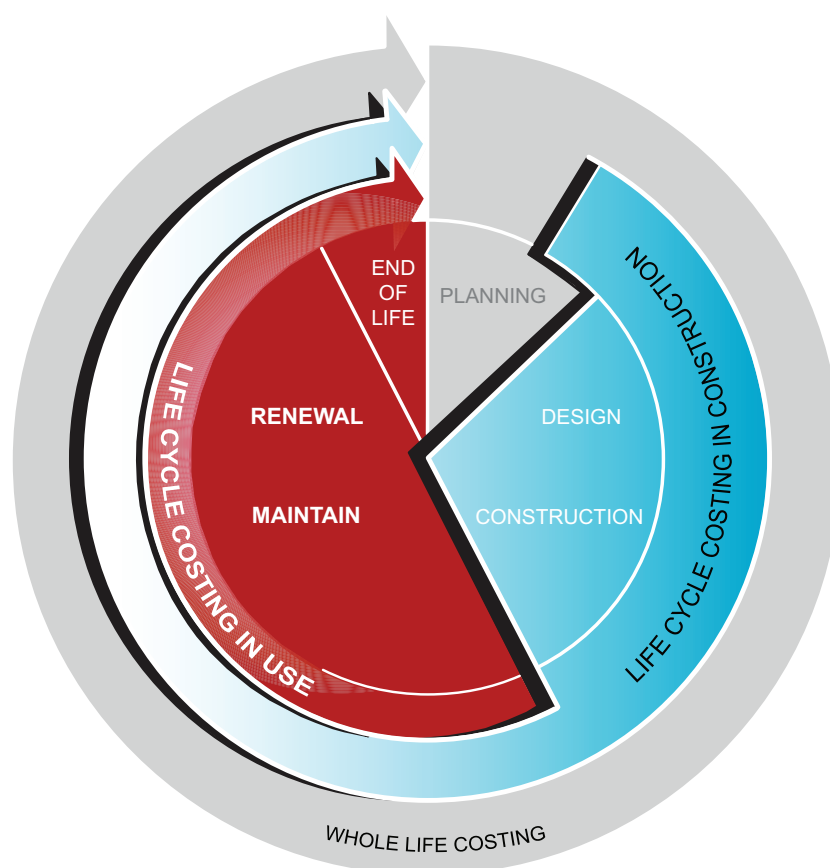




BSI Standards Publication

Guide for life cycle costing of maintenance during the in use phases of buildings



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This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 96, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 September 2013. It was prepared by Technical Committee CB/101, *Service life planning*. A list of organizations represented on this committee can be obtained on request to its secretary.

The initial drafting of this British Standard was produced in association with BIS as part of their ongoing programme of support for standardization.

Relationship with other publications

This British Standard is the second supplementary guide to BS ISO 15686-5. The first supplementary guide is PD 156865, which covers the life cycle cost during construction projects.

Information about this document

The guidance in this British Standard is aligned with industry cost planning data structures and methodology given in the RICS *New Rules of Measurement (NRM)* 1 [1].

This British Standard gives an approach to life cycle costing that places the focus on maintenance costs.

Clause 4 and Clause 5 describe the integrated LCC processes, key stages and the guiding principles and instructions for undertaking LCC of maintenance works. Clause 5 details how to undertake the cyclical process of LCC of maintenance through each of its stages and how this can be periodically updated throughout the in use phases of a building, facility or constructed asset. Clause 6 describes various methods, rules and techniques used in the process to agree the brief and subsequently plan, capture, evaluate, implement and review the LCC for maintenance works. Clause 7 categorizes and defines which maintenance costs to include or exclude and how to express them; it also provides a maintenance breakdown structure and cost categorization definitions. Clause 8 provides guidance on how the building data should be structured and classified to be interoperable with BIM data exchange formats. Clause 9 gives advice regarding the applicable information sources and data required to cost maintain and renewal works during the in use phases. Clause 10 provides practical guidance on how to inform the decision-making processes; it also helps the user to input information into other economic evaluations relating to wider property estate asset management and maintenance strategies.

Use of this document

As a guide, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

0 Introduction

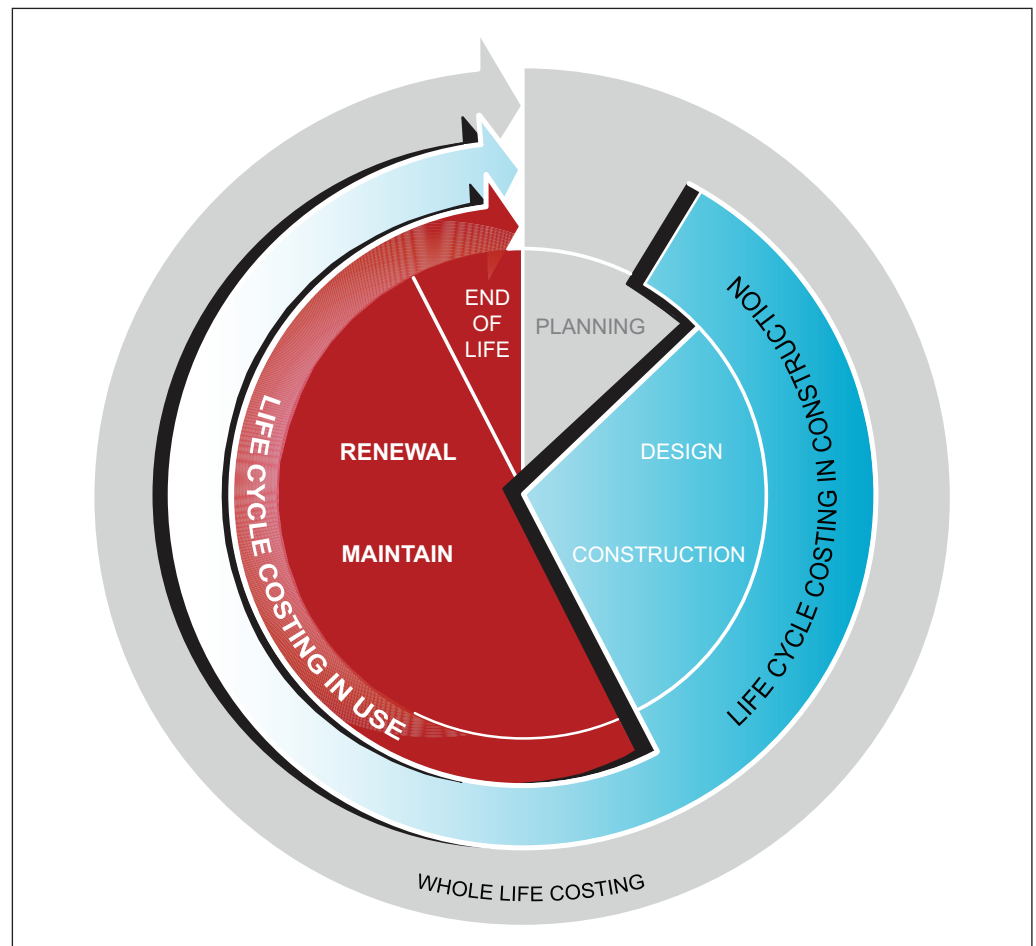
The objectives of this British Standard are to provide:

- a) standardized rules and a methodology for the life cycle costing (LCC) of maintenance during in use phases that fully integrate the process of creating and implementing two plans: maintain and renewal;

NOTE In this British Standard the term “in use” (see 3.1.26) covers the life cycle period after handover and prior to decommissioning; this is highlighted in Figure 1, which also shows its relationship to other cost headings within whole life costing.

- b) guidance on how to capture the appropriate asset information required for specific LCC outcomes;
- c) guidance on how to evaluate and prioritize the maintenance works when carrying out budgeting and funding scenarios;
- d) guidance on the implement stage of LCC management of maintenance works.

Figure 1 Life cycle costing during the various phases of a facility's life



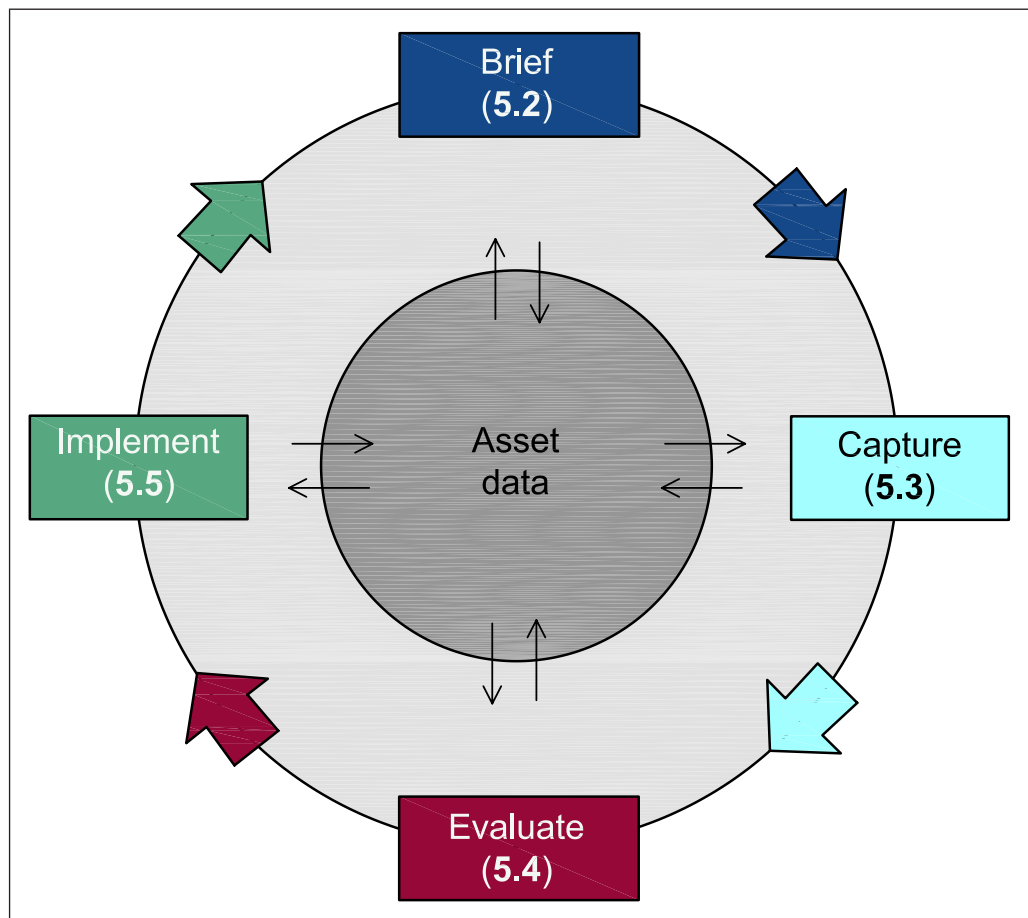
An overview of the key stages of life cycle costing of maintenance (see Figure 2) and their purpose is as follows:

- 1) brief: to define the scope and specific requirements for each of the typical LCC applications and plan the process of LCC of annualized maintenance (maintain) and forecasting the renewal programmes;
- 2) capture: to record the relevant data required to generate and update annualized maintenance (maintain) and/or life cycle renewal cost programmes, based on various forms of assessments;

- 3) evaluate: to inform budget setting and fund modelling by optimizing the planned maintain works and the renewal works cost programmes of work, including how to targeting and defend the maintenance and investment planning outputs;
- 4) implement: to schedule, tender, implement and cost manage works, including monitoring, auditing and reviewing the maintenance and renewal works cost expenditure against budget limits.

The context of the proposed application of LCC of maintenance is relevant to each stage given in 1) to 4).

Figure 2 Key stages of life cycle costing of maintenance



1 Scope

This British Standard gives guidance and recommendations on undertaking LCC of maintenance during the in use phases of facilities or constructed assets. It covers buildings, systems, assemblies, components, tasks/actions, resources and materials.

NOTE 1 The guidance covers maintenance planning during the in use (see 3.1.26) phases of a facility's life cycle.

This British Standard also gives guidance and recommendations on the planning and prioritization, budget-setting, optimization, implementation and monitoring of life cycle programmes of maintain and/or renewal works.

The guidance includes asset surveys and employer's maintenance management aspects of operation (as defined in BS ISO 15686-5) that are needed to plan and manage maintenance delivery including life cycle works.

This British Standard is intended for:

- a) public and private sector employers;
- b) PFI/PPP/PF2 consortia;
- c) property portfolio owners and occupiers and their investors/funders;
- d) estate managers, managing agents and facilities managers;
- e) building surveyors and engineers;
- f) engineering services and maintenance contractors;
- g) quantity surveyors and cost management practitioners;
- h) designers, constructors, insurers and procurement groups.

This British Standard applies to most types of facility. Its application is, therefore, wider than buildings alone and extends to other structures and forms of construction to accommodate diverse needs.

NOTE 2 See RICS NRM 1, Appendix B [1] for a list of functional unit types of facility and equivalent functional units associated with each.

NOTE 3 See B&ES SFG20 [2] for industry standard task schedules for planned preventive maintenance along with guidance on how to customize the annualized maintenance programmes by function and service levels.

NOTE 4 See CIBSE Guide M [3] for reference economic life expectancy data for buildings and services and guidance on how to apply to project and in use situations using factoring methods.

This British Standard covers the interoperability of LCC of maintenance with BIM. It is also aligned with the soft landings core principles of proving (or improving) performance post occupancy.

NOTE 5 Some references have been provided throughout the text to highlight where aspects of these might be relevant.

This British Standard does not provide guidance on the assessment of the operation (including energy and carbon costs), occupancy or end of life costs or whole life cost (as defined in BS ISO 15686-5).

Facilities maintenance management and procurement of facility-related services are specialist areas that link with LCC of maintenance and are covered in detail in BS 8210 and BS 8572.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS ISO 15686-5:2008, *Buildings and constructed assets – Service life planning – Part 5: Life cycle costing*

PD 156865:2008, *Standardized method of life cycle costing for construction procurement – A supplement to BS ISO 15686-5 – Buildings and constructed assets – Service life planning – Part 5: Life cycle costing*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this British Standard the terms and definitions included in BS ISO 15686-5, PD 156865 and the following apply.

NOTE Common terminology used in the industry can also be found in the RICS NRM 1 [1] and BCIS' Standard Form of Cost Analysis (NRM edition) [4].

3.1.1 annual equivalent cost

uniform annual amount equivalent to the project net costs, taking into account the time value of money throughout the period of analysis

3.1.2 asset

whole building, structure or unit of construction works, or a system or component or part thereof

[SOURCE: BS ISO 15686-10:2010, 3.1]

NOTE This definition includes infrastructure, assemblies, materials and landscaping.

3.1.3 asset register

collection of records holding information about facility assets in terms of their manufacturer, vendor, make, model, specifications, date of acquisition, initial cost, maintenance costs and requirements, accumulated depreciation and written-down value

[SOURCE: BS 8587:2012, 3.1.3]

3.1.4 base cost

cost of an existing or selected life cycle scenario against which enhanced or improved options can be compared or the cost of a specific solution selected as a benchmark with which to measure other options

3.1.5 base date

date at which rates and prices contained within cost analyses or benchmark analyses are based

[SOURCE: RICS NRM 1 [1], 1.3.3]

3.1.6 base rate

interest rate selected as the basis of the selected discount rate

NOTE This could be the current bank rate or the employer's cost of capital. The base rate is commonly adjusted by the inflation rate to give the discount rate.

3.1.7 building

construction works that have the provision of shelter for its occupants or contents as one of its main purposes, usually partially or totally enclosed and designed to stand permanently in one place

[SOURCE: BS 6100-1:2004, 3.1.3]

3.1.8 business criticality assessment

assessment based on the impact to the business of not undertaking the maintenance work

3.1.9 capital cost

acquisition costs where these are treated as capital expenditure

3.1.10 capital reinstatement value

current cost of reinstatement of the buildings in their present form, including demolition, site clearance and fees, but excluding VAT (except on fees)

NOTE Capital reinstatement value is sometimes incorrectly referred to as the "fire insurance valuation". Further information and guidance regarding this can be found in the ABI/BCIS House rebuilding cost index, RICS Valuation: professional standards [5].

3.1.11 component

product manufactured as a distinct unit to serve a specific function or functions

[SOURCE: BS 6100-1:2004, 6.1.3]

3.1.12 corrective maintenance

maintenance carried out after fault recognition and intended to put an asset into a state in which it can perform a required function

[SOURCE: BS EN 13306:2010, 7.5]

3.1.13 deferred maintenance

corrective maintenance which is not immediately initiated after occurrence of a failure or detection of a fault, but is delayed in accordance with given maintenance rules

NOTE For example, a faulty lock or a security door might be flagged as work to be carried out as part of a set maintenance schedule along with other similar works and therefore fall into the deferred maintenance category.

3.1.14 design life

service life intended by the designer

[SOURCE: BS ISO 15686-1:2011, 3.3, modified – Note has been deleted]

3.1.15 employer

person or organization responsible for initiating and financing a project and approving the brief

[SOURCE: BS 6100-1:2004, 8.3]

3.1.16 facility

physical setting used to serve a specific purpose

NOTE 1 A facility may be part of a building, a whole building or more than one building, and might include related constructions (such as roads and walkways), which, taken as a whole, serve a specific purpose.

NOTE 2 This term encompasses both the physical object(s) and its (their) use.

[SOURCE: BS ISO 15686-10:2010, 3.8]

3.1.17 facilities management

integration of processes within an organization to maintain and develop the agreed services that support and improve the effectiveness of its primary use

3.1.18 function

purpose or activity of users and other stakeholders for which an asset or a facility is designed, used or required to be used

[SOURCE: BS ISO 15686-10:2010, 3.10]

3.1.19 function condition index

ratio of the function unit cost estimate of predicted life cycle major repairs and replacements, (renewal works) identified by a condition and remaining life assessments, to the CRV, expressed over an agreed period of analysis

NOTE See also 3.1.10 for CRV.

3.1.20 function maintenance index

ratio of function unit cost estimate of annualized maintenance (i.e. maintain works including planned, reactive and proactive maintenance) to the CRV, expressed over an agreed period of analysis

NOTE See also 3.1.10 for CRV.

3.1.21 function type

primary use of a facility or part of a facility

3.1.22 functional unit

unit of measurement used to represent the primary use of a facility or part of a facility including all associated circulation space, such as bed space, house and retail area

NOTE See NRM 1, Appendix B [1] for a list of functional units.

[SOURCE: RICS NRM 1 [1], 1.3.3]

3.1.23 gross internal floor area

area of a building measured to the internal face of the perimeter walls at each floor level

NOTE For more information regarding the rules of measurement of gross internal floor area, see the RICS Code of Measuring Practice (6th edition) [6].

3.1.24 inflation

sustained increase in the general price level of labour, plant and equipment, and materials

3.1.25 inspection logbook

collection of inspection records produced during inspection activities

[SOURCE: BS EN 15331:2011, 3.13]

3.1.26 in use

phase of the life cycle of the asset after handover and prior to the end of life phase

NOTE The start of the end of life phase is signalled by decommissioning.

3.1.27 life cycle

consecutive and interlinked stages of the object under consideration

[SOURCE: BS ISO 15686-5:2008, 3.3.4, modified – Notes 1 and 2 have been deleted]

3.1.28 life cycle cost

cost of an asset or its parts throughout its life cycle, while fulfilling the performance requirements

[SOURCE: ISO 15686-5:2008, 3.1.7]

3.1.29 life cycle costing

methodology for the systematic economic evaluation of life cycle costs over a period of analysis, as defined in the agreed scope

NOTE LCC can address a period of analysis that covers the entire life cycle or (a) selected stage(s) or periods of interest thereof.

[SOURCE: ISO 15686-5:2008, 3.1.8]

3.1.30 life cycle costing in construction

methodology for the systematic economic evaluation of life cycle costs over a period of analysis taking place during the construction phase

3.1.31 life cycle costing of maintenance

methodology for the systematic economic evaluation of life cycle costs over a period of analysis taking place post completion of the construction phase and

prior to the end of life phase with the object of creating two plans: the maintain plan and the renewal plan

NOTE 1 This does not cover operation, occupancy or end of life costs.

NOTE 2 This includes the whole period to disposal (a transfer of ownership or responsibility) but might not be the whole period to end of life of the building or facility.

3.1.32 life cycle renewal cost

cost of scheduled renewal of major systems and components, forming part of the capital costs (not revenue budgets), excluding annual planned preventive maintenance, minor repairs and unscheduled reactive maintenance

3.1.33 maintain cost

cost of annualized maintenance (including planned, reactive and proactive maintenance and minor repairs up to an agreed limit of liability)

NOTE The maintain costs include the maintenance contractors on costs and risks provision, fees and taxation and inflation allowances (required to be included for certain LCC outcomes). An example of this would be the replacement of door or window ironmongery.

3.1.34 maintenance cost

total cost of necessary labour, material and other related costs incurred to retain a building or its parts in a state in which it can perform its required functions

NOTE For this British Standard where maintenance cost is referred to it includes both maintain costs and renewal costs.

3.1.35 maintenance of facilities

combination of all technical, administrative and managerial actions during the life cycle of a building (or a part of it), intended to maintain it at, or restore it to, a state in which it can perform the required function

3.1.36 maintenance manual

technical instructions intended to preserve an item in, or restore it to, a state in which it can perform a required function

[SOURCE: BS EN 13460:2009, 5.3]

3.1.37 maintenance plan

structured and documented set of tasks that include the activities, procedures, resources and the time scale required to carry out maintenance

[SOURCE: BS EN 13306: 2010, 2.5]

3.1.38 major replacement

work that involves the asset renewal or replacement of obsolete or worn out components or elements of a building and services at the end of their economic life

NOTE This classification of work is usually planned but might be instigated as a result of obsolescence (e.g. technology). An example of this would be cladding renewal.

3.1.39 net present cost

sum of discounted future cost cash flows

3.1.40 net present value

sum of the discounted future cash flows, including both cost and income

3.1.41 occupancy cost

operation cost incurred by the occupant during the in use period

3.1.42 period of analysis

period of time over which life cycle costs or whole life costs are analysed

[SOURCE: BS ISO 15686-5:2008, 3.3.6]

3.1.43 preventive maintenance

maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item

[SOURCE: BS EN13306:2010, 7.1]

3.1.44 present day value

money anticipated to be accrued in the future that has been discounted to account for the fact that it is worth less at the time of calculation

3.1.45 proactive maintenance

maintenance work that is undertaken to identify potential failures or defects that could lead to down time or major disruption

NOTE Proactive maintenance includes planned inspections of facilities, monitoring and audit tasks (e.g. plant room checks) and other management procedures.

3.1.46 reactive maintenance

reactive work activities that occur in the current annual maintenance program (i.e. maintenance carried out to no predetermined plan)

NOTE 1 This term is also referred to as unscheduled works.

NOTE 2 Activities included in reactive maintenance range from unplanned or unscheduled maintenance of a nuisance nature requiring low levels of skill for correction, to non-emergency tasks involving moderate to major repairs and correction requiring skilled labour.

3.1.47 redecoration

work carried out to restore the aesthetic value or weather protection of buildings and components

NOTE This is usually cyclical in nature and undertaken at regular predetermined times to ensure that required decorative state and protection is maintained.

3.1.48 reference service life

service life of a product component, assembly or system which is known to be expected under a particular set, i.e. a reference set, of in use conditions and which can form the basis for estimating the service life under other in use conditions

[SOURCE: BS EN 15686-1:2011, 3.22]

3.1.49 reliability centred maintenance

method for establishing a scheduled preventive maintenance programme which will efficiently and effectively achieve the inherent reliability and safety levels of equipment and structure

[SOURCE: BS EN 15331:2011, 3.20]

3.1.50 remaining service life

expected future life of an asset at a given point in time

3.1.51 renewal

planned major repairs, refurbishing, replacements and redecorations, plus specific improvements and upgrades as well as maintenance contractor's on costs, risks provision and fees, taxation and inflation allowances (if required for certain LCC outcomes)

3.1.52 risk

probability of an event (e.g. failure, damage) multiplied by its consequences (e.g. cost, fatalities, exposure to personal or environmental hazard)

[SOURCE: BS ISO 15686-7:2006, 3.12]

- 3.1.53 selected discount rate**
interest rate used for bringing future costs to a comparable time base
- 3.1.54 sensitivity analysis**
test of the outcome of analysis by altering one or more parameters from initial value(s)
- 3.1.55 time value of money**
measurement of the difference between future monies and the present day value of monies
- 3.1.56 uncertainty**
lack of certain, deterministic values for variable outputs used in an LCC analysis of an asset
- 3.1.57 unit rates**
monetary rate applied to an element, sub element or component per unit of measurement
NOTE For example cost per m, cost per m² and cost per m³ and also includes the function unit cost.
- 3.1.58 unscheduled maintenance**
repairs and/or replacement carried out after faults or damage have occurred
NOTE Generally they are reactive in nature and could include serious emergency work and first line response.
- 3.1.59 whole life cost**
all significant and relevant initial and future costs and benefits of an asset, throughout its life cycle, while fulfilling the performance requirements
- 3.1.60 whole life costing**
methodology for the systematic economic evaluation of all whole life costs and benefits over a period of analysis, as defined in the agreed scope

3.2 Abbreviations

For the purposes of this British Standard, the following abbreviations apply:

ACR	asset criticality rating
AEC	annual equivalent cost
AEV	annual equivalent value
AIRR	adjusted internal rate of return
ALE	asset life expectancy
ARM	availability, reliability and maintainability
ARS	asset risk scoring
B&ES	Building and Engineering Services Association (formerly HVCA)
BCIS	Building Cost Information Service
BIM	building information model
BFM	business focused maintenance
CAIP	capital asset investment plan
CAFM	computer aided facilities management
CAR	condition of asset rating
CDM	construction, design and management
CIBSE	Chartered Institute of Building Services Engineers
CMMS	computer maintenance management system
COBIE	Construction Operation Building Information Exchange
CRC	carbon reduction commitments

CRV	capital rebuild/reinstatement/replacement value
DRC	depreciation replacement cost
EPC	Energy Performance Certificate
FCI	function condition indexation
FMI	function maintenance indexation
GIFA	gross internal floor area
ICT	information and communications technology
IRR	internal rate of return
IFC	Industry Foundation Classes
ITOC	international total occupancy cost
KPI	key performance indicator
LCC	life cycle cost
LCR	life cycle renewal
NPC	net present cost
NPV	net present value
NRM	new rules of measurement
NS	net savings
PARL	percentage of asset remaining life
PDV	present day value
PFI	private finance initiative
PF2	private finance 2
PIB	planned inspections of building
PPM	planned preventive maintenance
PPP	public-private partnership
RCM	reliability centred maintenance
RICS	Royal Institution of Chartered Surveyors
RSL	reference service life
SIR	savings to investment rate
SoR	schedule of rates
TPI	tender price index (or indices)
WLC	whole life costing

4 Process and applications

COMMENTARY ON CLAUSE 4

Undertaking LCC of maintenance during the in use phase involves identifying the required maintain and renewal tasks, the associated timescales and costs. This clause provides an overview of how to integrate the process and typical applications needed to achieve specific outcomes in this undertaking. The guiding principles and instructions for undertaking the process are provided in Clause 5 and Annex A and Annex B, with informative worked examples relevant to these applications.

4.1 Integrating and standardizing the process: overview of the key stages

The objectives of this British Standard are based on integrating and standardizing the process, rules and methodology of the LCC in order to combine and optimize the maintain and renewal plans. The key stages of life cycle costing should conform to the process given in Figure 2.

4.2 Typical purposes and applications of LCC of maintenance

4.2.1 Purpose

The prime purpose of LCC of maintenance is to calculate the cost during the period of analysis; this should be done for specific outcomes, such as maintaining an acceptable level of performance of the asset(s), i.e. fit for the functional usage, including replacing the assets with like-for-like or modern equivalent.

The typical purposes and required outputs are:

- a) budgeting and obtaining funding for:
 - 1) annualized maintenance plans (maintain);
 - 2) LCR plans (over the agreed period of analysis: 1 to X years);
 - 3) asset depreciation/sinking fund requirements (if required);
- b) programmes of annualized maintenance and life cycle renewal works, including:
 - 1) prioritizing expenditure (e.g. based on conformity to obligatory compliance requirements and meeting defined fit-for-function maintenance standards, as applicable);
 - 2) funding and scenario modelling (i.e. do, defer and not do);
 - 3) planning the work schedule and timing, including expenditure monitoring, auditing and periodic updates;
 - 4) capturing feedback and lessons learnt to better inform future LCC programming.

4.2.2 Typical applications

LCC of maintenance may be used for the following applications:

- a) the evaluation of total facility options, functional or operational reviews, e.g. what level to maintain and invest in the asset (at whole building level or functional unit level);
- b) the evaluation of detailed options, (e.g. when to do repairs or refurbishment and when to replace, based on various forms of assessment), which can be done at elemental, system, sub-elemental and component level;
- c) the auditing, monitoring and due diligence reviews of the maintenance provisions on behalf of project funders (or review boards) and other stakeholder groups responsible for maintenance; or
- d) the use of LCC of maintenance information as part of a wider estate review covering analysis of relocation or consolidation strategies.

4.3 Fundamental attributes required in order to undertake the LCC of maintenance

When undertaking the LCC of maintenance, the approach and methodology should be:

- a) outcome driven: the plan should provide assurance that the LCC of maintenance achieves the stakeholder's specific needs and obligations/constraints so it should:
 - 1) be driven by the business needs of the organization and key stakeholders/end users;
 - 2) ensure that there is compliance with legal and organizational mandatory obligations;

- 3) avoid under- or over-maintaining assets (i.e. criticality risk-based maintenance);
 - 4) target investment and intervention decisions (i.e. what to do and when to do it, what to defer and what to abstain from doing);
 - 5) be suitable for the facility's intended functional usage and occupancy status (i.e. fit-for-function operational use, or appropriate to vacant space such as mothball regimes);
 - 6) support the delivery of a safe, secure, environmental and sustainable operation.
- b) holistic: the process should generate an integrated plan that combines the LCC of the annualized maintenance and the LCR programmes of works;
 - c) inter-operable: the process should have a standardized asset data structure and costing methodology used for LCC of maintain and renewal works that can be aligned to BIM models;
 - d) optimal: it should achieve the optimal balance between the maintain works and renewal strategies within the defined parameters set in the project brief;
 - e) systematic: the approach should sequentially cover the stages of the process within the life cycle;
 - f) transparent: it should provide access to information for the employer or owner to manage and make informed decisions;
 - g) flexible: it should accommodate and control changes in needs, resources, risks, condition status, performance requirements and budgets;
 - h) sustainable: it should be capable of being used, maintained and periodically updated. Also, it should provide evidence and input into wider environmental or sustainability assessment options.

NOTE More detailed guidance on asset management can be found in PAS 55 and ISO 5500.

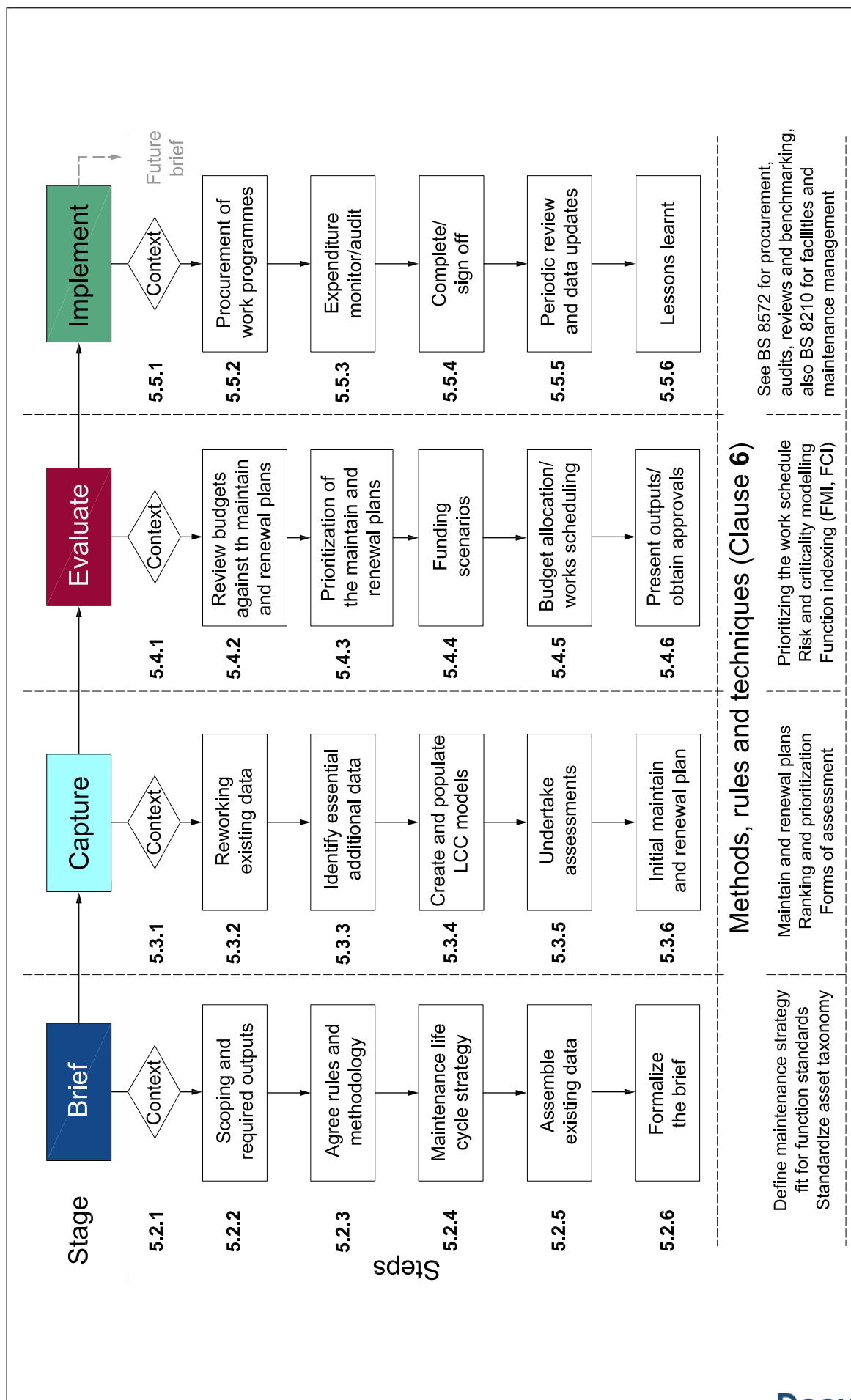
5 Guiding principles and instructions

5.1 Staged application of the integrated LCC process: overview of the key stages

Life cycle costing of the maintain and renewal works should follow an integrated process, which for ease of application has been split into four distinct, colour-coded stages, as shown in Figure 2 and in further detail in Figure 3.

The integrated LCC process is broadly summarized in 5.2 to 5.6, which sets out the steps involved in the LCC of maintenance during each stage.

Figure 3 Key stages and steps for LCC of maintenance



5.2 BRIEF STEPS

5.2.1 Context: understanding the stakeholder's LCC drivers and objectives

COMMENTARY ON 5.2.1

Capturing the stakeholder requirements for LCC has much in common with all other aspects of procuring services to support facilities, which are described in more detail in BS 8572:2011, Clause 5.

The main process of LCC has four stages: brief, capture, evaluate and implement, but the process sits within a broader organizational context, which the brief should reflect. The organizational context is variable, and the context should be checked iteratively for relevant changes.

The following aspects should be agreed between the employer and the LCC practitioner:

- a) the nature and purpose of the organization and their functional use of the building or facility;
- b) the vision, mission and objectives of the organization; these should be expressed in terms of how the asset is required to perform (i.e. maintaining the current performance or specific changes in future performance requirements);
- c) the responsibilities for the built assets in scope (e.g. management, ownership, asset stewardship, contractual accountability and the budgeting and funding of the works);
- d) the key stakeholders and relevant interest groups (both internal and external);
- e) the applicable statutory and legal requirements, and any other organizational mandatory requirements with which the organization needs to comply (e.g. mandatory security obligations for HMPS);
- f) the political, economic, social, technical and environmental conditions that impact on the activities of the organization (such as rationalization of the estate, and commitments to energy efficiency, CRC, etc.);
- g) the constraints, for example financial, human and other logistical resources, within which the organization has to operate (i.e. budget limits, resources and access/maintainability);
- h) the expected timescales (for the deliverables at each stage of the LCC process); any other specific considerations as defined at the offset or at subsequent stages of the LCC process (e.g. key business priorities like safety, customer experience, image, etc.);
- i) other specific LCC considerations as defined by the stakeholders (e.g. impact on customer experience, image and reputation, etc.).

5.2.2 Scope and required outputs: the project brief

Before attempting to undertake the LCC analysis, the purpose, scope and specific deliverables or outputs should be agreed in detail with the employer and any other key stakeholders who are to be involved in the process. The input into wider estate planning and other sustainability and whole life cycle costing assessments should also be agreed.

The following questions should be asked during the briefing stage to gain the agreements required:

- a) What is the LCC for?
- b) Who is the LCC for?

- c) What are the required deliverables or outputs? Such as:
 - 1) how the LCC of maintenance inputs to budgets, fund modelling or targeting asset investment plans;
 - 2) provision of a single LCC cash flow output for comparing a number of possible options;
 - 3) provision of a review of investment options, based on the costing of the specific intervention scenarios, and/or asset degradation models;
 - 4) an audit or due diligence review of specific plans, option studies, or related contractual obligations;
 - 5) any other outputs (as specifically defined by the employer).
- d) What is included and what is excluded from scope?
- e) Who is to undertake the LCC exercise?
- f) Are there any constraints that might affect the outcome of the LCC analysis?

Any potential project constraints and risks scenarios that might affect the outcomes should be defined (e.g. level and quality of asset data available, time to do LCC analysis, selected discount rate). The implications of these should be made clear to the employer to make sure these constraints are properly considered at the outset.

NOTE BS 8210:2012, Clause 7 provides guidance on issues affecting maintenance.

5.2.3 Agree rules and methodology

The process should be planned and agreed by all relevant parties as follows.

- a) The purpose and scope of the LCC analysis should be agreed and documented, specifying the number and nature of the assessment options (if required) and the number of iterations of the results (e.g. for setting and defending the budgets, scheduling and prioritizing of maintain and renewal plans).
- b) The maintenance life cycle strategy and any wider considerations (where relevant) should be clarified and documented (e.g. commitment to safety, performance, customer experience, improving resilience, achieving the lowest WLC and sustainability targets).
- c) The obligatory compliance levels and functional maintenance standards should be agreed and documented (i.e. the maintenance, inspection and monitoring regimes for the PPM, reactive maintenance and LCR interventions).
- d) The required project specific outputs should be specified (e.g. reporting format, structure of the maintenance and LCR plans for specific funding scenarios: maintain, refurbish, replace, etc.).
- e) The essential inputs should be specified, including the data collation rules and costing methodology (e.g. standardization of asset information to integrate the maintenance and the LCR plans).
- f) The methods, rules and techniques to be used and the extent of risk and cost sensitivity analysis should be agreed and documented (e.g. asset condition grading, ARS and PARL modelling).
- g) The completeness and accuracy of the available existing information required for the LCC analysis should be assessed.
- h) Any obvious gaps in available data should be identified and an agreement reached regarding how to capture the missing data (e.g. through asset verification surveys with or without a physical condition and a remaining life assessment survey).

- i) Budgets should be estimated and agreed (initially this may be based on historical maintenance expenditure, plus inflation). The duration of the budget should be selected, as follows:
 - 1) short-term budgets: to determine the costs of maintenance and interventions required within a year;
 - 2) medium and long-term budgets: to support the maintain and renewal plans adopted for a period exceeding one year.

5.2.4 Maintenance life cycle strategy

Before the end of the brief stage, the maintenance life cycle strategy should be defined for short and longer term maintenance requirements to support specific outcomes. Typically, the selection of maintenance strategies should take into account:

- a) minimizing whole life cycle costs;
- b) meeting statutory/legal and regulatory requirements;
- c) meeting asset performance targets (i.e. fit-for-function);
- d) managing and mitigating risks.

NOTE The maintenance life cycle strategy and service levels applicable to support the business needs (fit-for-function) are used to prioritize and cost the maintain and renewal plans, see 6.2.1 for more detailed guidance.

5.2.5 Assemble existing data

NOTE 1 There is likely to be an existing body of asset data (this could be derived from LCC in construction), which might be in paper or electronic format, or a mixture of the two. Where post occupancy evaluation or soft landings evaluation has been undertaken there is also relevant information available of actual, rather than predicted, performance in use, and there might be an indication of possible or desirable maintenance works necessary to improve performance.

The LCC data should be based on the existing asset data. An assessment of the accuracy and completeness of the existing data should be made in order to establish what additional information is needed to perform or undertake the LCC analysis and evaluation (see 5.3.2).

NOTE 2 The improved data needs to be fed back into the data set. This feedback is shown in Figure 2.

The value of asset data should be recognized because the relevant information is needed to enable informed decisions to be made. Asset data can be used to:

- a) create and retain an accurate maintenance asset register to use for scheduling and delivering the maintain and renewal plans;
- b) establish the physical condition and remaining service life of the assets, identify immediate repairs and to prepare short, medium and long-term asset investment renewal plans (i.e. major repair, asset refurbishment and replacement planning);
- c) establish the asset life expectancy and determine PARL data;
- d) obtain other forms of assessment data, where required (e.g. energy efficiency and associated improvement or upgrade plans due to obsolescence of technology, etc.).

NOTE 3 Examples of relevant datasets that might require maintenance and updating as deliverables are included in Figure 6.

5.2.6 Formalize the briefing

The employer or LCC sponsor should agree and formally document the plan and sanction the procedure before undertaking the next stage of the process.

The key deliverable of this stage is a formalized brief.

5.3 CAPTURE STEPS

5.3.1 Context

The context should be summarized as relevant to the capture stage of the process and communicated to those responsible for capturing data.

5.3.2 Rework existing data

Since capturing asset information might require significant time and money, this stage should be planned in advance and the extent of data collection should be evaluated on a case-by-case basis. The aim should be to rework as much of the existing asset information as possible, via a desktop study, to identify the specific quality of the existing data and the extent of the missing data required. Then the most cost effective method and form of collection (e.g. verification surveys) should be agreed between the relevant parties.

NOTE 1 Where LCC in construction has already taken place, there is a structured set of data available but it might still require updating, validation, verification and further data collection.

The asset information required to carry out maintain and renewal plans should be obtained and made available either for new construction or restoration of facilities (i.e. as built drawings and other relevant data in CDM files, operation and maintenance manuals and available BIM models).

NOTE 2 Attention is drawn to the Construction (Design and Management) Regulations 2007 [7].

If information is not available for existing facilities, the information should be progressively acquired in a systematic and structured manner and stored in controlled data files for a variety of subsequent usages.

NOTE 3 See 6.2.3 for the asset condition surveys and other forms of assessments/reviews.

The information required should describe the asset as a whole and its component parts (as agreed in the scope) and capture the salient asset details, together with its adequacy with respect to usability and value.

By standardizing and customizing the asset information data structure, the initial time and costs incurred to create an integrated asset database may be offset against several subsequent uses for the data, while also improving transparency and data quality.

NOTE 4 See 9.2.3 and Annex A for examples of relevant datasets which may need to be captured as a deliverable in this stage.

5.3.3 Identify essential additional data

As identified in 5.3.2, the completeness and accuracy of the existing data affects the scope of the capture stage. The rules and methodology set out during the brief stage should define the criteria for assessment of whether additional data is essential. This might require a gap analysis (for missing/incomplete data) and verification of the accuracy, completeness and currency of the asset information to undertake the LCC of maintenance.

The entire capture stage should be documented and streamlined to maximize the accuracy, consistency and efficiency of the following evaluate and implement stages.

5.3.4 Undertaking assessments

The following actions may be carried out at this stage.

- a) Specific asset information capturing surveys or other forms of assessment (as required), including identification and verification of the asset data in order to align with industry standard data protocols should be commissioned.
NOTE A worked example is given in 8.2 and Annex A, Figure A.1.
- b) The outputs from the assessments should be validated and data required for maintain and renewal planning should be compiled.
- c) A maintain resource/cost plan, reflecting the agreed functional maintenance standards or set PPM and proactive maintenance regime, should be undertaken.
- d) A clear list of maintenance renewal works required to bring the asset condition up to a level that conforms to the predefined functional maintenance standards (including cost) should be identified. The identified actions should subsequently be prioritized.
- e) In order to undertake a predictive LCR plan, the reference service life and PARL data on applicable assets should be obtained.
- f) The required appraisal options should be run through the LCC models and the analyses generated should be validated. If required in the plan, recommendations with accompanying justification should be made regarding appraisal options to take forward or reject.
- g) The additional asset information should be checked for quality and validated in order to generate the required maintain and renewal plans.

5.3.5 Data inputs into the LCC (maintain and renewal) models

The data required should be aggregated and input into LCC models that are suitable to produce or update maintain or LCR programmes, option appraisals and any other defined outputs required.

The following actions may be carried out at this stage.

- a) The project specific data, e.g. drawings, asset register, PPM regimes, condition surveys, operating and maintenance manuals, limit of renewal liability and any existing LCC models, should be compiled.
- b) Any recorded performance data, e.g. condition reports, defects lists and failure mode trend analysis, known maintenance/renewal works and logs of works carried out, including variations to scheduled works, should be compiled.
- c) Historical expenditure analysis and trends for maintenance works may be obtained (e.g. from the financial accounting systems or from the CAFM systems).
- d) The general information (normally publicly available, e.g. product data and manuals but also any benchmarking studies, or other relevant research as applicable, from specialist industry sources) should be collated.
- e) The LCC maintenance models should be set up to generate the required outputs, including customizing them to conform to the rules and methodologies specified in the brief stage. Then the model logic, data structures and formulae and any other relevant variables should be validated.
- f) The initial population of LCC models should use verified available data and the appropriate quality assurance checks and a gap analysis should be undertaken (leading to further data collection and population of the model, where required).

5.3.6 Initial maintain and renewal plans, including validation of the LCC models

The following actions should be carried out at this stage:

- a) the initial LCC reports should be produced and validated in the required format(s) to set up the basis for the evaluation process;
- b) the LCC plans and required output reports should be checked for quality and validated;
- c) the maintain and renewal plans and reports should be submitted as deliverables. If required, these should be modified and reissued to take into account any further comments made;
- d) the required LCC outputs and deliverables, should be agreed and documented in writing between the employer and other responsible person. This is the key deliverable for the capture stage.

5.4 EVALUATE STEPS

5.4.1 Context

The context should be summarized as relevant to the evaluate stage of the process and communicated to those responsible for evaluation, where a different group of people is responsible than for the capture stage of the process.

5.4.2 Review budgets against the maintain and renewal plans

The initial costings for the maintain and LCR plans, produced for the required LCC outcomes, should be compared against the budget limit set to identify the over- or under-expenditure from a short- and medium-term perspective and against differing funding streams (e.g. capital and revenue).

5.4.3 Prioritization of the maintain and renewal plans

The maintain tasks and the renewal actions required should be ranked in order of priority (taking into account timing/urgency, business and operational impact, health and safety implications, CRC and any other criteria set by the employer); more detailed guidance is given in 6.3.2 and Clause 10.

NOTE 1 Health and safety criteria affecting maintenance are given in BS 8210:2012, Clause 7.

The analysis of the initial maintain and renewal plans should be refined by prioritization and optimization methods, such as using asset criticality and risk/impact-based modelling techniques (see examples in Annex B). Funding scenarios should be identified and carried out in accordance with the rules and methodology defined in the brief stage (e.g. including "do nothing", "do something", "do the specific intervention" scenarios).

NOTE 2 Works may be prioritized by ranking them in accordance with assessments such as business criticality, see Annex B, Table B.1 to Table B.3.

NOTE 3 Relevant techniques might include FCI and risk-based prioritization techniques, to run "what if" budgeting and funding scenarios, based on predefined prioritized risks, impact scenario models.

5.4.4 Funding scenarios

The brief should define the appropriate criteria, scoring methods and any weighting to be used for fund scenario modelling during the evaluate stage; examples of funding scenario priorities might be as follows:

- Priority 1: strict compliant requirements, i.e. statutory/legal and mandatory/regulatory obligations;
- Priority 2: business critical maintenance, i.e. driven by business needs/high risk or impact of failure;
- Priority 3: non-critical maintenance, i.e. low impact and cost implications if run to failure;
- Priority 4: deferrable, i.e. do later where an asset has not yet reached an unacceptable performance.

5.4.5 Budget allocation and work scheduling

The following recommendations should be carried out at this stage:

- a) budgets for maintain and LCR works (i.e. total cost of maintenance) should be set and justifications made;
- b) fund modelling and target investment options should be developed, using prioritization and intervention assessment methods (e.g. "what if" scenario fund modelling and running intervention option studies);
- c) further input regarding issues involved in wider life cycle costing plans, as defined in the scope should be provided;
- d) all analyses should be compiled into a single deliverable (typically a report) that supports clear, costed recommendations regarding the proposed annual maintain and LCR plans, including the development of the short- and medium-term work scheduling, for final approvals by the employer.

5.4.6 Presenting the outputs and obtaining approvals

The validated outputs should be presented to the project stakeholders and any comments or challenges incorporated into the LCC of the maintain and renewal plans; this may include a number of iterations.

5.5 IMPLEMENT STEPS

5.5.1 Context

The context should be summarized as relevant to the implement stage of the process and communicated in the form of a written summary to those responsible for the implementation.

NOTE Further guidance on performance management is given in BS 8210:2012, Clause 8.

5.5.2 Procuring work programmes

Documents setting out the maintenance works programmes in the required format for tender should be developed, where required.

The implement stage may also include letting the contract(s) and managing the scheduling, delivery and monitoring of the annualized maintain and LCR programmes.

NOTE Further guidance on the procurement of work programmes can be found in BS 8572:2011, 5.11, 5.12 and Clause 6.

Actions required at this stage are likely to include:

- a) selection of the procurement route(s);
- b) decisions regarding the work to be carried out, to be deferred and not to be done, taking account of risks and constraints including budgetary constraints;
- c) preparation of tender documents, including developing the criteria against which bids are to be assessed;
- d) evaluation of bids against the assessment criteria and recommendations made for funding approval.

5.5.3 Expenditure monitoring and audits

Actions that should be carried out at this stage should include the following:

- a) development of the expenditure monitoring process and documentation/ audit on actual expenditure, works completion;
- b) monitoring the works against the contract, expenditure and anticipated performance level and periodically review against the LCC plan;
- c) checking the works to ensure that they meet performance requirements, in respect of both technical performance and time performance, as well as meeting any other specified performance requirements (i.e. quality assurance of the works done).

5.5.4 Completion/sign off and updates

Actions that should be carried out at this stage should include the following:

- a) procurement contracts(s) and signing them off on completion; and
- b) updating the asset database on project handover (i.e. updating the condition information with revised information to reflect works undertaken and completed, including revision of asset attributes, where required, for example, when specification of an asset has been changed by the works).

5.5.5 Periodic reviews and data updates

Actions that should be carried out at this stage should include the following:

- a) cost and performance analysis to feed back into future construction procurement and life cycle project works; and
- b) produce management reports to share salient information with project stakeholders and interested parties.

5.5.6 Lessons learnt

Actions required at this stage are likely to include improvement reviews to identify possible actions arising from lessons learnt to improve efficiency or value for money. A typical list of deliverables may include such a review.

5.6 Information for future LCC of maintain and renewal works

The process of implementation should generate useful information for future maintain and renewal planning, in particular the lessons learnt described in 5.4.6. The asset database should have been updated to reflect current performance as part of the works in 5.3, but there might be other information that should be incorporated into future plans.

NOTE 1 Examples of future maintenance planning might include:

- a) revision of standard rates, costs and time assessments for works;
- b) revision of preferred specifications or work methods; and
- c) identification of previously unsuspected requirements for maintenance works, identified in the course of opening up and undertaking planned works.

NOTE 2 For more detailed guidance on feedback data see BS EN 15331:2011, Clause 10.

6 Methods, rules and techniques for identifying, prioritizing and presenting the LCC plans

COMMENTARY ON CLAUSE 6

This clause provides guidance on the specific methods, rules and analysis techniques that can be used to create, cost and validate the annualized maintain plan and the LCR plan, in order to support the staged process, and to achieve the stated outcomes from the LCC of maintenance.

The purpose of the analysis described in these methods, rules and techniques is to quantify the LCC as an input into a decision-making process that determines programmes of work. Options, appraisal and recommendations for action are important inclusions. This clause broadly summarizes the key methods, rules and techniques required at each stage to support the process and produce the required outcomes.

It is important that all of these techniques share the same basic principles, i.e. that they are objective, evidence based and performed at an appropriate level of detail for each stage, as agreed in the scope.

Common methods of economic evaluations used for LCC are defined in BS ISO 15686-5 along with the basis for calculating the LCC. See Annex D for specific details on methods of economic evaluation.

6.1 Brief stage: methods, rules and techniques

6.1.1 Defining the maintenance strategy

A facility maintenance strategy should be established and used to determine the service life planning and maintenance requirements over the defined asset's life cycle. The strategy should identify and clearly state the function, performance and condition requirements of the applicable asset types and systems, as well as take account of relevant risks and constraints, i.e. listed buildings. This may also include a strategy to protect the property asset value. The maintenance strategy should be reviewed at regular intervals.

Whenever there is a significant change to the stakeholder's "needs", or asset performance requirements, it should be modified accordingly to enable the strategy to remain current.

A variety of techniques may be used to translate the maintenance strategies into maintain and renewal plans. Some of the commonly used techniques in the maintenance industry are:

- a) BFM service models, using business risk/criticality assessments;
- b) ARM assessments and other forms of durability assessments;
- c) condition-based maintenance regimes (e.g. thermal imaging and vibration analysis);
- d) RCM.

Irrespective of whatever technique is used, all maintenance works fall into one of the following categories:

- 1) absolute minimum: strictly compliant maintenance (i.e. statutory/legal and mandatory obligations);
- 2) optimal: fit-for-function critical maintenance, i.e. business needs/functional usage critical works;
- 3) discretionary: non-critical maintenance, i.e. do not do/defer or adopt a "run-to-failure" strategy;
- 4) vacate space strategy: i.e. apply mothball or decommissioning maintenance standards.

NOTE 1 A "run-to-failure" strategy is commonly used for non-critical assets where no interventions are carried out until failure occurs.

NOTE 2 See BS 8210 and PAS 55 that provide detailed guidance on how to develop the maintenance policy and strategies into practical maintenance service level and programme of works.

6.1.2 Functional maintenance standards and service levels

COMMENTARY ON 6.1.2

The maintenance industry uses PPM task schedules for routine servicing and maintenance activity, which usually rely on generic preventive tasks and task frequencies. Generic PPM maintenance can only be applied to similar maintainable assets operating under similar conditions and output requirements to those required in the maintenance schedules.

Maintenance schedules need to be customized to take account of the design, functional performance and other evaluation considerations to avoid under or over maintaining the assets or system types and to ensure full compliance with applicable legal and mandatory obligations. For example, an asset might operate over 24 hours for 7 days a week in certain situations, but only run for 8 hours a day in other situations.

NOTE 1 More details on functional requirements and maintenance standards may be found in BS 8572:2011, for example in Clause 8.

Functional maintenance standards should be used to determine appropriate service level programmes. Service levels may include performance targets for times to respond to failures depending on their priority rating or asset importance. Such service levels might distinguish between target times to make an asset safe, to temporarily resolve and to permanently resolve a service shortfall or failure.

Service level maintenance modelling (by function type) is a technique used not just to set up the initial maintain and renewal plans, but also to enable the employer to manage and control remodelling of future years' maintenance programmes of work. Maintenance modelling should be used to enable and:

- a) support the effective use of the existing assets, i.e. maintain and renewal, to a set standard;
- b) maximize the utilization of assets and the available resources and funding, i.e. value for money;
- c) impact positively on future asset LCR programming, i.e. improve capacity/reliability and asset performance/availability;
- d) provide control and flexibility (one of the key maintenance objectives, and maintenance levels may need to be controlled and varied to suit changes in terms of organizational needs or funding limits).

NOTE 2 Examples of service modelling techniques that allow such flexibility include:

- *proactive maintenance: inspections and trend analysis studies, i.e. proactive checks to avoid unscheduled maintenance;*
- *production-based maintenance: availability, reliability and maintainability analysis to optimize production for specific functional or industrial processes.*

The rules covering how to standardize the asset data structure, assess condition, how to grade condition, how to rate the priority of works and any other forms of assessment are dealt with in 6.1.3, 6.2.2 and 6.2.3.

6.1.3 Standardized the building information management: asset data structure and levels

Both the capture stage and the evaluate stage should have standardized rules for the asset information management to allow the necessary information to be captured at the level of detail necessary to meet the required outputs. The required outputs should be used to determine the criteria and rules for the condition grading and priority grading methods. The assessments and surveys undertaken can subsequently be used to generate the required outputs.

A clear asset information and cost breakdown structure covering the portfolio, estate, buildings, location, function, space and zoning, etc. and how this links to the asset maintenance register should be provided.

NOTE 1 For an illustrative worked example of a standardized asset information and cost breakdown structure see Annex A.

An assessment of the age and the remaining economic life of the asset information should be carried out to identify timing and costs of interventions.

The level of detailed analysis needed between the capture stage of the process and the evaluate stage should be made clear. For example, which stage is expected to generate costed options for review and which stage does asset criticality modelling, risk assessment and rating need to be applied.

The combination of condition, remaining life, criticality/priority, timing and cost should be used to generate the renewal programme and inform the CAIP.

NOTE 2 It has been assumed in 6.2 that the outputs of the capture stage of the process include a range of priced options of required works with a recommendation on works to be undertaken, which is reviewed against budget and timescales during the evaluate stage of the process.

The maintain and renewal plans should be structured in accordance with the example of a typical breakdown of the building information hierarchy and applicable maintainable asset types, as given in Annex A. In order to assess the cost of the identified LCC options and assessment, the methodology and record source of information should be identified, as well as to ensure interoperability with BIM.

NOTE 3 Clause 7 covers what costs to include and methods of improving the accuracy and cost certainty.

NOTE 4 Further information on standardized rules or the measurement of buildings and maintenance works is given in RICS NRM 1 [1].

NOTE 5 PAS 1192-2 specifies information management for the capital/delivery phase of construction projects using BIM.