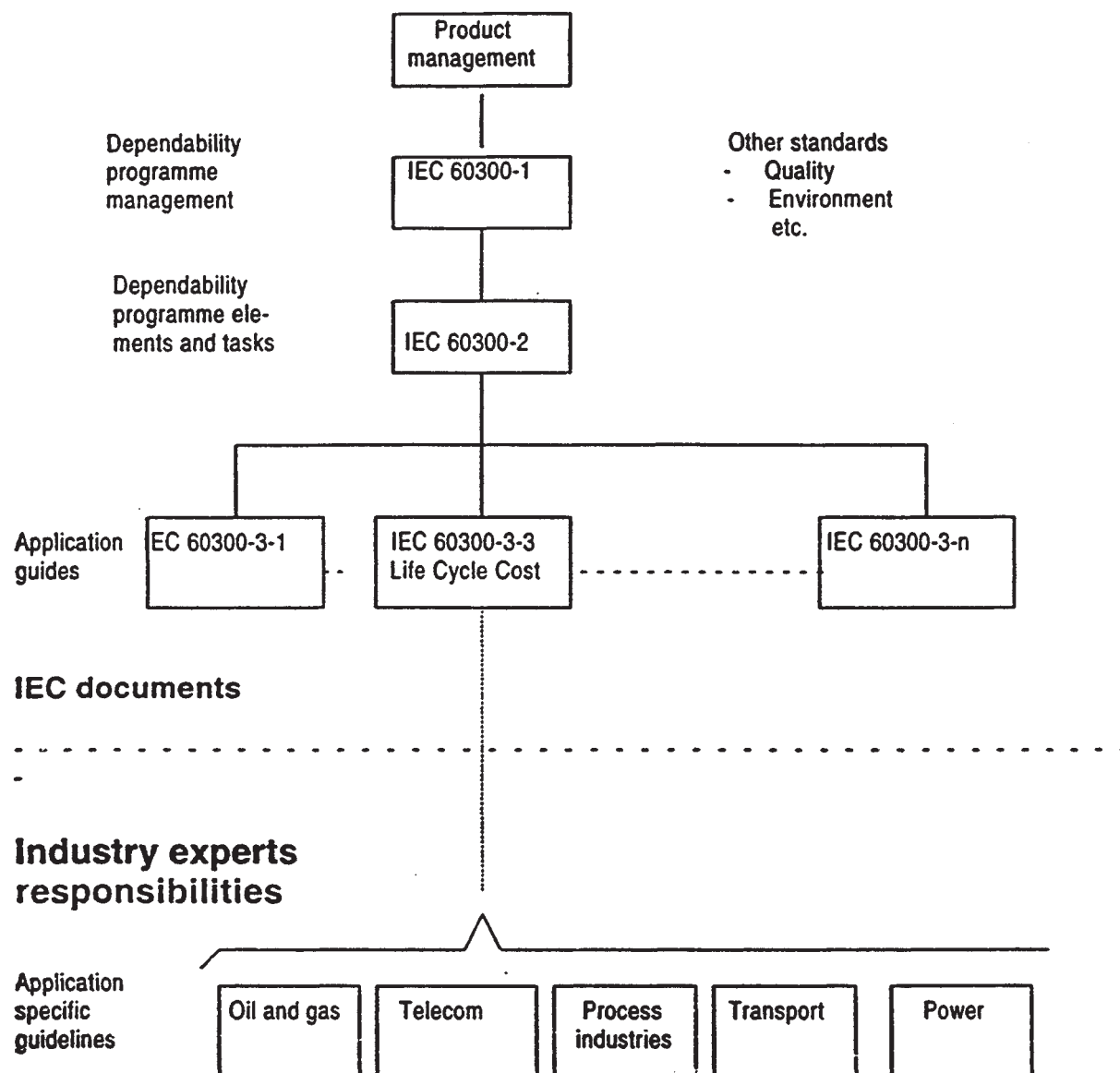


Figure 1. Application specific guidelines

2 Normative references

Normative references are given in the main document, i.e. IEC 60300-3-3.

The following normative documents contain provisions which, through reference in this text, constitute provisions of this document.

IEC 60300-3-9: Risk analysis of technological systems.

ISO 14040: Environmental management - Life cycle assessment - Principles and framework.

3 Terminology

For the purpose of this annex the terms and definitions of IEC 60300-1, IEC 60300-2 and IEC 50(191) apply. In addition, for the purpose of this annex, the terms and explanations, given in alphabetical order below, are used:

3.1

Base date

A fixed point in time set as the common reference for discounting the cash flows into or out of an investment project, for management accounting purposes.

3.2

Cost category

A descriptor applied to an item of expenditure (forecast or actual) to enable the costs of a project to be aggregated by the nature of the expenditure, e.g., labour, materials, energy, administration, etc, as an aid to project management.

3.3

Discounted cost:

The result when real cost is discounted by the real discount rate, or when nominal cost is discounted by the nominal discount rate.

3.4

Discount rate:

The interest rate at which the streams of cash inflows and outflows associated with an investment project are to be discounted

3.5

Internal rate of return (IRR):

The specific value of the discount rate that would produce a net present value of zero, for all the discounted streams of cash inflows and outflows associated with the project.

3.6

Net present value (NPV):

The net value, now, of all future items of income and expenditure related to an investment project, at a given rate of return.

3.7

Nominal cost:

The expected price that will be paid when a cost is due to be paid, including estimated changes in price due to forecast changes in efficiency, inflation/deflation, technology and the like.

3.8**Present value:**

Is the concept that a sum of money invested today will earn interest. A UC today is worth more than a UC to be received in the future by the amount of interest it earns. It is the amount needed to be invested now for n years at an interest rate $r\%$ to earn a future sum of money.

3.9**Real cost:**

The cost expressed in values of the base date, including estimated changes in price due to forecast changes in efficiency and technology, but excluding general price inflation and deflation.

3.10**UC:**

Units of Currency.

4 Life cycle cost concept**4.1 General**

Life cycle costing is the process of economic analysis to assess the total cost of acquisition and ownership of a product. It can be applied to the whole life cycle of a product or to parts or combinations of different life cycle phases.

The primary objective of life cycle costing is to evaluate and optimize a product's life cycle costs while satisfying specified performance, safety, reliability, maintainability, environmental and other requirements. The aim is to provide input to decisions making in all phases (especially in early phases) of a product's life cycle. The more common types of decisions for which the life cycle costing process is used to provide input are presented in IEC 60300-3-3, clause 4.

Fundamental to the concept of life cycle costing is a basic understanding of a product life cycle and the activities that are performed during these phases. The life cycle phases are defined in IEC 60300-2.

One of the reasons for performing Life Cycle Cost analyses is to identify cost drivers. The main cost drivers may differ considerably from one application to another. A cost that dominates in one application may be negligible in other cases.

An important objective in the preparation of application specific LCC models is to identify costs that may have a major impact on the LCC or may be of special interest for that specific application. Equally important is to identify costs that may only influence the LCC to a very small extent.

The life cycle cost may be estimated for:

- a single product, for example, a car one intends to buy
- a whole population, for example, all cars of a certain model
- a system, for example a power plant
- a specific industrial process, for example, manufacture of electronic components
- a maintenance organization.

Before developing an LCC model, objective and application for use of the model as well as different analysis view points, should be defined.

4.2 LCC model adaptation

See IEC 300-3-3, clause 7.3.

The LCC model may be adapted, for example, to make it possible to:

- determine whether a prospective investment is viable
- choose among different alternatives concerning design, manufacture, maintenance, disposal, etc.
- choose among different suppliers and products
- use it for contractual and verification purposes
- evaluate the effects of different maintenance concepts/approaches
- calculate the economical consequences associated with uncertainties and risks
- analyse costs associated with the environmental impact of the product.

An LCC model of sufficient detail to meet the objectives and which is tailored to suit the specific application may be adapted as required.

This includes the following steps:

- a) define the scope and physical bounds of the analysis in terms of hardware, software etc.
- b) define the output, reports etc.
- c) define resources that you need to use
- d) identify data required for the analysis
- e) identify uncertainties and risks associated with different costs
- f) identify costs which will not have significant impact on the overall LCC for the industry or application under consideration
- g) identify methods to integrate different cost elements into an LCC model which will provide the outputs required
- h) verify the model and review the model to ensure that it meets the intended purpose

5 Dependability and LCC relationship

As stated in IEC 60300-1, clause 5.1, reliability, maintainability and other dependability considerations should be an integral part of the design process and LCC evaluations. These factors should be critically reviewed when preparing product specifications, and be continually evaluated throughout the design phases in order to optimize product design to minimize life cycle cost.

Figure 2 below describes dependability factors translated into operation and maintenance costs.

Costs associated with reliability, maintainability and maintenance support performance, which are not apparent, but need to be accounted for in life cycle cost models, may include the following, as appropriate:

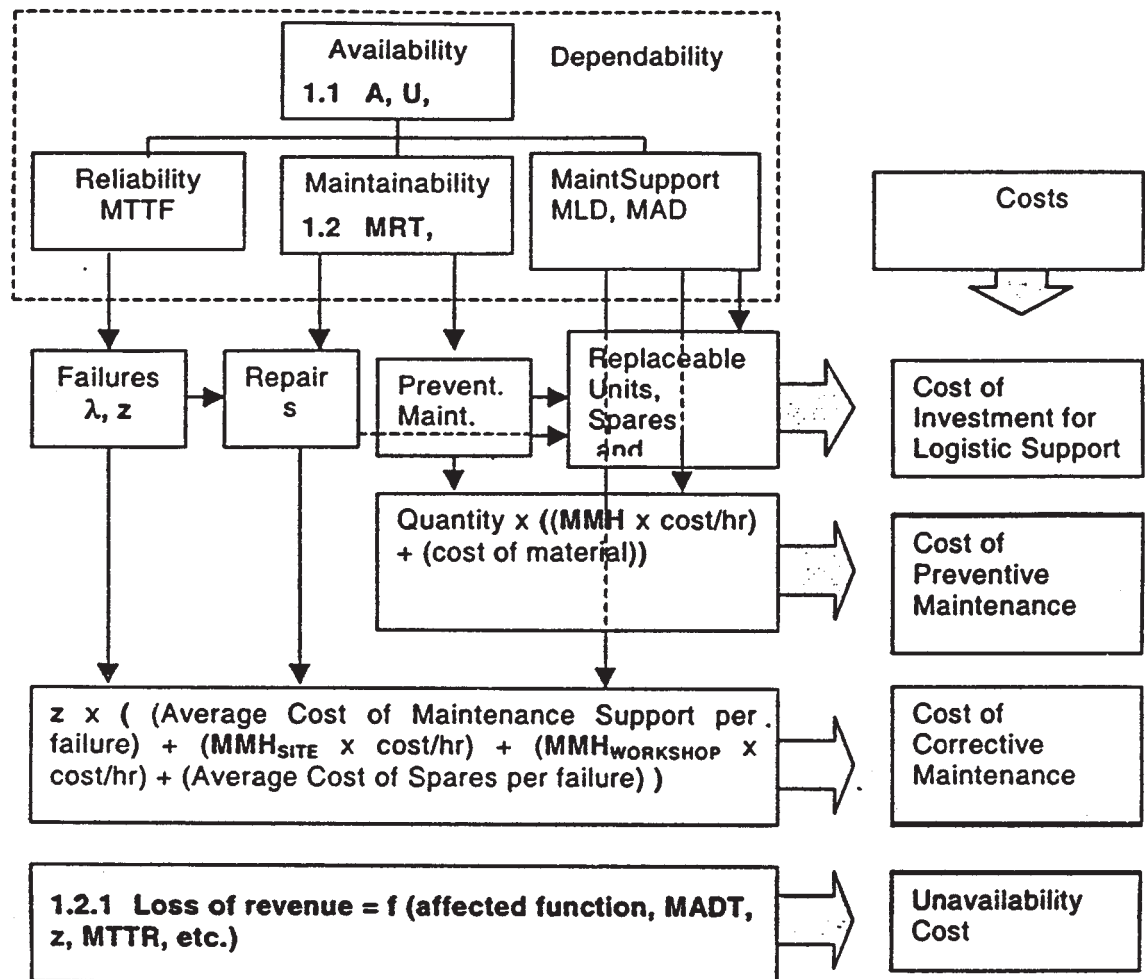
- unavailability costs (including costs associated with loss of product function)

See IEC 60300-3-3, clause 5.2.

- warranty costs and costs for warranty-types agreements.

See IEC 60300-3-3, clause 5.3.

- liability costs. See IEC 60300-3-3, clause 5.4.



In accordance with IEC 50(191) the following symbols and abbreviations apply:

A = Availability; MADT = Mean Accumulated Down Time
 MTTF = Mean Time To Failure; z = failure intensity; λ = failure rate
 MRT = Mean Repair Time; MTD = Mean Technical Delay; MLD = Mean Logistic Delay
 MAD = Mean Administrative Delay; MMH = Maintenance Man-Hours
 Mean Time To Restoration, MTTR = MRT + MTD + MLD + MAD

Figure 2 – Principal relationship between Dependability and LCC for the Operation and Maintenance phase

6 LCC modelling

6.1 General

In order to estimate the total life cycle cost of a product, or a defined part of its life cycle cost, it is necessary to first estimate the cost for applicable cost elements. To do this, each cost element has to be individually identified. See IEC 60300-3-3, clause 6.2.

The cost breakdown structure presents a breakdown of costs incurred over the major phases (or phases of interest) of the life cycle of a product.

The product/work breakdown structure is composed of a detailed breakdown of hardware, services, and data identifying all major tasks and supporting work packages.

The total LCC for the six life cycle phases, defined in IEC60300-3-3, Figure 1, of a product is

$$LCC = C_{CD} + C_{DD} + C_M + C_I + C_{OM} + C_D$$

where

C_{CD}	=	Cost, concept and definition phase
C_{DD}	=	Cost, design and development phase
C_M	=	Cost, manufacturing phase
C_I	=	Cost, installation phase
C_{OM}	=	Cost, operation and maintenance phase
C_D	=	Cost, disposal phase

See also Appendix A, Examples of LCC model development.

The appropriate life cycle phases, or parts or combinations of these phases, should be selected to suit the special needs of each specific analysis. In a more general way LCC can also be divided into acquisition cost and ownership cost. See IEC 300-3-3, clause 4.2.

Detailed expressions for costs for the different phases can be developed separately. The cost elements, factors etc. should have unique identities. In a situation where analyses should be performed while covering several phases, the identities of cost elements, factors etc. should be unique in the total LCC model. It is normally an advantage to maintain the product/work breakdown structure unvaried for the particular study.

IEC 60300-3-3 "Figure 3 - Cost element concept" and clause 7.3 "LCC model development" give some overall guidance for the cost breakdown and the LCC model development. More detailed information is given below.

LCC modelling includes

- Cost breakdown structure
- Product/work breakdown structure
- Selection of cost categories
- Selection of cost elements
- Estimation of costs
- Presentation of results

And when applicable

- Environmental aspects
- Uncertainties and risks
- Sensitivity analysis
- Treatment of costs

6.2 Cost Breakdown Structure

The cost breakdown structure is a life cycle oriented way of classifying costs. The cost breakdown structure links the different costs to meet the needs of the analysis. The individual cost is defined by its cost elements. See also IEC 60300-3-3, clause 6.2, and example in clause 7 below.

6.3 Cost categories

Design, development, manufacturing, etc. include activities that contribute to the Life Cycle Cost. The costs associated with the activities may be grouped based on the type of resource used, e.g.,

- labour
- materials
- fuel/energy
- overhead
- transportation
- administration
- travel
- storage
- environmental
- disposal
- waste
- landfill
- training
- documentation
- cost of fixed assets

The above groupings define what is referred to as the cost categories. See also IEC 60300-3-3, clause 6.2.

Typical costs incurred in the different life cycle phases of a product/project are given in IEC 60300-3-3, annex A.

Examples of how various cost categories arise in the operation and maintenance phase are:

a) Costs associated with operation

- Non-recurring costs, e.g., costs for initial training of staff, documentation, initial spares, equipment, facilities and special tools
- Recurring costs, e.g., costs for labour, consumables, power, on-going training and upgrading

b) Costs associated with preventive maintenance

- Non-recurring costs, e.g., costs for test equipment and tools, initial spares and consumables, initial training of staff and initial documentation
- Recurring costs, e.g., costs for labour, travel, spares, consumables, on-going training and documentation

c) Costs associated with corrective maintenance

- Non-recurring costs, e.g., costs for test equipment, tools, initial spares, initial training of staff, initial documentation and facilities
- Recurring costs, e.g., costs for labour, spares and consumables, travel, on-going training and documentation
- Cost due to loss of production, e.g., costs for compensation and loss of income

6.4 Product/work breakdown structure

The product/work breakdown structure gives the breakdown of the product to lower indenture levels. See also IEC 60300-3-3, Figure 3, and example in clause 7 below.

An example of a product breakdown structure, and LCC summary for a railway vehicle is presented in Appendix B.

6.5 Selection of cost elements

The cost element is the link between cost categories and the product/work breakdown structure. The selection of cost elements should be related to the complexity of the product as well as to the cost categories of interest in accordance with the required cost breakdown structure. See also IEC 60300-3-3, clause 6.2 and 6.3, and example in clause 7 below.

6.6 Estimation of cost

6.6.1 General

The costs related to each element should be estimated according to IEC 60300-3-3, clause 6.3.

Life Cycle Cost analyses may be performed at different levels of detail.

In IEC 60300-3-3, there are three basic methods that are commonly used to estimate the cost associated with a cost element. These methods are

- engineering cost method
- analogous cost method
- parametric cost method

Examples of application of each method are given in clause 6.6.2 - 6.6.4 below.

When carrying out an LCC analysis for a certain product, one or more of these methods, or other methods, may be used as appropriate.

In order to reduce different types of uncertainties involved in the LCC analyses, it should be possible to perform sensitivity analyses, for example by introducing minimum and maximum values to the parameters of the LCC model, according to clause 6.7 below, into the cost estimation equations.

6.6.2 Engineering cost method

When using the engineering cost method, the costs for the particular cost elements are directly estimated by examining the product component by component, or part by part. Often standard established cost factors, for example, the current engineering and manufacturing estimates, are used to develop the cost of each element and its relationship to other elements. Older estimates available may be updated to the present time by the use of appropriate factors, as annual discounting and escalation factors.

The engineering cost method can be illustrated by the following example concerning the cost related to a recurring cost element:

The labour cost for the manufacture of a power supply is to be estimated. The following information is given:

Product	Power supply
Life cycle phase	Manufacturing phase
Cost category	Labour cost

According to detailed assessment of manufacturing steps, provided by the manufacturing department, the time consumption for the production of one unit of the particular power supply is 38.8 person hours. Suppose the labour cost is UC 54.50/person hour. The total labour cost for the production of one unit is then $38.8 \times 54.50 = \text{UC } 2114.60$.

6.6.3 Analogous cost method

In this method, cost estimations based on experience from a similar product or technology are used. Historical data updated to reflect cost escalation, effects of technology advances etc., are utilized. This technique may be one of the least complex and least time consuming methods. It is easily applied to components of the system for which there is some experience and actual data.

The analogous cost method can be illustrated by the following example where an estimate of the cost for parts and material for a power supply, using experience from an older power unit, is used.

The following information is given:

Product	Power supply
Life cycle phase	Manufacturing phase
Cost category	Parts and materials

For a somewhat less complex power supply produced 4 years ago the cost for parts and materials was CU 220. Cost escalation over 4 years is taken to be 5%.

The cost for additional parts will be about UC 50.

Therefore, cost for parts and materials for the new power supply unit is estimated to be:

$$220 + 0.05 \times 220 + 50 = \text{UC } 281$$

6.6.4 Parametric cost method

The parametric cost method for LCC uses parameters and variables to develop cost estimating relationships. The method might be differently used in other areas.

The relationships are usually in the form of equations where, for example, person hours are converted into costs.

An example of the parametric cost method used for a calculation of active corrective maintenance cost for a sub system P14, is given in figure 3 below.

**Product Breakdown
Structure (P)**

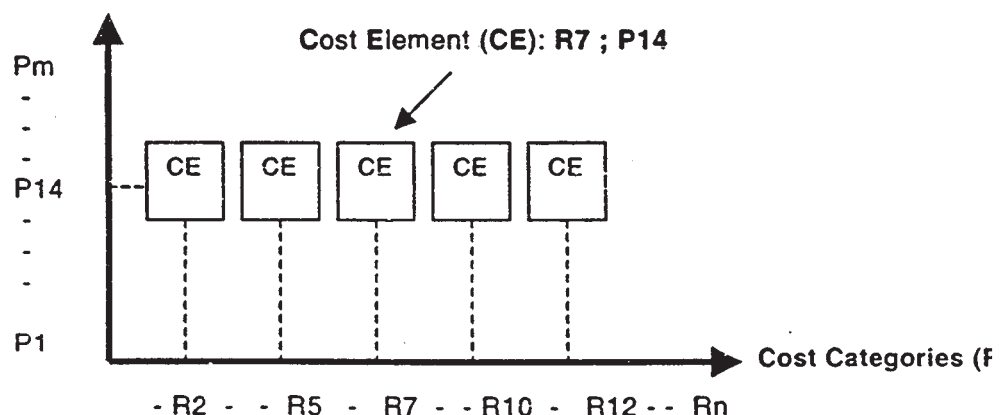


Figure 3. Example of Cost Elements used in the parametric cost method

In figure 3

- R2 = Investment in test equipment, workshop (non-recurring)
- R5 = Investments in spares, workshop (non-recurring)
- R7 = Labour, site (recurring)
- R10 = Labour, workshop (recurring)
- R12 = Spares consumption, workshop (recurring)

and

- P14 = Sub system P14.

Cost of active corrective maintenance for sub system P14 for a 10 years period =

$$= \text{Cost}(R2;P14) + \text{Cost}(R5;P14) + \{\text{Cost}(R7;P14) + \text{Cost}(R10;P14) + \text{Cost}(R12;P14)\} \times 10$$

(not taking into account effects of inflation etc.)

(Active corrective maintenance is defined in IEC 50, see definition 191 08-07 and figure 191-10).

Where, for example, the cost related to element (R7;P14) is calculated as follows

$\text{Cost}(R7;P14)$ = Labour cost, active corrective maintenance at site for sub system P14

$$\text{Cost}(R7;P14) = QP14 \times ZP14 \times C_L \times n \times \text{MRT} \quad \text{Cost/year}$$

where

- QP14 = Quantity or number of items, in this example QP14 = 1
- ZP14 = Expected number of failures/year for sub system P14
- CL = Labour cost/hour
- N = Number of persons required to carry out the repair
- MRT = Mean repair time in hours/action

Assume:

- QP14 = one item /system
- ZP14 = 0.3 failures/year
- CL = UC 50/hour
- N = one person
- MRT = 2.4 hours/action

Then

$$\begin{aligned} \text{Cost}(R7;P14) &= 1 \times 0.3 \times 50 \times 1 \times 2.4 = \\ &= \text{UC } 36/\text{year} \end{aligned}$$

To calculate the labour cost for 10 years, the result should be multiplied by 10. (Not taking into account effects of inflation, etc.)

If different factors, for instance inflation or discounting, have to be taken into account, this could be included in the estimation of cost related to each element or at a higher cost element level in the LCC model.

$\text{Cost}(R10;P14)$, etc., are calculated in a similar way.

6.7 Sensitivity analysis

In order to consider uncertainties involved in the LCC analysis, sensitivity analyses should be performed. Cost drivers, uncertain data, etc., may be varied to establish their impact on the total LCC or part of it. To facilitate this, special factors may be included in the formulas. This could be accomplished either in the formulas/equations for the individual cost elements or at a higher level.

To facilitate the sensitivity analysis, it is important that the LCC model is developed in such a manner that, when a common parameter, for instance person hour cost, is varied, this is automatically reflected wherever this parameter is used.

It may be desirable to use minimum or maximum values of certain parameters or even a distribution. The LCC model in that case should be developed to meet these needs.

It should be noted that the results of LCC calculations generally do not match with the actual/observed cost. This is because there are many influencing random factors, such as environmental conditions, human errors during operation etc., which cannot be accurately modelled in the calculations.

The calculated LCC value sometimes is interpreted as the expected (mean) value. Such an interpretation could be misleading. It is therefore recommended that the LCC model, in addition to the calculation of costs, provide for the estimation of the probability of realising the calculated LCC value.

For example, this can be done in the equation in clause 6.6.4 by replacing ZP14 (expected number of failures in a year) by such a value of the number of failures per year that the probability of exceeding this number is reasonably low, say 0.05.

The distribution of possible cost values can be calculated by replacing average values of the variables by the appropriate distributions of values using simulation (Monte Carlo) or by calculating the variance of the LCC based on the variance of the individual cost elements.

To facilitate sensitivity analyses, a special zero-setting constant may be used for all or some of the equations. By using this constant, one or more cost elements can easily be set to zero without changing any other parameter in the equations concerned.

6.8 LCC and environmental aspects

6.8.1 General

The society is becoming increasingly concerned about the environmental impact of products and services. All decisions made about a product's design, manufacture, use etc, including the environmental impact, may affect the price and ownership cost.

Life cycle costing is the process of economic analysis to assess the total cost of acquisition and ownership of a product. If the costs of the actions that have to be taken to fulfil the environmental regulations are included in the LCC studies, this will provide important inputs in the decision making process in the product design, development and use.

Suppliers and users of products and services should to pay attention to environmental consequences of production, operation, maintenance, logistics activities etc. The cost advantages of cheap but harmful activities must be carefully estimated.

Environmental issues as well as traditional factors such as cost and time have to be considered. Therefore, methods have to be used to rank environmental consequences of different activities. These methods can provide the bases for environmental planning and integrating environmental issues into the decision making.

While LCC analysis provides a picture of the economical aspects, a comprehensive instrument to study or judge the environmental impact of a product is Life Cycle Assessment (LCA).

Life Cycle Assessment is explained in ISO 14040, Life Cycle Assessment.

6.8.2 Co-ordination of LCA and LCC

LCA provides a comprehensive, multidisciplinary picture of the environmental impacts of a product and how changes to the product can alter these effects.

Evaluations are useful for comparison of burdens (e.g., costs) associated with different options as well as trade-offs with other factors such as performance, safety and economics.

The LCC analysis provides both a detailed and overall picture of the economical aspects. It is possible to choose the most economical design solution by evaluation of alternatives and by performing trade-off studies. Various operating and maintenance strategies to consider the environmental impact could be evaluated.

The life cycle cost analysis could also be effectively applied to evaluate the costs associated with a specific activity, for example, different disposal concepts.

LCA and LCC analysis should be co-ordinated. LCA should be performed as part of or integrated with life cycle costing analysis.

The LCC model should be used to facilitate environmental cost analyses. Factors influencing the environmental impact should be varied to perform sensitivity analyses to establish their impact on the total LCC.

For example, what will the effect be on the total LCC if a cabinet of aluminium is used instead of plastic material, what will the effect be on the acquisition cost and the cost of ownership and disposal.

When designing the LCC model, the environmental cost should be included in cost of acquisition and cost of ownership. This may be accomplished either by including the costs in suitable cost elements or at higher levels in the LCC model.

It should be advantageous to calculate the total cost for environmental impact activities, cost for energy consumption, etc., as separate cost categories.

Costs for the LCA and for other environmental analyses and activities that have to be performed should also be included.

6.9 LCC and uncertainties and risks

Any decisions made about a product's design and manufacture can affect its performance, safety, reliability, maintainability, maintenance support and ultimately its acquisition and ownership cost. There are many factors beyond the designers control that may introduce cost uncertainties with attendant economical consequences.

These may include uncertainties related to:

- a) Commercial and legal relationship between the owner and other organisations
- b) Economic circumstances of the organisation, country, e.g., exchange rates
- c) Political circumstances including legislative changes and factors
- d) Technology and technical issues such as safety and environmental impact

- e) Natural events, human behaviour etc.
- f) Unavailability due to system failures.

Systematic methods should be used to identify and evaluate uncertainties and risks associated with any product, activity, function or process. This should be done in a way that will enable the organisation to minimise losses (or maximize gains) and to quantify the probable consequences. As part of this, risk analyses should be carried out.

One objective of uncertainty and risk analyses is to identify presumptive risks, to separate the minor acceptable risks from the major risks and to estimate the consequences of each risk. The consequences may be expressed in terms of technical and human criteria but also in costs.

To get a better overview of the total costs involved, uncertainty and risk analyses may be performed as part of LCC analyses.

For example, how much will it cost the customer in loss of receipts, in loss of production, in fines, etc., if the actual number of failures is twice as high as the specified value.

The uncertainty and risk cost elements should be included in cost of acquisition and cost of ownership. This may be accomplished either by including the costs in suitable cost elements or at a higher level in the LCC model.

7 Example of a LCC analysis

7.1 General

The following example describes the LCC procedure and some methods for estimation of life cycle costs. The example refers to the Product "Data Communication Network (DCN)". The Product Breakdown Structure, shown in Clause 7.3, lists the different products included in the DCN.

The purpose of the analysis is to find major cost drivers related to the Operation and Maintenance phase as well as loss of revenues due to outages. Costs for infrastructure and some other costs related to Operation and Maintenance are not included. The analysis is based on "constant prices" and 15 years operation of the product.

The following costs, related to the Operation and Maintenance phase, are included in the analysis:

- Total Costs for 15 years of Operation and Maintenance (COM)
 - Costs, Investments (CI)
 - Costs, Operation (CO)
 - Costs, Maintenance (CM)
- Total Costs, Investments for Maintenance (CIM)
 - Costs, Facilities for Maintenance at Site (CIMS)
 - Costs, Facilities for Maintenance at Workshop (CIMW)
 - Costs, Replaceable Units (CIMR)
- Costs for Annual(Y) Operation (CYO)
 - Costs, Leasing of the Data Transport Network (CYOL)
 - Costs, Software upgrading (CYOS)
 - Costs, Unavailability associated costs (loss of revenue due to accumulated downtime of the Data Communication Network) (CYOU)

- Costs for Annual(Y) Maintenance (CYM)
 - Costs, Preventive Maintenance (CYMP), Person hours and Spares
 - Costs, Corrective Maintenance (CYMC), - " -
 - Costs, Corrective Maintenance at Site (CYMCS), - " -
 - Costs, Corrective Maintenance at Workshop (CYMCW), - " -
 - Costs, Spares (CYMS). Total cost for all Spares

The Cost Breakdown Structure (CBS) for this example is shown in Figure 4.

The analysis is performed in the following steps:

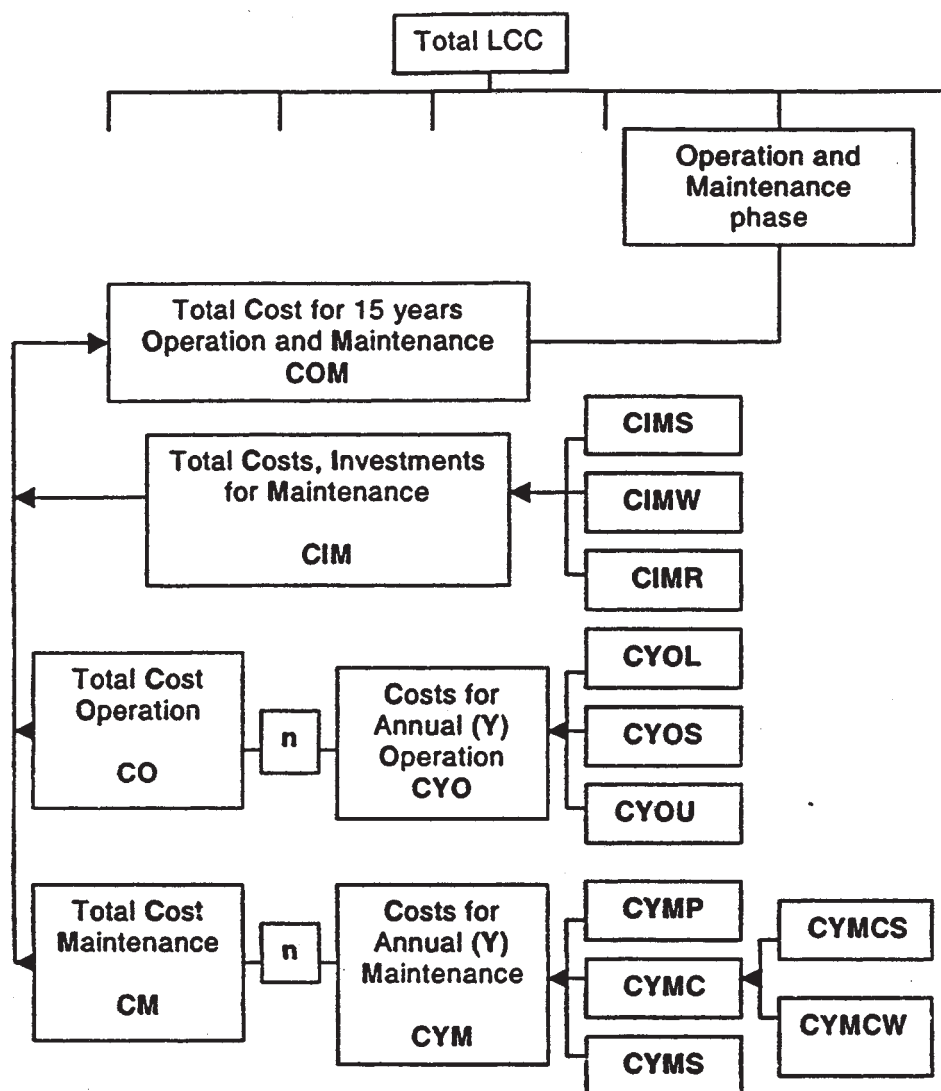
- Definition of an appropriate Cost Breakdown Structure
- Defining a detailed Product Breakdown Structure including a compilation of technical and cost data for the product
- Selection of Cost categories
- Establish the correspondence between the Product Breakdown Structure and Cost categories by means of Cost Elements (CE)
- Establish preconditions and assumptions for the analysis
- Perform the cost calculations
- Presentation of costs in accordance with the Cost Breakdown Structure

7.2 Cost Breakdown Structure (CBS)

As noted earlier in Clause 6.2, the Cost Breakdown Structure (CBS) is a life-cycle oriented way of classifying costs. The CBS links the different costs to meet the needs of the analysis.

The individual cost is defined by its Cost Element. See clause 7.4.

The CBS below describes the relation between costs applicable to this example.



$n = 15$ (number of years in operation)

Figure 4. Cost Breakdown Structure used for this example

7.3 Product Breakdown Structure

To perform the required calculations in accordance with the Cost Breakdown Structure above a detailed Product Breakdown Structure must be worked out. Tables 1-5 below present a Product Breakdown Structure, in 3 indenture levels, including some dependability and cost data for the product.

The product "P" is a Data Communication Network (DCN) consisting of N identical Communication Systems (CS) and a Data Transport Network (DTN). The Data Transport Network contains all data links within the DCN.

Table 1 - 1st indenture level: Data Communication Network

Level 1	Item name	Identification	Required Availability performance	Qty. (N)
P1	Communication System	CS	-	30
P2	Data Transport Network	DTN	99.99 % per link	1