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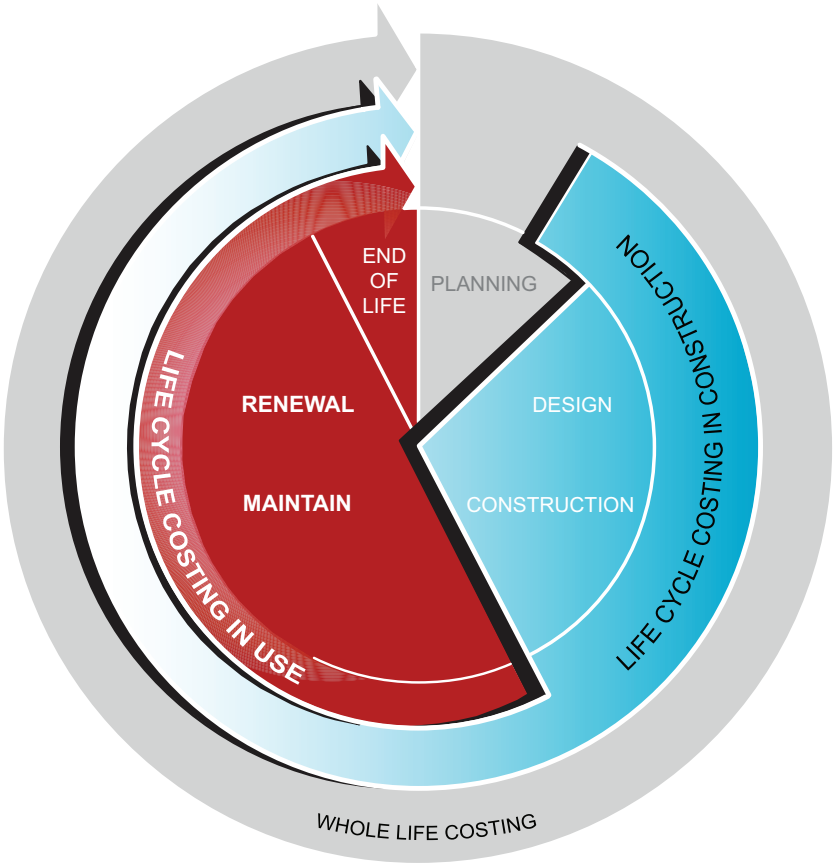
Guide for life cycle costing of maintenance during the in use phases of buildings



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Contents

Summary of pages
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;

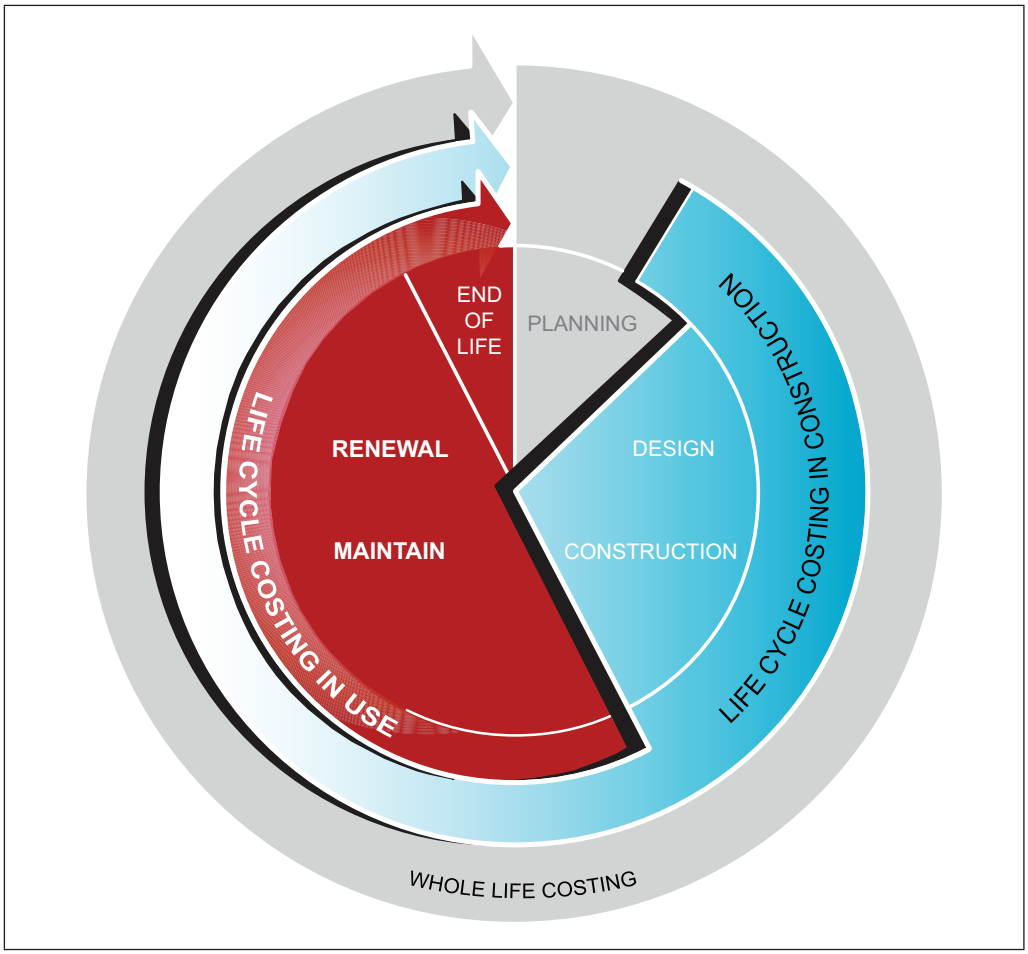
*NOTE In this British Standard the term "in use" (see **3.1.26**) covers the life cycle period after handover and prior to decommissioning; this is highlighted in Figure 1, which also shows its relationship to other cost headings within whole life costing.*

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;

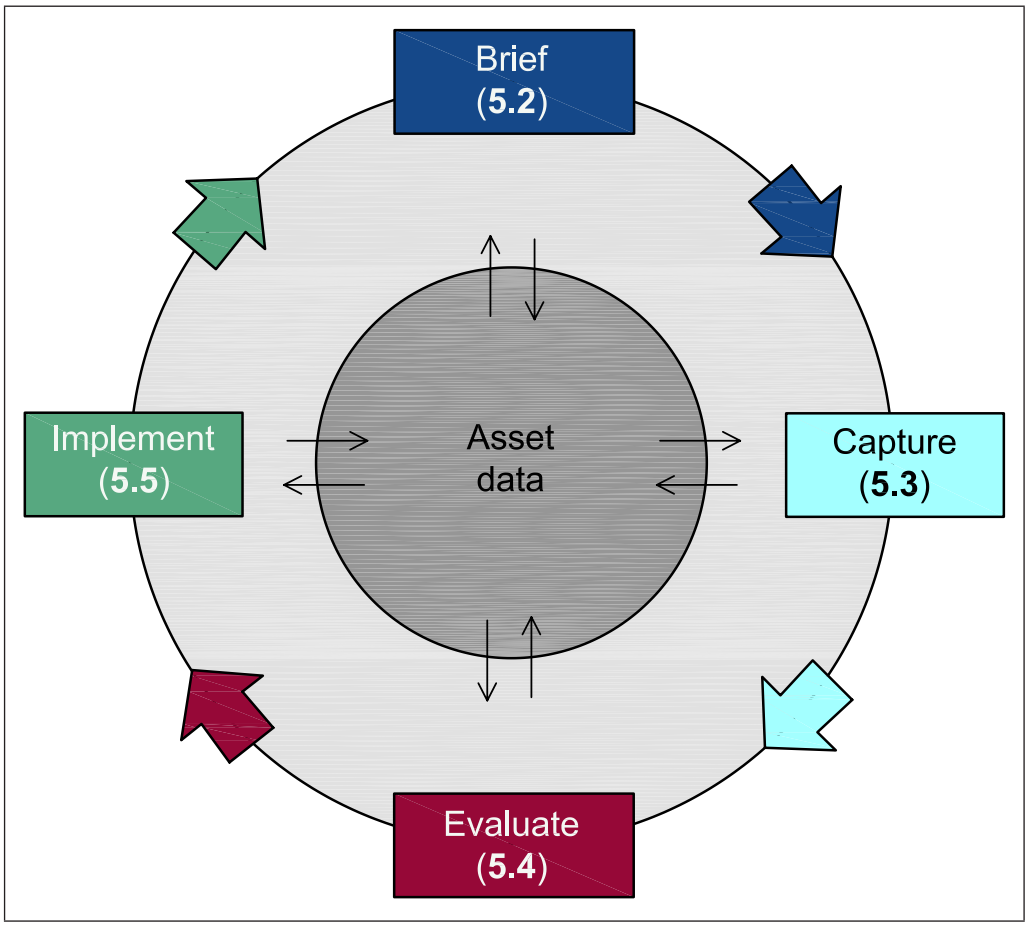
2) capture: to record the relevant data required to generate and update annualized maintenance (maintain) and/or life cycle renewal cost programmes, based on various forms of assessments;

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, assembley 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 m^2 and cost per m^3 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.

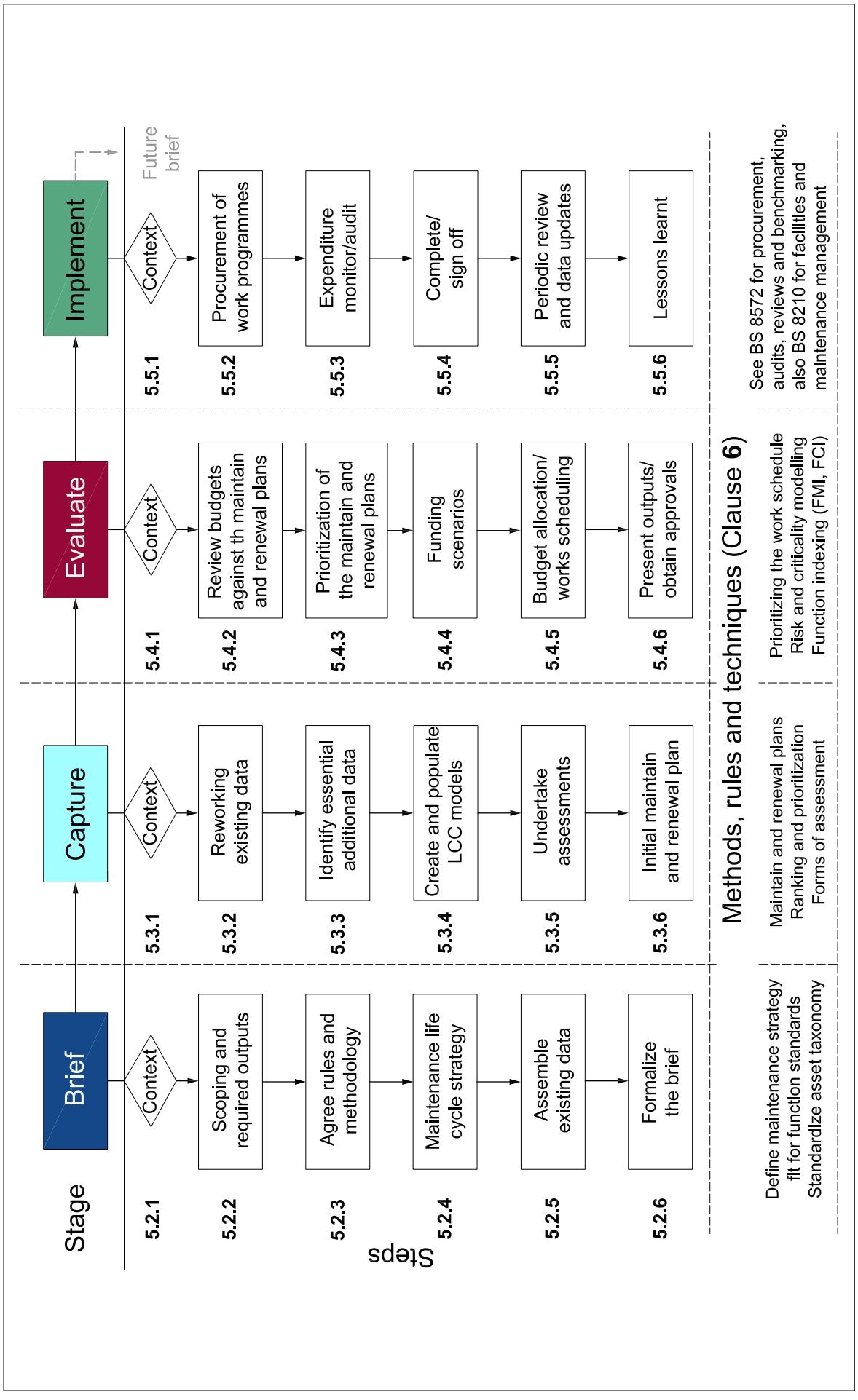


Figure 3 **Key stages and steps for LCC of maintenance**

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.

6.2 Capture: methods, rules and techniques

6.2.1 Maintain and renewal plans

The maintain plan and the renewal plan should be intrinsically linked; together they provide the basis for determining the total LCC of maintenance. These plans provide the management tools for scheduling the planned maintenance activities and forecast asset renewal interventions over time, as well as making provision for unscheduled activities and risks: identifying and allocating resources for the implementation of strategies predetermined by the owner, or responsible parties, of the facility or constructed asset.

The following should be addressed when formulating maintain and renewal plans:

a) the composition of the facility or functional unit, in terms of locations, spaces, rooms (at level 1 and 2 assets);

b) the applicable maintainable assets types, in terms of elements, sub-elements, components that create the asset hierarchy and taxonomy when linked to the facility breakdown structure (level 2 and 3 sub-assets);

c) the criticality analysis of the applicable maintainable assets within the facility maintenance strategy defined (i.e. asset importance and risk ranking, see **6.2.2**);

d) the definition of the maintenance tasks to be performed for each sub-element or component;

e) the current condition and remaining life of the applicable maintainable assets and the identified actions that are required to bring the assets back to, and maintain them at, the predetermined functional standard;

f) the available resources for maintenance (from the employer and maintenance support and supply chain).

Commonly used approaches for optimizing maintenance are outlined in **6.3.1**. These can be used to identify, in a structured way, planned and proactive tasks and the frequency of such tasks needed to formulate the maintenance plans to achieve the overall objectives and defined LCC outcomes.

6.2.2 Risk ranking: asset importance and condition grading methods

Condition grading should be used to define the physical condition status of existing assets and the importance and urgency to identified works, as indicated in **6.2.3** and in Table B.2.

NOTE 1 Priority of works grading may also be used as part of the condition assessment process, for example:

- *Priority 1: urgent;*
- *Priority 2: essential work;*
- *Priority 3: desirable work;*
- *Priority 4: long-term work.*

Condition grading may also be expressed in terms of the severity of any deterioration, for example grading the constructed assets:

a) as new: in required operational condition, having only minor defects with no significant effect on asset attributes either visually or functionally; requires only relevant PPM. There is no history of failures.

b) serviceable: operational but exhibiting some signs of deterioration, minor defects or damage while not having reduced functionality;

c) major repair required: operational, but moderate deterioration, defects or damage having some loss of functionality; there is a need for repair to reduce costs of failure, adverse business/operational impact;

d) replacement advised: as inoperable or unsafe, obsolete, severe deterioration, defects or damage having significant loss of functionality or which are close to failure.

*NOTE 2 For guidance on risk prioritization methods used for LCC of maintain and renewal works see **6.3.2**.*

NOTE 3 Examples of more detailed condition grading and priority rating methods are included in Annex B.

NOTE 4 More detailed guidance on condition grading and deterioration is provided in BG 35/2012 [8].

6.2.3 Assessing the performance of an asset

Detailed asset information should provide the basis for evaluating the effectiveness of the maintain plan and forecasting the LCR plans. The assessment of PARL may be used as the basis of the LCR plan, along with other relevant failure mode analysis data, if available. The expected costs of required works may be allocated during the data capture stage or the evaluate stage.

To maximize the value of the assessment, the data capture process should cover, as a minimum:

a) maintenance works to rectify breaches of statutory or legal compliance;

b) works required to maintain assets for the agreed period to the agreed service level;

c) works required to meet energy efficiency standards or other employer-usage definable performance requirements;

d) for each work, the determined associated time profile of when the work occurs or recurs;

e) the associated time profile of activities determines when the cost occurs (or recurs); this applies whether it is a cost benchmark or a detailed cost analysis;

f) costs that might be fixed or variable over time, including the recorded assumptions made in generating the cost profile, such as the source of reference service lives, and the basis of cost estimates (e.g. experience, quotations or supply only rates).

NOTE 1 Examples of FCI assessments are given in Annex B: Figure B.2, Figure B.4 and Table B.3.

NOTE 2 Examples of sensitivity analysis of life cycle replacement are included in PD 156865.

6.2.4 Other assessments

Other assessments may be used to identify other works for which available funding might be allocated. These might include works from the following categories:

a) health and safety: such assessments should include any issues of non-compliance and or any legislation that might have triggered the maintenance task;

b) environmental: assessments and studies regarding noise and pollution, for example, should be reported as a subset with a clear narrative describing the basis of the assessment and separately tabled corrective costs;

c) energy efficiency: assessments may be shown per asset (e.g. boilers and pumps) or spread across the buildings at portfolio or system level (e.g. works relevant to mechanical and electrical services or building cladding installations);

d) space utilization: such assessments might simply be an additional line of analysis to the main assessment, provided the employer has agreed a basis for the measurement in the initial brief. Space utilization assessments should be provided in summary form either by floor, department or building;

e) security: such assessments might cover criteria for access control or CCTV coverage, secure standards for windows and doors or specific zoning requirements. Reports and analyses should be shown under pre-agreed headings relating to security categories rather than by asset group or facility;

f) functional suitability: such assessments should show asset costs by specific function.

NOTE Other forms of assessments might also include accessibility, asbestos, resilience and capacity assessments, see [9] and [10].

6.3 Evaluation: methods, rules and techniques

6.3.1 Prioritizing and scheduling the maintain (PPM) and the renewal plan of works

PPM is a scheduled maintenance intervention that is undertaken to prevent asset breakdown and failures. Similarly lifecycle renewals are forecast to take place to a schedule.

When evaluating the scheduling of maintain and renewal works the following should be taken into account:

- Why do we need to do the PPM tasks or the asset renewal interventions?
- What maintain and renewal works needs to be done?
- When do these works need to be done?
- How the work can be undertaken safely and efficiently? i.e. accessibility/ maintainability.
- How much do the works cost, including associated works and localized adjustments?
- What works must be done – if funds available are not sufficient to cover all the works identified?

6.3.2 Risk criticality ranking and prioritization techniques

The results of prioritization techniques may be used to determine whether maintenance should or should not be carried out and can be used to rank the maintenance activities and replacements in order of priority.

*NOTE 1 Further general guidance on risk in procurement of services can be found in BS 8572:2011, **5.10**.*

Risk criticality ranking and prioritization involves the assessment of business risk, which comprises two combined but separate assessments, based on the following:

a) business criticality assessments; and

b) life cycle assessments (i.e. what needs to happen and when).

The criteria used for business critical assessments should provide the basis for ACR from a business focused maintenance perspective.

Typical examples of business criticality assessment criteria are as follows:

1) legal and statutory;

2) environmental;

3) operational;

4) sustainability;

5) reputation;

6) resources (e.g. cost/manpower).

Legal and statutory is a universally used criterion for compliance, whereas the other criteria should be selected to suit the specific business critical drivers or risk factors (e.g. security in prisons, customer experience in hotels).

NOTE 2 For an example of applying a business criticality assessment method in order to plan and prioritize the minimum and optimal PPM service levels, see Annex B.

The life cycle assessment method should define how the asset is required to perform over the defined service life or period of analysis. The performance gap between the current asset performance (from surveys, historical failure analysis and maintainability studies, etc.) and the future performance of an asset identifies

the predicted interventions (renewals) and life cycle investment required. Other factors should also be taken into account when assessing assets in scope, such as current asset condition grading and age, PARL and service life deterioration and degradation profiles.

The PARL is commonly assessed by comparing the age of installed assets against the remaining service life for each asset type, but the calculation is dependant primarily on salient asset information being captured and used to inform the intervention. If a PPM and inspection and condition monitoring regime are not in place, assets might fail sooner than expected. Condition factors are used in the determination of PARL and intervention thresholds in conjunction with asset criticality ranking determine when asset repairs and replacements are triggered.

NOTE 3 For an example of how to use PARL and ACR to govern the timing of renewal interventions using triggers for critical assets, see Annex B, Figure B.2.

6.3.3 Function condition indexing

*COMMENTARY ON **6.3.3***
FCI is based on the identified actions arising from condition surveys and PARL assessments, expressed as a ratio to the capital reinstatement value of CRV. This provides a visually powerful and easily understood index of the asset condition. Examples of the FCI formula and FCI grading methods are provided in Annex B.

In this form of indexing, the total cost of the identified LCR works are compared with the CRV, or rebuild costs. This gives a function investment index for the funding levels required to bring the asset up to or to maintain the asset to an agreed standard (e.g. condition B). By running funding scenarios the impact of funding, or not funding, investment can be profiled and the positive performance or deterioration of the asset over its life cycle can be visualized and understood.

Running "what if" scenarios using FCI with risk-based modelling techniques may be used to provide a basis on which to target investment spending. Such modelling techniques should be based upon identified operational risks and liabilities, business criticality assessments and other considerations versus funding level scenarios over various time horizons.

6.3.4 Understanding the impact of funding, or not funding, maintain and renewal works

Where the recommended works or the maintenance works required to meet the agreed standards exceeds the budget or funding available in a year, work might need to be deferred to later years. In order to properly inform this decision-making process, a risk-based methodology should be employed. The combination of asset condition, priority, risks, timing and cost should be used to generate the maintenance programme and renewal plan.

*NOTE For more detailed guidance on making more informed decisions see Clause **10**.*

6.4 Implement stage: methods, rules and techniques

6.4.1 Procurement of maintenance works programmes

Procurement documentation should be suitably detailed for the maintenance works and address issues such as the following:

a) scope of maintenance works;

b) special restrictions, e.g. escorting and access provisions;

c) management and design requirements;

d) quality and performance standards;

e) risk and uncertainty;

f) obligations aligned to those in the service contract or project agreement;

g) other issues specific to the works concerned.

NOTE 1 Generally, for the LCC of maintenance, the procurement route is on the basis of best-value tenders that requires the tendering conditions to quantify issues of value, timing and performance as well as cost. Within the public sector, there are specific rules associated with most economically advantageous tenders (e.g. MEATs, see OGC Guidance on the Competitive Dialogue Procedure [11]).

*NOTE 2 Detailed guidance on procurement strategy can be found in BS 8534 and BS 8572:2011, Clause **6** and guidance on vetting service providers can be found in BS 8572:2011, Clause **7**.*

6.4.2 Deferred maintenance works

Over the monitoring period, the timing of some works might change if the asset remains fit for purpose and operates as required. In these circumstances the reason for such deferral should be clearly identified, agreed and recorded. The resulting under-spend should be included in a revised budget report.

If maintenance works are deferred due to a change in business priority (e.g. other works are undertaken instead), any impacts that the deferral could have on the operating performance or safety of the asset should be investigated. Where adverse effects are identified, the deferral of the works should be reconsidered.

The consequential impact should be applied to future similar planned works, so expenditure, budgets and programme can be re-assessed. This process should be applied to works of a similar nature to ensure real-time data is utilized to maximum effect within a business.

6.4.3 Unforeseen maintenance works

When unforeseen maintenance works need to be undertaken due to sudden or unexpected failure, a clear summary of circumstances and remedial actions taken should be recorded and a reasoned request for additional funds made. The resulting over-spend should be included in a revised budget report.

If works are accelerated due to a change in business priority (e.g. to reflect company policy), acceleration should not have an adverse impact on operating performance or safety.

6.4.4 Amendment of basis of costs for future works

The incorporation of real time replacement cost data can improve the accuracy of cost forecasting and control. Similarly, a review of completed works might identify planned works that were not required in practice, allowing future occurrences to be omitted or replacement frequencies within the model to be amended.

Key data should be collected and recorded during the delivery of life cycle work, for review and incorporation into future models, estimates and forecasts. This data should include:

a) construction cost rates;

b) percentage of on-costs, overheads, profit and risk;

c) out of hours work allowances;

d) life cycle works management costs;

e) scale of replacement percentages;

f) replacement years;

g) programme data, duration of works.

6.4.5 Maintenance cost reporting, analysis and benchmarking

The guidance on the rules, methods and techniques should be used for standard maintenance cost reporting, analysis and benchmarking in accordance with **7.5.3**.

NOTE 1 The BCIS Standard form of cost analysis [4] and the RICS NRM 1 [1] both give specific guidance on cost planning, reporting, analysis and benchmarking.

*NOTE 2 Data formatting is important to ensure the maintenance costs can be interoperable with BIM, see also Clause **8**.*

7 Maintenance costs for inclusion or exclusion and how to express them

*COMMENTARY ON CLAUSE **7***
This guide provides a standard cost data structure for undertaking LCC of maintenance that is aligned with BS ISO 15686-5, PD 156865 and the RICS NRM 1 [1].

*Cost guidance and instructions along with cost mapping to industry accepted maintenance cost categories and naming and coding conventions are provided in **7.1.2**, Figure 4 and Table C.1 and Table C.2.*

7.1 Cost data structure for LCC of maintenance and the links to wider LCC/WLC

7.1.1 LCC plan scope

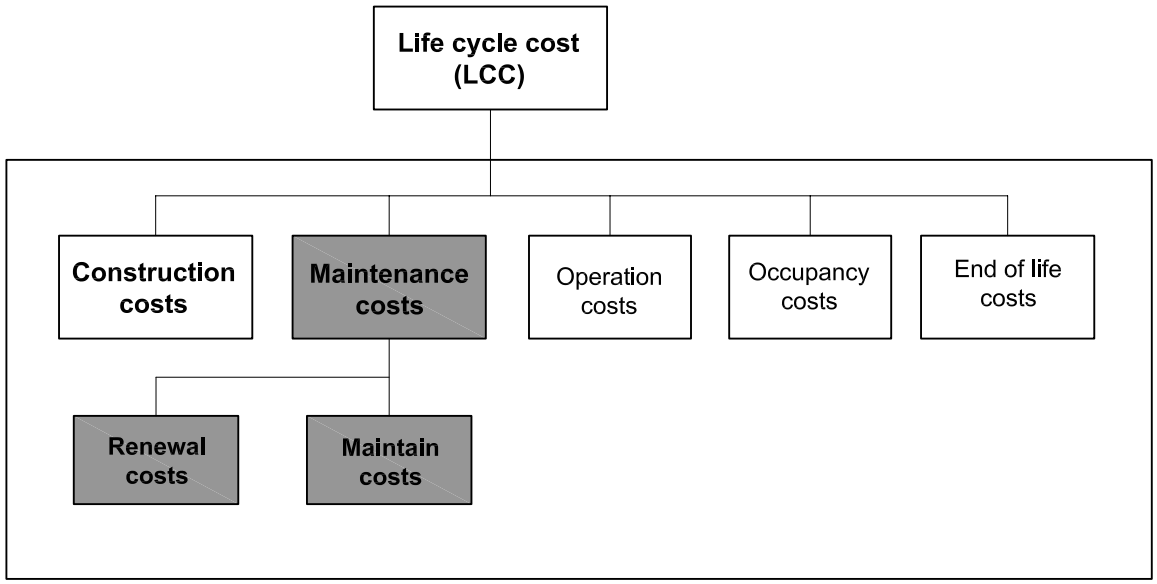
Before an LCC plan is undertaken, agreement should be reached as to its precise scope, i.e. what relevant costs are to be included, or excluded, and how they are to be expressed.

7.1.2 LCC data structure

Figure 4 provides a cost data structure for life cycle costing for maintenance and also clarifies which costs should (under normal circumstances), be part of it. It also indicates which costs are part of a wider economic evaluation, i.e. WLC, but may be included for making informed decisions (see Clause **10**).

Where LCC is to be reported as a part of an integrated assessment of building sustainability in accordance with BS EN 15643-4, the costs should be mapped to the data structure in Table C.3.

Figure 4 **Maintenance costs (renewal and maintain), as part of the wider LCC**



NOTE 1 Major repair and replacement costs are commonly known as renewal costs, excluding the routine PPM, minor repairs and reactive unscheduled maintenance. LCR cost is part of the maintenance cost element, as defined by the BS ISO 15686-5.

NOTE 2 Sometimes the operation, occupancy and end of life costs can be included within the LCC of maintenance study.

NOTE 3 Table C.1 shows the cost mapping to cross reference the cost data structure in this British Standard with PD 15686 and BS ISO 15686-5 cost structure, including links to the PD 156865 operations and occupancy elements.

NOTE 4 Table C.2 provides a cost mapping of the maintenance cost categories and codes in this standard to the ITOC and the RICS service charging cost structure.

NOTE 5 This figure is based on BS ISO 15686-5:2008, Figure 2.

7.2 Constituents of maintenance costs

The purpose and scope of the employer or key stakeholder's requirements (brief) should define the precise scope of costs to be included in the LCC estimates and cost plans.

Maintain and renewal costs to be included or excluded are to be defined as applicable using Table 1 and Table 2; these provide a common cost structure to facilitate more robust cost analysis and benchmarking.

Table 1 **Key constituents of maintenance work cost estimates and cost plans** *(1 of 2)*

Cost estimate	Key constituent
1) Base maintenance works estimate	Total of the maintenance works estimates, as agreed in scope: • maintain cost: planned, reactive and proactive tasks; • renewal cost: major repairs, replacement and redecorations; • can include grounds maintenance (cost separately if required as optional).
2) Maintenance works estimate (including on-costs)	1) plus on-costs, e.g. maintenance contractor's management and administration and overheads and profit.

Table 1 **Key constituents of maintenance work cost estimates and cost plans** *(2 of 2)*

Cost estimate	Key constituent
3) Base maintenance cost estimate	2) plus total of employer-definable costs including: • consultant and specialist fees; • other employer-defined maintenance related costs; • asset information cost: registers and assessments.
4) Total maintenance cost estimate	3) plus risk allowances and inflation (discounted if required).
5) Discounted total maintenance cost estimate	4) adjusted by selected discount rate over the period of the study.

[A)] VAT assessments and specialist taxation and incentives are normally excluded.

NOTE 1 The constructed asset includes new construction or refurbishment and adaptation works to an existing building or facility. The quantification of the initial construction or renovation of a building or facility, as well as the demolition of buildings and facilities, is dealt with as part of the capital building works.

*NOTE 2 The cost categories and definitions for estimates and cost plans and those aspects of operation cost that relate to carrying out the maintenance, e.g. employer's property management costs of asset registers and assessment data, overseeing the maintenance are given in Clause **7**. The wider aspects of life cycle costing, i.e. operation and occupancy and WLC are excluded. Notwithstanding this, some of these aspects can be included with the maintenance works, if required by the employer's scope of works, although it is advisable to clearly identify this.*

NOTE 3 For the international definition of costs, constituent maintenance and the wider life cycle costing (including income and other non-construction related costs and externalities) see BS ISO 15686-5.

Table 2 **Cost breakdown structure for maintenance and wider LCC** *(1 of 7)*

Cost category	Maintenance cost category definitions
Asset information cost	*Information required to manage and optimize the annualized maintenance plans (maintain) and service life planning the timing/scheduling of the life cycle (renewal) programme of works*
Asset maintenance registers [A), B)]	A record or inventory of all building and engineering services and maintainable assets applicable for annualized maintenance and service life planning of LCR works, agreed in the brief stage. Costs to include: • asset maintenance registers, i.e. initial production and subsequent updates; • identification of applicable level of assets required for the LCC of maintain or renewal plans; • verification for completeness and capturing specific assets details, e.g. make, model, capacity, rating and other asset details as required; • asset tagging and bar coding identification if required (optional); • relevant maintenance information available for the LCC maintain and renewal programming; • relevant as built/computer-aided design drawings/room data sheets and object BIM-related information.

Table 2 **Cost breakdown structure for maintenance and wider LCC** *(2 of 7)*

Cost category	Maintenance cost category definitions
Condition surveys, reports and the PARL asset assessment data [C]	Assessment of the applicable building or constructed asset's current age, condition grading and PARL (compared against accepted reference RSL and factoring methods), agreed in the brief stage. Included costs for initial, periodic and specialist asset surveys should include: • stock condition surveys; • PARL assessments; • inspection/monitoring regimes, e.g. site tours, thermal imaging and vibration analysis; • specialist surveys, e.g. historic listed building; • other costs, as applicable. Excluded costs for initial, periodic and specialist asset surveys: • inspections carried out as part of the maintenance contract work (included in the maintain regime); • general inspections and audits commissioned separately by or on behalf of the employer (these costs are to be included in the employer's definable maintenance management activities).
Other forms of assessment (optional) [D], [E]	Assessment of wider asset investment planning based on functional and performance considerations and other predetermined requirements (if required as part of the LCC plan), as agreed in the brief stage. Included costs for other forms of asset assessment may be: • capacity forecasts/resilience assessments; • energy efficiency reviews (EPC, CRC resulting in energy efficiency improvement work); • Equality Act 2010 [9] considerations and other regulatory risk surveys; • space utilization; • functional suitability (optional); • wider sustainability implications (to be agreed in scope); • other costs as applicable (if agreed in scope).
Maintain cost	Planned, reactive, and proactive maintenance costs (including on costs and employer costs)
Planned maintenance, including minor repairs and asset subcomponent replacement costs (up to set limit of liability)	Scheduled replacement of parts and scheduled servicing, maintenance and repairs to components and associated making good and minor redecorations including PPM or RCM, proactive maintenance. Included costs : • labour (annual man hours for scheduled or PPM programmed work); • subcontracted and specialist scheduled or PPM works; • consumables, plant and equipment, sundries; • premium costs for out of normal hours of working. Plus on-cost items, if it is a PPM-only contract. [F] Costs include both work with a frequency of less than a year and a cycle of more than a year, expressed as an AEC. Excluded costs: major repair, refurbishing replacement costs, *i.e. included in LCR cost* (*see LCR cost for guidance on definitions of "major" and "minor" replacement).*

Table 2 **Cost breakdown structure for maintenance and wider LCC** *(3 of 7)*

Cost category	Maintenance cost category definitions
Reactive, responsive and corrective maintenance, including unscheduled component replacement, repairs costs	Allowance for unforeseen or unplanned maintenance arising from early failure, inappropriate use, etc. and associated making good and minor redecorations. Included costs: • labour (man hours for reactive first line work); • subcontracted and specialist reactive cover; • consumables, plant and equipment, sundries; • premium costs for out of normal hours of working. Plus on-cost items, if it is a reactive cover only. [F)]
Proactive maintenance provision, including planned inspections and monitoring and site management procedures	Allowance for proactive maintenance provision. [G)] Included costs: • PIB; • tours of plant rooms and critical systems; • targeted monitoring, e.g. energy focused (BMS controls); • employer definable maintenance related activities; • others (as defined in scope). Plus on-cost items, if the proactive cover is costed separately. Also, the cost of works resulting from inspections should be included in reactive maintenance.
Maintenance contractors on costs and risk allowance, consultant fees and inflation, taxation, etc. [F)]	Included costs for planned, reactive and proactive: • maintenance contractor's management and administration; • maintenance contractor's overhead and profit; • contractor's consultants' fees and specialist works costs; • risk, including commercial/other considerations; [H)] • inflation/deflation to bring current cost estimate to the start date of the costing exercise (year zero), inflation during the period of the costing exercise should be covered by discounting using stated method of economic evaluation; • taxation and incentives (if required to be in scope), e.g. VAT normally excluded for costing.

Table 2 **Cost breakdown structure for maintenance and wider LCC** *(4 of 7)*

Cost category	Maintenance cost category definitions
Renewal cost	Planned major repairs, refurbishing, replacements, redecorations, plus specific improvements and upgrade works, e.g. improve energy efficiency (if in scope)
Major repairs [I)] and replacements, redecorations	Scheduled major repairs, refurbishing and replacement of major system elements and components (within set limits of liability) and associated making good and minor redecorations. Specific asset improvements and upgrades applicable to achieving certain LCC outcomes or as a result of obsolescence/technology, etc. Costs to include: • repair and replacement of major building assets and plant and equipment items; [J)] • access and location adjustment factors; • travel, transport and subsistence costs; • facilitating works; • pre-inspection costs; • landfill tax and income/disposal costs; • maintenance contractor's management of the works and specialist's on-costs; • maintenance contractors on-costs; • costs and income from disposal of replaced components and parts, where applicable; • any life cycle fund management and the employed direct labour where those costs are considered to be direct overheads to the works. On-cost items, temporary works, access costs, out of hours premium, design and commissioning costs, in connection with replacement should also be included if applicable.
Redecorations	Scheduled redecoration works to existing buildings. [K)] This excludes decorations carried out in connection with maintenance or replacement work. Plus on-cost items, if separate contracts.
Refurbishment and adaptation [L)]	Scheduled refurbishment, improvement, adaptation and upgrades during the in use period of analysis. If in scope, costs include: • improvement works to buildings or parts thereof; • refurbishment of whole installations including associated works; • upgrade works, e.g. carbon reduction/Approved document L of the Building Regulations 2010 [12]; • renewables, e.g. CHP, solar panelling; • alterations and churn costs. This excludes refurbishment and major adaptation carried out as part of initial construction or fit out works, or a subsequent refurbishment project, i.e. dealt with as part of construction works.

Table 2 **Cost breakdown structure for maintenance and wider LCC** *(5 of 7)*

Cost category	Maintenance cost category definitions
Maintenance contractor's on-costs and risk allowance, fees, taxation, inflation allowances [F)]	Costs to include (for planned, reactive and proactive maintenance works): • maintenance contractor's preliminaries and administration; • maintenance contractor's overhead and profit; • consultants fees and specialist works costs; • employer definable maintenance related works (if in scope); • risk including commercial/other considerations; [H)] • inflation; • taxes, e.g. VAT normally excluded for costing.
Employer costs	Employer definable maintenance costs in managing the work and other costs required to be included by the employer, or project sponsor, as agreed in scope
Employer's definable management and administrative costs	All employer cost involved in managing and administration of the maintenance of the facility or its parts. Included costs: • supervisory staff, e.g. building maintenance supervisors, maintenance managers; • professional staff or consultants, e.g. architects, engineers, surveyors; • clerical and administration staff; • any relevant general and regulatory inspections and surveys commissioned by or on behalf of the employer; • staff engaged to maintain the facility, e.g. care-takers and other responsible persons; • staff costs should include wages, expenses, overtime, insurances, administrative support, overheads, accommodation, supply of uniforms, travel costs, pensions. Excluded costs: a) contractor's management of the works and of any life cycle fund covered by the contractor on-costs (included in annualized maintenance, grounds maintenance or periodic LCR works); b) inspections carried out in connection with pricing the items of maintenance works (included in annualized maintenance, grounds maintenance, periodic renewal works); c) dilapidation surveys or remaining life surveys carried out in connection with disposal of the facility (included in employer definable maintenance costs outside of normal maintenance work). Condition surveys and other forms of assessment data (included in asset registers and assessment data) are included in a separate asset information cost section in this table.

Table 2 **Cost breakdown structure for maintenance and wider LCC** *(6 of 7)*

Cost category	Maintenance cost category definitions
Other employer defined costs	Other employer definable costs required to be included by the employer, as agreed in scope
Other employer definable costs, included in the LCC analysis	Other employer definable [M)] cost and benefits required to be included in the maintenance LCC plan. Included costs, for example: • mothball maintenance; • operation costs; • occupancy costs; • end of life liabilities, recycling, salvage, etc; • hand-back contractual obligations; • capital allowances; • asset depreciation/write down; • other elements (to be defined). This is not an exhaustive list, simply a guide.
Other (optional) LCC	Operation, occupancy and end of life costs, plus whole life costs (if part of wider study)
Operation costs	As defined in PD 156865, if formally requested by the employer. Operational costs may include the following: • cleaning; • utilities; • administrative costs; • property management of operation and occupancy; • staff engaged in servicing the occupiers; • waste management/disposal; • overheads: insurances; • taxes (as applicable); • security (manned and patrols); [N)] • employer-definable costs.
Occupancy costs	Occupancy costs may include the following: • ICT and IT services; • helpdesk function; [O)] • catering and hospitality (equipment); [P)] • security equipment maintenance; [N)] • vending machines; [Q)] • occupants' furniture, fittings and equipment; [R)] • employer-definable costs.

Table 2 **Cost breakdown structure for maintenance and wider LCC** *(7 of 7)*

Cost category	Maintenance cost category definitions
End of life costs	End of life costs, where not included in employer-definable maintenance costs: • disposal inspections; • demolition; • reinstatement to meet the contractual requirements; • employer-definable costs.
Whole life and other wider sustainability considerations (see Clause **10**)	Whole life and wider sustainability considerations: [S] • finance costs; • taxes and incentives, e.g. carbon tax/tariffs; • third party income while in use; • loss of income; • facilitating works; • employer-definable costs.

[A] Applies to asset registers in any form such as hardcopy, electronic, BIM.

[B] More detailed guidance on costing for gathering relevant asset information and establishing robust asset maintenance register for LCC exercises is given in Clause **9**.

[C] Make cost allowance for stock condition and obtaining relevant information from as built/operational and maintenance data files and site log books, plus capture local knowledge to inform findings.

[D] For detailed guidance on remaining service life data sources see **9.5**.

[E] See **6.2.4** for more detailed guidance and instruction on costing other forms of assessment.

[F] On-costs to be costed separately, depending on the type of contract for maintenance, e.g. PPM, reactive only or combined or fully comprehensive cover contract.

[G] Proactive maintenance activity to include early interventions to failing assets.

[H] Risks to include costs for relevant commercial or other considerations.

[I] Costs should be presented in an elemental and sub-elemental cost structure categories for buildings and external works, as illustrated in Annex A.

[J] The split between "major" replacement costs and "minor" repairs and replacement depends on the funding arrangements and contractual interface arrangements, and should be defined for each LCC exercise. For example, if the life cycle major replacement fund is set up, it might be defined by the life of the components or the cost of the replacement. The detailed split by assets or sub-asset should be made transparent and recorded at the outset of the LCC exercise, including references to any specific interface or contractual agreement, where applicable.

[K] Redecoration costs can be calculated within their associated elemental costings but should be shown separately.

[L] Refurbishment and adaptation are normally dealt with as construction project works.

[M] If user-defined maintenance costs are included in the study then it is important that these items are costed separately, in order to facilitate comparative benchmarking of the maintenance cost categories.

[N] The security equipment maintenance might be included as part of the annual maintenance.

[O] The helpdesk function might be included as part of the reactive maintenance provision (as annual maintenance).

[P] The catering and hospitality equipment might be included as part of the annual maintenance.

[Q] The vending machines maintenance might be included as a service equipment item under annual maintenance.

[R] The fittings, furnishings and equipment (FF and E) might be included as part of routine maintenance.

[S] For more detailed guidance on LCC/WLC see BS ISO 156586-5 and PD 156865.

*NOTE 1 See Clause **9** for guidance on inputs into wider economic evaluations and for guidance on planning, generating, presenting and comparing the costs.*

NOTE 2 Costs are presented in an elemental and sub elemental cost structure categories for building structure, fabric, finishes, FFE, services and external works, see Figure A.2.

7.3 Maintenance costs for inclusion or exclusion and how to express them

7.3.1 Purpose and scope of the costs to include and how to express them

At the outset the following should be agreed.

a) The purpose for which the cost information is required.

b) The stages at which the cost information is required (i.e. brief, capture, evaluate, implement).

c) The period of the study and establishing the specific study inputs and rules.

d) The assets to be included or excluded.

e) The scope of the work to be included or excluded.

f) The level at which costs are to be reported.

g) The method of economic evaluation to be used.

7.3.2 The purpose for which the cost information is required

*COMMENTARY ON **7.3.2***
*The typical purposes and applications for LCC information for each stage are summarized in **4.2**.*

LCC information is also used to input into other wider economic evaluations (see Annex D).

Cash flow predictions are commonly used in public and private sector maintenance procurement to establish an expenditure profile (e.g. six monthly or yearly, over the period of analysis), which can be used to set up a sinking fund for LCC of maintenance and also input into a wider economic evaluation (e.g. life cycle and whole life costing). LCC cash flow predictions are also used as part of a budgeting process.

A prediction of a cash flow over a period of time may be generated for a single asset (e.g. a boiler) or multiple assets (e.g. an air conditioning system) or a whole facility.

An option appraisal may use the cash flows of multiple solutions to a problem in order to compare the results, with or without a base case (e.g. to compare them with the current maintenance regime and the actual historical spend on maintenance costs).

7.3.3 Stages for which cost information is required

The stages covered should be stated. As the cost plans increase in detail with each stage, commissions may be made for individual or multiple stages.

*NOTE See Clause **4** for details of the four stages: brief, capture, evaluate and implement.*

7.3.4 Period of analysis and establishing the specific inputs and rules

The period of the study and the period of the calculation should be stated. The date to which the costs relate should be stated.

The specific inputs and rules of the study should be stated.

7.3.5 Assets to be included or excluded

The applicable assets included in the maintenance and LCC renewal work plans should be stated.

Where an asset register, or the equivalent, exists, it should be verified and kept updated.

A list of costs specifically excluded from the LCC analysis should be stated, e.g. furniture, ICT, as agreed in the study scope.

The precise scope of the costs to be included and excluded should conform to the maintenance standard cost data structure and definitions given in Table 2 and Figures A.1 to A.3.

The LCC analysis might indicate the costs that are included for the end of life aspects of the life cycle, if required in the scope. The end of life phase might include inspections and may involve costs for recycling, re-use, or disposal, income and decommissioning.

NOTE A new LCC analysis has to be prepared if a major refurbishment or adaptation is needed during the in use phases. The decision to undertake refurbishment should include assessment of the remaining life of existing assets and whether the original design life estimates remain valid when set against achieved service lives and any changed requirements by the occupier/employer stakeholders.

7.3.6 Level at which costs are to be calculated and reported

Calculations of LCC may be made at various levels of detail depending on the stage in the process, the agreed purpose and scope requirements and the information available.

The agreed level of costing and cost reporting should be stated, e.g. cost per metre squared per annum or cost per function (for the whole facility, function, or elemental, sub-element or components levels). Life cycle costing may be produced as:

a) an order of cost estimates for LCC of maintain and renewal works, based on:
    1) the benchmark building cost per metre squared (GIFA) data;
    2) the benchmark elemental cost per metre squared (GIFA) data; or
    3) the benchmark elemental cost per element unit cost data; or
    4) the benchmark functional unit cost data;
b) a detailed element cost plan based on estimates and costings of maintenance service levels and identified schedules of the component life cycle condition grading and remaining service life predictions (see **9.5** and Annex B).

For the order of cost estimating of maintenance, quantification of maintenance works should be determined by measuring the GIFA of the building or constructed asset or by projecting the number of functional units (using the functional unit method). In certain circumstances a combination of floor area methods and functional unit methods might need to be employed.

NOTE For further information regarding a floor area method, see the RICS Code of Measuring Practice [6].

For detailed elemental cost planning, the quantification of maintenance works should be determined by calculating the total estimated cost of maintenance works by considering the specification of the building fabric and service installations based on detailed elemental breakdown of the applicable maintainable assets in scope for each element.

In practice the detail of information available might differ for different elements, resulting in a cost plan that is made up of a mixture of benchmark data and detailed estimates.

The total cost should be presented in pound sterling and as the cost per square metre of the GIFA to two decimal places.

7.3.7 Method of economic evaluation to be used

LCC of maintenance is an economic evaluation method that takes account of all relevant costs over the defined time horizon (period of study), including, where required, adjustment for the time value of money. It can be presented in various ways, such as through the NPV, the internal rate of return or the payback period.

NOTE For details on the various evaluation methods see Annex D.

The requirement for presenting the costs should be stated. This is normally the cash flow and total NPV over the period of study at a selected discount rate.

The cost plan should always be presented in current prices (discount rate 0%) as well as at the selected discount rate.

7.4 Methods of estimating and costing building maintenance works

7.4.1 General

Estimating methods might vary for the following different categories of maintenance costs:

a) asset registers and forms of assessment, e.g. asset condition and remaining life surveys;

b) maintain plans;

c) renewal plans;

d) employer-definable other maintenance related elements.

Annual, periodic and cyclical costs should be calculated at real costs (within a cash flow over the required time period).

NOTE "Real" costs are current prices (at agreed base date for the cost plan) with no allowance for inflation. "Nominal" costs are the expected costs at the date when the cost is due to be paid (e.g. technology replacement costs at the time when it is replaced or becomes obsolete).

Lump sums and percentage adjustments should be apportioned to the appropriate elements or cost categories.

Preliminaries, on-costs, maintenance contractor's overheads and profit, out of hours working allowances, site maintenance management costs should be shown separately, where required to be included in the scope of the LCC plan.

Design fees and other consultant's/specialist's fees, included in the scope should be stated for each element of the LCC plan, e.g. maintenance related, such as asset condition surveys/investigation studies.

Risk allowances should include appropriate allowances for uncertainty for defined risks. These should be shown separately where required to be included in the scope of the LCC plan (see risk logs in Annex E).

7.4.2 Asset registers and forms of assessment

If an asset register is being set up or revised , the cost of this and the initial condition surveys should be based on estimates for the scope of the work required.

The estimate should cover all costs involved, including employers costs, where appropriate. It should include:

a) setting up and maintaining the asset registers;

b) carrying out conditions surveys, reports and remaining life assessments;

c) carrying out other forms of assessments (e.g. failure mode impacts, capacity, energy efficiency (EPC); space utilization and wider sustainability implications).

In undertaking a condition assessment and any other forms of assessment, the time and cost for an on-site survey is determined by a number of issues (in addition to normal estimations), such as:

1) potential extra time to survey, due to access constraints, escorting and legacy data issues;
2) availability and accuracy of existing building information and maintenance registers;
3) legacy data issues (unavailability of up-to-date asset information);
4) cooperation and assistance on the on-site staff and maintenance teams;
5) other issues (e.g. weather conditions, local risk assessments, lone working).

7.4.3 Planned maintenance

7.4.3.1 General

Published benchmark data might be available on a floor area basis, e.g. BCIS Occupancy Cost Reports [1)].

On new build schemes, costs may be estimated by using ratios to the capital costs.

For detailed estimates the two common methods are based on:

a) resource costs from labour loading the maintenance task schedules; and
b) measured work based on schedules of rates for minor repairs and replacements.

The accepted practice for generating a routine maintenance works costing (maintain cost) and LCR forecasts costing, generated from an asset register and asset condition surveys, are as included in Table 1 and Table 2, along with informative worksheets and detailed guidance notes and instructions.

7.4.3.2 Maintenance task schedules

Maintenance task schedules may be developed by individual employers or contractors, or from published sources. Applying these to the specific components to be maintained can provide an estimate of the resources required to be priced at current prices, including an allowance for materials/consumables.

NOTE B&ES provide a core library of industry standard PPM maintenance tasks schedules that can customized and prioritized to suit specific building functions, operating hours and contractual obligations and budgets.

7.4.3.3 Schedule of rates for building maintenance works

Schedules of rates are commonly used for letting maintenance on measured term contracts. Where an existing contract exists, these costs can be used to price the schedule of maintenance and repairs and replacement works.

If the base costs are to be used to establish an order of estimating or elemental cost plan, the unit rates used from cost analysis and benchmark sources should be updated to bring them into line with the estimate base date for the LCC estimate costing. Adjustment should also be made for the main contractors competitiveness, preliminaries and overheads/profit, plus any other relevant on-costs, where required, such as contractor's design/consultant fees.

[1)] These reports are available from www.bcis.co.uk [last viewed 9 August 2013].

Rates for plant and equipment are separately priced and should be added as associated works cost to the specific item of maintenance (e.g. scaffolding or access platforms).

Regional variations should be taken into account by adjusting base rates using published indexation for location factors and tender price adjustment indices.

NOTE Published indices are published by organizations such as BCIS.

7.4.4 Reactive maintenance (unscheduled)

Reactive maintenance is normally estimated at the building level as:

a) a percentage of the cost of the planned maintenance work (a 60/40 ratio is commonly used);

b) a cost per square metre of the facilities being managed; or

c) an estimate of the cost of the staff required. It should cover man hours for reactive, plus any provision for consumables, spares, plant and equipment, etc. as well as on-costs (including unallocated activities such as travelling costs, access/escorting time, attendance on subcontractors and the like, plus maintenance contractor's on-costs).

7.4.5 Proactive maintenance

Estimates may be based on the resources required to carry out inspections and monitoring activities (e.g. plant room checks, BMS trend analysis and use of thermal imaging/vibration analysis).

7.4.6 Renewal works

It is common practice to generate the LCR forecasts cost from either a capital cost plan, or from a detailed asset register and asset assessments, using a LCR cost planning model.

NOTE For informative worked examples of LCR plans generated from capital cost plans and from asset maintenance registers and condition/remaining life assessments see Annex B.

7.5 Reporting the results

7.5.1 General

LCC of maintenance may be measured and reported using a variety of metrics, depending on the actual purposes, project stage and relevant use, level of detail and type of study being undertaken.

7.5.2 Using LCM metrics and derived indicators

It is common practice to express the maintenance costs as an index based on the capital reinstatement cost of the building.

The key LCC metrics that may be used for assessing the costs of maintenance and life cycle replacements are given in Table 3.

Table 3 **Key LCC metrics for maintain and LCR**

Type of measure	Typical metrics
Total LCC per GIFA (m^2) for the maintain per annum and for the renewal programme (as a period average)	Total LCC maintenance cost per metre squared at base date prices, or NPV or other form of economic evaluation
Other methods of economic evaluation	NS; payback period, IRR, AEC
Derived indicators	Maintain and renewal cost per metre squared per annum (GIFA) and LCC for maintenance cost per functional unit/pa (e.g. cost per bed space, pupil, workspace)
Ratios: FMI and FCI versus the CRV	FMI expressed as the maintain cost as a percentage of capital reinstatement cost FCI expressed as the renewal cost as percentage of capital reinstatement cost
AEC of LCC	Total LCC cost per annum Elemental total LCC cost per annum
Derived indicators	Total LCC cost per metre squared (GIFA) per annum Elemental total LCC cost per metre squared per annum
Typical LCC analysis	Calculated on total net maintenance costs and also on gross maintain and renewal costs, including all on-costs in scope

7.5.3 Standard forms of cost analysis for reporting and benchmarking

A consistent basis for costing and analysing maintain works and LCR works should be used in order to facilitate more robust and accurate benchmarking.

Costs should be expressed as the cost per metre squared of GIFA per annum and in functional unit cost per metre squared per annum, e.g. cost per primary school.

Where appropriate or required by an employer, costs may be expressed as cost per square foot of GIFA, and cost per functional unit (or functional unit cost), as an alternative to, or in addition to, the cost per metre squared of GIFA. The functional unit may be an employer-defined unit so the functional unit should be clearly identified when costs are expressed in this way.

NOTE See published classification of types of functional units in BS EN 15221-6, BS EN 15221-7 and RICS NRM 1 [1].

Items included in and excluded from the estimated cost should be clearly communicated to the employer when reporting the maintain and LCR cost plans.

8 Interoperability of LCC of maintenance with BIM

8.1 Use of COBIE

Data should be made interoperable, for example through COBIE data exchange format, in order to ensure that existing building data is accessible to LCC of maintenance models, and to ensure that output data from LCC of maintenance models is accessible to other interoperable models.

NOTE 1 Where LCC has been assessed during the design and construction phase, the output could be structured into a COBIE format. This data can then be interoperable with any LCC of maintenance model.

*NOTE 2 The benefits of applying information modelling to existing facilities are also addressed in BS 8587:2012, **4.8.2**.*

The design or construction process may deliver a BIM using the COBIE dataset. The LCC of the building information maintenance model (i.e. the BIM post occupancy) can be developed from the information generated during construction linked to the applicable level for maintenance planning and reference service life planning. The building information maintenance model (whether generated during construction or in use) should be provided in the same format and the data referenced to physical systems, types (specifications) and components, and to virtual zones, floors and spaces. Mapping of the NRM 1 data structure [1] to COBIE is shown in Figure 5.

Classifications may be applied to the named objects to support conventional reports and groupings.

NOTE 3 COBIE is a standardized tabular representation of a facility and its constituents allowing the exchange of their detailed properties and impacts such as maintenance cost and carbon. COBIE is a subset of the IFC schema.

NOTE 4 See Figure 5 which provides an illustration of how the data structure for LCC of building information maintenance aligns with BIM using the COBIE data format structure.

8.2 Use of IFC

The design or construction process may deliver an IFC dataset. The building information maintenance model can be developed from the information provided.

Data should be generated in the same format as shown in Figure 5.

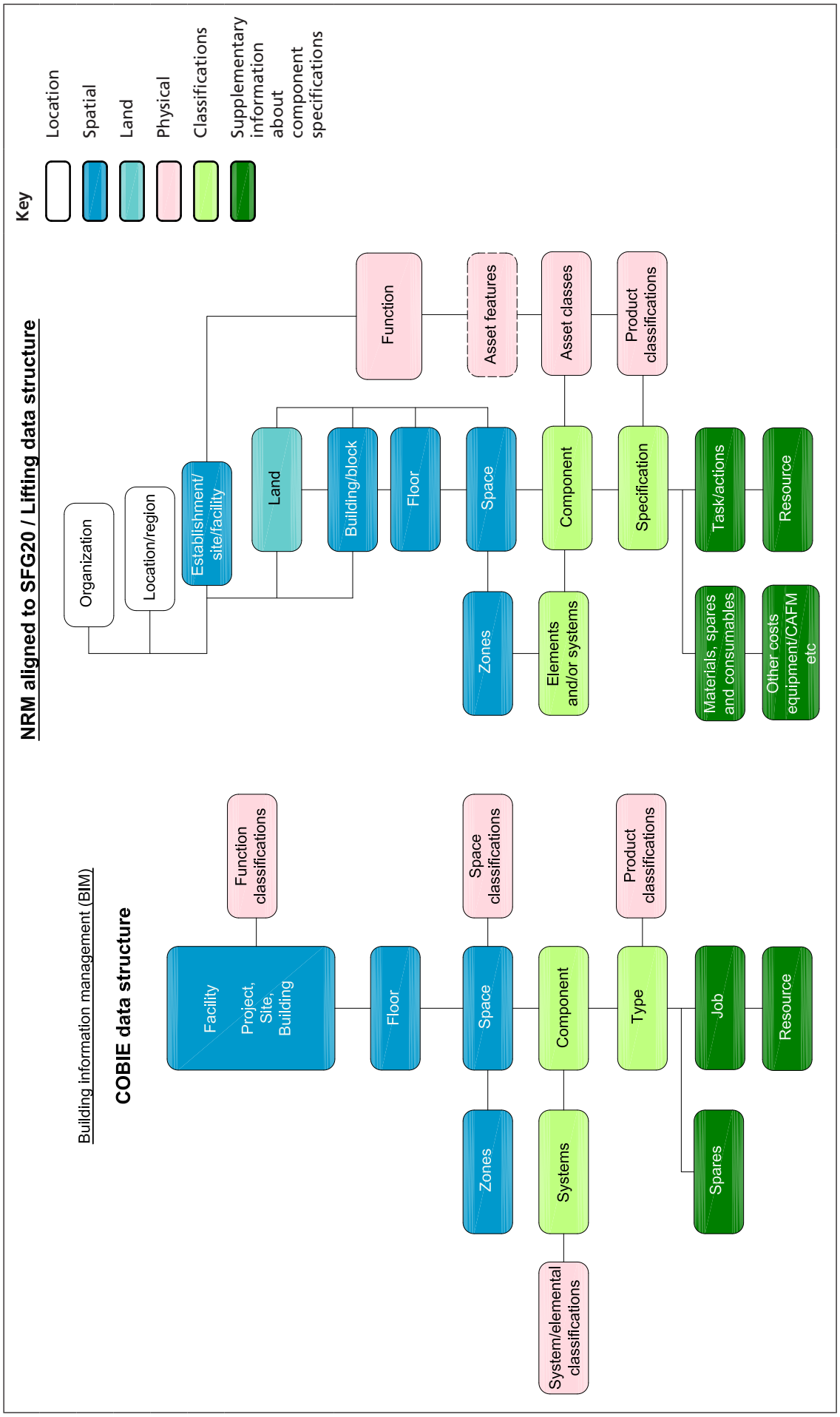


Figure 5 **Alignment of NRM 1 cost data structure [1] with COBIE data structure (BIM)**

9 Information sources and data required to undertake LCC of maintenance

9.1 General

LCC of maintenance is data intensive, and the data assumptions vary over time, therefore assumptions and data sources should be logged and maintained as they change. The level of information and data needed varies depending on the purpose and use of the LCC outputs, scope of costs and the stage in the process.

NOTE See Figure 2 for the LCC process and key stages, included in the Introduction.

9.2 Information sources and data requirements for undertaking LCC of maintenance works

9.2.1 General

Typically the asset data requirements for LCC of maintenance are to:

a) provide the data required to support defined maintenance life cycle strategies;

b) support the management of statutory/legal and regulatory requirements;

c) support the identification of efficiencies and benefit opportunities;

d) provide the basis for informed decision making;

e) inform the assessment and management of risks;

f) facilitates communications with stakeholders;

g) supports continuous improvement.

The information required to carry out maintenance should be available either for new construction and restorations of facilities (e.g. maintenance plans issued for construction and updated with "as built" documentation or from BIM).

For existing facilities, if not available, this information should be progressively acquired in accordance with the capture stage in **5.3**.

*NOTE See BS 8587 for useful information on how to manage information on facilities, including checklists of typical contents for a building manual and building user guide. It also provides a list of information that may be available from a CAFM system in BS 8587:2012, **4.4**.*

Annex A provides an informative worked example of a structured set of asset information at various levels.

9.2.2 General information and project particulars

The information required should indicate the applicable maintainable assets relevant to the purpose and scope of the LCC analysis.

NOTE For a summary of the typical general information and project-particular information see Annex F, Table F.1 and Table F.2.

9.2.3 Recording of cost data used in the LCC analysis or option appraisals

Detailed information should be collected after the general information and project particulars; the data collection should be accurately identified and coded.

See Figure 6 which provides a structured list of the sources of asset information and data required to be captured, for use during the evaluate and implement stages of the process. This is not meant to be exhaustive and some of the information that has been included may not be needed in all cases.

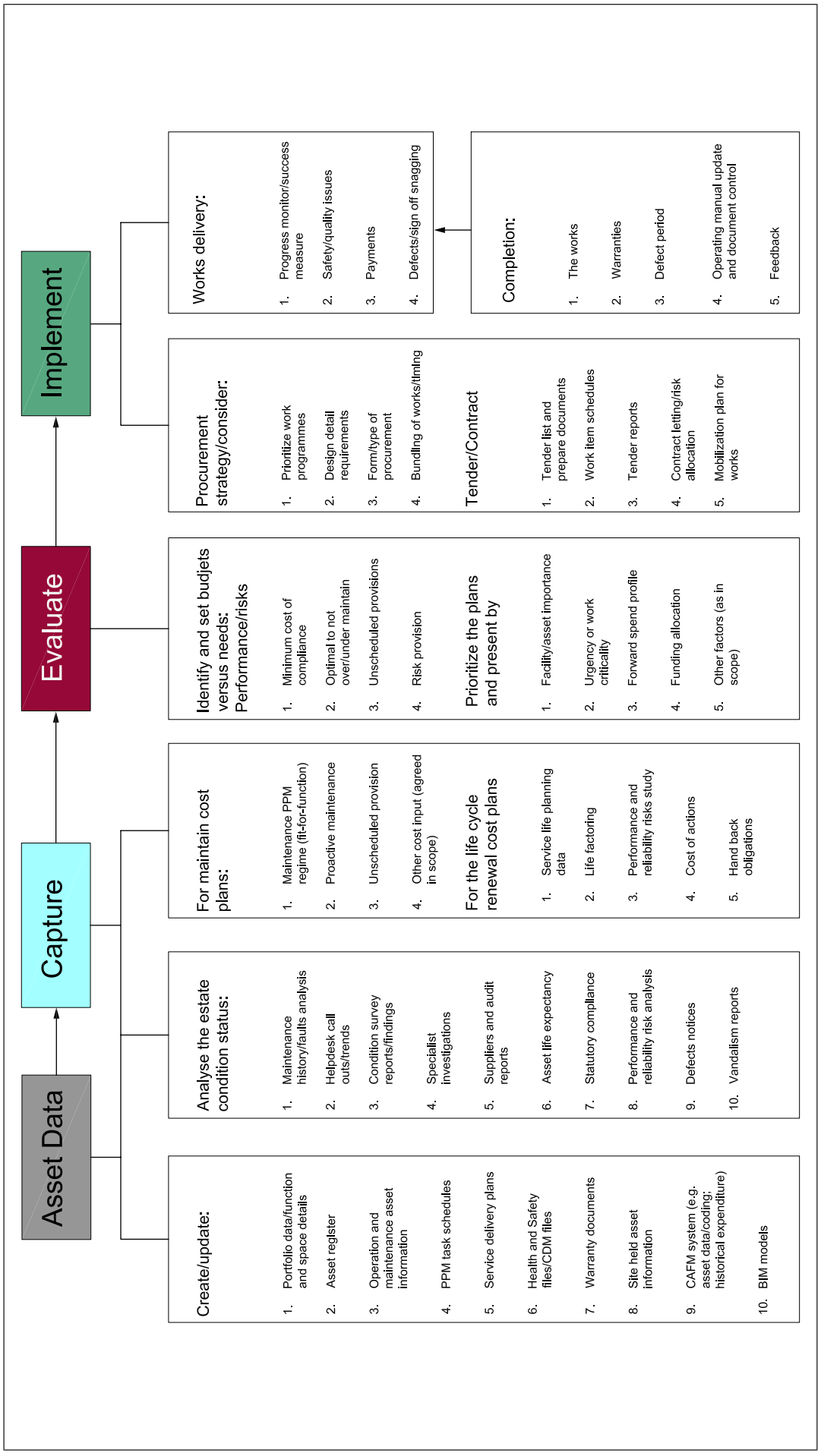


Figure 6 **Information sources and data required to undertake LCC of maintenance**

The project particular information required might also include the following (applicable on a caseby-case basis):

a) location and function use classifications (e.g. office), as agreed for the LCC analysis purposes;

b) measurement information, relevant according to intended functional maintenance standards to be adopted;

c) inventory of facilities, maintainable assets/equipment, identification; location and supporting description;

d) appropriate asset coding system for the facility, individual buildings, technological systems for each facility subdivided into technological units, technical elements, component parts and the material of which they are made;

e) coding system according to its functional dependencies;

f) drawings including sizes, position and layout of the various asset and components;

g) data about maintenance activities already performed (history of the components, if available);

h) assessment of efficiency, functionality and compliance with the applicable rules and standards;

i) remaining economic service life for each component; predicted in accordance with age, quality and conditions of use and in relation with the service life initially foreseen;

j) technical specifications, especially concerning equipment and building services in order to identify characteristics and established operating procedures;

k) repair and replacement costs for each component, as is the basis for financial assessment of the renewal plan;

l) cost for unavailability or down state estimate; at least for critical components, costs arising from the down state of its components or from the inability to provide the services for which they are intended (e.g. costs for liabilities, damages, damage to the corporate image);

m) information about critical construction solutions, for example atrium accessibility provisions;

n) instruction for inspections, operation and maintenance manuals; manufacturer's recommendations, to be used to develop the appropriate maintenance plan.

9.3 Asset data capture and the quality or interpretation of the existing asset information

Applicable asset data should be used to enable and inform the decision-making process. The quality and use of existing asset information should be investigated to ensure that it is suitable for the purpose. To do this, the following may be included:

a) the creation of an asset maintenance register to align with the planned maintenance task schedules;

b) the preparation of short-, medium- and long-term asset investment plans (renewal) works programmes;

c) a dilapidation assessment after a period of occupation (optional if required);

d) the establishment of the condition of the fabric, structure, plant and equipment and its remaining life expectancy;

e) the identification of actions required to bring the asset back to and maintain at a serviceable condition.

NOTE 1 For example, cost benchmark rates could be considered fit for purpose with updating through the use of indices but if the data is several years out of date, it might be considered to be unreliable and inappropriate. Experience can aid this judgement, otherwise advice may be sought from life cycle specialists.

*NOTE 2 For monitoring and the periodic updating of asset information, refer to the detailed guidance on monitoring and capturing feedback data in BS EN 15331:2011, Clause **9** and Clause **10**.*

9.4 Asset information: levels and extent of condition surveys and other assessments

The level and extent of asset information that is captured by condition surveys and other assessments depends on the purpose of the survey that is being carried out and the resources available. The level and extent of data captured can vary.

Typical examples of the levels and asset data capture and condition surveys are:

a) selective asset information focusing on business critical assets to limit cost of asset collation;

b) broad brush surveying of condition to provide an overall assessment of the condition of the built assets;

c) sampling surveys to capture a representative view of the assets and their condition or predicted life span;

d) fully detailed block and room-by-room asset inventory and condition and remaining life assessments.

NOTE For further information refer to BSRIA's Condition surveys and asset data capture [8].

9.5 Condition grading and age or remaining life, and the use of reference service life data

In order to carry out LCC of maintenance, asset condition grading should be captured. Each applicable asset within the scope should have its CAR assessed using the agreed condition grading method in **6.2.2**.

The performance of each asset should be assessed to enable PARL, as described in **6.2.3**.

NOTE 1 There are a number of sources in which information regarding service life data can be found. These include the publications CIBSE Guide M to maintenance [3], BMI/BCIS Life expectancy of building components [13], BLP Construction durability database [14] and HAPM Component life manual [15]. Some third party certification and product approvals, if used, might include statements of durability. Service life data can be obtained from published sources (such as [3], [13], [14] or [15]) or in-house records of maintenance, for example.

The default for the expected RSL for components and materials represents a particular set of assumptions that should be recorded in the data sources. These assumptions are unlikely to replicate the exact project conditions and therefore the service lives need to be adjusted to represent the predicted actual in-service conditions. Some RSLs might also be quoted as lasting for at least X years or are limited to a minimum estimate (e.g. 60 years) so might need to be adjusted or varied by suitably experienced life cycle practitioners.

NOTE 2 The BMI/BCIS life expectancy of building components [13] and the equipment service life data in chapter 13 of CIBSE Guide M [3] provide industry recognized sources for the RSL for the LCC of major repairs and replacement programmes. It is important to use these indicative lives with caution, and to bear in mind that they assume the appropriate maintenance is to be undertaken. In any event, it is also important to consider the operational environment in which the asset is used. A hospital, for

example, is in full operation for 24 h every day and therefore would have higher usage of a particular asset than a school or an office.

Default service lives and replacement cycles are adjusted to the specific project conditions, using what is known as a factoring method. BS ISO 15686-1 and BS ISO 15686-8 deal with how to factor estimates or component service lives. The default assumption is that the value of each factor is 1.

Where the project conditions are worse than are assumed in the reference case, a value of less than 1 should be used (typically either 0.9 or 0.8) for each relevant factor. Conversely, if the project conditions are better than assumed in the reference case, use a value of more than 1 (typically 1.1 or 1.2) for each relevant factor.

Examples of factoring the RSL, which in this case would reduce the life by 30% are given in Table 4.

Table 4 **Examples of factoring the RSL**

Factors	RSL assumption	Project conditions
A – Quality of components	RSL for windows	High quality specification, assume 1.1
B – Design level	Not stated	Assume 1
C – Work execution level	In accordance with good practice [see BS 8000 (all parts)]	Assume 1
D – Indoor environment	Not applicable	Not applicable
E – Outdoor environment	South East of England	East coast of Scotland (exposed to more aggressive climate), assume 0.8
F – In use conditions	External envelope	External envelope, assume 1
G – Maintenance level	Regular cleaning and inspection	None, assume 0.8
Resultant values	1	1.1 × 0.8 × 0.8 = 0.704 factored result

NOTE This table is taken from PD 156865:2008, Table 6.1.

9.6 Information management: standard data conventions and use in technology or CMMS

Maintenance management should be organized so that they are supported by information systems that are appropriate for the complexity of the activity carried out. Information used to plan, model, manage and deliver maintenance and LCR programmes of work are commonly computerized according to the size and complexity of the real estate asset data.

The structure of the information management systems or CMMS should be capable of:

a) adopting and standardizing the asset information data conventions to enable integrated planning of maintenance and LCR programmes of works;

b) collecting, storing and analysing data and feedback;

c) containing maintenance planning functions, e.g. PPM, proactive and inspection task schedules;

d) scheduling and managing resources; including direct labour, contracted and suppliers;

e) aiding the effective management of the maintenance plan in terms of preparing, updating, evaluating, modifying and optimizing the scheduled activities, frequency and costing;

f) generating the required outputs and reports;

g) supporting cost analysis and benchmarking.

NOTE Detailed guidance on complete computerized maintenance information system and BIM is outside of the scope of this British Standard.

10 Informing the decision-making process

10.1 Informing the budgeting, fund modelling and investment business case

As indicated in Figure 2 and Clause **5** and Clause **6**, all stages of the LCC process have methods that should be used to ensure that the LCC meets the objectives set during the brief stage. The outputs from the LCC result in the employer having to make hard choices regarding what to fund, or not to fund, against other competing funding demands, which forms part of a wider decision-making process.

This clause indicates how different techniques can contribute to this. It also focuses on how to use the outcomes from the LCC of maintenance to make better informed decisions, regarding:

a) setting and defending the maintenance budgets;

b) mitigating risks and liabilities;

c) driving maintenance prioritization;

d) targeting investment in asset renewals;

e) informing estate planning and rationalization studies;

f) inputs into environmental and sustainability assessments;

g) feedback and inputs into future construction procurement LCC studies.

10.2 Setting and defending the maintenance budgets

The initial budget (originating in the brief stage of the process) should be set on the basis of achieving, as a minimum, the maintenance and life cycle asset renewal strategies, focusing on relevant costs applicable to legal compliance and the mitigation of operational risks and liabilities.

The budget, as established during the capture stage and the subsequent evaluate analysis part of the process, should aim to identify and quantify:

a) the financial provision that is needed to maintain the in-scope assets to a defined standard (i.e. assure legal compliance/not under or over maintain);

b) the business and operational risks and liabilities identified by asset condition grading, performance and risk ranking of doing or not doing various scenarios for specific business/operational outcomes;

c) a set of prioritized maintain and renewal options compared with the available budget limits and any specific organizational obligations or timelines, e.g. assessing the choice between repairs or replacement, or upgrades to meet energy efficiency standards.

Subsequently, the LCC maintain and renewal plan of works should be presented in a clear and effective manner, in a format that can easily be understood by non-technical people. Since maintenance is often seen as being a low priority, it is

important to justify the business case for funding the maintain and renewal works in terms of:

- must dos: to ensure legal compliant maintenance is funded;
- must dos: to address assets that are function critical (as defined by the strategy);
- should dos: to avoid adverse impacts on the business or organization's performance;
- should dos: to drive down the total LCC of maintenance (revenue and capital);
- could dos: short-term alternative options, such as refurbish rather than replacements.

During the evaluate stage of the process, these options should be investigated in more detail and evidence compiled to support the "must dos" (priority 1) and "should dos" (priority 2) work items; priority 3 and 4 work items, which are less critical and may be deferred, if funding is not available.

The options should be presented as prioritized programmes of works with the associated costs and commentary on the performance impact of different choices for business case approval.

10.3 Mitigating risks and liabilities

In order to be able to manage and mitigate the risks and liabilities, the asset information needed to understand and quantify risks and liabilities should be captured, in maintenance terms, from a short-term and a medium- to long-term perspective (i.e. life cycle period of analysis).

A proactive approach, using risk management techniques, should be adopted to ensure salient asset information is available to use to suitably inform the decision-making process, such as:

a) asset criticality assessments to identify what are the compliant and most critical assets;

b) audit to ensure that the relevant compliance maintenance requirements are in place;

c) asset condition and performance reviews of all the critical assets and sampling of the other assets;

d) targeted fault and failure mode analysis to identify poor performing assets;

e) identifying critical assets with >20% PARL;

f) obtaining local knowledge from site operators and supply chain on potential high risk items;

g) identifying the urgent work items and prioritize all other works items (priority 1, 2, 3 and 4).

10.4 Driving maintenance prioritization

Once the key asset information has been identified, a list of maintain and asset renewal works with costings should be created. These works should then be placed in the following categories:

a) minimum costs: to enable full conformity to legal, regulatory and mandatory requirements;

b) optimal costs: that meet agreed LCC criteria, e.g. asset criticality-based maintenance;

c) discretionary costs: as defined by criticality and priority 1 to 4 modelling methods;

d) reactive provisions: unscheduled work costs (deferred works to run to failure strategy);

This should include appropriate allowances for the following:

- management and administration and on-costs;
- others related costs (e.g. risk provision, consultants/specialist fees and taxation, etc.).

The presentation format should be visual or graphical to ensure ease of assimilation and understanding of the overall trends and highlight the levels of funding requirements required. The use of red, amber, green colour coding helps to simplify and convey a powerful message.

NOTE The examples in Annex B use red, yellow and green prioritization colour coding for various types of presentations.

10.5 Targeting investment in asset renewals

Life cycle investment planning should achieve the optimal balance of whole life costs, taking into account the required asset performance, condition, risks and benefits over the period of analysis.

Much of the work described in this standard would be wasted if there is not a clear commitment to properly invest in aging assets and allocate suitable funding to renewals where necessary.

The funding request should be presented in terms of business outcomes and benefits/threats, which provides compelling evidence to support the need for targeted investment in critical assets.

The maintain and renewal plans should clearly define the minimum expenditure along with LCC options regarding the timing of the rest of the identified asset renewal works over the period of analysis.

There are often affordability constraints, resulting in various iterations, to optimize what works are funded and also agree how the non-funded works are dealt with in the medium term.

10.6 Informing estate planning and rationalization studies

For large portfolio estate owners or occupiers, the answers to the following questions should be determined.

a) Is the asset portfolio or estate the right size (to meet operational needs)?

b) Are the assets fit for the intended business purpose (i.e. do they add value or are they a drain on the business resources)?

c) What does it cost to maintain at the required level (cost of ownership)?

The LCC of maintenance should provide sufficient information to allow for prioritization and optimization of the combined maintain and renewal programmes, and also enable the estate planning team to use this information to inform the estate planning reviews and rationalization studies.

In order to assess how well the assets are performing (to measure, monitor and manage) and demonstrate which assets or sites are contributing most or least to the outcomes of the business, KPIs pertinent to the business activities may be required. The KPIs adopted should support the estate/portfolio vision and identify

the current condition and asset performance. Types of typical KPIs used for estate planning could be as follows:

a) strategic monitoring: to ensure the assets are being maintained to required performance targets, including future proofing how the asset is required to perform during its intended service life;

b) asset performance: to assess the effectiveness and efficiency of asset maintenance plans, using a series of metrics (such as outages, mean time to repair, business disruption, etc.);

c) compliance assessments: to ensure legal/statutory and regulatory requirements are being delivered;

d) total cost of maintenance versus set baseline (i.e. cost reduction targets);

e) impact on asset valuation (e.g. open market or residual valuations).

In order for the KPIs to be useful in driving long-term cost efficiency, they need to show how much the estate/portfolio is needed (operational importance), how much is being used (utilization), how much it costs to run (cost of ownership) and how much it is worth (asset value).

The outcome of the estate planning reviews should identify the short- and long-term estate plan, which should then drive the future maintenance strategy and level of investment, or not, in the estate or facilities in scope.

Specific facilities could be classified by the following strategies:

1) hold, e.g. absolute minimum only maintenance spend (i.e. sweat the asset);

2) hold and maintain, e.g. optimal maintenance only (i.e. compliance and critical assets);

3) hold, maintain and invest, e.g. property has strategic importance to business needs;

4) de-invest, e.g. designated for disposal (i.e. target hand back maintenance obligations).

10.7 Inputs into environmental and sustainability assessments

The LCC of maintenance of existing assets is highly relevant to the assessment of works needed to meet environmental or sustainability objectives. Any existing priorities or policies relevant to such objectives should be identified in the brief stage.

Disrepair or poor management that might be contributing to excessive consumption of energy or other scarce resources should be identified in the capture stage. The cost of undertaking works to improve these aspects should also be identified at this stage.

An assessment of packages of works that may improve environmental performance (if required) should be provided in the evaluate stage. It should also be indicated at this stage whether they should be carried out as a separate programme of work or as part of general planned maintenance activities. The techniques described in **6.4** should also provide a justification and costing for the prioritization of works that are intended to improve environmental performance.

The implement stage should result in an improvement in environmental performance, which should be reported as appropriate in the context of the specific organization.

NOTE See Figure 2 regarding the progression of stages.

10.8 Feedback and inputs into the construction procurement LCC studies

Feedback from LCC of maintenance can be used to improve construction procurement. The typical applications of LCC that should be used during the construction procurement process are as follows (see PD 156865:2008, **4.1** for further information):

a) preliminary analysis;

NOTE 1 This can be to inform strategic investment decisions or the budgetary process, e.g. to support a business decision regarding whether or not to proceed with a construction project, to compare strategic options for the project, or to set or test the budgets and affordability limits.

b) evaluation of all facility options;

NOTE 2 F*or example, whether to refurbish or remove investment from the asset.*

c) evaluation of detailed design options;

NOTE 3 This can be done at elemental, system, sub-elemental and component levels, e.g. when comparing repair to replacement and upgrade or refurbishment.

d) determination of the optimum maintenance and life cycle asset replacement strategies;

e) determination and information for the CAIP or sinking fund requirements;

NOTE 4 This is to help control the expenditure on, or financing of, future planned maintenance and capital assets replacement programmes.

f) provision of information to the analysis of relocation or consolidation strategies;

g) provision of auditing, monitoring and due diligence reviews on the LCC provisions on behalf of project funders or review boards.

Annex A (informative)

Example of standardized and integrated asset data structure

A number of examples regarding various data structures are given in this annex to demonstrate how data is mapped and classified at different levels of the data hierarchy. These examples are as follows:

- Figure A.1 shows an example of a portfolio level to spatial level data structure;
- Figure A.2 shows an example of a building level linked to a maintainable asset data structure;
- Figure A.3 shows an example of services data structure linked to PPM maintenance task and reference service life codes, as provided in the B&ES SFG20 tasks [2] and CIBSE Guide M [3].

Figure A.1 **Example of a portfolio level data structure**

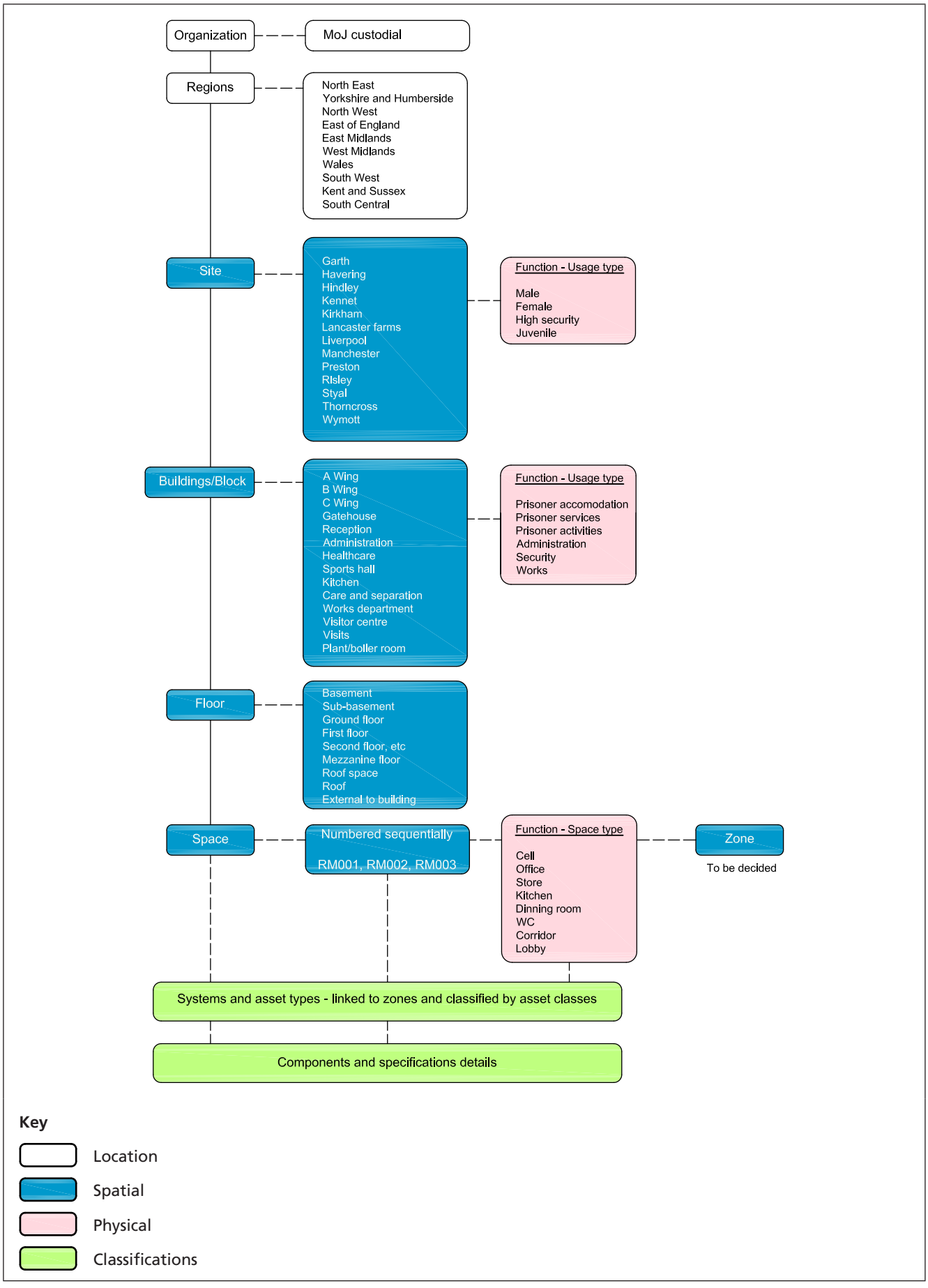


Figure A.2 **Example of elemental levels linked to a maintainable asset data structure**

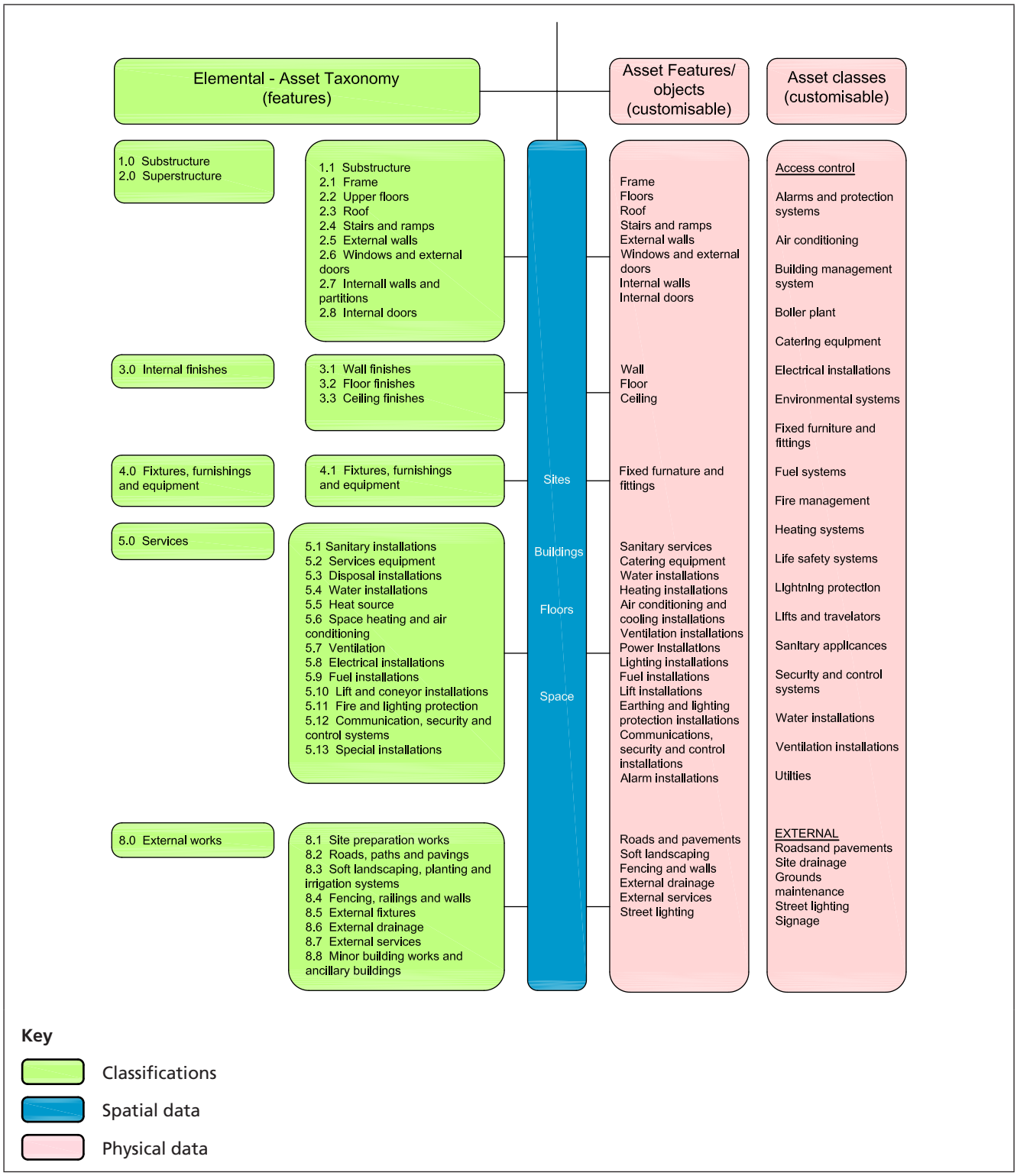
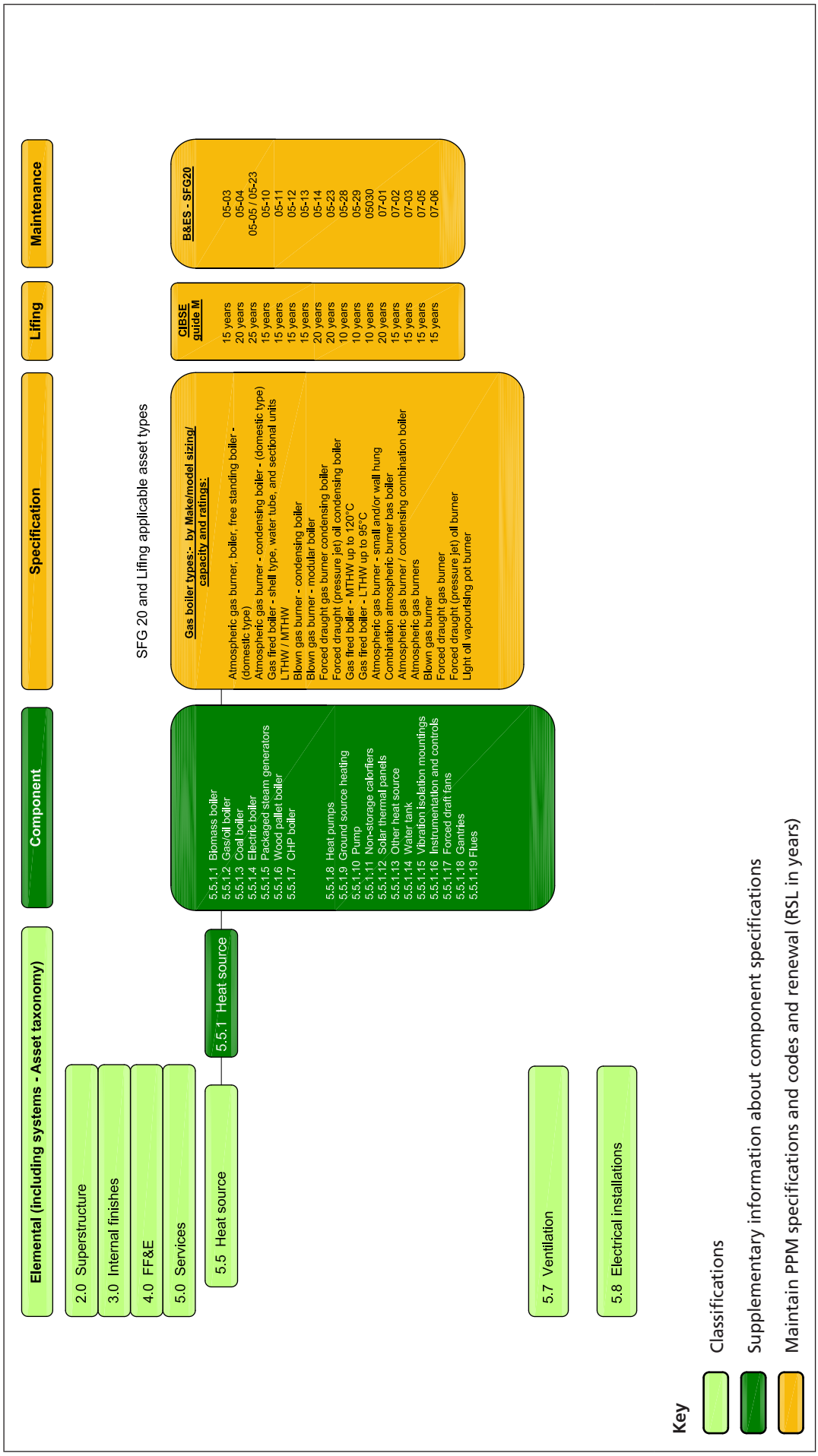


Figure A.3 **Example of elemental, sub elemental and component level aligned to a maintainable assets data structure and service life codes**



Annex B (informative)

Examples of methods, rules and techniques

A number of informative examples of specific methods, rules and techniques used to prioritize maintenance service levels and expenditure; condition grade and rank asset performance and express the identified renewal works in the form of FCI profile by function type are given in this annex. They can be used to target investment and help inform the maintenance budgeting and funding process.

- Table B.1 shows an example of how to prioritize the PPM maintenance service level, by using the asset criticality ranking method.
- Figure B.1 shows an example of asset criticality prioritization of maintenance expenditure (by priority1, 2 and 3 – or red, yellow and green coding).
- Figure B.2 demonstrates, by example, the parameters governing the timing of major repairs to critical assets (when PARL is greater than 20%) and when to trigger a renewal action (PARL is less than 20% but greater than 5%) to allow time to execute the renewal works).
- Table B.2 provides a method and rules for condition categories, descriptions and definitions.
- Figure B.3 provides the formula for FCI for rating how assets are performing.
- Table B.3 shows an example of FCI summary output by size and type (prison establishment), including the FCI scores for the identified renewal works per annum, expressed as a percentage of the CRV.

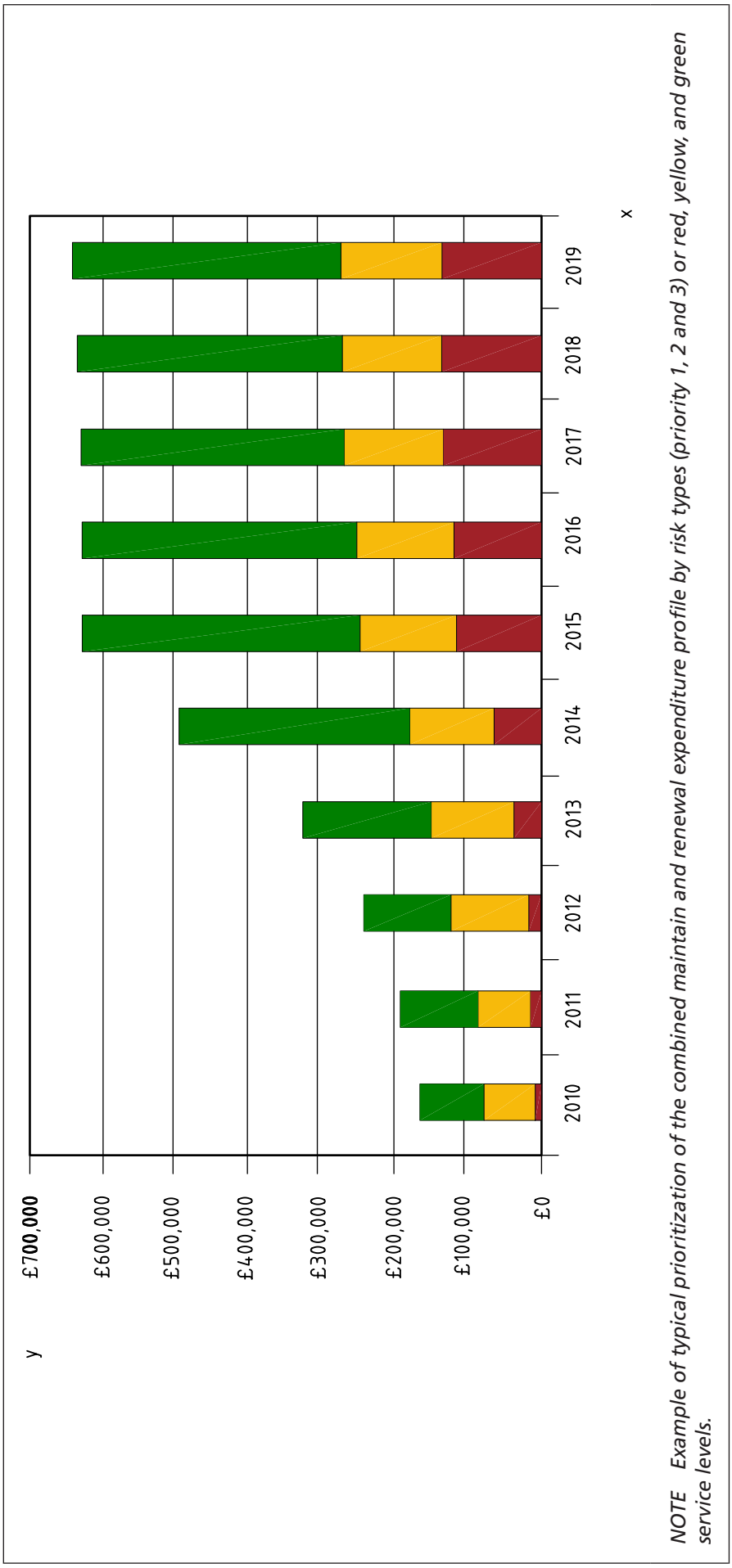
  NOTE This highlights how the asset condition status deteriorates year on year if the identified renewal actions are not funded. The FCI spend summary therefore provides a baseline of asset performance including when to trigger a refurbishment or think about de-investment in the asset.
- Figure B.4 provides an example of FCI benchmarking by function types.

Table B.1 **Example: how to prioritize the PPM maintenance service levels, by using the ACR method**

B&ES CODE SFG20	Asset type/maintenance descriptor	ACR							PPM task frequency sets					
									months					
		LS	E	O	S	R	A	Score	1	2	3	6	12	24
05-03	Atmospheric gas burner – free standing boiler	Y	H	M	L	H	M	75						
05-12	Forced draught gas burner	Y	H	M	L	H	M	75						
09-03	Chilled water chiller	N	L	M	L	L	L	30						
22-01	Fire alarm system	Y	L	H	M	H	H	90						
23-07	(Fire fighting) suppression system	Y	L	H	L	H	H	85						
28-01	Heating emitter (convector)	N	L	M	L	M	M	40						
32-06	Domestic hot water calorifier	Y	H	M	L	H	L	70						
32-15	Water heater	Y	L	M	L	M	M	40						
37-01	Emergency lighting (self-contained)	Y	L	H	L	M	L	50						
44-06	Earthing and bonding	Y	L	H	L	H	L	65						
44-07	Distribution board	Y	L	H	M	H	H	90						
45-02	Chilled water pump	N	L	M	L	L	L	30						
48-05	Foul soil and vent pipe	N	L	L	L	L	L	25						
51-01	Domestic services (shower)	Y	L	M	L	M	M	40						
56-02	CWS storage tank	Y	M	M	L	M	M	45						
59-01	Chilled water a/c terminal units	N	L	L	L	L	L	25						

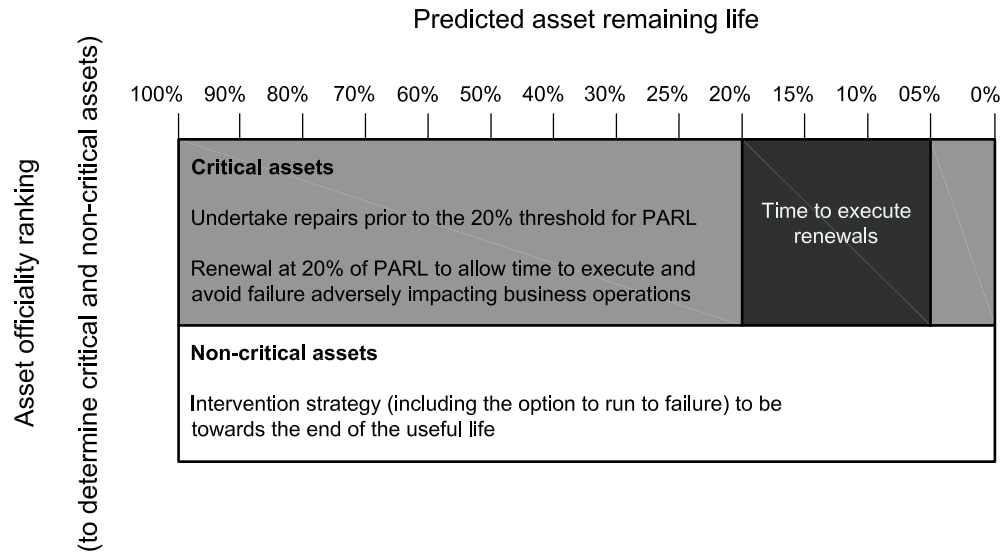
Key		Risk Scoring Criteria		Critically Ranking		Score
	ARS	LS	Legal and statutory	H	High	25
	Legal and statutory risk	E	Environmental	M	Medium	10
	High or medium risk	O	Operational	L	Low	5
	Low risk	S	Security			
Y	Yes	R	Resources			
		A	Availability			

Figure B.1 **Example of asset criticality-based prioritization of maintenance expenditure (by priority 1, 2 and 3)**



NOTE Example of typical prioritization of the combined maintain and renewal expenditure profile by risk types (priority 1, 2 and 3) or red, yellow, and green service levels.

Figure B.2 **ACR and PARL methods**



NOTE 1 There is a 1% to 20% threshold set to allow time to execute the renewals before failure on critical assets.

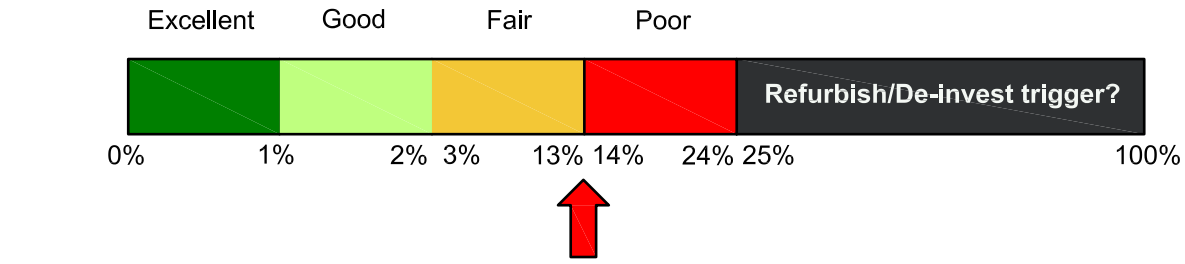
NOTE 2 ACR is used to determine the critical and non-critical assets.

Table B.2 **Example of method and rules of condition categories, descriptions and definitions**

Category	Description	Definition
A	As new	Requires only relevant PPM. No history of failure or excessive corrective maintenance on it.
B	Serviceable	Operational, but exhibiting some signs of ageing or deterioration. Requires PPM and infrequent corrective minor repairs to it.
C	Major repairs	Operational, but in need of major repairs to the asset or its sub-assets to make it serviceable and arrest frequent corrective intervention, negate business and operational risk.
D	Replacement advised	Inoperable or unsafe, considered at risk of imminent failure, requires an economically unviable major repair or is obsolete. Intervention would have little impact on prolonging asset life or reducing corrective repairs.
E	Upgrade	To meet changes in legislation or improve efficiency, energy or environmental performance.
F	Asset required	Does not currently exist, but required for operational or health and safety reasons.
X	Unknown	Not found or is inaccessible.

*NOTE Refer to **6.2.2** and **9.5** for more detailed guidance on condition grading methods.*

Figure B.3 **Formula for FCI for rating how assets are performing**



Key

- Over 25% = refurbish or de-investment trigger
- 14% to 24% = poor
- 3% to 13% = fair
- Less than 2% = good
- Less than 1% = excellent

Table B.3 **Example of FCI: summary output by size and function type over a 5 and 10 year period**

Function	CRV	Year				Total	
	£	1 up to 2	2 up to and including 3	4 up to and including 5	6 up to and including 10	Up to end of year 5	Up to end of year 10
		%	%	%	%	%	%
Administration	2 821 650	0	9	11	9	20	29
Farms	5 970 000	0	0	1	6	2	8
Industries	13 415 700	0	2	1	6	3	9
Inmate accommodation	30 399 000	5	3	5	8	13	21
Perimeter security	533 050	0	1	7	18	8	26
Prisoner activities	5 859 600	0	7	5	11	12	23
Prisoner services	9 195 450	0	9	4	10	13	22
Staff facilities	1 016 750	0	12	14	27	26	53
Works	2 761 200	0	2	2	31	5	35
Site wide total		2	6	4	9	12	22
Sinking fund model (PDV)	73 126 950 (total)	£1 665 778	£4 312 608	£2 866 584	£6 926 522	£8 844 970	£15 771 492

Key: FCI rating

Over 25% =	refurbish or de-investment trigger
14% to 24% =	poor
3% to 13% =	fair
Less than 2% =	good
Less than 1% =	excellent

NOTE 1 Assumptions: FCI is based on condition assessment. An identified backlog of works to bring up to and maintain the sinking fund model at condition B status. The sinking fund model is the per annum investment funding required to cover renewal works over a defined period of time.

NOTE 2 Year 1 total includes major project works.

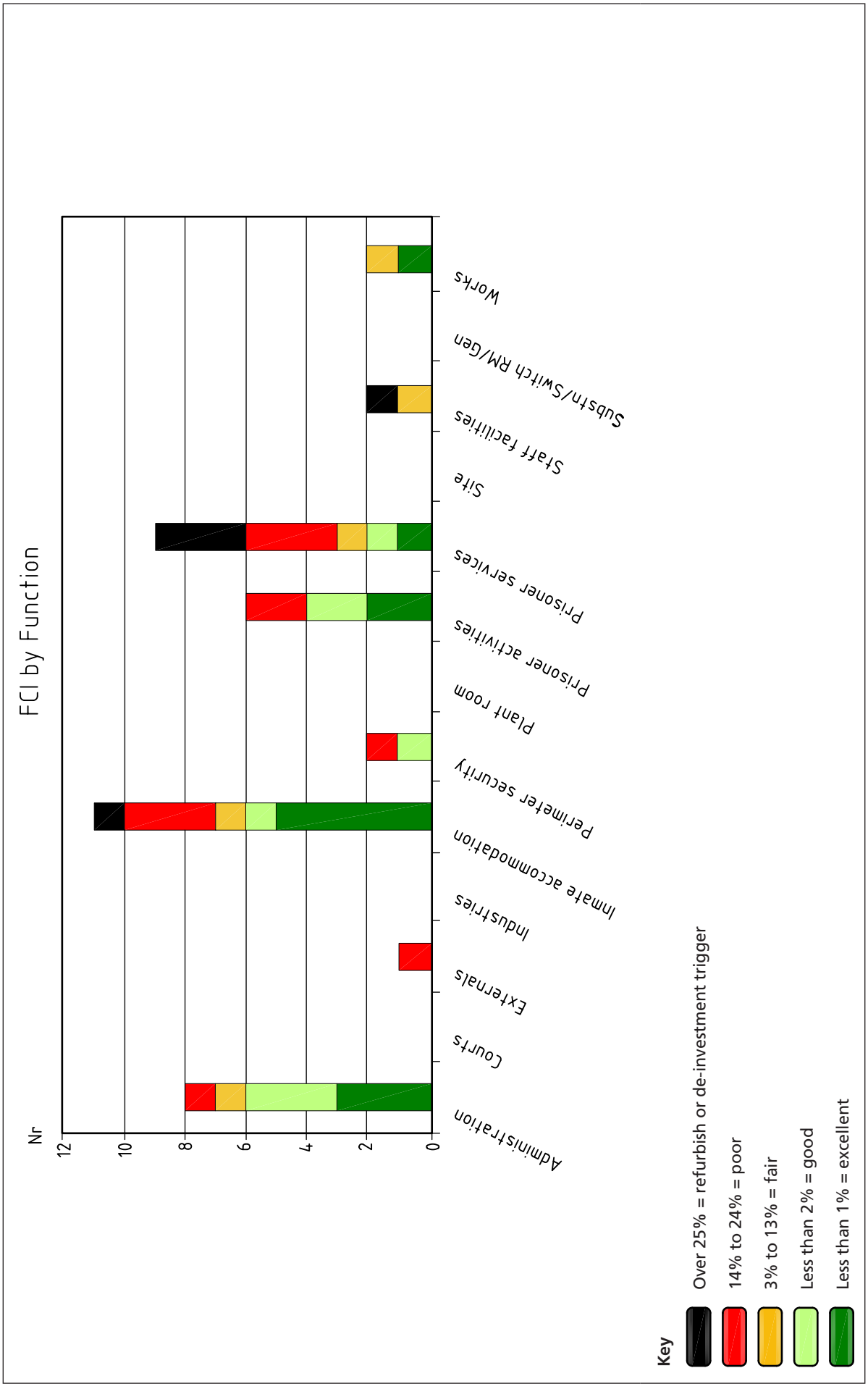


Figure B.4 **Example of FCI benchmarking by function types over a number of establishments: graphical summary**

Annex C (informative)

Menu and cost mapping to various standards and classification structures

The figures and tables in this annex provide the basis for integrating construction with the maintain and renewal cost structures (i.e. standardized menu for undertaking life cycle costing) , as well mapping the cost categories given in this British Standard with other standard cost classifications.

- Figure C.1 provides a menu for scoping the costs included in LCC of maintain and renewal works with links to the construction cost categories.
- Table C.1 may be used to correlate maintenance cost categories with the LCC and the scope of costs within PD 156865 and BS ISO 15686-5.
- Table C.2 provides a cost map of BS 8544 to the ITOC codes and the RICS service charging cost structures.
- Table C.3 provides a cost map of BS 8544 to BS EN 15643-4.

Figure C.1 **Menu for scoping the costs included in LCC of maintain and renewal works – with links to the construction cost categories**

Construction	Y/N	Renewal	Y/N	Maintain	Y/N
Capital building works		**Forward maintenance**		**Annualised maintenance**	
Construction works		Major repairs/replacements - predicted scheduled actions		Planned - scheduled tasks	
Refurbishment works		Refurbishment and upgrade works		Proactive - inspect/monitor	
Fit-out and adaption works		Redecorations (If seperated)		Reactive - unscheduled tasks	
End of life works (demolition)					
Main contractor costs		**Maintenance contractor costs**		**Maintenance contractor costs**	
Preliminaries		Management and administration		Management and administration	
Overheads and profit		Overheads and profit		Overheads and profit	
Other costs		**Other costs**		**Other costs**	
Development/project		Consultants/specialist fees		Consultants/specialist fees	
Project/design		Employer definable works		Employer definable works	
Base costs estimate (excluding risks/inflation/VAT)		**Base costs estimate (excluding risks/inflation/VAT)**		**Base costs estimate (excluding risks/inflation/VAT)**	
Risk allowance estimate		Risk allowance estimate		Risk allowance estimate	
Inflation estimate (construct)		Discounting (renewal)		Discounting (maintain)	
VAT assessment (if included)		VAT assessment (if included)		VAT assessment (if included)	
Other considerations		Other considerations		Other considerations	
Total cost limit (at agreed base date cost)		**Total cost limit** (at base date or discounting)		**Total cost limit** (at base date or discounting)	

Table C.1 **Cost mapping BS 8544 to PD 156865 and BS ISO 15686-5**

BS 8544:2013, Table 2	**PD 156865:2008, Table 3.1**		**BS ISO 15686-5:2008, Figure 3**
Maintenance cost category	**Life cycle costs**		**Scope of costs**
Asset information cost			
Asset maintenance registers	**3.3.1**	Property management	Maintenance management
Condition surveys, reports and remaining service life expectancy assessment data			
Other forms of asset assessment (optional)			
Maintain cost			
Planned servicing and maintenance (minor replacement), repairs and maintenance costs (PPM regime)	**2.4**	Minor replacement, repairs and maintenance costs	Repairs and replacement of minor components or small areas and cyclical regulatory costs
Reactive servicing and maintenance (unscheduled replacement), repairs and maintenance costs	**2.5**	Unscheduled replacement, repairs and maintenance	
Proactive maintenance provision			
Maintenance contractor's on-costs, risk provision and inflation (discounting)			
Grounds maintenance cost			
Grounds maintenance costs (if separated), maintenance contractors on-costs, risk provision and inflation (discounting)	**2.6**	Grounds maintenance	Grounds maintenance
Renewal cost			
Major repair and replacement costs	**2.1**	Major replacement costs	Replacement of major systems and components
Redecoration costs	**2.3**	Redecorations	Redecoration
Improvement and adaption	**2.2**	Subsequent refurbishment and adaption costs	Adaption or refurbishment of asset in use
Maintenance contractor's on-costs			
Risk provision and inflation (discounting)			
Employer defined other maintenance costs			
Employer maintenance management costs	**3.3.1**	Property management	Maintenance management
User-definable maintenance costs	**2.7**	Employer definable costs	Consultants/specialist fees and taxation

Table C.2 **Cost mapping BS 8544 to the ITOC codes and the RICS service charging cost structures**

BS 8544:2013, Table 2	IPD ITOC codes		RICS service charge code	
Maintenance cost category				
Asset information cost				
Asset maintenance registers	CE2	Facilities management	1	Management fees
Condition surveys, reports and remaining service life expectancy assessment data	CE3	Project management	4	Health and safety and environmental management
Other forms of asset assessment (optional)				
Maintain cost				
Planned servicing and maintenance (minor replacement), repairs and maintenance costs (PPM regime)	CC3	Internal repair and maintenance	12	Mechanical and electrical services
	CC4	M and E repair and maintain and renewal	13	Lift and escalators
	CC5	External and structural repair and maintenance	14	Suspended access equipment
Reactive servicing and maintenance (unscheduled replacement), repairs and maintenance costs	CC3	Internal repair and maintenance		
Proactive maintenance provision	CC4	M and E repair and maintenance		
Maintenance contractors' on-costs	CC5	External and structural repair and maintenance		
Grounds maintenance cost				
Grounds maintenance (if separately contracted)	CC13	Grounds maintenance	10	Cleaning and environmental
Renewal cost				
Major repair and replacement costs	CC3	Internal repair and maintenance	22	Forward funding
	CC4	M and E repair and maintenance		
	CC5	External and structural repair and maintenance		
Redecoration costs	CC3	Internal repair and maintenance	15	Fabric repairs and maintenance
	CC4	M and E repair and maintenance		
	CC5	External and structural repair and maintenance		
Improvement and adaption	CB1	Fit out and improvement	21	Major works
	CC6	Minor improvements		
Employer defined maintenance costs				
Employer maintenance management costs	E2	Facilities management	1	Management fees
User definable (consultant/specialist fees)	E3	Project management		

Table C.3 **Cost mapping BS 8544 to BS EN 15643-4: building life cycle information**

Before use stage			Use stage					After use stage			
A0	**A1-A3**	**A4-A5** [A)]	**B1-B7**					**C1-C4** [B)]			
Pre-construction	Product stage	Construction process	B1 use [C)]	B2 maintenance [D)]	B3 repair [E)]	B4 replacement [F)]	B5 refurbishment [G)]	Deconstruction	Transport	Waste processing	Disposal
A0 Land and associated fees/advice			B6 Operational energy use [H)]								
			B7 Operational water use [I)]								

A) A4-A5 should be used for all construction costs in Figure C.1.

B) C1-4 should be used for all end of life costs in Figure C.1. Any minor income as a result of sale of materials for recycling are to be taken in the net figure reported, such income should be included in the report and noted specifically.

C) B1 should be used for any other LCC in use costs not specifically included elsewhere.

D) B2 should be used for all maintain costs as shown in Figure C.1.

E) B3 should be used for all renewal costs except major repairs/replacements, refurbishments and adaptations in Figure C.1.

F) B4 should be used for all major repairs/replacements in Figure C.1.

G) B5 should be used for all refurbishments and adaptations in Figure C.1.

H) B6 should be used for net energy costs (not included in this British Standard). Any renewables that have been taken into account in the net figure should be included in the report.

I) B7 should be used for mains water costs (not included in this British Standard). Any water recycling that has been taken into account in the calculation of mains water costs should be included in the report.

NOTE BS EN 15643-4 requires the cost headings A0, A1-A3, A4-A5, B1, B2, B3, B4, B5, B6, B7 and C1-C4 to be separately reported. If no costs are recorded in any of these headings, they are reported as none under the appropriate heading. It is not essential to report the sub-cost headings not shown above (for example, C1 for deconstruction and C2 for Transport) separately.

Annex D (informative) Example of methods of economic evaluations, discount techniques and equations used for LCC of maintenance works

D.1 Indicators and techniques used in LCC and wider WLC analysis

A number of different analysis techniques exist for use in LCC or wider WLC analyses where investment or value is considered on a broad basis. Using these techniques can help the user to gain an overall picture of the value implications. It is important to clearly express the results in reports of the analysis, indicate what they mean and provide clear recommendations on the basis of the results.

NOTE The *equation may vary depending on whether measurement is from year 0 or year 1. Often these measures are built-in functions in software packages and the basis of the calculation needs to be checked.*

D.2 Annual cost or AEV

The annual cost or AEV is a uniform annual amount equivalent to the project net costs, taking into account the time value of money throughout the period of analysis.

This technique is used to compare the merits of competing investments where the natural replacement cycle is not an exact multiple of the period of analysis. The AEV is the regular annual cost that, when discounted, equals the NPV of the investment.

By choosing the option with the lowest AEC, the option with the lowest total cost is chosen.

To calculate the AEV:

$$AEV = \frac{Cd}{(1+d)^n - 1}$$

where:

- AEV is the annual equivalent value;
- C is the cost incurred in year n;
- d is the expected real discount rate per annum;
- n is the number of years between the base date and the occurrence of the cost.

For example:

$$AEV = \frac{100 \times 0.06}{(1+0.06)^{25} - 1} = 1.82$$

Therefore, a cost of 100 units in 25 years' time at an interest rate of 6% is equivalent to an annual investment of 1.82 units.

D.3 Payback period

The payback period is the time it takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment, its subsequent operating costs and the time at which cumulative savings offset the investment.

Simple payback takes real (non-discounted) values for future monies. Discounted payback uses present values. Payback in general ignores all costs and savings that occur after payback has been reached.

When considering investment with future expenditure, a discounted payback can be used to reflect the time value of money. It is possible that an investment with a short payback is a poorer option than one with a longer payback when looked at over the entire period of study. Generally, however, payback is a useful technique to compare large and small investments (although AIRR is also used) or to assess the time period during which the investment is at risk.

D.4 Net savings

NS are the present value of operating-related savings minus the present value of additional investment costs.

A calculation of the NS is used to assess benefits, especially when they come in the form of cost reduction. A project is considered cost effective if the net saving is positive. The NS technique can also be used to compare investment options. Choosing an option with the highest NS is the same as choosing the option with the lowest WLC.

Similarly, when analysis is being used to assess the lowest WLC of a combination of options, the combination that offers the greatest overall NS is the most economically viable.

D.5 Savings to investment ratio

The SIR expresses the ratio of savings to costs. The SIR is calculated by dividing the present value of operating related savings of an option by the present value of additional investment costs attributable to that option.

The SIR can be used to assess whether an investment is cost effective (a SIR greater than 1) and for option selection (by choosing the option that has the highest SIR). The calculation can be used to prioritize projects (by ranking options in descending SIR order) subject to budget constraint. If the budget is insufficient to fund all cost-effective projects (those with a SIR greater than 1) a ranking of options in descending SIR order can determine the priority of alternative investments. If projects vary in expenditure, an allocated budget might not be enough to allow selection of a combination of options that have been ranked using the SIR.

D.6 Internal rate of return or adjusted internal rate of return (AIRR)

The IRR or the AIRR is the compound rate of interest that, when used to discount the costs and benefits over the period of analysis makes costs equal benefits when cash flows are reinvested at a specified interest rate.

By using the AIRR it is possible to calculate the test discount rate that generates an NPV of zero AIRR that can be used to rank different sizes of investment and different patterns of cash flow over time. If all cash flows are negative costs, then the AIRR cannot be calculated.

D.7 Net present value, net present cost

The NPV is the sum of the discounted future cash flows, both cost and benefits or revenues. Where only costs are included, this is NPC.

NPV is a standard measure of LCC analyses, which is used to determine and compare the cost effectiveness of proposed solutions. It can be applied across the full range of construction investments, covering whole investment programmes, assets, systems, components and operating and maintenance models. The costs and revenue or benefits to be included in each analysis are defined according to its objective.

NOTE For example, revenues from recycling materials or from surplus energy generation are typically included in LCC analysis of alternative sustainability options.

Annex E (informative)

Example of a LCC risk log and mitigation guidance

There are a number of key risks that it is important to take into account in LCC during the operational phase. These risks require ongoing management during the operational and in use phase of an asset's life cycle. It is necessary to continue to monitor the consequences and impacts with an appropriate strategy for managing risk so that continuous improvement can be demonstrated and risks managed.

Table E.1 provides examples of typical risks to be addressed when undertaking LCC of maintenance works through all the stages of the process.

Table E.1 **General risks log applicable to all elements of LCC of maintenance** *(1 of 4)*

Risk	Consequence	Mitigation and risk management technique
Scope creep	Poor understanding of requirements Pressure from other parts of the employer's business	Scope definition: cost time and resource implications Clear deliverables and LCC analysis outcomes agreed in the brief scope
Design and construction risks not adequately managed, e.g. poor workmanship or design	Poor quality asset leading to defects and increased LCCs	Incorporate quality monitoring into the detailed design and construction phases Put in place defect management protocol Create standard specification based on in use performance Obtain long-life warranties obtained for key components/systems
Product failure prior to predicted life due to manufacturer defect	Increased LCCs or inadequate funds available for replacement	Test or call upon any product manufacturers' warranties that were put in place at procurement phase
Early failure of component	Increased LCCs or inadequate funds available for replacement In PFI/PPP type projects investment returns could be lost or project could enter debt service lock up or default	Sensitivity analysis using different replacement assumptions Risk contingency costed to cover early failure or costs of replacement exceeding estimates (typically assessed on a percentage basis, e.g. 5%) Use of sinking fund or maintenance reserve allows for monies to be securely held in the event of replacement funds being needed at short notice (now typically a funding requirement if the project is funded privately) Use of annual asset condition surveys to monitor performance and physical performance looking forward 5 years on a rolling basis Detailed 5-year life cycle forward rolling plan that takes original LCC plan and adjusts predicted expenditure based on condition survey Monitoring element expenditure and trends through feedback mechanism

Table E.1 **General risks log applicable to all elements of LCC of maintenance** *(2 of 4)*

Risk	Consequence	Mitigation and risk management technique
Initial net construction prices for labour and material rates have not been adjusted sufficiently to take account of access costs carrying out LCC works	Increased LCCs or inadequate funds available for replacement	Allowances to be made for specific elemental access costs, e.g. scaffolding, access, escorting and permit to works obligations
Initial net construction prices for labour and material rates have not been adjusted sufficiently to take account of extra costs of carrying out LCC replacement works in an existing facility and disposing of removed waste materials or components	Increased LCCs, or inadequate funds available for replacement	Allowances to be made for specific strip-out and disposal costs (typically 5% to 8%)
Part or sectional replacement not feasible due to poor design, including inadequate maintenance considerations) obsolescence, lack of spare parts	Increased LCC or actual replacement is more extensive than estimated, e.g. vinyl flooring in corridors requiring complete rather than partial replacement Potential for mis-match of products	Monitoring the detailed design and construction phases Supply chain management
Lack of availability of contractors for carrying out works	Increased LCCs, or inadequate funds available for replacement at right time	Supply chain management
Delay in achieving required security clearances for asset review team	Programme delays, increased costs and reputational damage	Identify employer security requirements and timetable at an early stage and submit required paperwork as part of project set-up phase Implement training to assist asset review in the accurate completion and submission of required paperwork for asset review team Obtain agreement from key stakeholders to ensure all parties are aware of the security clearance process at an early stage and gain their full support
Lack of availability of suitably qualified surveyors for carrying out works	Payment of above market rates to attract right resource and skills Potential delay to programme and increased cost	Carry out a thorough pre-qualification and procurement exercise in good time On-going supply chain management

Table E.1 **General risks log applicable to all elements of LCC of maintenance** *(3 of 4)*

Risk	Consequence	Mitigation and risk management technique
Maintenance interface disputes with maintenance contractors	Increased LCCs or inadequate funds available for replacement at right time as funds used for reactive maintenance rather than LCC works	Clear interface agreement for cap in place to distinguish between the LCC works and reactive maintenance
Maintenance risks not adequately managed, e.g. poor workmanship or wrong specification	Poor quality assets leading to unplanned failures, defects and increased maintenance LCCs	Regular maintenance quality monitoring during the operational phases Standard specification based on in use performance
Incomplete or poor quality legacy data on existing assets	Potential for inaccurate or poor quality asset data which is relied upon in the CAIP or asset management plan	Undertake pre-survey quality assurance checks on data and cross-reference with existing knowledge at local site team level
Non-availability or difficulties procuring and implementing a compatible CAIP or AMP system	Inability to efficiently process, analyse and prioritize asset data which could delay the programme Impact on maintenance programme or/and potential asset realization	Early engagement with employer to scope and specify system requirements Regular engagement with employer procurement team to flag and escalate potential delays at an early stage Plan for using alternative paper-based system as an interim measure
Incompatibility of asset management databases or systems	Inability to efficiently process, analyse and prioritize asset data which could delay the programme Procure a new system to complete the programme/ project Unforeseen costs to replace system and for delays in programme	Early engagement with employer to review project objectives, current system functionality and compatibility in order to inform the decision on whether a new system is required
Inefficient decision-making process	Programme delays, increased costs and reputational damage	Agree and implement robust governance processes at the outset which is supported by a robust business case
Design expertise needed for the LCC, e.g. M and E not included in initial cost rates	Increased LCCs and impact on time of replacement	Pricing of design risk allowance in LCC for specialist items
Lack of financial resources for management of LCCs during the operational phase of the life cycle	Increased LCCs or inadequate funds available for replacement	Managing a LCC fund typically requires administration and management and this should be priced within the LCCs (typically 5% to 8%)
Initial net construction prices for labour and material rates do not take account of sub-contractor costs for carrying out LCC replacement works	Increased LCCs or inadequate funds available for replacement	Allowance of sub-contractor preliminaries on-cost element priced at appropriate market tested level on a percentage basis to cover site costs and mark-up (typically 8% to 10%)

Table E.1 **General risks log applicable to all elements of LCC of maintenance** *(4 of 4)*

Risk	Consequence	Mitigation and risk management technique
Labour or material replacement costs higher than initial estimates	Increased LCCs or inadequate funds available for replacement	Sensitivity analysis of various levels of cost increase Risk contingency priced to cover higher costs of replacement exceeding estimates (typically 5%) Restrict risk through use of an agreed SoR with maintenance or replacement contractor Feedback on real costs from operating projects to bids
Labour costs increase due to labour inflation beyond predicted levels	Increased LCCs or inadequate funds available for replacement at right time	Sensitivity analysis on inflation assumptions Price differential inflation allowance with LCC (typically 1% to 2% p.a.) Monitor differences between cost indices, e.g. BMI, TPI and RPI
Labour costs higher than predicted, as LCC works cannot be carried out during normal working hours	Increased labour cost element of LCC (as high as 30% for evening working and up to 60% for weekend working)	Restricting risk under contracts through agreed access and timing of work with building occupier or employer Restricting risk under contracts through use of an agreed schedule of labour rates with maintenance or replacement contractor
Discount rates change due to economic conditions	In use investment analysis could be inaccurate or move away from target	Use of sensitivity analysis to test different discount rates and related impacts, monitoring of rates against original assumptions made when LCCs were costed

Annex F (informative)

Information and data assumptions used for undertaking LCC of maintenance

The level of project information and data needed to produce a LCC maintenance study varies depending on the purpose, use of the LCC outputs, the scope of the costs and the agreed period of analysis.

Clause **9** defines the general and specific information required and data sources needed to undertake the LCC of maintenance works.

Table F.1 and Table F.2 provide more detailed examples of information and required data assumptions that are relevant to the brief and capture stages (Table F.1) and the evaluate and implement stages (Table F.2). It is advisable that where there are any exclusions or additions to those categories given in these tables, these are indicated in a report. It is important that the report states how and where the exclusions or additions are likely to affect the LCC plan.

NOTE This is not an exhaustive list and not all of this information is required for every type and application of LCC of maintenance.

It is important to obtain specific project information and data sources from the employer, the maintenance providers or industry sources and made transparent during the generation and reporting of the required LCC maintenance outputs.

The level of information required for the LCC of the in-scope elements on which the LCC is to be based needs to be established and formally agreed with the employer, and/or key stakeholders, at the outset as part of the brief stage.

Table F.1 **Information for the brief and capture stages** *(1 of 6)*

LCC descriptor	Project-particular information and data sources (applicable and desirable)
Project particulars	
Project description/title	Agree a brief description of the LCC of maintenance project and the estate, buildings and facilities in the scope
Employer and key stakeholders	State the names and contact details of key personnel, from the key stakeholder groups involved in defining the requirements and also in providing information relevant to undertaking the LCC of maintenance
Purpose and required reporting outputs from the LCC of maintenance study	State the specific use of the LCC evaluation and the required outputs including: • whether the LCC plan is to be used for a business case study, for option appraisal (e.g. for the public sector it needs to be carried out in accordance with Office of Government Commerce (OGC) gateway process), or for producing a cash flow for a sinking fund or any other stated purpose; • any specific requirements in respect of reporting (e.g. basis of economic evaluation: PDV, NPV, payback period);
Level of risk analysis (if required)	• any specific level of risk to be assessed (e.g. maximum/minimum/most likely or 10%/50%/90% confidence levels), see Annex E risk log.
Scope of costs	State what costs are to be included or excluded and how to express them.

Table F.1 **Information for the brief and capture stages** *(2 of 6)*

LCC descriptor	Project-particular information and data sources (applicable and desirable)
Agree the rules and methodology to be used for the LCC analysis in the evaluate and implement stages	**5.2.3** sets out the basis for agreeing the rules and methodology for undertaking LCC of maintenance works, which covers agreeing the purpose; scope of costs; required outputs and format of presenting the results; base dates; time (period of analysis); procurement and market conditions; obligations and constraints; options appraisals; level of information to be used; and other relevant considerations as defined by the stakeholder's requirements.
Portfolio/building(s) or facilities: salient details	Provide information and details for the portfolio of buildings or facilities, or constructed assets, including salient details of the establishments/sites, building/facilities and or functional usage. This information includes (where available): • location/region; • estate and facility classification (e.g. assign estate category); • buildings/blocks and naming conventions and/or numbering; • buildings and facilities to be in the scope or excluded; • outline specifications (salient details on forms of construction); • construction date (year of installation); • last major refurbishment date.
Building/facilities details on function and space usage [A)]	Compile salient information on the function and space usage of the building/facilities, including (where available) floor plans, zoning, sections, space types, elements and systems descriptions, applicable to undertaking the LCC of maintenance analysis. Function and space usage information (where available) may include: • function unit type (classification: e.g. office - stating GIFA size range, with or without air conditioning); • spatial classifications (space types); • number of storeys and storey heights, including basement floors (if any); • basement floors (if any); • floor areas (GIFA measurement) overall and split by each floor level; • usable area (split down by function unit type, if possible); • circulation area; • ancillary areas; • unoccupied areas; • other areas requiring regular maintenance (e.g. infrastructure assets). In addition, provide information on the areas not applicable to maintenance and any areas that are out of the scope (e.g. sub-tenanted premises or vacant spaces).

Table F.1 **Information for the brief and capture stages** *(3 of 6)*

LCC descriptor	Project-particular information and data sources (applicable and desirable)
Specialist characteristics	State if there are any special characteristics, for example: • listed buildings; • statutory notices (e.g. dangerous structures); • decommissioned or/mothballed site status; • other considerations (as applicable).
Location/geographical details	Advise on the geographic location of the facilities and/or estate portfolio for cost indexing buildings/facilities and the clustering/ grouping by location/region relevant to work packaging and cost management protocols.
Building use	
Current occupancy	Compile salient information including: • the use of building/facility, i.e. functional use of the built environment; • space utilization, e.g. office and partial laboratory areas – adapted mixed use; • the hours of operation, e.g. 24/7 prison or 8.30 pm to 6.00 pm work-week days; • tenure details, e.g. owned, leasehold, sub-let, etc.; • other considerations (as applicable).
Intended occupancy use	State if there are any special characteristics, for example: • listed buildings; • statutory notices, e.g. dangerous structures; • decommissioned or/mothballed site status; • other considerations (as applicable).
Asset information and maintenance strategies	
Current asset register	State: • whether there is a current asset register and/or BIM available; • when was it was updated. Check the coverage and accuracy/completeness of the current asset data (compared with the required maintainable asset structure that has been defined). Decide whether it is to be used to form the basis for the proposed LCC of maintenance or LCR work.
Maintainable assets: in scope (building and infrastructure assets)	Establish the applicable maintainable asset types for the proposed LCC exercise. The applicable maintainable asset elements and components (in scope) may include: • the building fabric and structures; • the finishes and decorations; • the building services; • the fixtures, fittings and furnishings; and • the external works and infrastructure.

Table F.1 **Information for the brief and capture stages** *(4 of 6)*

LCC descriptor	Project-particular information and data sources (applicable and desirable)
Maintenance strategies and service level regimes/delivery plans	Define the appropriate asset maintenance strategies for the specific asset types, i.e. inventions and service models for PPM, proactive inspections and renewal programmes of works. [B)]
Documentation and reports	
Maintenance documentation	Compile details of available drawings, any warranty documents, operation and maintenance manuals, health and safety files and other documentation relevant to the LCC. Details should include: title, reference, revision, date, author and location for viewing purposes.
Existing condition surveys and legacy defects reports	Compile salient information from: • the CAR and condition reports available; • the knowledge available from employer/site maintenance teams regarding asset condition and remaining life of the assets (e.g. forward maintenance works plans and known identified capital investment lists); • the specialist condition reports available (e.g. lifts, structures).
Maintenance reports	Historical records of performance, defects and analysis of maintenance delivery: • maintenance performance, availability and cost reports; • asset degradation and intervention studies; • legacy defects logs and dilapidation reports; • backlog/deferred maintenance lists available; • help desk records and service/audit reports (as applicable).
Historical expenditure analysis and trends [C), D)]	Compile volumetric data on previous years of maintenance activity (where available): • reactive trends, from help desk and historical expenditure analysis; • resources and cost of PPM (direct labour); • work assigned to sub-contracted maintenance tasks, e.g. specialist work; • extent of proactive maintenance tasks, e.g. tours, inspections; • expenditure on consumables; • expenditure on plant and equipment; • expenditure on maintenance, management-related activities; • expenditure on minor, major repairs and replacement works; • expenditure on other maintenance activities (as applicable); • analysis of maintain and renewal works by function and asset types; • analysis of forecast life expectancy and actual intervention of asset types; • defects lists, warranty records and vandalism incidents; • other considerations, e.g. insurance claims, grants.

Table F.1 **Information for the brief and capture stages** *(5 of 6)*

LCC descriptor	Project-particular information and data sources (applicable and desirable)
Current contracts and maintenance arrangements	
Conditions of the current maintenance contract(s)	Indicate the type of contract, title, termination obligations, insurances and warranties obligations, other key contractual terms and conditions and, for standard contracts, the edition, revision and standard amendments. In the case of standard form of contract/sub-contract, specify any amendments to clauses/conditions to any supplementary or special clauses/conditions.
Current maintenance arrangements	Compile salient information including: • who currently provides the maintenance, e.g. in house/outsourced; • what form of contract is currently in place, i.e. open book, lump sum and or comprehensive cover and SoR for corrective works; • PPM task schedules, customized asset maintenance strategies/plans; • other considerations (as applicable).
Details of the current resources deployed on maintenance-related activities	Provide a description of the work packages including: • supervisory and technical support staff (in-house and consultancy); • services attendance, porters, site managers (i.e. persons who are responsible for day-to-day maintenance such as caretakers); • security staff related to the facility (record whether the security systems costs are to be included in maintenance costs); • waste disposal (general waste, recycling, special waste from maintenance); • property management (facilities management, stock stores, general management, administration cost, any regulatory considerations, general inspections); • details of existing subcontracts; • details of any Transfer of Undertakings (Protection of Employment) Regulations 2006 [16] or Service Provision Change (Protection of Employment) Regulations (Northern Ireland) 2006 [17] obligations.
Details of sub-contracted maintenance work packages	Compile salient information if applicable: • sub-contracted maintenance work packages; • key contractual terms and conditions (e.g. type of contract/ termination); • service level provision; • risk transfer and payment mechanism; • other considerations (as applicable).

Table F.1 **Information for the brief and capture stages** *(6 of 6)*

LCC descriptor	Project-particular information and data sources (applicable and desirable)
Asset surveys and assessment data	
Level of asset survey [E), F)]	State the scope and level of asset surveying information on which the LCC is to be based on the following plans: a) annualized maintenance plans: 1) maintainable assets (to the level of all applicable asset types); 2) operation and maintenance as built information and drawings; 3) warranty documentation/insurance considerations (if required); 4) defects listings (if applicable); 5) environmental management and health and safety files. b) LCR plans: 1) ACR for all applicable maintainable assets; 2) asset condition grading; 3) PARL for all maintainable assets; 4) other forms of assessments (e.g. energy or capacity, Equality Act 2010 [9]). To reduce cost or time the survey may focus on critical assets only. [G)]

A) This is the same data that is normally provided for capital cost estimating and cost planning purposes.

B) The standard asset data structure given in NRM 1 [1] can be used as a common basis for integrating constructed assets to all applicable maintain and renewal asset types to standardize and facilitate a robust LCC analysis.

C) Information may be taken from the CMMS and from finance accounting systems.

D) The data, and how the existing data is to be used to set a baseline for comparative LCC analysis and benchmarking need to be stated.

E) As capturing asset information requires significant time and costs, the extent and level of the asset survey can be reduced by the reworking of existing data on a case-by-case basis.

F) If the existing data is in a poor state then a full asset identification survey is required. However, if the data can be utilized, then additional information can be captured as part of an asset verification survey.

G) See **6.2.3** and **6.2.4** for guidance on levels and usage of various forms of asset assessments.

Table F.2 **Information for the evaluate and implement stages** *(1 of 7)*

LCC descriptor	Project-specific information and data sources (applicable and desirable)
General project particulars	
Project details and the named parties involved	As defined during the brief and capture stages, restate the specific parties involved in the detailed evaluate stage and the implement stage respectively.
Purpose and required reporting outputs from the LCC of maintenance study (modify what was agreed in the brief stage)	State the specific use of the LCC evaluation and the required outputs including: • whether the LCC plan is to be used for a business case study, for option appraisal (e.g. for the public sector it needs to be carried out in accordance with Office of Government Commerce (OGC) gateway process), or for producing a cash flow for a sinking fund or any other stated purpose; • any specific requirements in respect of reporting (e.g. basis of economic evaluation: PDV, NPV, payback period); • any specific level of risk to be assessed (e.g. maximum/minimum/most likely or 10%/50%/90% confidence levels), see Annex E risk log.
Project-specific options (types of appraisals)	State specific options to be considered in the LCC scenarios, such as: • setting the level and budget for maintenance regimes (e.g. compliance/and fit-for-function); • predicting the asset renewal interventions (cash flow over the period of analysis); • asset degradation studies to inform funding and investment scenario modelling; • BIM modelling (COBIE data drops); • others as applicable (e.g. types of cladding systems compared with a traditional brick and block cavity option).
Scope and levels of data to be used	
Level of LCC data used	State the scope and level of the LCC data used, e.g.: • multi-asset or portfolio/estate level; • single asset or whole building level; • cluster level (multi-element level); • elemental level; • system level; • component or a more detailed level.
Level of design (stage) upon which LCC based	State the level of design on which the LCC is to be based, e.g. handover stage; this is particularly relevant when the LCC renewal is generated from a capital cost plan (post-practical completion for a new constructed asset, as built with variations).

Table F.2 **Information for the evaluate and implement stages** *(2 of 7)*

LCC descriptor	Project-specific information and data sources (applicable and desirable)
Asset information	
Types of asset information and forms of assessments	State the type of asset information on which the LCC is to be based e.g.: • maintenance standards for PPM tasks, e.g. B&ES SFG20 task schedules [2]; • condition surveying, i.e. past and/or new commissioned surveys; • other forms of assessment, e.g. PARL.
Use of data from other forms of assessments (optional, if required).	Other forms of assessments, required for wider economic evaluations, including: • space utilization; • functional suitability; • energy efficiency; • environmental; • design quality; • maintainability; • sustainability; • other assessments, as applicable.
Where the LCC data is built up from	State whether the data for the LCC exercise is built up from first principles or whether parametric or predicted data is used. State how the source data has been modified to the project and also record all salient assumptions.
Time frames	
Units of time for costing	State the units of time for costs, e.g. years, months, weeks, days for calculations; define whether the LCC forecast requires smoothing/other cash flow considerations.
Time (period of analysis)	State the: • period of analysis; • any hand-back liability period beyond the period of the LCC analysis, e.g. boilers to have an additional 5 year service life beyond the date of hand back; • construction practical completion and handover dates (defects period); • phasing/sections, if applicable; • ALE for applicable asset types in scope; • basis of years, i.e. calendar, financial.
Base date(s)	State the base dates for the LCC and the basis for cost indexation: • base date for pricing the LCC of maintenance; • construction completion and last major refurbishment dates; • life cycle replacement start and end dates (period of study); • maintenance start and end dates (period of analysis); • operation start and end dates (period of analysis); • occupancy start and end dates (period of analysis); • end of life (date and any period of liability beyond).

Table F.2 **Information for the evaluate and implement stages** *(3 of 7)*

LCC descriptor	Project-specific information and data sources (applicable and desirable)
Location indexation	
Location/indexation	State where the project is. [A)] Location factors and tender price adjustment. [B)]
Methodology	
Define the process and methodology to be used	State the specific process and methodology to be used for the LCC exercise for: • capturing and quality assurance or validation of maintenance information required; • defining the maintenance strategies and LCC renewal interventions; • identifying how well the assets are performing (using condition grading CAR scores and PARL assessments); • use of risk and sensitivity analysis (optional); • how the methods are to be used during the various stages of the process.
Cost data (included and excluded in scope)	
Scope of the costs	State what costs are to be included or excluded and how to express them (see Clause **7** for guidance on how to apply this in practice, Table 2 for the selection of costs to include or exclude in the LCC analysis and Figure 5 for an overview of WLC/LCC).
Other maintenance-related costs (as agreed in scope)	State what on-costs are to be included or excluded, e.g. maintenance contractor's management and administration charges and also their overheads and profit. State other maintenance-related costs such as consultant's fees and inspection costs, risks and contingency provisions and other employer-related costs, as agreed in the scope. State end of life costs, e.g. residual cost to meet hand-back obligations.
Other cost inclusions, where LCC might be part of a wider economic evaluation study, e.g. WLC or life cycle environmental assessment sustainability	State: • any items that have been included that are outside the normal scope of LCC plans, e.g. non-construction costs, income and externalities; • any user-specific costs not in the standard forms that are to be included; • any abnormal costs affecting the LCC plan, e.g. allowance for future legislative changes, non-adoption of roads; • any specific allowances for inflation (other than those implicit in the selected discount rate).
Capital cost plan used for generating the LCC renewal cost plans	State: • whether there is a capital cost plan available; • whether there is a current LCR model available; • whether variations have been included in the LCR model; • other considerations (as applicable). State how any construction costs used to generate the LCC for maintenance plans have been treated, e.g. all in year zero, pro-rata over a period and adjust if needed.

Table F.2 **Information for the evaluate and implement stages** *(4 of 7)*

LCC descriptor	Project-specific information and data sources (applicable and desirable)
CRV	State the capital rebuild value, often known as the reinstatement cost that is used for insurance purposes or from DRC valuations. CRV are required for the FMI and FCI or function reinvestment indexation purposes, where the cost of identified actions/works is expressed over the CRV to calculate the relevant indexation respectively.
Renewals and source data	
LCR (major repairs and replacement works)	State: • the employer requirements, e.g. meeting all legal obligations, corporate social responsibility and business critical maintenance by function, e.g. operational and image/reputation criteria; • the standards required to be maintained, e.g. condition or performance; • the working restrictions, e.g. access hours; • allowance for associated work to undertake the replacement; • the procurement context, e.g. direct labour, outsourced. Document and agree with the interested parties the interface between the major replacement costs, minor replacement and repair costs, and the unscheduled replacement, repairs and maintenance costs (e.g. where the responsibilities lie for facilities management and the LCR funds).
Responsibility limits (maximum repair liability)	State boundaries between the routine maintenance and the CAIP in major repairs and replacements, i.e. maximum repair liability limits.
RSL (sources of data)	State the source of RSL data [C] to be used in the LCC evaluation including: • the employer site or estate records captured by the organization; • the published data, e.g. BCIS [D], CIBSE Guide M [3] reference service life norms; • sector databases, e.g. HAPM [E] and BLP whole life cost data for housing [F]; • licensed data, i.e. BCIS on-line services [D]; • research data, e.g. BSRIA [G] and the product manufacturer's data; • unpublished data, e.g. the employer or the consultant's service life databases; • other sources, e.g. universities and other industry sources.
Subsequent refurbishment and adaptation costs [H]	State for specific improvements and upgrade works, if required in the scope: • the employer requirements; • the standards required to be satisfied, e.g. condition or performance regime; • an allowance for associated costs needed for the completion of the refurbishment; • the procurement context, e.g. direct labour, outsourced labour. Refurbishment and major adaptation is covered in the construction cost planning.

Table F.2 **Information for the evaluate and implement stages** *(5 of 7)*

LCC descriptor	Project-specific information and data sources (applicable and desirable)
Maintain cost	
Minor replacement, repairs and PPM, reactive and proactive maintenance costs	State for the purpose of planned, unscheduled and proactive maintenance: • the employer requirements; • the standards required; • the working restrictions; • the procurement context, e.g. whether direct labour or outsourced; • the provision for unscheduled maintenance; • any insurance considerations; • other information as defined by the user.
Other LCC costs (if required to be in scope)	
End of life costs or the period of analysis	State: • the employer requirements; • the allowance for dilapidations, and reinstatement; • the allowance for outstanding maintenance, reduced life, etc.; • any disposal inspections; • any special disposal costs, e.g. nuclear waste, batteries; • the requirement for demolition of the building if this is covered by the period of analysis.
Employer-defined costs (if required and agreed in the scope of the LCC analysis)	State: • the employer maintenance management costs; • the professional consultancy costs, e.g. surveys and technical services; • the auditing and monitoring costs; • the inspection regimes; • the taxes and incentives; • the finance costs (auditors and depreciation costs, if required); • other costs (as applicable). State how these costs are to be used, or not, in the LCC of maintenance.
Sunk costs (excluded)	Sunk costs are the cost of goods and services already incurred or irrevocably committed, e.g. past surveys; they should be excluded from the LCC plan.
Property insurance	Property insurance should be included. Other insurance that is payable as part of the normal work process should be included in the costs of the work to which they relate.
Future legislation	The LCC plan may only include allowances for legislation that has been enacted and this should be stated. Assumptions about future legislation that has not been enacted that are required to be included need to be shown separately.

Table F.2 **Information for the evaluate and implement stages** *(6 of 7)*

LCC descriptor	Project-specific information and data sources (applicable and desirable)
Other considerations	
Procurement route and market conditions	State: • the contractual procurement route, e.g. design and build and operate and maintain with or without finance, in the form of PFI; • the procurement stage, e.g. initial feasibility, outline design, pre-tender; • market conditions; • the tender basis, e.g. open book, lump sum, fixed price, fluctuating price.
Comprehensive provision	State if a provision is included for comprehensive cover and set threshold values.
Other considerations	State whether there are any commercial issues that influence how the LCC is undertaken. Where commercial issues are identified, decide on the appropriate course of action, record how this has been incorporated into the LCC and make reference to the specific issues involved in the LCC report.
Documentation used for the actual LCC analysis	State: • the list of documents forming the basis of the LCC analysis (both the project documents and external documents, e.g. product literature); • any sources of data used, e.g. project-specific and those in the public domain).
Exclusions	State any items that were required but have been excluded from the LCC results.
Presentation of the costs and methods of economic evaluation [l)]	State the method of economic evaluation to be used for the LCC analysis, and: • how costs have been presented, e.g. discounted, NPV; • other financial reporting and methods of evaluation, e.g. IRR, capital-to-cost in use ratio, payback period; • metric: use of FMI, FCI and function reinvestment indexation and other LCC metrics.
Discount interest rates	State: • the employer's requirements; • the discount interest rates used in the calculation (if applicable); • where discount rates are nominal, i.e. including an element of inflation.

Table F.2 **Information for the evaluate and implement stages** *(7 of 7)*

LCC descriptor	Project-specific information and data sources (applicable and desirable)
Tax (if applicable)	Where taxes are included in the LCC plan, the following information needs to be noted: • the rates should be included; • the VAT should be excluded (or, if included, it should also be separately stated); • the taxes payable as part of the normal work should be included in the costs of the work to which they relate; • the effect on employer's tax should normally form part of separate advice. Any allowances for the impact on employer's tax included in the LCC analysis should be stated separately.
Risks and uncertainty (if required; optional) [J]	State how the LCC assessment of the risks and uncertainty are to be dealt with by reference to the LCC risk register and mitigation plans, on a case-by-case basis.

[A] The BCIS location classifications may be used for this found at www.service.BCIS.co.uk [last viewed 16 August 2013].

[B] BCIS indices may be used for this and are found at www.service.BCIS.co.uk [last viewed 16 August 2013].

[C] Service life data can be obtained from published sources (such as [3], [13], [14] or [15]) or in-house records of maintenance, for example (also see **9.5**). ISO 15686-4 is currently in preparation and when published might be a useful source of service life data.

[D] This is available from www.bcis.co.uk [last viewed 9 August 2013].

[E] This is available from www.hapm.com [last viewed 19 August 2013].

[F] This is available from www.blpinsurance.com/added-services/whole-life-cost-modelling-costed-maintenance-plans [last viewed 19 August 2013].

[G] This is available from www.bsria.co.uk [last viewed 19 August 2013].

[H] The LCC analysis only normally includes improvements and upgrade works.

[I] Refer to Clause **7** and Annex D for guidance and detailed instructions on-cost presentation and economic evaluations.

[J] Refer to Annex E for guidance regarding how to deal with the risks and uncertainty associated with the LCC and for an example of an LCC risk log including mitigation plans.

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3) This was formerly known as the Heating and Ventilating Contractors Association.

4) This is an online web-based specification, available at http://www.sfg20.com [last viewed 17 August 2013].

5) See Building Defects Insurance website at http://www.blpinsurance.com [last viewed 17 August 2013].

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