BS 8536-2:2016

# Briefing for design and construction –

## Part 2: Code of practice for asset management (Linear and geographical infrastructure)

## Publishing and copyright information



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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 98, an inside back cover and a back cover.

# Foreword

## Publishing information

This Part of BS 8536 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 October 2016. It was prepared by Technical Committee FMW/1, *Facilities management*. A list of organizations represented on this committee can be obtained on request to its secretary.

## Relationship with other publications

BS 8536, *Briefing for design and construction*, comprises two parts:

- *Part 1: Code of practice for facilities management (Buildings infrastructure);* and
- *Part 2: Code of practice for asset management (Linear and geographical infrastructure).*

## Information about this document

The initial drafting of this part of BS 8536 was produced in association with the Department for Business, Energy and Industrial Strategy (BEIS) as part of their ongoing programme of support for standardization.

Briefing for design and construction focuses on those aspects of design, construction, testing and commissioning, handover and start-up of operations that are concerned with achieving the required operational performance of a new or upgraded asset. These aspects can include: energy use and greenhouse gas emissions; water abstraction and consumption; waste prevention, reclamation, recycling, treatment and disposal; noise and vibrations; and asset availability, access, inclusiveness, utilization, safety, security, capability, capacity, resilience, serviceability/maintainability, adaptability, quality, cost, value and comfort.

The aim is fourfold: to improve the focus of the supply chain on the performance of the asset in use; to extend supply chain involvement through to operations and defined periods of aftercare; to involve the operator, operations team or asset manager, as appropriate, from the outset of the project; and to take account of the need to maximize the value of the asset.

This standard broadly aligns with the principles of *The soft landings framework* published by UBT and BSRIA [1] and the principles identified in *Government Soft Landings* [2]. Soft landings (**2.1.61**) is concerned with the smooth transition from design and construction into operation and use of an asset. It advocates close collaboration during briefing, design, construction and handover between the delivery team and the operator, operations team or asset manager, as appropriate, in matters affecting operations and end-users, in order to maintain focus on the required outcomes.

This standard forms part of an existing set of standards connected with asset/facilities management and building information modelling. Whilst this standard assumes the use of "BIM Level 2" for projects, the adoption of soft landings is not precluded where "BIM Level 2" cannot be achieved across the project.

## Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

### Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its 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.

The word "should" is used to express recommendations of this standard. The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

### 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

This British Standard considers matters relating to projects for the delivery of built assets according to defined operational requirements, including maintenance, and performance outcomes. For the purpose of this British Standard, the term "delivery team" covers the collective efforts of designers, constructors and other specialists, representing the disciplines and skill-sets engaged in the delivery of a new asset or the upgrading of one existing. An integrated delivery team offers benefits in terms of coordinated design and problem solving, as well as consideration of constructability and operational impacts. This British Standard emphasizes the importance of adopting a whole-life view of an asset and the need to realize value from it; not solely its design and construction or upgrading. In this regard, it is important to recognize that a vast amount of information and data about an asset is generated and exchanged during its lifetime and that a security-minded approach to the handling of such information and data will need to be adopted.

The principle of constructability is widely applied in design. However, the principle of operability has not historically been considered to the same extent. Design decisions have to be based upon accurate and relevant information and data, and their impact on operational needs has to be understood before they are committed to construction. The most effective time to comment on the suitability or effectiveness of design is before it is finalized. Testing assumptions during design is necessary to understand how the asset will perform in operation. Whilst it is too late to comment on the design of the asset once it is operational, systematic measurement, analysis, comparison and feedback can be useful in informing the design of future assets.

This British Standard is intended to complement and strengthen briefing practices and procedures by:

a) promoting the early involvement of the operator, operations team or asset manager, as appropriate; and

b) extending the commitment on the part of the delivery team to aftercare post-handover of the asset and its safe, secure, efficient and cost-effective operation in line with environmental, social, security and economic performance outcomes and targets.

The requirements of inclusive design and of managing design in construction have been incorporated to anticipate the implications for managing assets and their environments inclusively and effectively when they become operational. This British Standard outlines the primary activities, information, questions and deliverables to be addressed by the designers, constructors and other specialists to support their work and so ensure that the asset owner and the operator, operations team and asset manager, as appropriate, are provided with as much certainty as possible in regard to the required operational performance of the asset.

This British Standard broadly aligns with the principles of *The soft landings framework* published by UBT and BSRIA [1] and the principles identified in *Government Soft Landings* [2].

# 1 Scope

This Part of BS 8536 gives recommendations for briefing for design and construction in relation to energy, telecommunication, transport, water and other infrastructure to ensure that design takes account of the expected performance of the asset in use over its planned operational life. It is applicable to the provision of documentation supporting this purpose during design, construction, testing and commissioning, handover, start-up of operations and defined periods of aftercare.

This British Standard is not intended to provide detailed guidance on design or construction, but is concerned with information and data that are needed in order that due consideration can be given to operability and performance requirements for the new or upgraded asset. It does not cover decommissioning or other end of life activities.

This British Standard is intended for use by individuals and organizations preparing or contributing to design, construction and operations, in both the public and private sectors, including owners upgrading an existing asset, organizations procuring a new asset, and the designers, constructors, suppliers, operators, licensees, operations teams, asset managers and other specialists engaged in such activities.

# 2 Terms, definitions and abbreviations

## 2.1 Terms and definitions

For the purpose of this British Standard the following terms and definitions apply.

### 2.1.1 access

ability of reaching and using a service or facility
[SOURCE: BS ISO 16439:2014, **3.2**]

### 2.1.2 activity

task that is needed to produce a deliverable

### 2.1.3 adaptability

ability to be changed or modified to make suitable for a particular purpose
[SOURCE: BS ISO 6707-1:2014, **9.3.78**]

### 2.1.4 aftercare

defined period post-handover of an asset in which the delivery team passes on information and knowledge to the operator, operations team or asset manager, responds to queries and problems, and monitors and reviews the asset's performance

### 2.1.5 as-constructed information

expression of the design, its working detail, construction work and/or installations, functions and operation and maintenance needs of an asset in a form suitable for use in managing that asset

### 2.1.6 asset

item, thing or entity that has potential or actual value to an organization
[SOURCE: BS ISO 55000:2014, **3.2.1**]

### 2.1.7 asset information model (AIM)

data and information that relate to assets to a level required to support an organization's asset management system
[SOURCE: PAS 1192-3:2014, **3.1.4**, modified]

### 2.1.8 asset information requirements (AIR)

data and information requirements of the organization in relation to the asset(s) for which it is responsible
[SOURCE: PAS 1192-3:2014, **3.1.5**, modified]

### 2.1.9 asset management

coordinated activity of an organization to realize value from assets
[SOURCE: BS ISO 55000:2014, **3.3.1**]

**2.1.10 asset management plan**
documented information that specifies the activities, resources and timescales required for an individual asset, or a grouping of assets, to achieve the organization's asset management objectives
[SOURCE: BS ISO 55000:2014, **3.3.3**]

**2.1.11 asset management system**
management system for asset management whose function is to establish the asset management policy and asset management objectives
[SOURCE: BS ISO 55000:2014, **3.4.3**]

**2.1.12 asset portfolio**
assets that are within the scope of the asset management system
[SOURCE: BS ISO 55000:2014, **3.2.4**]

**2.1.13 asset-related service**
support provision for an asset delivered by an internal or external service provider

**2.1.14 asset system**
set of assets that interact or are interrelated
[SOURCE: BS ISO 55000:2014, **3.2.5**]

**2.1.15 baseline**
specification or product that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development, and that can be changed only through formal change control procedures
[SOURCE: BS ISO/IEC 12207:2008, **4.6**]

**2.1.16 brief**
working document which specifies at any point in time the relevant needs and aims, resources of the client and user, the context of the project and any appropriate design requirements within which all subsequent briefing (when needed) and designing can take place
[SOURCE: BS 7832:1995, **2.1**]

*NOTE Annex A offers an example of a "Brief checklist".*

**2.1.17 briefing**
process of identifying and analysing the needs, aims and constraints (the resources and the context) of the client and the relevant parties, and of formulating any resulting problems that the designer is required to solve
[SOURCE: BS 7832:1995, **2.2**]

**2.1.18 building information modelling (BIM)**
process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information
[SOURCE: PAS 1192-2:2013, **3.7**]

**2.1.19 commissioning**
process by which equipment, a system, a facility or a plant that is installed, is completed or near completion is tested to verify if it functions according to its design specification and intended application
[SOURCE: BS ISO 50004:2014, **3.1.1**]

**2.1.20 common data environment (CDE)**
single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multidisciplinary teams in a managed process
[SOURCE: PAS 1192-2:2013, **A.30**]

**2.1.21 constructability**
degree to which the design of a planned asset assists its construction and utilization

**2.1.22 cost-benefit analysis**
process that assesses the relation between the cost of an undertaking and the monetary value of the resulting benefits
[SOURCE: BS ISO 16439:2014, **3.10**]

**2.1.23 deliverable**
product or service as an outcome of a process

**2.1.24 (project) delivery team**
group of organizations or individuals contracted either directly or indirectly to deliver services or products to the project
[SOURCE: PAS 1192-2:2013, **3.33**]

**2.1.25 design review protocol**
procedure for ensuring a structured and systematic review of a design at defined points in the project life cycle

**2.1.26 digital plan of work (dPoW)**
generic schedule of phases, roles, responsibilities, assets and attributes, made available in a computable form
[SOURCE: BS 1192-4:2014, **3.3**]

**2.1.27 employer's information requirements (EIR)**
pre-tender document setting out the information to be delivered, and the standards and processes to be adopted by the supplier as part of the project delivery process
[SOURCE: PAS 1192-2:2013, **3.21**]

**2.1.28 end-user**
person receiving asset-related services
[SOURCE: BS EN 15221-1:2006, **2.4**, modified]

**2.1.29 engineered system**
combination of components that work in synergy to perform a useful function

**2.1.30 environmental indicator**
sustainability indicator related to an environmental impact
[SOURCE: ISO 21929-1:2011, **3.11**]

**2.1.31 facilities management**
integration of processes within an organization to maintain and develop the agreed services that support and improve the effectiveness of its primary processes and activities
[SOURCE: BS EN 15221-1:2006, **2.5**]

*NOTE Also known as "facility management".*

**2.1.32 facility**
tangible asset that supports an organization
[SOURCE: BS EN 15221-1:2006, **2.6**]

**2.1.33 flawless start-up**
fault-free commencement of operations
[SOURCE: BS 8587:2012, **3.1.15**]

**2.1.34 handover**
act of passing responsibility for, and control over, an asset to the owner or operator following testing and commissioning

**2.1.35 impact**
any change that might be adverse or beneficial
[SOURCE: BS ISO 15392:2008, **3.13**]

**2.1.36 inclusive design**
design that seeks to include everyone irrespective of needs, circumstances or identity

**2.1.37 information exchange**
structured collection of information at one of a number of predefined stages of a project with defined format and fidelity for the purpose of communication
[SOURCE: PAS 1192-2:2013, **3.25**, modified]

**2.1.38 information model**
graphical model, non-graphical data and supporting documentation comprising the project information model (PIM) and asset information model (AIM) of an asset

**2.1.39 key performance indicator (KPI)**
measure that provides essential information about the performance of asset-related services delivery
[SOURCE: BS EN 15221-1:2006, **2.13**, modified]

**2.1.40 level of definition**
collective term used for and including level of model detail and the level of model information
[SOURCE: PAS 1192-2:2013, **3.30**, modified]

**2.1.41 level of model detail**
description of the graphical content of an information model at each work stage

**2.1.42 level of model information**
description of the non-graphical content of an information model at each work stage

**2.1.43 occupant**
user who spends a significant proportion of their time in or about a facility

**2.1.44 operability**
capable of being put into use as intended

**2.1.45 operations team**
functional group responsible for the day-to-day running and maintenance of an asset

**2.1.46 operator**
organization responsible for the day-to-day operation of an asset

**2.1.47 organizational information requirements (OIR)**
data and information required to achieve the organization's objectives
[SOURCE: PAS 1192-3:2014, **3.1.26**]

*NOTE The management activities leading to the OIR are the equivalent of the employer's key decision points in PAS 1192-2.*

**2.1.48 owner**
individual or organization owning or procuring an asset

*NOTE This can refer to both existing and prospective owners.*

**2.1.49 performance**
measurable result
[SOURCE: BS ISO 55000:2014, **3.1.17**, modified]

**2.1.50 plain language question**
request for information that is expressed in simple, easy-to-understand terms

**2.1.51 portfolio management**
centralized management of the processes, methods and technologies used to analyse and collectively manage projects

**2.1.52 post-implementation review (PIR)**
measurement of the outcomes of a project for the delivery of an asset and the performance of that asset in operation with the lessons to be learned for future projects

**2.1.53 programme management**
process of managing a number of related projects

**2.1.54 project execution strategy**
high-level statement of the intentions and arrangements for the execution of a project

**2.1.55 project information model (PIM)**
information model developed during the design and construction phase of a project
[SOURCE: PAS 1192-2:2013, **3.35**]

**2.1.56 quality**
degree to which a set of inherent characteristics of an object fulfils requirements
[SOURCE: BS EN ISO 9000:2015, **3.6.2**]

**2.1.57 scope of work**
design, construction and/or installation, testing and commissioning, handover and start-up activities necessary to deliver an operational asset

**2.1.58 security-minded**
understanding and routine application of appropriate and proportionate security measures in any business situation so as to deter and/or disrupt hostile, malicious, fraudulent and criminal behaviours or activities
[SOURCE: PAS 1192-5:2015, **3.1.26**]

**2.1.59 sensitive built asset**
built asset, as a whole or in part, that may be of interest to a threat agent for hostile, malicious, fraudulent and/or criminal behaviours or activities
[SOURCE: PAS 1192-5:2015, **3.1.27**]

**2.1.60 service level**
complete description of requirements of a product, process or system, with their characteristics
[SOURCE: BS EN 15221-3:2011, **3.1.11**]

**2.1.61 soft landings**
process for the graduated handover of a new or upgraded asset, where a defined period of aftercare by the delivery team is an owner's requirement that is planned and developed from the outset of the project

**2.1.62 sponsor**
individual or organization initiating and promoting a project or scheme

**2.1.63 stage**
division of a standardized process map for the acquisition of a facility, at some of which the requirements can be delivered
[SOURCE: PAS 1192-2:2013, **3.22**]

**2.1.64 stakeholder**
person, group or organization that has interests in, or can affect, be affected by or perceive itself to be affected by, any aspect of the project
[SOURCE: BS ISO 21500:2012, **2.14**]

**2.1.65 stakeholder impact analysis**
method for evaluating the influence that stakeholders possess in regard to an organization, asset or project

**2.1.66 steady state**
stable operation and use

**2.1.67 strategic asset management plan (SAMP)**
documented information that specifies how organizational objectives are to be converted into asset management objectives, the approach for developing asset management plans and the role of the asset management system in supporting achievement of the asset management objectives
[BS ISO 55000:2014, **3.3.2**]

**2.1.68 trigger-related event**
response to a trigger and the reflection of the altered state of the asset in the AIM
[SOURCE: PAS 1192-3:2014, **3.1.33**]

**2.1.69 upgrading**
major modification work on an asset or part thereof that improves its overall performance

**2.1.70 value improving practice**
practice with a demonstrated, statistically-reliable connection between its use and a better outcome

## 2.2 Abbreviations

| | |
|---|---|
| AIM | Asset Information Model |
| AIR | Asset Information Requirements |
| BIM | Building Information Modelling |
| BREEAM | Building Research Establishment Environmental Assessment Method |
| CDE | Common Data Environment |
| CDF | Concurrent Design Facility |
| COBie | Construction Operations Building information exchange |
| DQI | Design Quality Indicator |
| EIR | Employer's Information Requirements |

| | |
|---|---|
| ERP | Enterprise Resource Planning |
| HSSE | Health, Safety, Security and Environment |
| KPI | Key Performance Indicator |
| LEED | Leadership in Energy and Environmental Design |
| OIR | Organizational Information Requirements |
| PIM | Project Information Model |
| PIR | Post-Implementation Review |
| RASCI | Responsible, Accountable, Support, Consulted and Informed |
| SAMP | Strategic Asset Management Plan |

# 3 Design and construction for operability

## 3.1 Key principles and requirements

*COMMENTARY ON **3.1***

*Design and construction for operability takes into consideration the needs of the owner, operator, end-users and other key stakeholders in regard to a new or upgraded asset. The asset is likely to hold its value or benefit for the owner and end-users if it is trouble-free, efficient and cost-effective in terms of operation.*

*This British Standard broadly aligns with the principles of The soft landings framework published by UBT and BSRIA [1] and the principles identified in Government Soft Landings [2].*

The overarching principles are that the project for the delivery of the new or upgraded asset should take account of operational requirements and the expected performance outcomes from the outset, through all work stages (see **3.5**), and into operation. Design and construction should be guided by these principles and be followed by defined periods of aftercare to ensure that the owner, operator and end-users are able to derive the expected benefits and required operational performance of the asset.

*NOTE 1 Projects are set up for success from the outset; otherwise, they are unlikely to achieve their expected objectives or match the operational performance required by the owner, operator and end-users where these are known. This implies an emphasis at the front end of the project, where the ability to influence changes in design is relatively high and the cost of making those changes is relatively low. It involves developing sufficient strategic definition through which the owner can articulate requirements and address uncertainty and risks, then make the decision to commit resources to the project in a controlled manner. The project might not be self-standing and, instead, might form part of a programme, portfolio or network. Interdependencies are likely to exist between such projects with the need to consider them holistically; notwithstanding, this British Standard addresses projects alone. It does, however, apply to situations where a project is broken down into sub-projects covering an asset system (see **3.4** and **4.1.1**).*

These principles should be supported by the following.

a) The project for delivering a new asset or upgrading an existing asset should derive from the owner's asset management plan (see **2.1.10**) aligned with the business objectives as part of an asset management system (see **2.1.11** and BS ISO 55000, BS ISO 55001 and BS ISO 55002).

b) The owner or a delegated authority on the owner's behalf (see **3.6.3**) should be capable of defining the business case for the project, its objectives,

expected benefits and the required operational performance of the asset (see **4.1.1**). Appropriate professional advice should be sought where any aspect cannot be adequately defined.

c) The owner or the delegated authority should be capable of expressing the security needs for the project and the ongoing operation of the asset. Appropriate professional advice should be sought where any aspect cannot be adequately defined. Where the project relates to a sensitive built asset, a built asset security manager should be appointed (see PAS 1192-5 for the development of an appropriate and proportionate security-minded approach).

d) An evidence-based approach to design and construction should be adopted that is driven by outcomes that are explicit and measurable, wherever possible, and which reflects the requirements of the owner, operator, end-users and other key stakeholders in regard to the expected benefits and the required operational performance of the asset (see **3.2**).

e) Clear targets should be set for the expected benefits and the required performance outcomes at the start of the project (see **3.3**), which should be aligned with the owner's business objectives, as reflected in the business case (see **4.1.1**), and capable of being cascaded through the supply chain. These targets should be reviewed at defined information exchange points within work stages (see **3.9.4**, PAS 1192-2, PAS 1192-3 and BS 1192-4) and, finally, during operation of the asset.

f) Decisions in regard to design and construction should aim to maximize the value of the asset based upon the desired balance between cost, risk and performance (see **3.3** and BS ISO 55000, BS ISO 55001 and BS ISO 55002).

g) The appointment of the delivery team (see **3.6.6** and PAS 91) should incorporate a commitment to defined periods of aftercare (see **4.1.4**).

h) A post-implementation review (PIR) should be undertaken at prescribed intervals during a defined period of extended aftercare with the involvement of the delivery team and this, including the lessons learned, should be recorded and stored in the asset information model (AIM) so that they are available to the owner, operator, licensee, operations team or asset manager, as appropriate, and other parties determined by the owner (see **4.8.2.3.4**).

i) The transition from design through construction and into operation should include the phased and final transfer of project information and data for operational purposes from the project information model (PIM) to the asset information model (AIM) (see **3.9.4** and PAS 1192-2, PAS 1192-3 and PAS 1192-5).

j) The adoption of "BIM Level 2" should be considered to provide a fully-populated asset data set to support asset management through the use of the owner's defined enterprise system during the operational life of the asset (see **3.9.4** and BS 1192:2007, PAS 1192-2, PAS 1192-3, BS 1192-4 and PAS 1192-5).

*NOTE 2 Formal methods exist for examining the relationship between benefits and costs such as cost-benefit analysis and benefit-cost ratio – see, for example, ASTM E2204-15,* Standard guide for summarizing the economic impacts of building-related projects *[3].*

*NOTE 3 PAS 91 provides detailed guidance on the prequalification of appointees.*

*NOTE 4 The common data environment (CDE) provides a single source of information for the project (see **3.9.4**, BS 1192:2007, PAS 1192-2 and PAS 1192-3).*

*NOTE 5 There is a strong argument for creating the AIM at the start of the project so that it can be operated alongside the PIM and used by the owner to process information received throughout the project, rather than attempting to transfer all project information and data at once prior to handover of the asset (see **4.8.1** and PAS 1192-3). Doing so would provide more time for verification purposes and facilitate the training of the operator's or operation team's personnel in readiness for the start-up of operations.*

*NOTE 6 "BIM Level 2" represents federated file-based digital information with some automated connectivity (see PAS 1192-2 and PAS 1192-3).*

*NOTE 7 The owner might utilize an enterprise system [e.g. enterprise resource planning (ERP) system] to support its asset management.*

*NOTE 8 There is a relationship between this standard and BS ISO 55000, insofar as the latter deals with assets in general and this standard deals specifically with briefing for the design and construction of operational built assets.*

## 3.2 Evidence-based approach

This British Standard recommends an evidence-based approach to design and construction, where decisions should be based on the best available information from multiple sources, including but not limited to the owner's business objectives, current operations, the lessons learned from previous projects, design modelling and simulation, and performance evaluations. This approach should be extended to include the provision of evidence to support proposals and recommendations prepared by the delivery team. Information and data for these purposes should be handled, stored and protected in accordance with the owner's security requirements (see PAS 1192-5).

*NOTE 1 Evidence-based design and construction are likely to result in improvements to the project's expected benefits and the achievement of more exacting operational requirements with respect to environmental, social, security and economic performance, including demonstration of the owner's, operator's and end-users' satisfaction with the asset in operation.*

*NOTE 2 Information and data related to the owner's current and future business objectives and operations might include sensitive commercial/economic details and intellectual property that need to be afforded appropriate and proportionate protection.*

*NOTE 3 BS 7000-4 provides guidance on the management of design, including a general approach to briefing.*

## 3.3 Outcomes

Performance outcomes should be set at the Strategy work stage (see **3.5** and **4.1**) and monitored during each subsequent work stage up to and including Operation and End of life (see **3.5** and **4.8**), with post-implementation review (PIR) (see **2.1.52** and **4.8.2.3.4**) at prescribed intervals during a defined period of extended aftercare (see **4.8.2.3**) which should be used as the basis for measuring operational performance.

a) Environmental – the asset should meet performance targets, such as those for energy use, greenhouse gas emissions [carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and hydrofluorocarbons among others], water (e.g. quality, abstraction, consumption and pollutant prevention), soil and landscape (e.g. quality, remediation and changes), noise and vibrations, waste (e.g. prevention/reduction, reclamation, recycling, treatment and disposal) and/or other environmental indicators defined by the owner and operator (see Annex B for an approach and typical measures forming a part of the PIR).

b) Social (i.e. functionality and effectiveness) – the asset should be designed and constructed to meet performance targets, such as those relating to asset

availability, utilization, access, inclusiveness, safety, capability, capacity, resilience, serviceability/maintainability, adaptability, quality and comfort, and/or others defined by the owner and operator (see Annex C for an approach and typical measures forming a part of the PIR, and BS ISO 15686-2 for an approach to service life prediction).

c) Security – the asset and the creation, use, storage and disposal of asset-related information and data should meet the security requirements of the owner, operator, licensee, operations team or asset manager, as appropriate, and end-users (see PAS 1192-5 for the development of an appropriate and proportionate security-minded approach).

d) Economic – the asset should meet performance targets for capital cost and operational cost to enable whole-life costs to be estimated and value to be assessed (see Annex D for an approach and typical measures forming a part of the PIR).

Performance outcomes and targets should be specific to the project and should be verified in each work stage (see **3.5** and Clause **4**). As far as possible, a quantitative approach should be taken to measuring performance and value. Consideration should be given to differentiating outcomes over various planning horizons (i.e. short, medium and long term) or other agreed basis, particularly in regard to environmental performance and certain aspects of social performance (e.g. asset availability, inclusiveness, utilization, safety, capacity, resilience and serviceability/maintainability). Consideration should be given to whole life carbon as part of the measurement of environmental performance over the long term and as a basis for the assessment of the asset's sustainability (see PAS 2080).

*NOTE 1 An indicator is a quantitative, qualitative or descriptive measure. PD ISO/TS 21929-2 provides examples of environmental, social and economic performance indicators. It includes a framework for developing indicators for use in the assessment of economic, environmental and social impacts, and establishes a core set of aspects and impacts to be taken into account when developing systems of indicators.*

*A number of methods exist for measuring performance. One example is the* Design quality indicator (DQI) *[4], which is a five-stage method for evaluating the design over the project life cycle against three quality principles: functionality, build quality and impact. Another example is the BREEAM Communities [5], which is a scheme for measuring and certifying the sustainability of large-scale development plans. It provides a framework to support planners, local authorities, developers and investors through the master planning process.*

*NOTE 2 PAS 2080 specifies requirements for the management of whole life carbon in infrastructure, both in the provision of new assets and the upgrading of existing infrastructure. It covers requirements for establishing effective governance systems for reducing whole life carbon through the use of a carbon management process.*

*NOTE 3 A new or upgraded asset can help the owner to meet the requirements of key stakeholders, such as regulators, and new legislation.*

*NOTE 4 It is important to recognize that the full impact of the new or upgraded asset might not be seen for many years. For this reason, the evaluation of the asset's performance over what might be regarded as the long term falls outside the scope of this standard.*

*NOTE 5 The realization of value from an asset depends upon many factors, including striking the desired balance between cost, risk and performance. The definition of what constitutes value depends on the entity owning or operating the asset and could extend to other key stakeholders. Value can be tangible or intangible, financial or non-financial, and changes over the life of the asset (see BS ISO 55000). Benefit and utility are synonymous with value and all three are linked to cost.*

## 3.4 Process requirements

The following requirements should be met as the minimum.

a) Design and construction – the asset should be designed and delivered to the required operational requirements to allow it to perform as expected for its planned life subject to an appropriate maintenance regime (see **4.3.2.3**, BS ISO 15686-2, BS ISO 15686-5, BS 8210 and BS 8544). Where the project covers an asset system, additional processes for capturing and managing requirements should be considered (see **4.1.1**). In this regard, the owner should determine whether or not specific processes for configuration management, system integration and verification are required during design and construction (see **4.5.1** and BS ISO/IEC/IEEE 15288). Where deemed necessary, these processes should be incorporated in the relevant work stages (see Clause **4**).

b) Commissioning, training and handover – the commissioning and handover of the asset should be supported by training to meet the needs of the operator, end-users and other key stakeholders (see **4.6** and **4.7**).

c) Asset management – the asset management plan should be efficient and cost-effective in terms that are quantifiable (see **3.7** and **4.7.7**).

d) Information and security management – the management of information and security should be efficient and effective in terms that are quantifiable (see PAS 1192-5).

The processes in a) to d) should be measured principally through key performance indicators (KPIs) to determine their effectiveness.

*NOTE 1 Operational requirements can extend to the owner's internal technical standards for design, construction, operation and maintenance.*

*NOTE 2 KPIs measure progress towards achieving objectives or other factors that are critical to success (see BS EN 15221-1). They represent the significant measures that allow the owner to act quickly upon any deviation in performance.*

## 3.5 Plan of work

*COMMENTARY ON **3.5***

*A plan of work outlines the work stages and the digital plan of work establishes the level of model detail and the level of model information that need to be delivered by each originator during delivery, or upgrading, and operation of the asset in each work stage for a specific project. Progression depends on satisfying predefined criteria at decision points (or gates) that include requirements relating to environmental, social, security and economic performance. In this regard, it is important to recognize the iterative nature of some work activities, where the need to reassess assumptions is a normal and necessary feature. In the case of design, the process is not linear and is likely to involve some degree of iteration in order to converge on an acceptable solution.*

The work stages should be based on the following and may be adjusted to suit the owner's specific needs.

0 **Strategy** – defines the owner's/sponsor's business plans and case for the project, including required outcomes and other core considerations.

1 **Brief** – develops the project objectives, including required project and performance outcomes from the asset over different planning horizons.

2 **Concept** – prepares the concept design, including outline proposals for the general design treatment, structural design and engineered systems.

3 **Definition** – develops the design, including coordinated and updated proposals for the general design treatment, structural design and engineered systems.

4 **Design** – prepares the technical design, including structural and engineering design information, detailed cost and operational data.

5 **Construct and Commission** – plans, organizes and coordinates off-site fabrication with on-site construction, including transportation, assembly, testing and commissioning.

6 **Handover and Close-out** – training of the operations team and handover of the asset to the owner/operator and start-up of operations.

7 **Operation and End of Life** – steady-state operations, aftercare, post-implementation review (PIR), including benchmarking and lessons learned.

*NOTE 1 This recommended plan of work reflects a generic approach derived from various sources including the Construction Industry Council and the BIM Task Group (www.bim-level2.org) [viewed 2016-10-05].*

The plan of work should ensure that the deliverables of all originators of information and data are identified and appropriate to the decisions required at each work stage, and should be adopted as the basis for delivering, or upgrading, and operating the asset. This plan should be specific to the project, "digitally checkable" and capable of supporting "BIM Level 2" (see **3.9.4**).

*NOTE 2 "BIM Level 2" represents federated file-based digital information with some automated connectivity. A digital plan of work (dPoW) implies the use of "BIM Level 2". The BIM Toolkit [6] (https://toolkit.thenbs.com/) [viewed 2016-10-05] has been developed as an optional tool to provide step-by-step help to define, manage and validate responsibility for information development and delivery at each work stage.*

Figure 1 outlines the progression from the Strategy work stage through to Operation and End of Life, where the decision to proceed from one work stage to the next depends upon the owner signing-off on key decisions. For this reason, decision points (or gates) should be incorporated into each work stage to evaluate the progress achieved in alignment with the expected benefits, operational requirements and the required environmental, social, security and economic performance of the asset (see **3.3**). The owner should determine the timing of decision points, information exchanges (see **3.9.4** and PAS 1192-2, PAS 1192-3, BS 1192-4 and PAS 1192-5) and the criteria to be satisfied, taking into account the adopted procurement method.

*NOTE 3 Decision points can occur at any time within a work stage and are likely to be determined by the owner's internal policy and decision making. It would not be appropriate for the delivery team, when appointed, to determine such timing. Discussion between the owner and delivery team on the alignment of decisions and information exchanges would, however, be in both parties' interest.*

Figure 1 **Work stages**

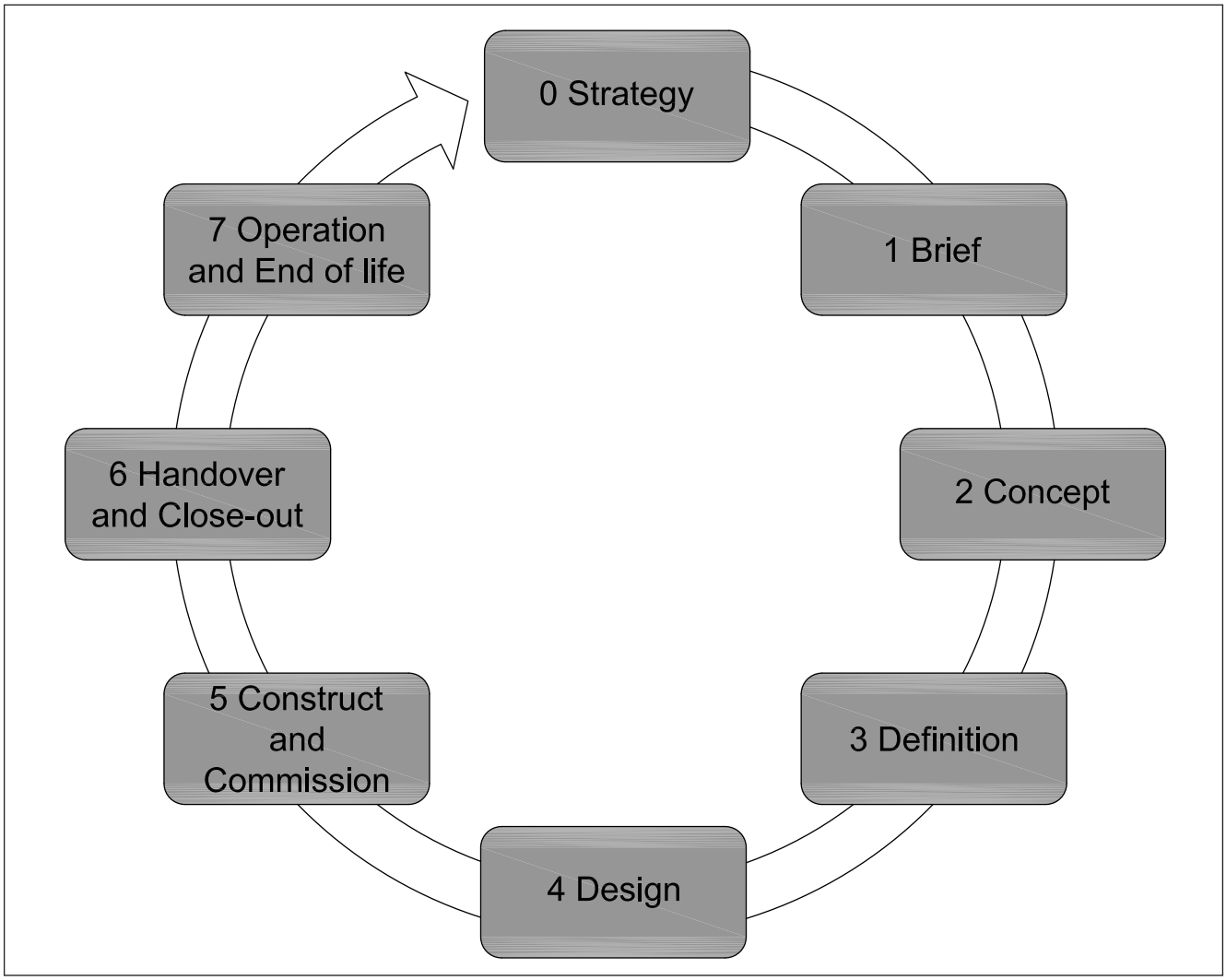
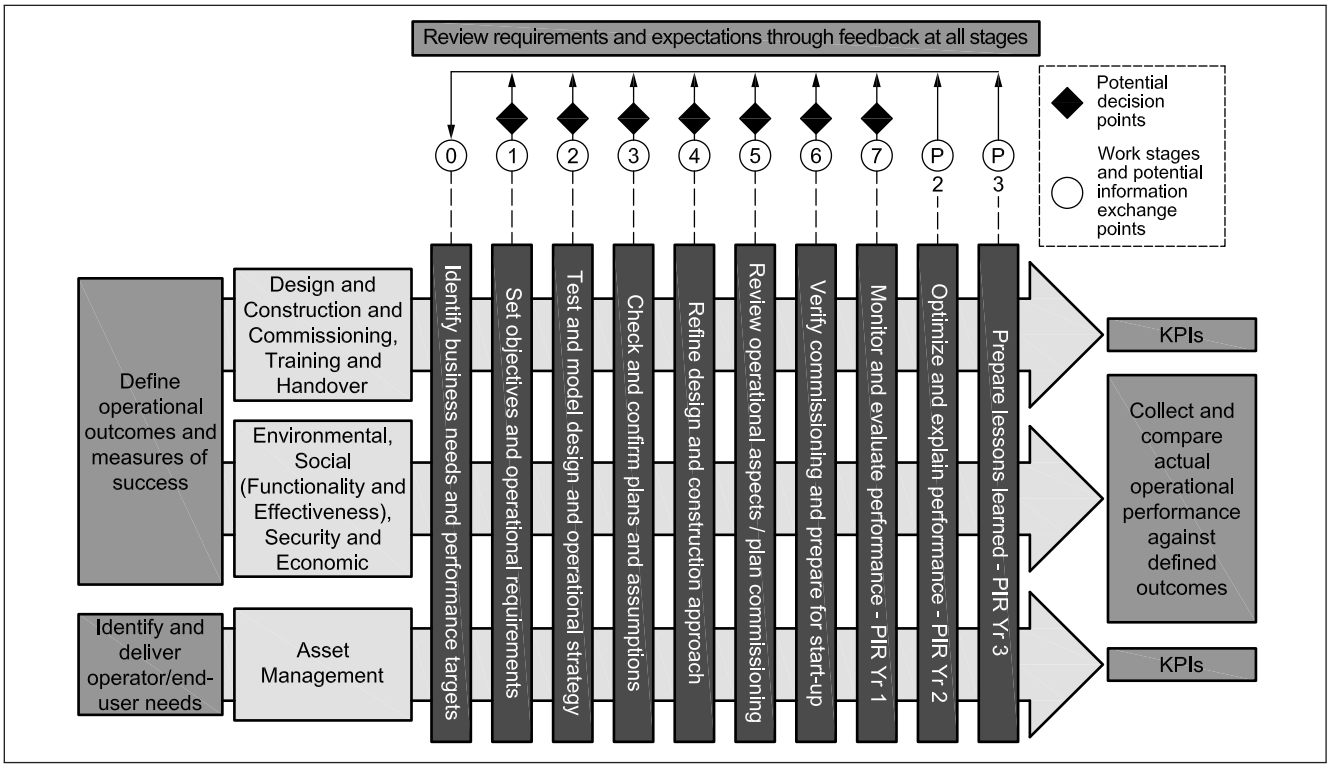



Figure 2 summarizes the overall approach in which requirements and expectations are reviewed through continual feedback. Progression to the next work stage should be conditional upon satisfying defined criteria relating to the expected benefits, operational requirements and the required environmental, social, security and economic performance of the asset (see **3.3**).

*NOTE 4 The approach advocated in Figure 2 reflects the information delivery cycle described in PAS 1192-2 and effectively extends its scope to cover performance-related requirements for the asset.*

Figure 2 **Overall approach highlighting the importance of performance reviews and feedback**




## 3.6 Roles and responsibilities

### 3.6.1 General

*COMMENTARY ON **3.6.1***

*BS ISO 55000, which is concerned with "management systems for the management of assets", adopts the term "organization" throughout to refer to the entity receiving asset management. This part of BS 8536 is concerned with a broader range of considerations that involve multiple entities, including asset owners, operators, licensees, designers, constructors and other specialists. For clarity, this standard differentiates between entities by name; hence, the term "organization" is used in a general sense only.*

The owner or any delegated authority on its behalf (see **3.6.3**) should ensure that there is a clear governance structure with defined roles and responsibilities that are resourced by personnel with the appropriate level of competence, skills and experience.

The appointment of a delivery team (see **3.6.6**), and operator, operations team or asset manager (see **3.6.4**), as appropriate, should be made having regard to the need to establish the clearest possible understanding of the respective parties' duties and obligations from the outset of the project. The incorporation of periods of aftercare within the Operation and End of life work stage extends the traditional involvement of the delivery team, so the particular commitments this entails from all affected parties should be made explicit. The appointment of the operator, operations team or asset manager, as appropriate, should be made before any decision is reached on whether or not to proceed with the project. Where this is impractical, the owner should ensure that expertise on asset management is available so that operational requirements and the expected performance of the asset form an integral part of the decision making.

*NOTE 1 PAS 91 provides detailed guidance on the prequalification of appointees.*

There should be, from the outset of the project, an explicit working approach that requires agreement between the various parties on the work activities and their timing, with the associated information requirements and deliverables (see Clause **4**). The basis upon which decisions are to be made should be clearly defined and communicated to all involved parties from the earliest practicable point. This task can be greatly assisted if the owner or delegated authority is proactive in ensuring that the roles and responsibilities of the parties are properly defined and communicated.

*NOTE 2 Defining and managing the organizational information requirements (OIR), the employer's information requirements (EIR) and the built asset security information requirements (BASIR) are important considerations (see PAS 1192-3, PAS 1192-2 and PAS 1192-5, respectively).*

*NOTE 3 Agreeing the working approach and the basis of decisions up front is likely to avoid inefficiencies and reduce the potential for conflict between the parties.*

Where the asset is sensitive or the owner and/or operator has decided to implement more than baseline security measures, advice/guidance should be sought from the owner's/operator's built asset security manager on all security aspects related to the design, construction and operation of the asset and the protection of asset information and data (see PAS 1192-5).

### 3.6.2 Owner

*COMMENTARY ON **3.6.2***

*Soft landings [1], [2] is intended to assist owners and operators in getting the best out of their new or upgraded asset by providing a unified approach for addressing outcomes from an integrated process of briefing, design, construction and commissioning of the asset. The emphasis is upon greater involvement of the delivery team with the operator, operations team or asset manager, as appropriate, and end-users before, during and after completion of construction, to assure operational readiness in the expectation of a flawless start-up, steady-state operations and sustained performance in use. Much of the information required to support soft landings is already collected in the normal course of delivering a project. Where soft landings has been adopted, the owner is expected to nominate a person with responsibility for ensuring that it is developed to suit the project throughout design and construction and into operation of the asset. This person might be referred to as the "soft landings champion", "owner's representative" (see BS 8536-1), "project sponsor" or by some other term of the owner's choosing. The term "sponsor" has been adopted in this standard (see **3.6.3**).*

The owner should appoint a sponsor (see **3.6.3**) whose principal task is to ensure that design and construction is planned, implemented and controlled to ensure a smooth transition into operation and for the defined periods of aftercare. The sponsor should be expected to have first-hand working knowledge of the owner's organization and an understanding of the asset's future. Where an existing asset is to be upgraded, the sponsor should have an understanding of its history.

*NOTE There is the chance that the sponsor might be seen as a project manager. For clarity, the project manager is responsible for delivering the asset to an agreed scope of work, schedule and cost/budget and, normally, has no involvement or interest once the project has been delivered and the asset is operational. Similarly, the asset manager might have limited expertise or interest in the project's delivery, other than to ensure that the asset, once delivered, performs as required. There is, therefore, the need for a person who possesses a more strategic interest in, and understanding of, the combined project delivery and asset management process than either of the aforementioned.*

### 3.6.3 Sponsor

*COMMENTARY ON **3.6.3***

*A sponsor often acts as the owner's "internal client" to provide leadership during project development, to ensure that the project is efficient and cost-effective. The sponsor is normally accountable for the business case, obtaining funding and determining performance and other requirements, and is supported by the delivery team, if appointed at this time (see **4.1.2**). The sponsor maintains an overview of the project, ensuring it remains on target to deliver the expected benefits and achieve the required operational performance. This role includes responsibility for ensuring that the principles of soft landings are incorporated into the project delivery process and into operation of the asset for an agreed period of extended aftercare.*

The sponsor should be appointed for the entire period from the Strategy work stage and into Operation and End of life, including the full period of extended aftercare, to provide continuity of purpose and consistency of approach. The sponsor should report to the owner and should consult with the representative(s) of end-users or other key stakeholders as appropriate. The role of the sponsor should not duplicate that of the project manager, where appointed.

The role of the sponsor should be to maintain the focus of all parties on the required project outcomes and operational performance, as well as on an evidence-based approach during all work stages from Strategy through to Operation and End of life, including the period of extended aftercare. The role of the sponsor should not be delegated to another party, but another person or persons may be engaged in a supporting role to deal with any day-to-day questions and issues that arise which would distract the sponsor from more strategically-important matters.

The role should involve regular reference to the schedules or equivalent documentation that identify the work activities of the delivery team with their associated information requirements and deliverables. The sponsor should facilitate input from the operator, operations team or asset manager, as appropriate, and end-users to the work of the delivery team. The sponsor may communicate directly with the designated manager for the construction work.

The sponsor should ensure that the following are achieved, as a minimum:

a) establishment of the expected benefits and required operational performance of the asset (see **3.3**) and the operational budget;

b) verification through successive work stages that the expected benefits and required operational performance will be achieved (see Clause **4**);

c) plans for commissioning, training and handover of engineered systems and the phasing in of asset management (see **4.6**, **4.7** and **4.8**);

d) liaison with the owner's built asset security manager, where one has been appointed, to ensure that the owner's security requirements are fulfilled;

e) post-implementation review (PIR) to establish if the asset is performing as expected (see **4.8.2.3.4**), including measurement of actual operational performance against the required performance from environmental, social, security and economic perspectives (see **3.3**) based on information and data taken from reliable sources during the extended period of aftercare; and

f) coordination of the preparation of an advisory report by the operator, operations team or asset manager, as appropriate, with input from the delivery team where required (see **4.8.5**), during the extended period of aftercare covering the need for any corrective actions, the presentation of benchmarking data and the lessons learned (see **4.2.2.2**).

*NOTE PAS 1192-2 refers to an employer's representative possibly having responsibility for ensuring that information requirements are included in project contracts and for subsequently authorizing the transfer of information. This is a role that can be fulfilled by the sponsor.*

### 3.6.4 Operator, operations team and asset manager

*COMMENTARY ON **3.6.4***

*The owner might be the operator of the asset or another party might fulfil this role, including those situations where a licence is granted to operate a service based on the asset as would occur in the case of a toll road, bridge or tunnel. In all situations, it is necessary that the interests of the operator are taken into account from the outset. These interests extend to the needs of the end-users of the asset. In a larger organization, an operations team, asset management team or, perhaps, an asset manager is responsible for the asset on a day-to-day basis, including its maintenance; or a separate organization, acting as a concessionaire or licensee, might be responsible. In a smaller organization, there might be no equivalent arrangement. Nonetheless, someone has to provide expertise on operational matters and that might have to fall to a consultant engaged for this purpose. This person is necessary to provide comment and advice on the implications of design and construction proposals from an operational perspective as they are developed from the Strategy work stage through to the Handover and Close-out work stage.*

The operator, operations team or asset manager, as appropriate, should be given authority by the sponsor to provide appropriate information and data concerning the operational strategy and operational requirements, including performance outcomes and targets, operational cost and budgets, and the procurement of asset-related services where applicable (see BS 8572), to the delivery team. The delivery team should ensure that contributions are duly recorded and made available to the sponsor upon request. A RASCI chart should be created by the sponsor to clarify overall responsibilities.

*NOTE 1 Annex E gives an extract from a RASCI chart.*

*NOTE 2 PAS 1192-3 contains guidance on the need for the operator, operations team or asset manager, as appropriate, to identify the owner's information needs, referred to as the employer's information requirements (EIR) in PAS 1192-2 (see **3.9.1**).*

*NOTE 3 PAS 1192-5 contains guidance on the need for a security-minded approach to asset management and the need for the owner/operator to set out a security strategy, security management plan and security information requirements for the asset.*

### 3.6.5 End-users

*COMMENTARY ON **3.6.5***

*The users of the asset are a key stakeholder group and are collectively referred to as "end-users" because they are generally the ultimate beneficiaries of the services provided by the asset in operation.*

The sponsor should ensure that the interests and needs of the end-users of the asset are taken into account through a process of stakeholder engagement (see **4.1.3**). Depending on the number and diversity of end-users, the sponsor may consider it appropriate to arrange for representation on a group, rather than an individual, basis.

The collection, use and storage of personally-identifiable information and data should be handled in a security-minded manner.

*NOTE Asset-related systems might contain a range of information and data about end-users, for example information about passes or access tokens and emergency contact details.*

### 3.6.6 Delivery team

*COMMENTARY ON **3.6.6***

*An integrated, collaborative approach to design and construction is necessary to assure both the constructability of the design and the operational performance of the asset. The term "delivery team" is used throughout the standard to refer to the combined, collaborative efforts of the many disciplines that can be required to assist in transforming the owner's business objectives into an operational asset. An integrated delivery team reduces the likelihood of "silo working", decreasing the prospect of errors and omissions. Specialist contractors, suppliers and manufacturers can be regarded as an integral part of the delivery team. Particular requirements in regard to these supply chain entities warrant additional consideration (see **3.6.7**).*

The sponsor should appoint an integrated delivery team to ensure there is an emphasis on collaborative working based on shared responsibilities and goals that are aligned with those of the owner and the operator, where the latter is a separate entity (see **3.6.4**), and/or the operations team. The sponsor should determine the composition of the delivery team, taking account of the breadth and depth of competences, skills and experience needed in the project through each successive work stage from Strategy through to Operation and End of life while maintaining continuity of purpose in regard to the owner's business objectives throughout (see **4.1.1**). The team should be extended by the sponsor to include personnel from the operations team or, where no such arrangement presently exists, an asset manager should be appointed to ensure that operational requirements and performance outcomes (see **3.3**) are taken into account in each work stage.

The delivery team should support the role of the sponsor in pursuing an operational asset that meets defined performance outcomes and targets. The delivery team should nominate a person from within its body to be responsible for coordinating all transition-related activities with the sponsor.

The delivery team should ensure that roles and responsibilities for the project are aligned to work activities, with their associated information requirements and deliverables. Responsibility assignment matrices (e.g. RASCI charts) should be prepared for this purpose by the delivery team, and their format should be approved by the sponsor. Each RASCI chart should be updated as necessary in each work stage and in readiness for the subsequent work stage (see Clause **4**). RASCI charts should be coordinated with an organization chart for the project prepared by the delivery team to show reporting/communication between all parties within the project delivery organization, with interfaces to external entities and other key stakeholders as appropriate. Design responsibility matrices should complement the use of RASCI charts by providing a focus on assigned design responsibilities, the level of model detail and the level of model information exchanged (see **3.9.4**).

*NOTE 1 Annex E gives an example RASCI chart and a detailed responsibility matrix.*

The delivery team should advise the sponsor of the need for any additional competences, skills and experience required in the team as soon as it becomes apparent. Where the engineered systems are complex, the owner, or the sponsor on its behalf, should consider the appointment of an independent commissioning manager if not already appointed. The commissioning manager should be appointed early in the project's life. Where there is a known or perceived security threat to the asset, the owner should consider the appointment of a built asset security manager, if not already appointed, at the outset of the project.

*NOTE 2 PAS 1192-5 outlines a security triage process which an owner can use to establish the level of security-minded approach required for its asset and associated information and data, and any asset information and data it might hold regarding neighbouring assets or facilities.*

### 3.6.7 Specialist contractors, suppliers and manufacturers

*COMMENTARY ON **3.6.7***

*In the course of delivering a new or upgraded asset, much work devolves to specialist contractors, suppliers and manufacturers. The success of the transition from design through construction and into operation depends on the effective integration of the supply chain covering all of the entities necessary for delivering the operational asset. The management of multiple organizational, technical and contractual interfaces between these entities is part of the task and is a factor in that success. Specialist contractors have a pivotal role in the sense of standing between the designers and construction managers and the manufacturers and suppliers of myriad materials, products, components and systems. It is essential that specialist contractors are effectively integrated into the approach to be taken, including the work activities, information requirements and deliverables in each work stage.*

As far as practicable, specialist contractors, suppliers and manufacturers should adopt an approach that supports the key principles (see **3.1**) throughout all work stages in which they are involved. Each specialist contractor, supplier and manufacturer, as appropriate, should identify its contact person for the purpose of transition and inform the transition coordinator (see **3.6.6**) within the delivery team. The contact person should attend meetings of the delivery team, when requested, to present proposals concerning the respective parties' work, including details of the operational requirements of systems, equipment, controls and user interfaces, as appropriate.

Specialist contractors should be retained to assist the owner and other members of the delivery team during handover and to monitor performance during start-up and operation of the asset. Specialist contractors may be based on site full-time during an initial period of aftercare (see **4.8.2.2**) to assist with end-user queries and to undertake optimization of systems as necessary. In this case, the sponsor should make these requirements clear and ensure that they are embodied in the scope of work and subsequent agreements with the specialist contractor.

*NOTE PAS 91 provides detailed guidance on prequalification for construction tendering.*

Specialist contractors identified by the sponsor might be required to provide support for an extended period of aftercare (see **4.8.2.3**), in which case the roles and responsibilities should follow those required in the Operation and End of life work stage.

Specialist contractors should be required, where appropriate, to contribute their information and data to the common data environment (CDE) (see BS 1192:2007, PAS 1192-2, PAS 1192-3 and PAS 1192-5). Depending on the security requirements of the owner/operator, any specialist contractor supplying information relating to sensitive aspects of the asset should follow the owner's/operator's security policies, processes and procedures regarding the creation, use, storage and disposal of asset information and data.

## 3.7 Collaboration and alignment

*COMMENTARY ON **3.7***

*"Design and construction for operability" aligns the interests of those who design and construct an asset with those who subsequently operate and use it. Success is due, in large part, to a collaborative approach between the various parties, but also to monitoring and verifying the alignment of the work of the delivery team and the developing design with the expected benefits and required operational performance of the asset.*

The sponsor should ensure that the delivery team understands the necessity of a collaborative approach to its work and the importance of active engagement with the operator, operations team or asset manager, as appropriate. The delivery team should provide evidence of its approach in the form of a schedule of work activities, with their associated information requirements and deliverables, for each work stage (see Clause **4**). This should take the form of a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities with their associated deliverables for each work stage. This should be supplemented by a detailed responsibility matrix covering assigned design responsibilities, the level of model detail and the level of model information exchanged (see **3.9.4**).

*NOTE 1 Annex E gives an example RASCI chart and a detailed responsibility matrix.*

The delivery team should obtain early input about the operator's, end-users' and other key stakeholders' interests and needs, which should be assisted by the sponsor who should prepare a plan for stakeholder engagement (see **4.1.3**). End-users, or their representative(s), should be allowed to express their views in an environment that is conducive to obtaining an honest and accurate understanding of their needs.

An aim should be to establish clear measures, outcomes and targets for environmental, social, security and economic performance. In the case of environmental outcomes, these should cover energy performance, in particular energy use and greenhouse gas emissions, water consumption, waste reduction, noise and vibrations, and social outcomes should cover functionality and effectiveness, for example asset availability, utilization, access, inclusiveness, safety, capability, capacity, resilience, serviceability/maintainability, adaptability, quality and comfort. Security outcomes should focus on the practical steps to be taken to reduce the risk of loss, compromise or disclosure of information and data about sensitive aspects of the design, construction or operation of the asset. Economic outcomes should focus on capital, operational and whole-life costs as early as possible and, thereafter, should consider ways in which costs might be reduced whilst maintaining functionality and effectiveness. All performance outcomes and targets should, as far as practicable, be subject to monitoring and verification through all work stages.

*NOTE 2 The adoption of value improving practices, if properly controlled, can assist in identifying functions that add cost, but which are of no value to the owner, and then eliminating them. Value engineering is a common and proven methodology for this purpose. It is important, however, to ensure that value engineering is a genuine attempt to seek value improvement, which implies a relationship between cost and quality, and is not simply a cost-cutting exercise. The adoption of whole-life costing and applying lessons learned can be similarly regarded as value improving practices.*

Commissioning, training and handover should be planned jointly by the delivery team and the operator, operations team or asset manager, as appropriate, overseen by the sponsor, to ensure operational readiness, flawless start-up and early optimization of operational performance (see **4.6** and **4.7**). End-users, or their representative(s), should be involved in this planning.

The delivery team should be involved in post-implementation review (PIR) as a process for evaluating the performance of the asset over at least the first three years of its operational life to establish actual outcomes and to record and share lessons learned (see **4.8.2.3.4**). The PIR should extend to measuring the impact of the operator's or operations team's asset management plan on the performance of the asset (see **3.4** and **4.7.7**).

*NOTE 3 The advantages of this approach, including post-implementation review (PIR), are the optimization of operational performance of the asset within the operational budget as soon as possible and the alignment of operational performance with the required performance outcomes set prior to the start of design and construction. Achievement of the required outcomes could be regarded as an indication of the operator's and end-users' likely satisfaction with the asset and offers some assurance with respect to operational cost.*

The sponsor should ensure that operational input is a continual, but controlled, contribution during design and construction work to ensure that the design of the asset is subject to evaluation from an operational perspective. A design review protocol should be used to support this work, together with a plan for information exchange (see BS 1192-4). The delivery team should respond on matters of alignment of the developing design with the expected outcomes, changes to the design that have been necessary and the extent to which performance targets for the operational asset are likely to be met. Confirmation of the associated capital and operational costs should be provided by the delivery team, with input from the operator, operations team or asset manager, as appropriate, at points defined for each work stage for the purpose of information exchange (see **3.9.4**, Clause **4** and PAS 1192-2, PAS 1192-3, BS 1192-4 and PAS 1192-5).

## 3.8 Risk (threat and opportunity) management

The threats and opportunities that could affect realization of the value and performance of the asset should be systematically assessed and managed in each work stage. This assessment should be undertaken periodically to identify any condition or event that could erode value or impact negatively or positively on the operation of the asset and determine the actions needed to manage them. The assessment should include identification and analysis of threats (downside risks) and opportunities (upside risks), responses to risks and the controls to be applied. Security risks, in particular, should be assessed at various points throughout the life cycle and when certain trigger-related events occur, with the security strategy updated accordingly.

Account should be taken of the operator's and end-users' interests in the asset when identifying and assessing threats and opportunities. Details of such risks and actions arising should be recorded in a risk register and reflected in the estimates of capital cost and operational cost and the project schedule.

*NOTE 1 Downside risks are factors that can have a potentially negative impact on the asset, such as hazards faced in the construction work, and are commonly referred to as threats. Upside risks are factors that can add value to the outcome and are more commonly referred to as opportunities. The latter might arise from a re-examination of the scope of work against the business and project objectives, e.g. changes to take advantage of more energy-efficient technology.*

*NOTE 2 PAS 1192-5 includes a risk management process for assessing the security risks throughout the asset's life and requirements for developing and maintaining holistic security risk management.*

The risk register should be established and maintained from the outset and is one of the deliverables in the Strategy work stage (see **4.1.9**). It should be used to record any identified threats and opportunities, an assessment of their potential impact and the likelihood of their occurrence. For threats, actions should be explored to reduce or avoid their potential impact. For opportunities, actions should be explored to realize or enhance the improvement. The risk register should be kept up to date throughout all work stages so that it reflects the current situation and should be utilized in the process of collating lessons learned.

*NOTE 3 A risk register formally records conditions or events, which could threaten or improve outcomes, to be taken into account in risk assessment/analysis. The register is not simply a repository, but a tool to help gain a current understanding of conditions or events and the threats and/or opportunities they represent. As time passes, some threats and opportunities will materialize, others might disappear and new ones will appear. Annex F provides examples of threats and opportunities.*

## 3.9 Information requirements

### 3.9.1 Employer's information requirements (EIR)

*COMMENTARY ON **3.9.1***

*The employer's information requirements (EIR) set out the information to be delivered, and the standards and processes to be adopted by the delivery team, including its supply chain, as part of the project delivery process. The information requirements set out in the EIR are intended to provide enough information to answer the "plain language questions" required at a particular work stage at an appropriate level of model detail (see **3.9.3**, Annex G and BS 1192-4). The EIR would be expected to include the following as a minimum: a) information management; b) commercial management; c) security management (see PAS 1192-5); and d) competence assessment. The EIR would normally exist as a self-standing document, cross-referenced to other documentation used across the work stages. It does not, however, expressly consider the information that the delivery team or the operator, operations team or asset manager, as appropriate, might need from the owner or the sponsor on its behalf.*

The owner should define its requirements adequately and clearly in terms of the information to be provided by the delivery team and its timing, and the standards and processes to be adopted in this regard. The points at which information exchanges are required should be specified in the EIR by reference to the applicable work stage and decision point (or gate) (see **3.5**).

*NOTE 1 PAS 1192-2, BS 1192-4 and PAS 1192-5 provide detailed guidance in this regard. In the case of information management, BS 1192-4 offers an approach to the definition of information requirements in relation to the asset, the business context and matters of compliance. The EIR can incorporate a schedule of plain language questions (see **3.9.3** and Annex G).*

*NOTE 2 PAS 1192-5 provides guidance on the creation of a security management plan and the development of security information requirements that inform both the EIR and the asset information requirements (AIR) (see **3.9.2**).*

*NOTE 3 BS 1192-4 provides guidance on a common structure for the exchange of information, i.e. COBie, to ensure that information can be reviewed and validated for compliance, continuity and completeness.*

A closely-related document is the brief, which should be used as a basis for developing and, subsequently, for evaluating design and construction proposals (see **4.5.7**). The brief should be delivered in a digitally-checkable form supplemented by the EIR.

### 3.9.2 Asset information requirements (AIR)

The owner should define the asset information requirements (AIR) to be met in order that the organizational information requirements (OIR) can be satisfied, together with the information exchanges by which information and data are transferred to, and from, the asset information model (AIM) (see PAS 1192-3 and PAS 1192-5). This transfer should be phased so that the operator, operation's team or asset manager, as appropriate, is given sufficient time to verify information and data, as well as prepare for its new or changed responsibilities, including any training that might be necessary.

*NOTE Organizational information requirements (OIR) are broadly synonymous with plain language questions (see **3.9.3** and PAS 1192-2).*

### 3.9.3 Plain language questions

*COMMENTARY ON **3.9.3***

*The sponsor requires information from the delivery team. Similarly, the delivery team requires information from the sponsor and the operator, operations team or asset manager, as appropriate, in order to perform its work and to contribute effectively to the expected outcomes. This communication is best handled through a structured information exchange, where all questions are framed in plain language, with the answers recorded and shared within the delivery team and with the operator, operations team or asset manager, as appropriate. The efficiency of this process depends to a large extent on the clarity with which questions are put by the sponsor, or to the sponsor, how the subsequent answers are interpreted and how the decisions that arise from them are implemented. This often involves confirming understanding then recording details in the owner's information management system, including the relevant parts of the project information model (PIM).*

Plain language questions should be drafted for each work stage for the purpose of obtaining information to enable decisions to be taken in a timely and effective manner, including the key question of whether or not to proceed to the next stage. The purposes for which information is required should be stated. The information required to answer questions, and any clarification or confirmation arising, should be delivered at the appropriate information exchange points (see PAS 1192-2, PAS 1192-3 and PAS 1192-5).

*NOTE 1 There is a crossover from plain language questions to EIR and vice versa (see **3.9.1**). The organizational information requirements (OIR) are broadly synonymous with plain language questions, where the intention is for the owner, or sponsor on its behalf, to elicit information from the delivery team and vice versa. Annex G gives example plain language questions to be asked of the delivery team by the sponsor.*

*NOTE 2 A list of security-related plain language questions are available on the CPNI website: http://www.cpni.gov.uk/advice/Cross-cutting-advice/Digital-built-assets-and-environments/ [viewed 2016-10-05].*

### 3.9.4 Information management and modelling

Information management should be recognized as encompassing the definition and management of the information model from design, through construction, and into operation of the asset (see PAS 1192-2). The use of information modelling in general and the creation and management of a project-specific building information model in particular should be seen in the context of the owner's information management system. The owner should take steps to ensure that there is sufficient information technology in place to support "BIM Level 2", where this is to be adopted.

The sponsor should consider the following requirements with respect to BIM:

a) the common data environment (CDE) to be used – BS 1192:2007, PAS 1192-2, PAS 1192-3 and PAS 1192-5 provide guidance in this regard;

b) details of the information required from the delivery team to support optimal operational performance of the asset – PAS 1192-3 and PAS 1192-5 provide guidance in this regard;

c) the format and means for information exchange – COBie may be used for this purpose – BS 1192-4, PAS 1192-2, PAS 1192-3 and PAS 1192-5 provide guidance in this regard;

*NOTE 1 COBie provides a common structure for the exchange of information and ensures that information can be reviewed and validated for compliance, continuity and completeness.*

d) the structure and format of the asset information model (AIM) that is to

receive the content from the project information model (PIM) – PAS 1192-3 and PAS 1192-5 provide guidance in this regard;

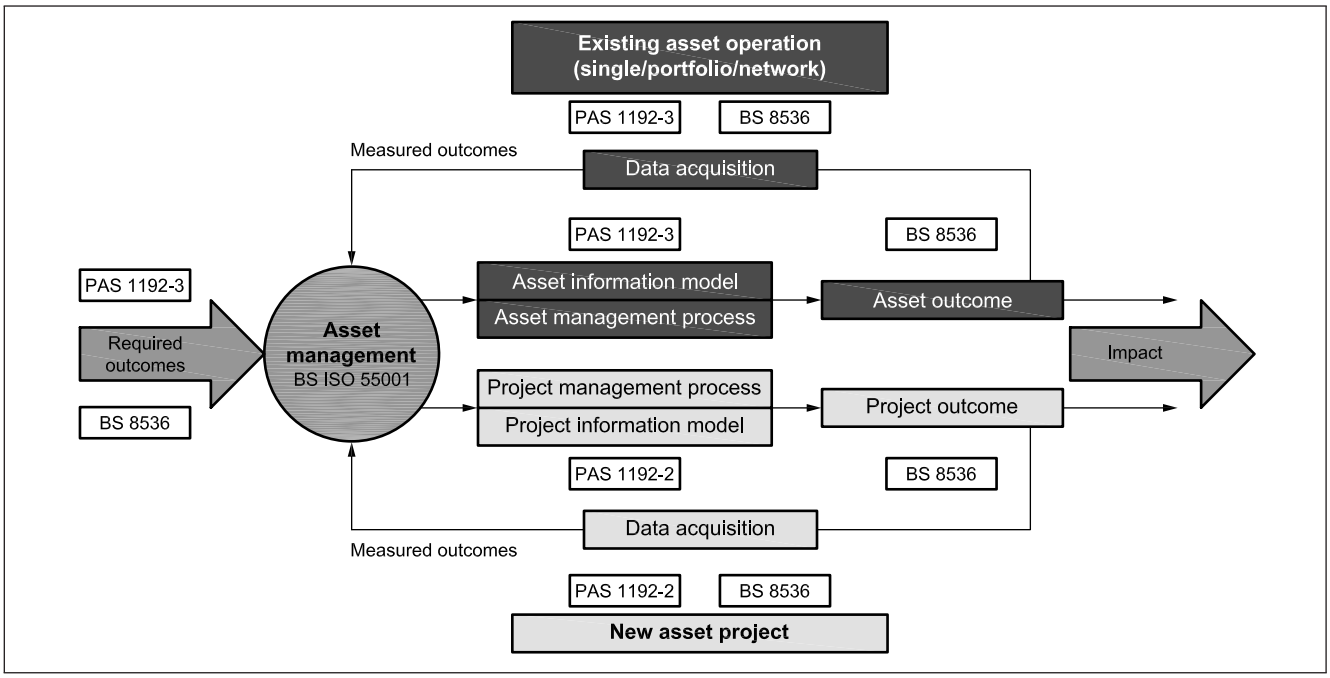
e) details of how content from the project information model (PIM) is to be transferred into the owner's asset information model (AIM) – PAS 1192-2, PAS 1192-3 and PAS 1192-5 provide guidance in this regard;

f) requirements, policy, processes and procedures for the security of information and data, including the management of access, both physically and digitally – PAS 1192-5 provides guidance in this regard; and

g) software to be used to meet operational and security requirements, such as the owner's defined enterprise system (see PAS 1192-3 and PAS 1192-5).

*NOTE 2 Figure 3 brings into focus the relationship between assets and projects. A common failing in practice is that the systematic feedback that occurs in the asset management process is not mirrored in the project management process. The result is that project outcomes are not acquired and analysed, and so cannot be transferred to the owner's asset management system. The figure also emphasizes the important relationship between this British Standard and those standards supporting "BIM Level 2", namely PAS 1192-2, PAS 1192-3 and BS ISO 55001. PAS 1192-5 contains further information on how security requirements can be integrated into these information models.*

Figure 3 **Asset-project systems and feedback**



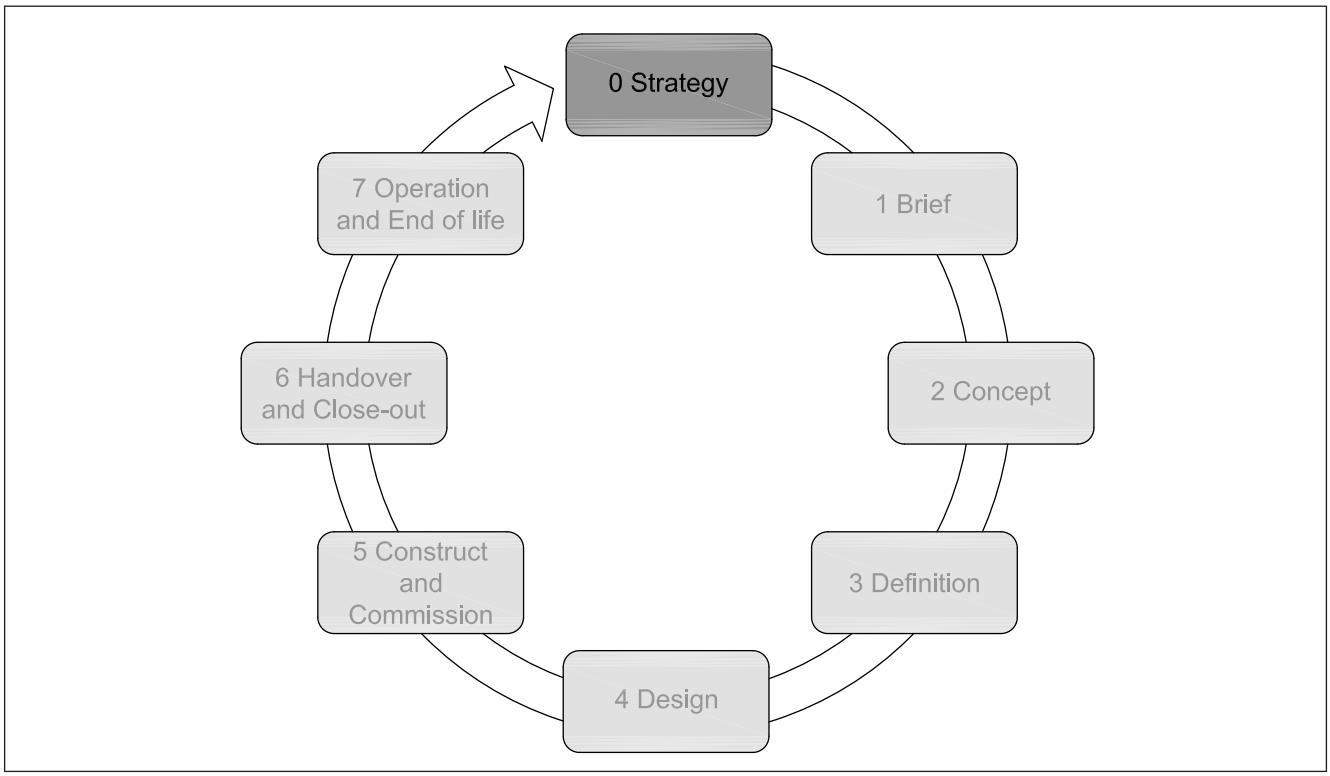

## 3.10 Arrangement of work stages

*NOTE Clause **4** is structured in accordance with the work stages outlined in the plan of work (see **3.5**) as the project progresses from its commencement to the operation of the asset. The same or similar headings are used in each work stage, wherever practicable, to ensure consistent treatment of both guidance and recommendations. In a number of cases, the latter are broadly similar, although might contain important differences.*

The requirements contained in each work stage (see Clause **4**) should be properly considered before they are encountered and the preceding stage, where applicable, should be concluded satisfactorily before the transition to the next work stage. Work stages or parts of them should not be omitted, but the approach may be scaled down if it is felt that the requirements are inappropriate or in excess of reasonable needs.

# 4 Work stages

## 4.1 Strategy




### 4.1.1 General requirements

*COMMENTARY ON **4.1.1***

*The Strategy work stage is concerned with defining the business case for the new or upgraded asset, the project outcomes, required operational performance and other core considerations. It provides an essential baseline to assist in clarifying strategic intentions, not least the asset's contribution to the business of the owner. This stage can be thought of as one of strategic definition.*

The owner, or the sponsor on its behalf, should develop the business case and supporting considerations, including the expected benefits and the required performance of the new or upgraded asset, in terms of its contribution to the business. The work activities associated with this strategic definition (see **4.1.2**) should be identified together with the information and data required for this purpose (see **4.1.6**). Where the project is intended to cover an asset system and the needs of multiple stakeholders (see **4.1.3**), a formalized approach to capturing and managing requirements should be considered (see **3.4**, **4.1.2** and BS ISO/IEC/IEEE 15288).

*NOTE In the public sector, the development of the business case is highly prescribed. HM Treasury [7] defines a five-case model for the new or upgraded asset. This anticipates a well-founded case for change that provides a holistic fit with other parts of the sponsoring organization and the public sector (i.e. the strategic case), and which demonstrates best public value (i.e. the economic case), commercial viability (i.e. the commercial case), affordability (i.e. the financial case) and achievability (i.e. the management case) among other criteria.*

The information management strategy should be agreed between the sponsor, the delivery team, and the operator, operations team or asset manager, as appropriate, with the actions needed to collect, record and store information and data to support the primary activities (see **4.1.2**) of this work stage and subsequent stages. The extent of information modelling should be considered by the owner or the sponsor on its behalf.

The security triage process (see PAS 1192-5:2015, Clause **4**) should be undertaken and where a security-minded approach is to be applied as a result, a security strategy, security management plan and security information requirements should be developed by the owner for the asset, taking advice as necessary.

### 4.1.2 Primary activities

The owner, or the sponsor on its behalf, should determine the extent to which the following work activities might apply to its strategic definition of the asset and the project required to deliver it:

a) identify the business-related activities and processes that the new or upgraded asset will be required to support;

b) undertake the security triage process and, where a security-minded approach is required, develop a security strategy, security management plan and security information requirements appropriate and proportionate to the owner's business, processes, service provision, assets and personnel;

*NOTE 1 PAS 1192-5 specifies the processes that assist an organization in identifying and implementing appropriate and proportionate measures to reduce the risk of loss or disclosure of information and data.*

c) identify the owner's, operator's, end-users' and other key stakeholders' high-level needs;

*NOTE 2 A formalized approach to capturing and managing requirements is available to assist in identifying and defining needs (see **4.1.3** and BS ISO/IEC/IEEE 15288).*

d) determine the required project outcomes, including the expected benefits and the required operational performance of the asset from the high-level needs;

e) determine the environmental, social, security and economic performance targets, as appropriate;

f) identify the uncertainties and major risks in the project and capture these in a risk register;

g) determine how the delivery team could assist in identifying the high-level needs and performance targets, if appointed at this time;

h) review or identify the particular competences, skills and experience that the delivery team should possess;

i) review or determine the basis of the engagement of the delivery team and its relationship with the operator, operations team or asset manager, as appropriate, end-users and other key stakeholders;

j) identify the particular competences, skills and experience that the operator, operations team or asset manager, as appropriate, could contribute to design and construction;

k) identify existing policies and standards that are relevant to the design, construction and operation of the asset (e.g. internal design standards, construction standards and asset management standards);

l) identify a design standardization policy, where applicable, drawing on any owner-defined standard design elements, especially those driven by operational needs;

m) assemble lessons learned from previous projects, including validated case studies and other reliable, documented sources;

n) prepare a project management schedule to show the relationship between the phases in the project, the main activities, target dates and other key milestones, and the time added as contingency (i.e. schedule contingency);

*NOTE 3 In project planning and scheduling, it is customary to manage schedule information in a hierarchy where each level (of possibly five) has a distinct purpose and is intended for use by a defined stakeholder group. The Level 1 project management schedule provides an overview of the project for use by key stakeholders, whereas the Level 3 construction and system testing schedule is used by the construction manager.*

o) establish an initial estimate of capital expenditure to include cost contingency and a statement of its accuracy;

*NOTE 4 A cost estimate is normally expressed as a single figure with a range above and below it to reflect the perceived uncertainty and risks at the time the estimate is prepared. As an example, an initial (or screening) capital cost estimate might attract an upper range in the region of +40% or higher; the lower range is likely to be of less practical use and is generally regarded as highly optimistic. Costs tend to be understated by decision makers and others taking an optimistic view of a project's outcomes. Later, when more is known about its design, construction and risk exposure, a quantitative cost risk analysis is likely to confirm the realistic view rather than the optimistic view. Similar consideration is given to estimates of the project's time [see n)].*

p) determine the approach to whole-life cost assessment;

q) establish an initial view of revenue income and/or benefits, as appropriate, including sensitivity analyses; and

r) determine the requirements and arrangements for the delivery of project information and asset information, in particular the phased handover of information and data.

The owner, or sponsor on its behalf, should determine which, if any, of the activities in a) to r), with the exception of the activity listed in b), should be undertaken by the delivery team, if appointed. The owner or sponsor should determine which, if any, of the following activities the operator, operations team or asset manager, as appropriate, should undertake:

1) identify the performance benchmarks for this type of asset for use in establishing targets and the processes for subsequently measuring performance;

2) identify the approach to be taken to post-implementation review (PIR);

3) establish an initial view of operational expenditure, covering operations, maintenance, replacement costs, and costs relating to energy use, water consumption, waste disposal and other environmental indicators, as a minimum;

4) identify any existing strategic asset management plan (SAMP) and supporting policy or procedures and, where none exists, prepare such a plan in outline;

5) identify the extent of existing information modelling covering the owner's assets;

6) identify any security requirements for the asset in operation and during design, construction, testing and commissioning, handover and start-up; and

7) identify a holistic approach to address security around the aspects of people and process, as well as physical and technological security.

*NOTE 5 BS ISO 55000, BS ISO 55001 and BS ISO 55002 provide guidance on the factors to be considered by an organization when managing its assets. PAS 1192-5 specifies the processes that will assist the owner in identifying and implementing appropriate and proportionate measures to reduce the risk of loss or disclosure of information and data.*

### 4.1.3 Stakeholders

#### 4.1.3.1 General

*COMMENTARY ON **4.1.3.1***

*There is a direct connection between the definition of stakeholders' needs and the definition of requirements for the new or upgraded asset. First, stakeholders are identified and their likely impact upon the asset over its life cycle are analysed. Second, stakeholder needs are assessed in terms of requirements for the asset, which are then prioritized. Third, updating of the stakeholder impact analysis is considered as progress is made in the project and where there are changes in stakeholders, their interests or needs. BS ISO/IEC/IEEE 15288 outlines a stakeholder needs and requirements definition process.*

Internal and external stakeholders should be identified and their interest in the new or upgraded asset should be assessed and documented. The extent to which information can be communicated to third parties should be determined and provided in line with any relevant security requirements in place. The sponsor should be aware of the requirement to safeguard personally-identifiable information, particularly when responding to requests for information under legislation. A communication plan should be prepared to assist with these tasks.

*NOTE 1 Annex H offers an example of stakeholder identification.*

*NOTE 2 Attention is drawn to statutory duties relating to data protection and the protection of personally-identifiable information and those arising in connection with planning, transfer of employment and equalities' legislation.*

Responsibility for eliciting the interests and needs of end-users of the asset and other key stakeholders should rest with the sponsor. Stakeholder needs should be documented in a way that allows for assessment in terms of requirements for the asset (see **3.6.5**).

*NOTE 3 Attention is drawn to legislation covering construction, design and management (CDM) and, in particular, the role of the principal designer and the arrangements for the handover of the health and safety file to the owner [8], [9].*

#### 4.1.3.2 Stakeholder impact analysis

A stakeholder impact analysis should be undertaken to determine how, and the extent to which, stakeholder interests and needs impact on the asset in terms of its design, construction, testing and commissioning, handover, start-up of operations and steady-state use. Where an existing asset is being upgraded, account should be taken of audits and other reviews of the asset, including those pertaining to its immediate surroundings from the perspective of end-users. Account should be taken of any actions recommended by the sponsor for the delivery team that involve specific stakeholder interests, needs and rights in the asset.

*NOTE Annex I offers an example of preliminary stakeholder impact analysis.*

#### 4.1.3.3 Prioritization of needs

The results of the stakeholder impact analysis used to assess stakeholder interests and needs in the asset should be made available to the delivery team if prepared by the sponsor. The results should reveal the nature, extent and relative importance or weighting of all expressed needs. Any prioritization should be made explicit. A statement should be prepared that expresses the needs of the owner and operator, where the latter is a separate entity, and end-users. The criteria forming the basis of this expression should be capable of translation into operational requirements and the subsequent measurement of performance as defined by the owner, or the sponsor on its behalf, and/or the operator (see **3.3** and **4.8.2.3.4**).

*NOTE Multiple stakeholders are likely to have different perspectives on operational requirements and performance outcomes, necessitating close scrutiny of needs and their subsequent prioritization. BS ISO/IEC/IEEE 15288 outlines a stakeholder needs' and requirements' definition process.*

A stakeholder communication plan should be prepared to support the ongoing engagement with stakeholders.

#### 4.1.3.4 Updating the analysis

Further stakeholder identification, assessment and impact analysis should take place during subsequent work stages and prior to Construct and Commission, to provide an opportunity to act upon any change in stakeholders, their interests or needs. The communication plan should be updated as changes in stakeholders or their interests and needs become known.

### 4.1.4 Operational performance and aftercare

*COMMENTARY ON **4.1.4***

*Instead of operational requirements informing and, to a certain extent, driving design and construction decision making, they can sometimes be left until design has commenced or even until construction is under way. Any definition of project success needs to be broadened to include the achievement of operational performance requirements; after all, these are the ends that the owner/operator is seeking, whilst the project is the means to those ends. Handing over the asset can no longer be seen as, more or less, the final act for the delivery team. Ensuring that the asset performs as required necessitates defined periods of aftercare that allow for the adjustment and optimization necessary to achieve the operational performance.*

The initial and extended periods of aftercare should be determined by the owner, or the sponsor on its behalf, and incorporated in all agreements involving the delivery team, including specialist contractors, suppliers and manufacturers, and the operator, operations team or asset manager, as appropriate, and should be regarded as an integral part of project delivery and the subsequent operation of the asset.

*NOTE 1 Six to eight weeks might be an appropriate period for initial aftercare, with three years as an appropriate period for extended aftercare.*

Performance targets should be determined by the owner, or the sponsor on its behalf, based on a range that is recognized as achievable, and should be agreed with the delivery team. Measurement should be based on reliable sources of data, such as project records, meters, control systems and operational records. During the periods of aftercare, data should be collected by the operations team or the asset manager, as appropriate, then analysed to determine the variance, if any, between actual performance and target performance as part of the owner's and, where applicable, the operator's benchmarking (see **4.8.5**). Targets should be achievable and not aspirational.

*NOTE 2 Measures of the variance between actual and target performance enable the operations team to pinpoint the cause(s), enabling adjustment and optimization of the asset's operational performance as soon as possible (see **4.8.2.3.4**). Attention is drawn to BS ISO 15489-1, which provides detailed guidance on the creation, capture and management of records regardless of structure, form or media.*

Where the owner, or sponsor on its behalf, determines that changes to performance outcomes and/or targets are necessary, details should be communicated to the delivery team and the operator, operations team or asset manager, as appropriate, then recorded in the relevant part of the project information model (PIM).

*NOTE 3 Performance outcomes and targets might have to be reconsidered if, during the prequalification of prospective (supply chain) tenderers, it becomes apparent that the required performance is unlikely to be met.*

The period of extended aftercare should include an assessment of the functionality and effectiveness of the asset through post-implementation review (PIR) (see **4.8.2.3.4**). A proven methodology should be selected for this purpose as opposed to an *ad hoc* arrangement that might be devised more for expediency than systematic evaluation.

*NOTE 4 The* Design quality indicator (DQI) *[4] is a five-stage method for evaluating the design over the project life cycle against three quality principles: functionality, build quality and impact.*

*NOTE 5 Long-term considerations, for example ongoing optimization of the asset's operational performance and planned maintenance, can extend for decades, necessitating a long-term view of the predicted design life and operational performance of the asset.*

### 4.1.5 Risks

The risk register should be used to record threats to the achievement of the project objectives, expected benefits and required performance outcomes and targets, and the opportunities for improving those outcomes and the operational performance of the asset. A risk identification workshop should be conducted for this purpose.

The sponsor, or the delivery team if appointed, should undertake a qualitative assessment of conditions and events recorded in the risk register to determine their potential impact and the likelihood of their occurrence. Periodic reassessment of risks should be used to update the risk register and associated risk responses (see **3.8**). The owner, or sponsor on its behalf, should proactively monitor and check the status of risks recorded in the risk register, the events that give rise to them and the results of any risk responses.

The owner, or sponsor on its behalf, should be aware of the business risks associated with the failure or impaired performance of systems depending on information technology arising from malicious acts, such as damage caused by malware, hackers or disaffected personnel.

The owner, or sponsor on its behalf, should determine the most appropriate response to risks that have been assessed, taking into account the practicability and affordability of any proposed action, including the owner's capability, or, where applicable, the capability of the delivery team or any other stakeholder. No useful purpose is served by an action that involves allocating a particular risk to a party that is ill-equipped to handle it. Account should be taken of the potential that might exist to avoid the risk or realize the opportunity, reduce or increase the extent of exposure for the owner and operator, and the likelihood of its occurrence, together with an indication of the schedule, resource and cost implications of doing so.

### 4.1.6 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.1.2**) and contributing to the deliverables (see **4.1.9**) in this work stage:

a) the owner's business case for the new or upgraded asset;

b) strategic fit;

c) value/project drivers;

d) uncertainties and major risks (threats and opportunities) affecting the owner's business;

e) lessons learned from previous projects, as appropriate;

f) the owner's, operator's, end-users' and other key stakeholders' high-level needs;

g) preliminary indication of the extent to which the asset is likely to satisfy the high-level needs;

h) the owner's security requirements, including the security of information and data;

i) operational requirements for health, safety, security and environment (HSSE);

j) performance objectives for the asset and details of any special operational requirements;

k) availability of performance benchmarks for comparison;

l) criteria for determining project success, where not covered by performance-related measures;

m) details of any master plan or strategic statement on development;

n) characteristics of the site;

o) initial development options;

p) limit of available capital expenditure;

q) sources of funding and owner's cost of borrowing;

r) anticipated operational expenditure on asset management, including maintenance;

s) anticipated revenue income or likely value of the asset at completion, where applicable;

t) anticipated (non-monetary) benefits of the asset at completion, where applicable;

u) time frame and key dates;

v) details of any technical strategy;

w) details of any standardization requirements;

x) strategic asset management plan (SAMP);

y) information management strategy, including the extent of information modelling considered to be appropriate; and

z) owner's requirements for the governance of projects.

*NOTE 1 Instead of considering capital expenditure and operational expenditure separately, total expenditure could also be considered.*

*NOTE 2 HSSE considerations might include specific operational requirements and performance targets; for example, in the case of safety, the operator might be committed to "zero accidents" and in the case of security, it might be "no physical vulnerabilities".*

Each of the information requirements in a) to z) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

The owner, or sponsor on its behalf, should consider the types of intellectual property it holds or might develop, and the extent to which it wishes that property to be protected.

### 4.1.7 Roles and responsibilities

The sponsor should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.1.2**) and their associated deliverables (see **4.1.9**) for this work stage.

*NOTE 1 If the delivery team is in place, the responsibility may be delegated to them.*

The RASCI chart should be kept up to date and should be used to inform a similar requirement at the start of the Brief work stage. Details of the information exchange requirements for this work stage should be summarized in a detailed responsibility matrix prepared by the delivery team, where appointed (see **3.7**).

*NOTE 2 Annex E gives an example RASCI chart and a detailed responsibility matrix.*

### 4.1.8 Information systems and tools

The owner, or sponsor on its behalf, should define the information management strategy for the project (see **4.1.1**), including the employer's information requirements (EIR) (see **3.9.1**) and subsequent arrangements for the capture and phased and final transfer of project information and data for operational purposes from the project information model (PIM) to the asset information model (AIM) (see **3.9.4**). The arrangements to support asset management through the use of the owner's defined enterprise system (see PAS 1192-3) or other means should be defined. The operator, operations team or asset manager, as appropriate, should assist with these arrangements where requested by the owner, or sponsor on its behalf. The intended arrangements for the asset information model (AIM) should be confirmed.

The security requirements for the information systems and tools should form part of the owner's security strategy and security management plans for the asset. The requirements should encompass people, processes, physical and technical aspects.

### 4.1.9 Deliverables

The sponsor should furnish the delivery team with the following information, as a minimum:

a) strategic definition, including an elaborated business case;

b) required high-level outcomes with respect to environmental, social, security and economic performance, including targets for energy use, greenhouse gas emissions, water consumption, waste reduction, noise and vibrations, functionality, effectiveness, capital cost and operational cost;

c) performance evaluation measures and approach to be taken to post-implementation review (PIR) to be introduced into the Operation and End of life work stage;

d) results of stakeholder analysis in terms of stakeholders' interests, needs and likely impact;

e) communication plan to support stakeholder engagement;

f) risk register;

g) format for presenting evidence to support subsequent design and construction proposals; and

h) plan for the next work stage.

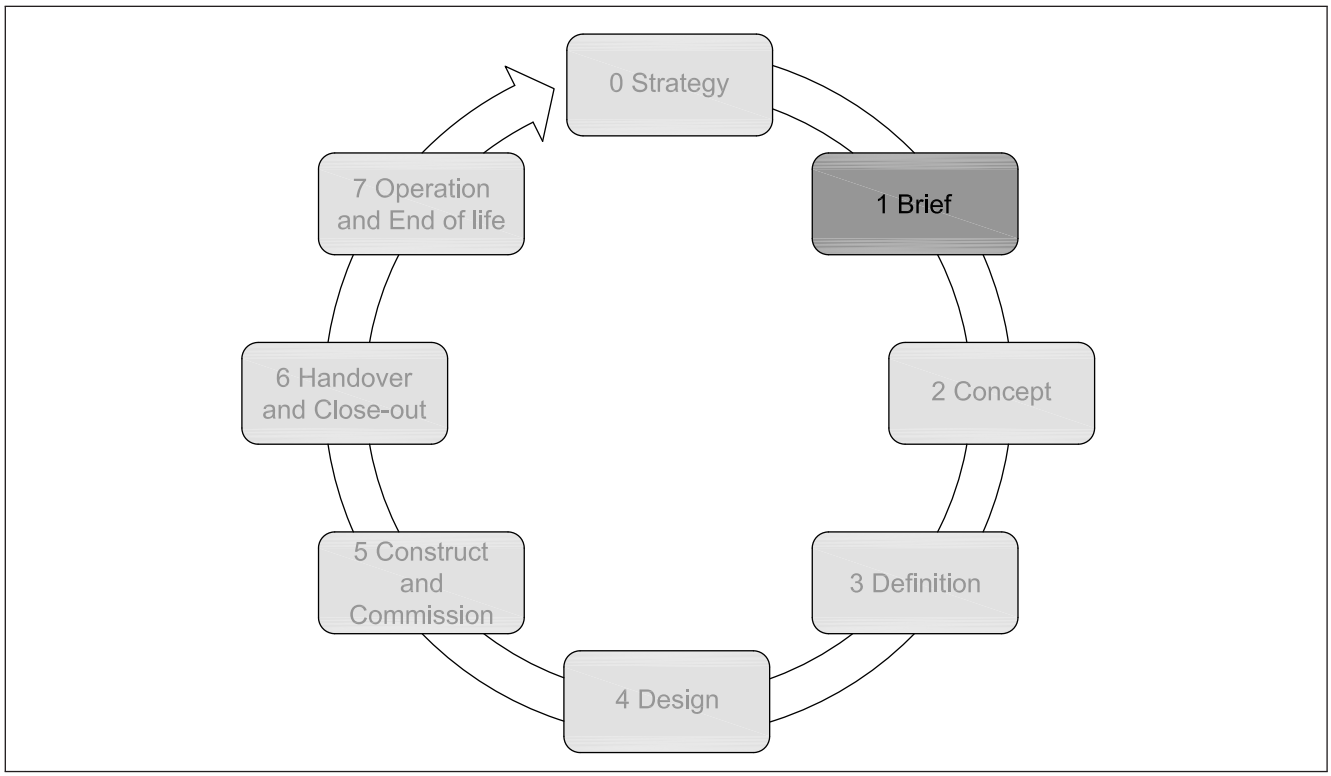
*NOTE The emphasis on evidence-based design and construction (see **3.2**) means that there has to be agreement up front on the format of evidence for supporting assertions, assumptions and the decisions that stem from them.*

### 4.1.10 Key decisions and next steps

The sponsor, in consultation with the owner, should reach a decision on whether or not there is a sufficient business case for the new or upgraded asset, and the sponsor should inform the delivery team, if appointed at this time, and the operator, operations team or asset manager, as appropriate. Where the owner intends to proceed, the delivery team should give the sponsor the opportunity to review and approve the planned work activities and their associated information requirements and deliverables for the Brief work stage prior to its commencement.

*NOTE A question that can be considered here is: "Does the owner fully understand what is being started?" The answer helps to bring focus to the consequences of early decisions concerning the strategic definition, as well as the broad scope of work and approach to the project.*

## 4.2 Brief




### 4.2.1 General requirements

*COMMENTARY ON **4.2.1***

*The Brief work stage is concerned with developing project objectives, including operational requirements and performance outcomes and/or targets for the asset over defined planning horizons [e.g. short, medium and long term or other period(s) defined by the owner]. It is a pivotal point in the life cycle of the asset at which the project objectives, expected benefits, operational requirements and required performance outcomes and/or targets are defined, discussed and agreed between the owner, or sponsor on its behalf, the delivery team and the operator, operations team or asset manager, as appropriate. The benefits, requirements and outcomes are revisited in subsequent work stages to ensure that the team(s) continues to align itself with the expected performance against which actual performance of the asset, as well as its own performance, will be measured.*

The sponsor should assemble the delivery team, the operator, operations team or asset manager, as appropriate, and any other key stakeholder or specialist who the sponsor considers has a contribution to make to the preparation of the initial brief for the new or upgraded asset. The delivery team should take responsibility for preparing this initial brief and should ensure that the details of information exchanges between it and other parties are adequately defined (see PAS 1192-2 and PAS 1192-5). The plan for information exchange should be used to define and control this work. This task should be undertaken by the delivery team with the assistance of the operator, operations team or asset manager, as appropriate.

### 4.2.2 Primary activities

#### 4.2.2.1 Initial brief

The delivery team should prepare the initial brief for the asset, covering such work activities as:

a) define the scope and boundary conditions for the proposed asset and project;

b) summarize the relevant lessons learned from experience with previous projects and how they relate to the asset and project;

c) identify the current use and capacity of the site and any features likely to impact on the decision to develop, extend or reconstruct, as appropriate;

d) identify constraints in the provision of public utilities (e.g. electricity, water and sewerage) or other infrastructure;

e) determine the environmental performance outcomes and/or targets for the asset over defined planning horizons (see **3.3**);

f) prepare a statement on the general design philosophy and how it will address the project objectives, expected benefits, operational requirements and required performance outcomes and/or targets;

g) prepare a schedule of the named areas or zones and any named systems comprising the proposed asset that are known at this time;

h) prepare a method for evaluating the performance in use with respect to functionality and effectiveness;

i) identify a method for assessing construction waste that can be used when reviewing design proposals;

j) define the project's governance and organization, supported by an organization chart to show the positions and relationships between the sponsor and other parties in a way that reflects the anticipated procurement arrangement where known;

k) define the methodology for whole-life cost assessment – BS 8544 provides guidance in this regard;

l) update the risk register;

m) update the project management schedule;

n) update the estimate of capital cost;

o) update the estimates of schedule contingency and cost contingency; and

*NOTE 1 In the case of public sector projects, HM Treasury [7] calls for an adjustment to time and cost estimates to counter optimism bias by decision makers (see **4.1.2**), because of the tendency for times and costs to be understated whilst benefits are overstated. An approach involves uplifting the initial time and cost estimates based on experience of previous, similar projects at the same point in the project life cycle and the use of empirical data, where available. This approach can be helpful where expertise, data or tools for utilizing more sophisticated time (schedule) and cost risk analyses are lacking.*

p) determine how project information is to be transferred from the project information model (PIM) to the asset information model (AIM), asset register and the owner's defined enterprise system (see **3.9.4** and PAS 1192-3 and PAS 1192-5).

The sponsor should determine which, if any, of the activities in a) to p) and which of the following activities the operator, operations team or asset manager, as appropriate, should undertake:

1) develop or update the strategic asset management plan (SAMP) and policy, as appropriate;

2) prepare a plan for measuring operational performance during the Operation and End of life work stage;

3) identify the need for any temporary transfer of personnel and/or equipment and outline how this should be managed;

4) prepare an estimate of operational cost, including a simple model of environmental performance, and capital replacement costs; and

5) prepare or update the environmental management plan, as appropriate.

*NOTE 2 Annex A offers an example of a "Brief checklist".*

#### 4.2.2.2 Review of experience

*COMMENTARY ON **4.2.2.2***

*The owner and the project benefit from the experience gained on previous projects and in managing existing assets. Much of this experience is vested in people, but some might be found in validated case studies and other reliable, documented sources of lessons learned.*

The sponsor should assess the experience of the owner in the context of the project being proposed and highlight any perceived shortcomings in that experience to the owner. Where considered appropriate for the appointment of the delivery team, the sponsor should conduct a review of the relevant experience. The sponsor should allow for the participation of the operator, operations team or asset manager, as appropriate, in review meetings and may also permit the representative(s) of end-users and other key stakeholders to attend.

The delivery team should study the owner's asset portfolio and/or undertake a review of published studies of similar existing assets in order to determine if there are worthwhile lessons to be learned. The delivery team should collate feedback and lessons learned from previous projects in which its members have been directly involved to ensure that the design takes into account constructability and operability criteria.

#### 4.2.2.3 Intermediate reviews and verification

*COMMENTARY ON **4.2.2.3***

*It is possible that, over time, there might be some drift in the direction that the design takes which, if not checked, could result in a misalignment between the expected and actual outcomes and the performance during start-up of operations. Peer reviews at key points during design development and in the Construct and Commission work stage reduce the likelihood of this occurrence.*

Peer review and verification should be used to test the ability of design and construction proposals to meet the expected outcomes and required environmental, social, security and economic performance.

The delivery team should define a process for peer review and verification for use at key points during design development and construction. These intermediate checks should be aligned with decision points (or gates) and should reflect the adopted procurement method. The delivery team should determine its approach, including the timing, frequency of workshops, nature of facilitation, attendees and the method by which outputs can be captured for evidential purposes and later reference. The sponsor should consider attending design reviews, but should leave the task of facilitation to a member of the delivery team. The delivery team should inform the sponsor of the topics to be peer-reviewed and verified, and should capture and record the outputs to inform subsequent work stages up to and including the Operation and End of life work stage.

*NOTE A review and verification process termed "pitstopping" has been defined by BSRIA [10].*

Where a complex asset system is involved, the sponsor should consider the appointment of a suitably-qualified, independent authority to undertake reviews with the support of the delivery team.

#### 4.2.2.4 Environmental, social, security and economic performance

The delivery team should agree a set of performance outcomes with the owner, or sponsor on its behalf, the operator, operations team or asset manager, as appropriate (see **3.3**). These outcomes should provide the basis upon which the performance of the asset is to be measured after handover (see **4.7**).

The outcomes should be continually referenced during peer review and verification (see **4.2.2.3**) and should be revised only where there are changes in the owner's requirements, changes to the design and any known changes in the intended use (e.g. expected activities, intensity of use or hours of operation of the asset) approved by the owner or the sponsor on its behalf. The delivery team should assist the sponsor in the active monitoring of environmental, social, security and economic outcomes and targets. Progress towards meeting targets should be assessed and agreed at decision points (or gates) within the subsequent work stages.

The sponsor should ensure that an energy monitoring strategy is developed in collaboration between the delivery team and the operator, operations team or asset manager, as appropriate. The estimated energy use of the asset should be measured at intervals during design and construction coinciding with peer review and verification. The delivery team should ensure that appropriate and sufficient equipment is specified and available to meet the owner's requirements for monitoring the environmental performance of the asset once handed over. Similar provisions should be considered to deal with monitoring water consumption and other environmental indicators. The delivery team should ensure that energy and water consumption data are based on metering and that any sub-metering is recorded, where applicable.

### 4.2.3 Risks

The delivery team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and the opportunities that might enhance outcomes.

The delivery team should proactively monitor and check the status of threats and opportunities recorded in the risk register, the events that give rise to them and the results of any risk responses. Where considered appropriate, the sponsor should ensure that functional experts are available to address specific technical and non-technical risks.

### 4.2.4 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.2.2**) and contributing to the deliverables (see **4.2.7**) in this work stage:

a) statement of the project's scope;

b) schedule of the named areas or zones and any named systems comprising the proposed asset;

c) overall design concept and likely impact on the physical environment;

d) details of physical constraints or other conditions on or around the site;

e) details of constraints with respect to public utilities and other infrastructure;

f) technical challenges likely to be encountered in either design or construction;

g) extent to which the asset is likely to satisfy the operator's, end-users' and other key stakeholders' needs;

h) operational requirements or other determinants of availability and capacity for the asset;

i) the owner's security requirements, including the security of information and data;

j) approach to obtaining planning and other permissions;

k) details of logistical requirements (e.g. deliveries, servicing and maintenance) once in operation;

l) updated risk register;

m) updated view of capital expenditure, where applicable;

n) updated anticipated operational expenditure on asset management;

o) updated anticipated income or likely value of the asset at completion, where applicable;

p) updated anticipated non-monetary benefits of the asset at completion, where applicable;

q) strategy for procuring asset-related services (see BS 8572) during operation of the asset;

r) engineered systems' philosophy;

s) details of specific requirements in asset management (e.g. durability and design life) affecting the choice of materials, products or components (see BS 7543 and BS ISO 15686-2);

t) basis of whole-life cost assessment – BS 8544 and BS ISO 15686-5 provide guidance in this regard;

u) information management plan;

v) extent to which information modelling is to be used and who should manage it;

w) details of specific operational requirements with respect to HSSE; and

x) extent to which any transfer of personnel and/or equipment and subsequent move-in might be necessary and any phasing, where applicable.

Each of the information requirements in a) to x) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

### 4.2.5 Roles and responsibilities

The sponsor should request that the delivery team, where appointed, prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.2.2**) and their associated deliverables (see **4.2.7**) for this work stage. As far as practicable, this preparation should commence before the conclusion of the Strategy work stage. The RASCI chart should be kept up to date and should be used to inform a similar requirement at the start of the Concept work stage. Details of the information exchange requirements for this work stage should be summarized in a detailed responsibility matrix (see **3.7**).

The owner, or sponsor on its behalf, should appoint an independent commissioning manager, where the engineered systems are complex, to oversee and be responsible for all commissioning activities. Where a commissioning manager is to be appointed, the appointment should be made during this work stage.

### 4.2.6 Information systems and tools

The owner, or the sponsor on its behalf, should confirm, or revise, the arrangements for the phased and final transfer of project information and data for operational purposes from the project information model (PIM) to the asset information model (AIM). The arrangements to support asset management through the use of the owner's defined enterprise system (see PAS 1192-3 and PAS 1192-5) or other means should be confirmed or revised. The operator, operations team or asset manager, as appropriate, should assist with these arrangements where requested by the owner or sponsor on its behalf.

### 4.2.7 Deliverables

*NOTE 1 The primary deliverable at the end of the Brief work stage is the initial brief. The acceptability of the brief by the owner, or sponsor on its behalf, is likely to be dependent upon it meeting the required operational performance.*

The delivery team should provide the sponsor with the following, as a minimum:

a) the response to the owner's, operator's, end-users' and other key stakeholders' needs in the form of a digitally-checkable, initial brief that can be used as a basis for developing and subsequently verifying design and construction proposals;

b) the response to the project objectives, expected benefits and required performance outcomes and/or targets as an integral part of the initial brief that includes details of the method(s) for measuring actual performance against targets;

c) an indication of whether or not any commitments by the owner to statutory energy or greenhouse gas emission targets are likely to be satisfied by the design concept;

d) evidence that the relevant owner's security requirements have been met;

e) updated risk register;

f) a draft environmental management plan; and

g) a record of engagement and checking that has taken place with the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users.

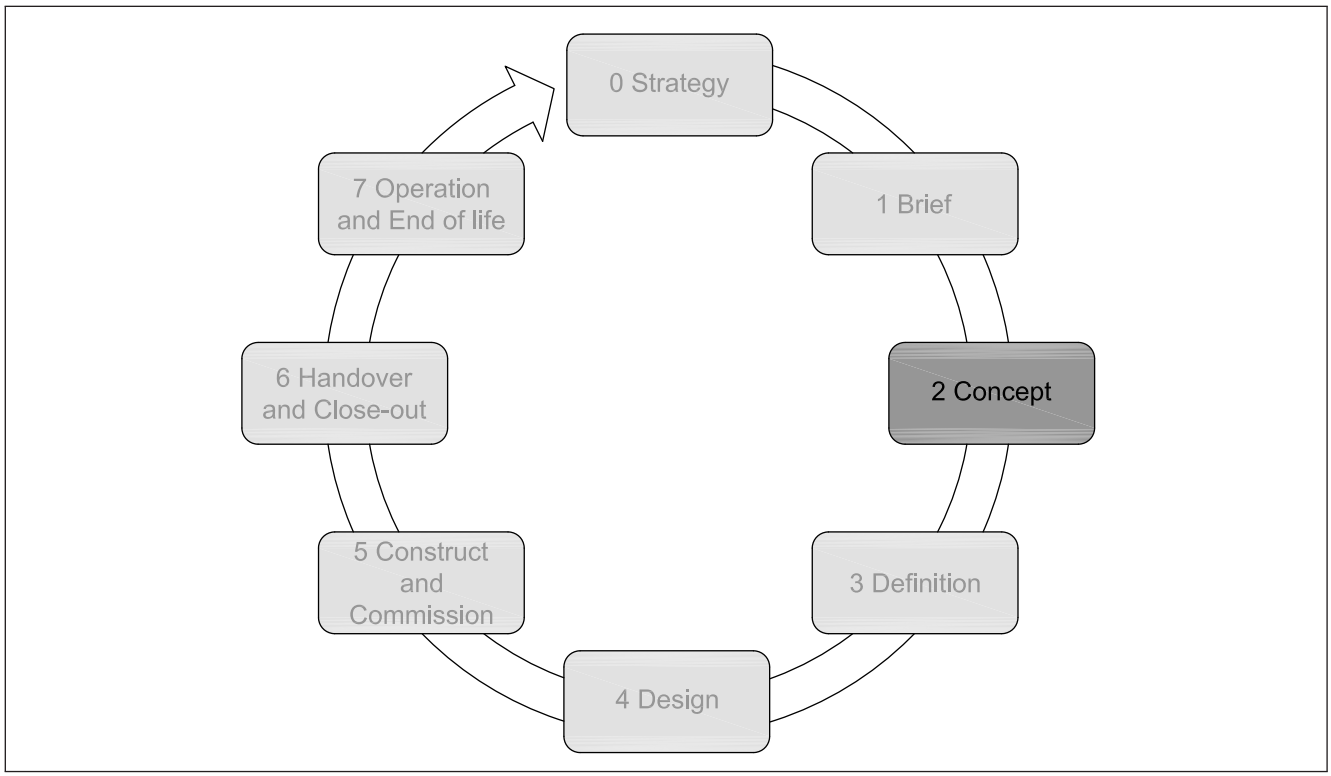
*NOTE 2 Annex A offers an example of a "Brief checklist".*

### 4.2.8 Key decisions and next steps

The owner, or sponsor on its behalf, should reach a decision on whether or not there is a sufficient basis to proceed with the proposed project and inform the delivery team and the operator, operations team or asset manager, as appropriate. Where the owner, or sponsor on its behalf, intends to proceed, the delivery team should give the sponsor the opportunity to review and approve the planned work activities, and their associated information requirements and deliverables, for the Concept work stage before the conclusion of this work stage.

*NOTE A question that can be considered here is: "Has enough been done to understand the needs of the owner, operator, end-users and other key stakeholders in regard to the project and its required outcomes?" The answer helps to inform the delivery team on the approach to be taken in subsequent work stages.*

## 4.3 Concept




### 4.3.1 General requirements

*COMMENTARY ON **4.3.1***

*The Concept work stage is concerned with preparing the concept design, including outline proposals for the general design treatment, structural design, engineered systems and outline specifications, supported by cost information and a project execution strategy. This work stage addresses the feasibility of the proposed approach to the design, where key criteria relate to environmental, social, security and economic performance. It provides an opportunity for considering and, where appropriate, agreeing revisions to the initial brief which can then be finalized.*

The delivery team should define the scope of work and its boundary conditions, its feasibility, areas of uncertainty and major risks, and recommend the option that holds the most promise in terms of its ability to achieve the expected benefits and required operational performance outcomes and/or targets. The sponsor should review the concept in terms of its general design treatment, structural form and engineered systems content, supported by cost information and a project execution strategy as a minimum, to determine if it aligns with the expected performance requirements for the asset. Any adjustment to the concept should be confirmed with the owner or, at the owner's direction, with the sponsor following discussion and agreement between the delivery team and the operator, operations team or asset manager, as appropriate. Any agreed deviations from the initial brief or required performance outcomes and/or targets should be recorded and captured in the relevant part of the project information model (PIM).

*NOTE Annex A offers an example of a "Brief checklist".*

### 4.3.2 Primary activities

#### 4.3.2.1 Concept design

The delivery team should prepare the concept design for the asset, covering such work activities as:

a) identify and assess uncertainty and major risks (threats and opportunities);

b) update the risk register;

c) prepare a project execution strategy;

d) finalize the schedule of named areas or zones and any named systems comprising the proposed asset;

e) prepare high-level simulation models to examine the alignment of the proposed design with the expected benefits and required operational performance outcomes and/or targets;

f) review design predictions against the expected benefits and required operational performance;

g) agree the methods and associated measures for evaluating environmental, social, security and economic performance;

h) devise a plan for recording energy and other environmental performance, end-user satisfaction, fine-tuning and evaluation of actual performance against required performance;

i) prepare a plan for reporting the results of performance evaluation;

j) outline commissioning needs, including those for engineered systems, and the standards to be applied;

k) prepare a plan for commissioning, training and handover;

l) determine the operational resources needed to support commissioning, training and handover;

m) prepare a plan for satisfying training needs;

n) update the project management schedule;

o) update the estimates of capital cost and operational cost;

p) assess the whole-life costs of major elements and systems – BS 8544 provides guidance in this regard;

q) determine if the estimated capital and operational costs are within the agreed limits; and

r) update the required schedule contingency and cost contingency.

The operator, operations team or asset manager, as appropriate, should undertake the following activities in consultation with the sponsor and the delivery team:

1) prepare an analysis of the fit between the concept design and operational requirements;

2) review and contribute to the estimates of capital cost and operational cost and the assessment of whole-life costs;

3) prepare an operational model, operational management plan and operational expenditure budget;

4) outline the initial period of aftercare including those responsible for managing it;

5) outline the extended period of aftercare, including annual visits and reviews as a basis for optimizing operational performance;

6) identify who will be required from the operations team to support the aftercare to be provided by the delivery team;

7) prepare a plan for the removal and replacement of equipment, fabric and debris, where applicable; and

8) update any transfer proposals with respect to personnel and/or equipment.

#### 4.3.2.2 Design reviews

The delivery team should agree the definition of design-related information to be reviewed with the sponsor, the operator, operations team or asset manager, as appropriate. This definition should include a record of assumptions made in the course of design that might affect any aspect of the construction, commissioning, handover, start-up, operation and maintenance of the asset (see **4.3.2.3**).

Design reviews should adopt a structured and systematic approach based on the agreed deliverables for this work stage (see **4.3.7**). Where found necessary and agreed with the sponsor, the delivery team should update the performance outcomes and/or targets for energy use, greenhouse gas emissions, water consumption, waste reduction, noise and vibrations or other environmental indicators. The delivery team should prepare an energy model based on reliable estimates of regulated and unregulated load, where applicable.

The energy model should be updated and refined during the project as thermal and electrical loads and hours of occupation, where applicable, become clearer. The model should be maintained so that it is able to inform the energy analyses performed during aftercare and at the times post-implementation review (PIR) is undertaken.

Where found necessary and agreed with the sponsor, the delivery team should update the required social, security and economic performance outcomes.

The delivery team should allow for the participation of appropriate specialist contractors in design reviews, and record and act on identified access, commissioning and potential maintenance risks, where applicable. The risk register should be updated accordingly (see **4.3.3**).

*NOTE An important consideration is ensuring that the asset remains capable of performing as intended over its lifetime (see BS ISO 15686-2 and BS ISO 15686-10). This requires appropriate inspection and maintenance regimes (see BS 8210). Inaccessible areas and components pose risks and necessitate a risk response.*

#### 4.3.2.3 Asset maintenance management

*NOTE It is important that the proposed arrangements for asset maintenance take account of manufacturers' and other authoritative advice on appropriate maintenance regimes if the expected benefits and required operational performance are not to be impaired.*

The delivery team should review and comment on the sponsor's proposed arrangements for asset maintenance in consultation with the operator, operations team or asset manager, as appropriate, and review them at subsequent project decision points (or gates) up to and including the Handover and Close-out work stage to ensure that they remain appropriate.

### 4.3.3 Risks

The delivery team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and the opportunities that might enhance outcomes. Particular attention should be paid to operation and maintenance implications as design proposals and information become available, in particular preserving or protecting the asset from specific threats and vulnerabilities.

### 4.3.4 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.3.2**) and contributing to the deliverables (see **4.3.7**) in this work stage:

a) energy performance requirements to be met;

b) output requirements from the engineered systems;

c) capacity of existing public utility services and other infrastructure, where applicable;

d) method(s) for measuring energy in use and greenhouse gas emissions;

e) requirements for aligning with assessment methods (e.g. BREEAM and LEED [1)]), where applicable;

f) regulatory requirements to be met;

g) the owner's security requirements, including the security of information and data;

h) arrangements for managing information modelling;

i) expected benefits from the successful operation of the asset;

j) required performance outcomes for use in post-implementation review (PIR);

k) extent of aftercare required;

l) commissioning and training plan;

m) extent of design for manufacture and assembly/disassembly;

n) data for whole-life cost assessment of major elements, systems and components;

o) procurement plan;

p) approach to meeting owner-specific performance requirements;

q) extent of an inclusive design that anticipates the needs of disabled people and others with equalities-related needs, especially provisions for access, movement and emergency evacuation;

r) acceptable deviations from the initial brief;

s) format for presenting outline proposals to the owner or the sponsor on its behalf;

t) risks to be reflected in a schedule and cost risk assessment;

u) acceptability of the updated project management schedule based on a realistic assessment of time;

v) updated strategic asset management plan (SAMP), where applicable; and

w) updated plan for transfer of personnel and/or equipment and subsequent move-in, where applicable.

Each of the information requirements in a) to w) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

[1)] BREEAM: http://www.breeam.com/ and LEED: http://www.usgbc.org/leed [viewed 2016-10-05].

### 4.3.5 Roles and responsibilities

The delivery team should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.3.2**) and their associated deliverables (see **4.3.7**) for this work stage. The RASCI chart should be kept up to date and should be used to inform a similar requirement at the start of the Definition work stage. A detailed responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design, their level of model detail and the level of model information to be exchanged.

### 4.3.6 Information systems and tools

The arrangements to support asset management through the use of the owner's defined enterprise system (see PAS 1192-3 and PAS 1192-5) or other means should be confirmed or revised. The operator, operations team or asset manager, as appropriate, should assist with these arrangements where requested by the owner or sponsor on its behalf.

### 4.3.7 Deliverables

*NOTE The primary deliverables at the end of the Concept work stage are the final brief and the design concept. Together, they indicate the project's feasibility.*

The delivery team should provide the sponsor with the following, as a minimum:

a) a digitally-checkable copy of the final brief, including the relationship of the structural design to the general design treatment and supporting information and data, together with evidence of any other aspect of the concept demonstrated in this work stage and other concepts that have been considered and actively rejected;

b) an indication of whether or not the expected benefits and required operational performance can be achieved by the design concept, including the preferred engineered systems' philosophy;

c) an indication of whether or not any commitments by the owner to statutory energy targets are satisfied by the design concept;

d) evidence that the relevant owner's security requirements have been met;

e) an updated risk register;

f) a project execution strategy; and

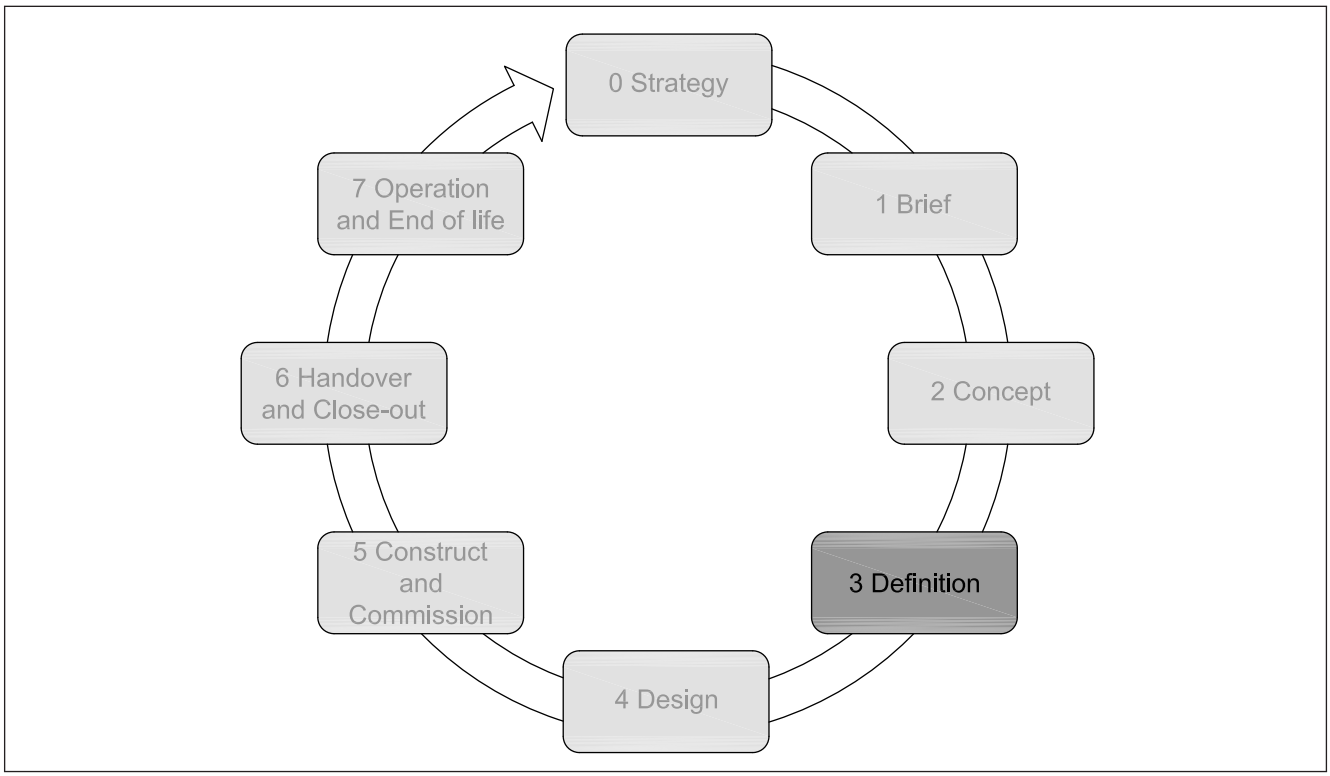
g) a record of engagement and checking that has taken place with the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users.

### 4.3.8 Key decisions and next steps

The owner, or sponsor on its behalf, should reach a decision on whether or not there is a sufficient basis to proceed following what amounts to a feasibility study for the proposed asset. The delivery team and the operator, operations team or asset manager, as appropriate, should be informed accordingly. Where the owner or sponsor, as appropriate, intends to proceed, the delivery team should give the sponsor the opportunity to review and approve the planned work activities, and their associated information requirements and deliverables, for the Definition work stage before the conclusion of this work stage.

*NOTE A question that can be considered here is: "Has the delivery team looked wide enough in terms of considering and assessing the options available?" The answer to this question either confirms the intended approach to design development or indicates if the owner, or sponsor on its behalf, has to reconsider the initial brief or, perhaps, the strategic definition and the business case for the new or upgraded asset.*

## 4.4 Definition




### 4.4.1 General requirements

*COMMENTARY ON **4.4.1***

*The Definition work stage is concerned with developing the design, including coordinating and updating the proposed general design treatment, structural design, engineered systems and outline specifications supported by updated capital and operational costs. It provides the opportunity to ensure that the main aspects of the design have matured sufficiently to enable detailed, technical design to commence in the subsequent Design work stage.*

The delivery team should ensure that the design proposal takes into account the needs of the operator, operations team or asset manager, as appropriate, and end-users in regard to the required operational performance of the asset and that design assumptions are recorded and then tested in reviews of the design proposals (see **4.3.2.2**).

The delivery team should ensure that the design proposal lends itself to safe, economical construction and that it has been verified from an operability perspective for the level of model detail and level of model information available at this point. In this regard, the delivery team should assess the activities required to operate the asset and reduce the associated risks to as low as reasonably practicable (ALARP). The operator, operations team or asset manager, as appropriate, should assess the impact of the design proposal upon its plans for operation and maintenance, including the delivery of technical and business services, where applicable, and advise the delivery team of any situation where safety might be compromised.

The sponsor should require the delivery team and the operator, operations team or asset manager, as appropriate, to report on any aspect of the developing design that might compromise achievement of the project objectives, expected benefits or the ability to achieve the required operational performance outcomes and/or targets. An updated estimate of the operational cost for the asset should be provided by the operator, operations team or asset manager, as appropriate, to the sponsor and the delivery team.

The sponsor should clarify any uncertainty on the part of the delivery team in regard to work activities, information exchanges or deliverables.

### 4.4.2 Primary activities

The delivery team should prepare the definition of the asset, covering such work activities as:

a) explore the design proposal by means of an information model or other method for explaining the asset to the owner, or sponsor on its behalf, the operator, operations team or asset manager, as appropriate, end-users, and other key stakeholders;

b) undertake model-based design performance simulations that take into account the accuracy of prediction achieved in the past from similar simulations;

c) determine if the design proposal is capable of meeting the required environmental, social, security and economic performance;

d) determine if the design will deliver an asset that is safe to access, maintain and use;

e) identify any additional operational requirements that are necessary for achieving the agreed environmental performance;

f) report on the extent to which any operational constraints have been advised to the operator, operations team or asset manager, as appropriate, and the planning authority where applicable;

g) prepare an update of what will be required for aftercare, including the extent of the engagement needed from all involved parties;

h) prepare aftercare plans as agreed between the sponsor and the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users;

i) undertake an operational HSSE risk assessment, identifying any hazards, measures to eliminate or reduce the risks and plans to control the risks during operation of the asset;

j) prepare an integrated master schedule to show the interfaces between design, procurement, construction, commissioning, handover, start-up and operations;

k) update the estimates of capital cost and operational cost;

l) update the required schedule contingency and cost contingency;

m) prepare descriptions for the operation of controls on all engineered systems;

n) identify any controls for use by end-users and the steps to be taken to ensure they can operate them safely and correctly;

o) identify the commissioning needs for each system and the related standard(s) and methods; and

p) update the plan for commissioning, training and handover.

The operator, operations team or asset manager, as appropriate, should undertake the following activities, as a minimum:

1) participate in reviews of the design proposals and comment on whether or not the design is capable of meeting the required environmental, social, security and economic performance;

2) provide an updated operational model, operational management plan and operational expenditure budget;

3) review and comment on the updated estimate of operational cost;

4) identify the parties needed to witness demonstrations;

5) update the training plan for the operator, operations team or asset manager, as appropriate, and end-users where necessary;

6) prepare an updated plan for the removal and replacement of equipment, fabric and debris, where applicable; and

7) prepare a schedule of assets and breakdown into major components, including estimated costs, for management accounting and taxation purposes.

### 4.4.3 Option appraisal

The options available to satisfy functional, technical and operational needs and the extent to which these can be practically achieved should be assessed. Options should allow for the measurement of environmental, social, security and economic performance, and comparison with the required outcomes (see **3.3**). In particular, the delivery team should:

a) indicate when alternative solutions (e.g. designs, systems, products and materials), identified from a combined operational and inclusive perspective, are available, and inform the owner which solution (or combination) optimizes energy use and minimizes greenhouse gas emissions and whole-life cost;

b) be explicit when deciding on any matter that could impact on operations, in particular energy use, greenhouse gas emissions, water consumption, waste disposal, noise and vibrations, other previously defined environmental indicators, and whole-life cost;

c) obtain information from manufacturers on the operational cost (including maintenance), breakdown frequency and lifetime of components and parts (including the energy consumed by them), and other information required for the safe and correct operation of the asset; and

d) obtain current lead times for engineered systems and other major systems and components.

All information should be provided to determine whether or not operational parameters are acceptable and to permit the option of visiting manufacturers and/or existing operational assets to verify details before reaching a decision.

### 4.4.4 Risks

The delivery team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and the opportunities that might enhance outcomes.

### 4.4.5 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.4.2**) and contributing to the deliverables (see **4.4.8**) in this work stage:

a) the extent of design development needed to demonstrate detailed proposals for site layout, planning and spatial arrangements, general design treatment, structure, engineered systems, constructability and operability;

b) the owner's security requirements, including the security of information and data;

c) acceptability of the proposed approach to cost planning of construction and maintenance;

d) acceptability of the cash-flow forecast;

e) the extent to which lessons learned from previous projects have been acted upon;

f) the extent to which rule-based, auto-generation of objects has been utilized;

g) the extent of design coordinated at the component level of model detail;

h) the completeness of calculations in regard to any energy-related planning conditions and their implications; and

i) the design's compliance with standards, specifications and the final brief.

Each of the information requirements in a) to i) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

### 4.4.6 Roles and responsibilities

The delivery team should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.4.2**) and their associated deliverables (see **4.4.8**) for this work stage. The RASCI chart should be kept up to date and should be used to inform a similar requirement at the start of the Design work stage. A detailed responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design, their level of model detail and the level of model information to be exchanged.

### 4.4.7 Information systems and tools

The arrangements to support asset management through the use of the owner's defined enterprise system (see PAS 1192-3 and PAS 1192-5) or other means should be confirmed or revised. The operator, operations team or asset manager, as appropriate, should assist with these arrangements where requested by the owner or sponsor on its behalf.

### 4.4.8 Deliverables

The delivery team should provide the sponsor with the following, as a minimum:

a) evidence that lessons learned from previous projects have been acted upon;

b) evidence of how the design proposal meets the needs of the operator, operations team or asset manager, as appropriate, end-users and other key stakeholders;

c) evidence that the relevant owner's security requirements have been met;

d) detailed proposals with respect to:

   1) site layout;

   2) planning and spatial arrangements;

   3) general design treatment;

   4) structure;

   5) engineered systems;

   6) constructability; and

   7) operability.

e) evidence that the design conforms to standards, specifications and the final brief;

f) the extent of design coordination at the component level of model detail;

g) details of rule-based, auto-generation of objects, where applicable;

h) calculations for determining energy use and how energy performance has been considered in the design;

i) calculations supporting environmental-related planning conditions, where applicable;

j) evidence that the asset will be safe to operate and use;

k) evidence that the design proposal as developed demonstrates principles in support of operational requirements, including access for disabled people and others with equalities-related needs;

l) details of the cost plans for construction and maintenance; and

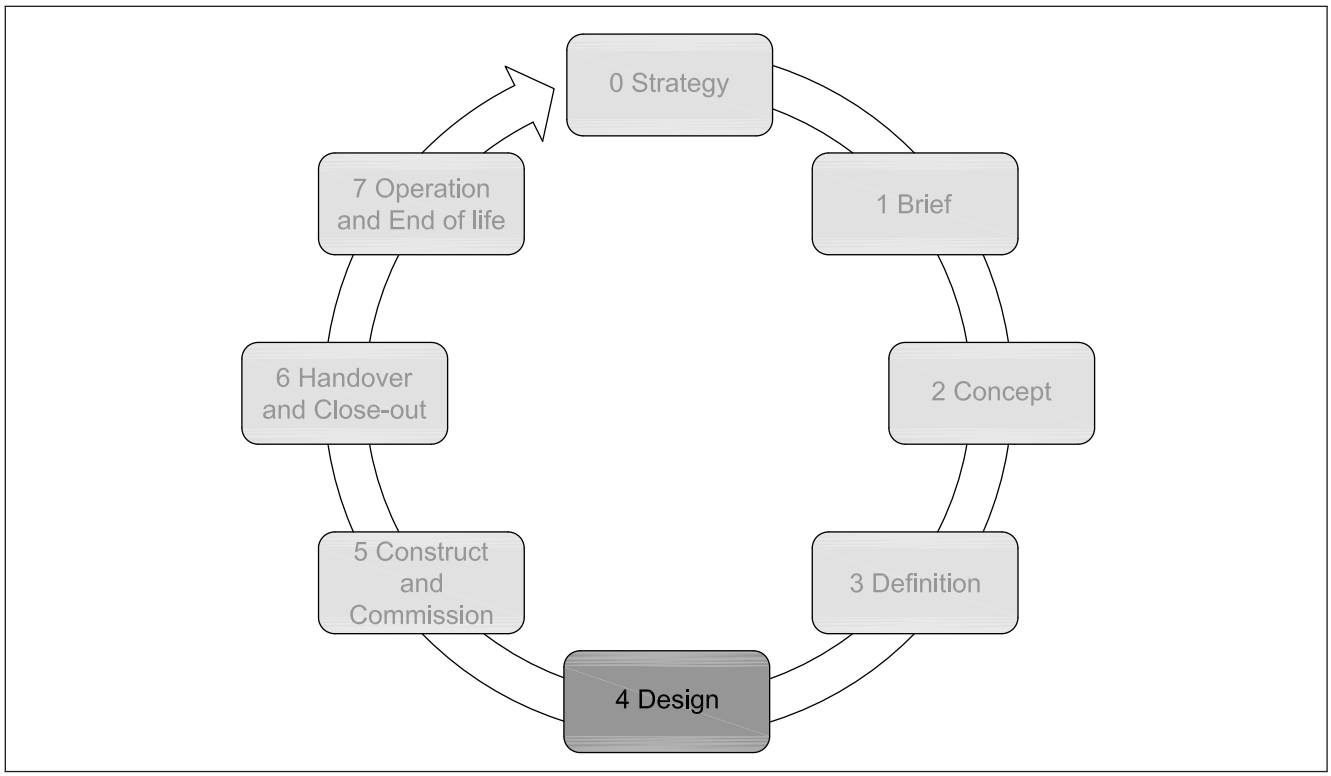
m) cash-flow forecast.

### 4.4.9 Key decisions and next steps

The owner, or the sponsor on its behalf, should reach a decision on whether or not there is a sufficient basis to proceed to detailed design and should inform the delivery team and the operator, operations team or asset manager, as appropriate. Where the sponsor intends to proceed, the delivery team should give the sponsor the opportunity to review and approve the planned work activities, and their associated information requirements and deliverables, for the Design work stage before the conclusion of this work stage.

*NOTE A question that can be considered here is: "Is the approach to design capable of being translated into a detailed, technical design supported by specifications?" The answer helps to confirm the intended approach or indicates if the design has to be reconsidered.*

## 4.5 Design




### 4.5.1 General requirements

*COMMENTARY ON **4.5.1***

*The Design work stage is concerned with preparing the technical design, including structural and engineering design information, and detailed cost and operational data. This work stage is likely to involve the supply chain beyond the immediacy of the delivery team in finalizing the details of the design prior to construction. Specialist suppliers and manufacturers are likely to be involved where components and systems are subject to significant off-site manufacturing. This work stage is one where the incidence of design changes is likely to rise, necessitating an effective change control procedure. In this connection, it is important to recognize the many minor changes that are more in the nature of design development than a change in the scope of work.*

The sponsor should review the technical aspects of the design and, where considered appropriate, should visit specialist suppliers and manufacturers to confirm the acceptability, or otherwise, of systems, components, products and materials. The sponsor should determine whether or not specific processes for configuration management, system integration and verification (see **3.4** and BS ISO/IEC/IEEE 15288) are to be incorporated in this work stage and in the subsequent Construct and Commission work stage.

Any adjustment to the design should be approved by the sponsor following discussion between the delivery team and the operator, operations team or asset manager, as appropriate. Any agreed deviations from the design or performance requirements should be recorded and captured in the project information model (PIM). A procedure for design change control should be implemented by the delivery team, where the authority for approving those changes classed as significant should rest with the sponsor. The criteria for classifying design changes should be determined by the sponsor.

### 4.5.2 Primary activities

#### 4.5.2.1 Technical design

The delivery team should prepare the technical design for the asset, covering such work activities as:

a) implement a change control procedure;

b) update the information model;

c) agree with the sponsor the method of production and form of delivery for the information and data required to operate the asset;

d) undertake model-based design performance simulations that take into account the accuracy of prediction achieved in the past from similar simulations;

e) prepare method statements covering operation and maintenance in consultation with the operator, operations team or asset manager, as appropriate;

f) prepare aftercare plans and schedules in consultation with the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users;

g) outline the extent and content of the asset information model (AIM), including operation and maintenance information, and a specification for extracting relevant BIM-related data, where applicable;

h) prepare an updated plan for the removal and replacement of equipment, fabric and debris, where applicable;

i) update the plan for commissioning, training and handover;

j) update the training needs' plan;

k) prepare a security plan for construction, where applicable;

l) prepare the operational HSSE plan for construction and operations;

m) update the risk assessments and the risk register;

n) update the estimates of capital cost and operational cost;

o) update the integrated master schedule;

p) prepare a construction and system testing schedule and a commissioning and performance testing schedule, wherever possible; and

q) update the required schedule contingency and cost contingency.

The operator, operations team or asset manager, as appropriate, should undertake the following activities, as a minimum:

1) participate in reviews of the technical design and comment on whether or not the design is capable of meeting the required environmental, social, security and economic performance;

2) identify any changed operational requirements that are necessary in order to meet the energy performance target(s);

3) provide an updated operational model, operational management plan and operational expenditure budget;

4) review and comment on the updated estimate of operational cost;

5) prepare an asset replacement and removal strategy, where applicable;

6) provide a definition of the requirements for the asset register and any specific maintenance plans;

7) provide a scope of work and specification for the procurement of maintenance services, where applicable;

8) advise on the need to recruit personnel for the operations team, where applicable;

9) advise on the need for procurement of service providers, where applicable; and

10) confirm the arrangements for the transfer of asset data to the asset information model (AIM) or asset register, as appropriate.

*NOTE BS 8572 contains guidance on the procurement of asset-related services.*

#### 4.5.2.2 Design change control

*COMMENTARY ON **4.5.2.2***

*There is always the possibility that a proposed change, whilst attractive, might erode value in the asset. Changes to the scope of work might have implications for the design and impact cost, schedule or performance in use. Any alteration in the project's baseline – scope, quality, cost, schedule and performance – can be regarded as a change. It is important, however, to distinguish between a design change and design development, where the latter is a matter of increasing levels of definition.*

Design changes should be avoided in this work stage unless considered necessary for reason of safety, security or inoperability. Changes might be necessary where the results of peer reviews and verification show that the required performance or other outcome or objective cannot be achieved.

A design change control procedure, incorporating a design change protocol, should be implemented to evaluate proposed changes to the design before they are submitted for approval to the sponsor so that the full implications for the safe, secure, efficient and cost-effective operation of the asset can be verified. This design change protocol should record details of the proposed change, including:

a) a description of the proposed change;

b) justification for the change (e.g. if the scope of work is unsafe, insecure or inoperable, or if value improvement is sought);

c) basis of the design (e.g. description and details of the system, component, process or activity to which it relates);

d) impact on end-users of the asset, including disabled people and others with equalities-related needs;

e) impact on the whole-life cost and value of the asset, on the schedule for construction work and on operations; and

f) authority responsible for approving the change.

Approved changes to the design should be reported formally to the sponsor at intervals, as necessary, reflecting the extent and urgency of the change and the time required for design or redesign or other deviation from the project's baseline.

*NOTE Failure to consider and consult widely on the impact of a proposed change could result in unintended negative consequences.*

#### 4.5.2.3 Design documentation

The delivery team should allow for the review of the information model and supporting documentation, with comments from the sponsor and the operator, operations team or asset manager, as appropriate, in terms of the design achieving the required environmental, social, security and economic performance outcomes and/or targets. The delivery team should ensure that any monitoring and metering systems proposed by specialist contractors or suppliers are consistent with those of the delivery team and that they satisfy the owner's performance monitoring requirements.

#### 4.5.2.4 Asset maintenance management

The delivery team should review and comment on the owner's and/or operator's arrangements for the procurement of maintenance services to ensure that they are appropriate.

### 4.5.3 Risks

The delivery team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and the opportunities that might enhance outcomes.

The delivery team should produce an updated operational HSSE risk assessment, identifying any hazards, measures to eliminate or reduce the risks, and plans to control the risks in operation. The risk register should be updated accordingly. Details of this risk assessment should be provided to the operator, operations team or asset manager, as appropriate, at the end of the Handover and Close-out work stage.

### 4.5.4 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.5.2**) and contributing to the deliverables (see **4.5.7**) in this work stage:

a) the information needed to enable construction to take place;

b) the alignment of the design with the needs of the operator, operations team or asset manager, as appropriate, and end-users in terms of access, inclusiveness, safety, security, serviceability, maintainability, adaptability and operational cost, as a minimum;

c) the owner's security requirements, including the security of information and data;

d) the availability of a procedure or protocol for controlling the distribution and security of documents, information and data;

e) any requirement to obtain firm price quotations as a precursor to procuring the engineered systems and other long-lead items;

f) updated lead times for engineered systems and other major components and systems;

g) source of specialist maintenance service provision (e.g. lifts/elevators and other engineered systems);

h) the definition and extent of operation and maintenance information; and

i) method statements for work where existing engineered systems and public utilities are to interface with the new or upgraded asset.

Each of the information requirements in a) to i) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

### 4.5.5 Roles and responsibilities

The delivery team should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.5.2**) and their associated deliverables (see **4.5.7**) for this work stage. The RASCI chart should be kept up to date and should be used to inform a similar requirement at the start of the Construct and Commission work stage. A detailed responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design, their level of model detail and the level of model information to be exchanged.

### 4.5.6 Information systems and tools

The arrangements to support asset management through the use of the owner's defined enterprise system (see PAS 1192-3 and PAS 1192-5) or other means should be confirmed or revised. The operator, operations team or asset manager, as appropriate, should assist with these arrangements.

The delivery team should provide an information model or adopt another medium for testing the perceptions of the operator, operations team or asset manager, as appropriate, and those of end-users in regard to the asset and later for assisting in the optimization of operational performance and the whole-life cost of the asset.

### 4.5.7 Deliverables

The delivery team should provide the sponsor with the following, as a minimum:

a) evidence that the design can be delivered through the proposals for construction;

b) evidence that the design proposals are likely to meet the outcomes and targets for environmental, social, security and economic performance;

c) evidence that the calculations in relation to energy have been verified and that the owner has been advised of any changes that might impact the required performance;

d) evidence that the relevant owner's security requirements have been met;

e) evidence that the design and construction proposals satisfy construction, design and management (CDM) legislation and operational HSSE requirements for construction, operation and maintenance, including information models to show access provisions and method statements to cover maintenance activities;

f) evidence that the design and construction proposals satisfy the requirements for obtaining statutory and other approvals during the Handover and Close-out work stage;

g) simulations of energy use, greenhouse gas emissions, sound attenuation, public address and voice alarm performance, fire and smoke modelling and evacuation, and vehicle and people movement capacities, where applicable;

h) details of metering of energy use, water consumption, waste reduction and other previously defined environmental indicators;

i) evidence that the design and construction proposals meet the needs of the operator, operations team or asset manager, as appropriate, in terms of materials, performance, maintenance regimes, cleaning methods and adaptability;

j) evidence that the design and construction proposals provide sufficient information for the owner to initiate procurement of asset-related services (see BS 8572);

k) evidence that the automated transfer of asset data content to the asset information model (AIM), the owner's defined enterprise system (see PAS 1192-3) or other means can be achieved where this has been defined as a requirement;

l) evidence that the updated capital cost and operational costs are within the agreed expenditure limits;

m) updated budget estimates;

n) descriptions of controls for all engineered systems, including those controls intended to be used by end-users; and

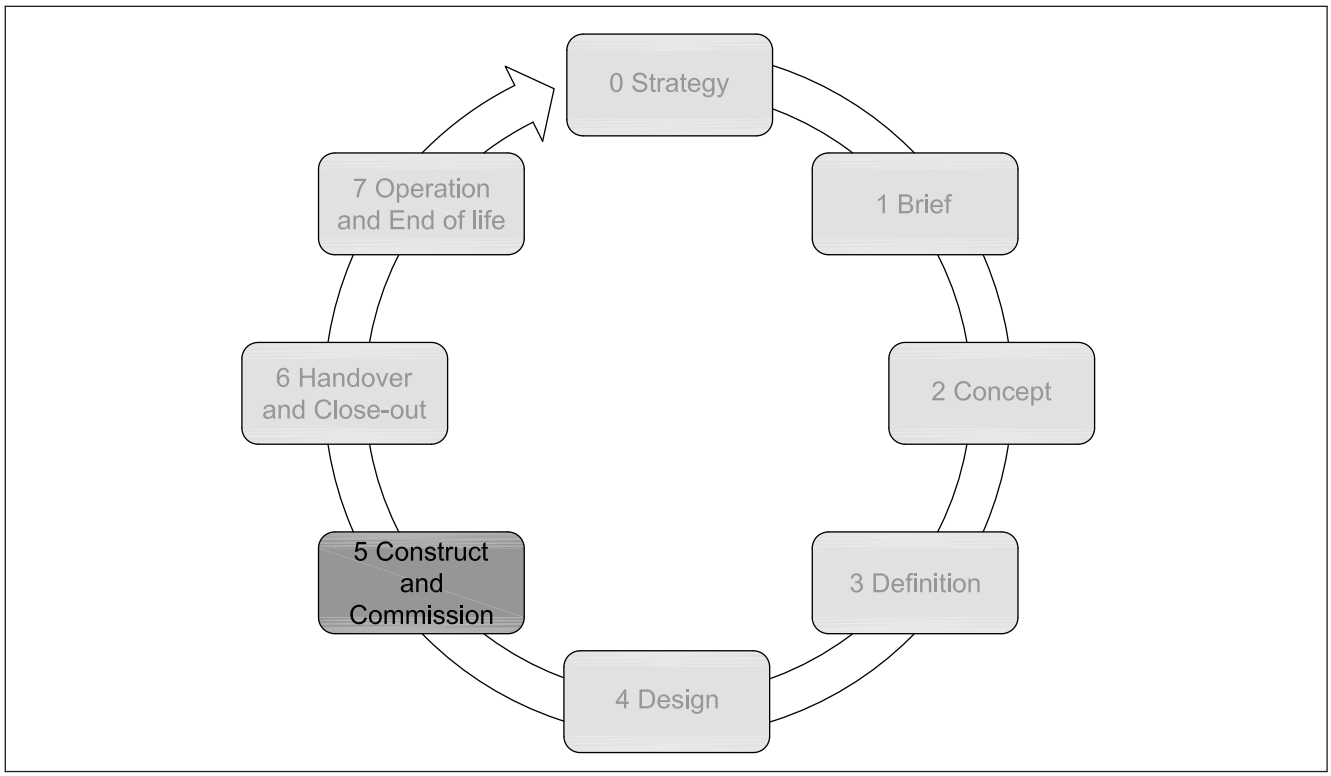
o) evidence that the specification for operation and maintenance information has been defined in consultation with the operator, operations team or asset manager, as appropriate, and end-users or their representative(s).

### 4.5.8 Key decisions and next steps

The owner, in consultation with the sponsor, should reach a decision on whether or not there is a sufficient basis to proceed with construction and should inform the delivery team and the operator, operations team or asset manager, as appropriate. Where the owner intends to proceed, the delivery team should give the sponsor the opportunity to review and approve the planned work activities, and their associated information requirements and deliverables, for the Construct and Commission work stage before the conclusion of this work stage.

*NOTE A question that can be considered here is: "Has the design reached a sufficiently mature state to be moved into construction?" The answer to this question largely determines the owner's final investment decision and the commitment to construction work. At this point, the owner is faced with making the largest financial commitment for the project.*

## 4.6 Construct and Commission




### 4.6.1 General requirements

*COMMENTARY ON **4.6.1***

*The Construct and Commission work stage is concerned with planning, organizing and coordinating off-site manufacturing with on-site construction, including assembly, testing and commissioning with supporting schedules, for example a construction and system testing schedule and a commissioning and performance testing schedule. This work stage is fundamentally the means by which the required project outcomes are realized. It is inevitable that some adjustments will be needed to the design during construction to resolve operability issues and to avoid quality failures. This stage emphasizes the importance of testing and commissioning as essential to ensure a smooth transition from construction to the subsequent work stages of Handover and Close-out and Operation and End of life.*

The sponsor should require the delivery team to provide a detailed schedule covering the construction work and the testing and commissioning of the asset, including engineered systems and other systems or installations where functionality, integrity and effectiveness need to be demonstrated. Any adjustment to the design during this work stage should be agreed by the sponsor following discussion and agreement between the delivery team and the operator, operations team or asset manager, as appropriate. Any agreed deviations from the design or performance requirements should be recorded and captured in the project information model (PIM). The procedure for design change control should continue through this work stage and be used to capture lessons learned for subsequent post-implementation review (PIR) and feedback to all involved parties.

### 4.6.2 Primary activities

The delivery team should prepare for construction and commissioning of the asset, covering such work activities as:

a) verify (e.g. by laser scanning) that the asset has been constructed, within the defined tolerances, against the virtual construction model;

b) review all construction, engineering and installation details, and highlight any that will impact negatively upon the actual performance relative to the required performance;

c) highlight any unavoidable changes in design that might give rise to a change in the performance of the asset;

d) update the information model in light of further design and operational information and data, where applicable;

e) update the security plan for construction and commissioning;

f) update the operational HSSE risk assessment;

g) update the risk register;

h) update the required schedule contingency and cost contingency;

i) prepare forecasts of final capital cost and predicted operational cost;

j) update the commissioning specification;

k) update the commissioning and training plan in conjunction with the commissioning manager;

l) identify any skills that end-users and other key stakeholders need to have acquired before attending commissioning demonstrations;

m) prepare a schedule of pre-commissioning activities;

n) update the construction and system testing schedule and the commissioning and performance testing schedule, and roll up changes in summary form to the integrated master schedule;

o) prepare and maintain a 14-day look-ahead construction schedule;

p) update the handover plan to include training requirements for the operator, operations team or asset manager, as appropriate, and end-users;

q) prepare a detailed move-in plan for personnel and/or equipment, where applicable;

r) collate the operation and maintenance information, supported by manufacturers' operating manuals; and

s) collate the general design treatment, structural design, engineered systems design and public health information necessary to obtain statutory approvals.

The operator, operations team or asset manager, as appropriate, should undertake the following activities, as a minimum:

1) determine whether or not the engineered systems and other major components and systems can be maintained safely, securely and correctly and in compliance with relevant legislation;

2) provide an operational HSSE risk assessment;

3) comment on the construction and system testing schedule and the commissioning and performance testing schedule from the perspective of witnessing demonstrations; and

4) contribute to the updating of the handover plan.

### 4.6.3 Commissioning plan

The delivery team should develop a plan for managing the commissioning of the asset and the equipment and systems that it comprises in conjunction with the operator, operations team or asset manager, as appropriate. This process can be greatly assisted by a detailed schedule or schedules (see **4.6.2**). The delivery team should ensure that the commissioning is witnessed by appropriate parties, including the sponsor and the operator, operations team or asset manager, as appropriate, and that the required performance outcomes are achieved to the sponsor's and owner's satisfaction.

### 4.6.4 Operation and maintenance information

The delivery team should submit operation and maintenance information, supported by manufacturers' operating manuals, for review by the sponsor and the operator, operations team or asset manager, as appropriate, in accordance with the requirements defined for information exchange. The delivery team should revise the information in light of feedback then seek approval and sign-off prior to the conclusion of this work stage.

### 4.6.5 Risks

The delivery team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and the opportunities that might enhance outcomes.

### 4.6.6 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.6.2**) and contributing to the deliverables (see **4.6.9**) in this work stage:

a) the owner's security requirements, including the security of information and data;

*NOTE Many new supply chain personnel and their employers will be introduced to the project for the first time during this work stage and could be unaware of the owner's security requirements.*

b) arrangements to ensure that the project's construction site will be managed safely and securely;

c) arrangements for managing construction waste, including the identification of any waste substances that might pose a hazard to the safety of personnel, property or the environment;

d) procedure for involving the sponsor in decisions on proposed changes to the design during construction, testing and commissioning;

e) witnesses required for commissioning work;

f) manufacturers' operating manuals; and

g) format for presenting evidence to support physical deliverables.

Each of the information requirements in a) to g) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

### 4.6.7 Roles and responsibilities

The delivery team should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.6.2**) and their associated deliverables (see **4.6.9**) for this work stage. The RASCI chart should be kept up to date and should be used to inform a similar requirement at the start of the Handover and Close-out work stage. A detailed responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design, their level of model detail and the level of model information to be exchanged.

### 4.6.8 Information systems and tools

The arrangements to support asset management through the use of the owner's defined enterprise system (see PAS 1192-3 and PAS 1192-5) or other means should be confirmed or revised. The operator, operations team or asset manager, as appropriate, should assist with these arrangements. Project information and data for operational purposes, including operation and maintenance information supported by manufacturers' operating manuals, that need to be transferred from the project information model (PIM) to the asset information model (AIM) during this work stage should be defined in the plan for information exchange.

The delivery team should ensure that a robust project planning and scheduling tool is used to plan and schedule construction, coordinate contractor interfaces and sequence activities for commissioning and training, including the deployment of appropriate levels of resources.

### 4.6.9 Deliverables

The delivery team should provide the sponsor and the operator, operations team or asset manager, as appropriate, with the following, as a minimum:

a) evidence that the asset has been constructed, within the defined tolerances, against the virtual construction model;

b) information on design changes, including changes in materials and products;

c) information on changes, other than to the design, affecting the project's baseline or required operational performance;

d) evidence that the information required for statutory approvals has been prepared and has been provided to the owner and the operator, operations team or asset manager, as appropriate;

e) evidence that the relevant owner's security requirements have been met;

f) evidence that information exchanges have taken place as planned and to the extent and level of model detail and level of model information required;

g) evidence that all systems, plant and equipment incorporated into the works can be safely, securely and correctly maintained in compliance with current legislation;

h) evidence that design details prepared by specialist contractors, suppliers and manufacturers have been reviewed to check that the required performance can be achieved;

i) evidence that the updated commissioning specification has been produced and agreed with the operator, operations team or asset manager, as appropriate, and end-users;

j) operation and maintenance information, supported by manufacturers' operating manuals; and

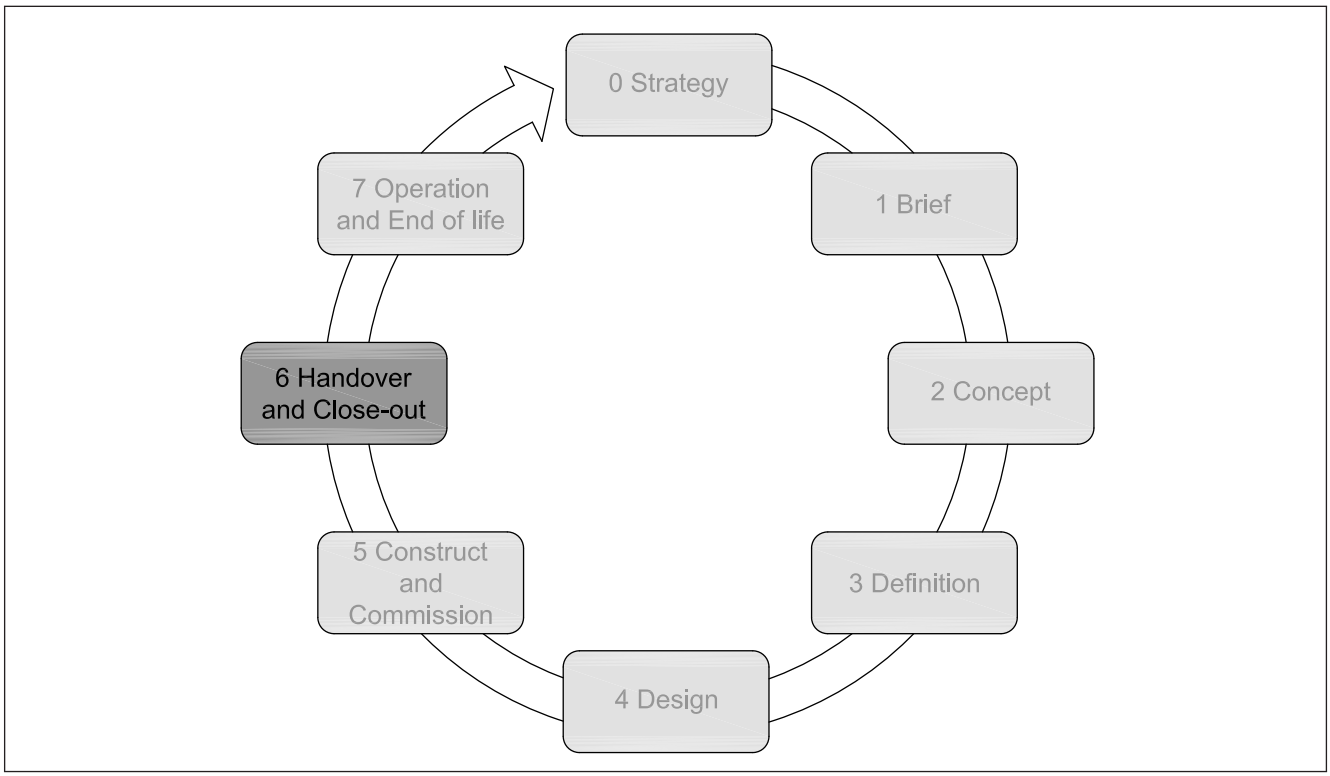
k) evidence that all commissioning activities have been conducted.

### 4.6.10 Key decisions and next steps

At the end of this work stage, the sponsor should determine whether or not the construction work and testing and commissioning have advanced sufficiently to meet the project's objectives for delivery of the asset, and should inform the delivery team and the operator, operations team or asset manager, as appropriate, of its decision. Where the sponsor determines that the project has met its objectives, the delivery team, including those responsible for aftercare, should give the sponsor the opportunity to review and approve the planned work activities and their associated information requirements and deliverables for the Handover and Close-out work stage before the conclusion of this work stage.

*NOTE A question that can be considered towards the end of this work stage is: "Has the delivery team executed the construction work according to the defined project objectives?" The answer to this question determines the owner's actions in the remaining work stages.*

## 4.7 Handover and Close-out




### 4.7.1 General requirements

*COMMENTARY ON **4.7.1***

*The Handover and Close-out work stage is concerned with the training of the operations team, handover of the asset to the operator and the start-up of operations. It can be highly advantageous for the owner, sponsor and operator if end-users, or their representative(s), are included in discussions about expectations in regard to the use of the asset. The care with which defects, faults and other shortcomings are identified, logged and investigated is a significant determinant in their being rectified within an acceptable period during the Operation and End of life work stage.*

The sponsor should require the operator, operations team or asset manager, as appropriate, to provide a detailed plan for the purpose of training those who have been or who will be given responsibility for the day-to-day operation of the asset and others who would benefit from direct observation of the operational aspects of the asset. The delivery team should prepare a technical guide to assist the operator, operations team or asset manager, as appropriate, in the day-to-day operation of the asset (see **4.7.2.8**). The procedure for Design change control should continue through this work stage and be used to identify and log defects and faults and any performance that falls outside the expected or permitted operating range of products and systems. The log should be reviewed by the delivery team and the operator, operations team or asset manager, as appropriate, with their recommendations fed back to the sponsor.

### 4.7.2 Primary activities

#### 4.7.2.1 Preparation for handover

The delivery team should prepare for handover of the asset, covering such work activities as:

a) summarize the changes that have been incorporated and advise on whether or not their implications have been brought to the attention of the sponsor and the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users;

b) verify the commissioning information provided by the suppliers in accordance with the methods identified in the commissioning specification;

c) prepare a schedule for coordinating on-site activities and the witnessing of balancing, regulating and performance testing by the sponsor and the operator, operations team or asset manager, as appropriate;

d) record all equipment and system settings and outputs from commissioning and inform the sponsor and the operator, operations team or asset manager, as appropriate;

e) identify where any operational details and performance targets have been adjusted in light of commissioning results;

f) finalize the plan for energy and water consumption metering, where applicable;

g) prepare a plan to identify the extent of energy use and greenhouse gas emissions;

h) determine how non-technical users will know how to operate the asset efficiently, where applicable;

i) create the as-constructed information and data from the verified as-constructed model (see **4.6.2**);

j) contribute to the asset information model (AIM) [see 5) below];

k) review the updated operational information provided by the operator, operations team or asset manager, as appropriate;

l) prepare the forecast of outturn capital cost; and

m) prepare a detailed analysis of the outturn capital cost.

The operator, operations team or asset manager should undertake the following activities, as a minimum:

1) review and comment on all commissioning and handover-related information;

2) provide updated operational information to the delivery team;

3) review and comment on all operation and maintenance information;

4) update the estimate of operational cost;

5) transfer information and data from the project information model (PIM) to the asset information model (AIM);

6) update the schedule of assets to be maintained, including a responsibility assignment matrix (e.g. a RASCI chart); and

7) prepare a cost breakdown of the asset for management accounting and taxation purposes.

#### 4.7.2.2 Operational readiness

The delivery team should prepare an operational readiness plan in advance of the start-up of operations. This should include regular reports on the status of the completion of the asset against previously agreed milestones and dates as handover approaches. The plan should include details of commissioning and training activities, preparation of operation and maintenance information, completeness of as-constructed information, the technical guide and the setting up of a helpdesk or other support system for end-users. The training needs of end-users and the arrangements for training sessions should form an integral part of this operational readiness plan.

The delivery team should organize training for the sponsor and any other person identified by the latter in regard to operation and maintenance before and after handover. Handover training for the operations team should be digitally recorded by the delivery team for future use. A copy of the recording should be handed over to the owner during the initial period of aftercare (see **4.8.2.2**).

The delivery team should carry out initial end-user training and familiarization prior to handover. All training should be digitally recorded by the delivery team.

#### 4.7.2.3 Commissioning check

The delivery team should check that commissioning records include energy use data, as far as practicable. The delivery team should review the commissioning records with the sponsor and the operator, operations team or asset manager, as appropriate, and prepare a schedule for post-handover optimization of the asset's performance in line with the requirements for the periods of initial aftercare (see **4.8.2.2**) and extended aftercare (see **4.8.2.3**). This schedule should be initiated during the Design work stage (see **4.5.2**) and be finalized in this work stage.

The delivery team should ensure that individual metering systems are functioning accurately, are adequately labelled according to end use and that their data are reconciled to within 5% of the main meters prior to handover. Meters should be zeroed immediately prior to handover. Any non-functioning or inaccurate meters should be labelled as such and recorded as a defect to be resolved during the initial period of aftercare.

*NOTE Attention is drawn to BS ISO 15489-1, which provides detailed guidance on the creation, capture and management of records regardless of structure, form or media.*

#### 4.7.2.4 Asset maintenance management

The delivery team should review and comment on the owner's proposed asset maintenance arrangements to ensure that they remain appropriate for the as-constructed asset.

#### 4.7.2.5 Engineered systems

The delivery team should provide a demonstration to the operator, operations team or asset manager, as appropriate, of the asset's engineered systems and control interfaces, and demonstrate the methods for adjustment. The delivery team should inform the operator, operations team or asset manager, as appropriate, on the zoning strategies and modes of operation, where applicable.

User-controlled interfaces should be clearly legible and should be tested by the delivery team and the operator, operations team or asset manager, as appropriate, and a selection of end-users.

#### 4.7.2.6 Move-in

Where the asset involves accommodation intended for occupation by either the owner's personnel or that of other end-users, a move-in plan should be prepared by the delivery team as part of the operational readiness plan (see **4.7.2.2**). The team should liaise with the sponsor and the operator, operations team or asset manager, as appropriate, to agree the arrangements and to confirm the areas to be used for the fitting-out of the owner's equipment and furniture and to manage the timing of occupation.

#### 4.7.2.7 Aftercare team workplace

The owner should provide a prominent and accessible workplace for the aftercare team from the first day of start-up of the asset for the defined periods of initial and extended aftercare.

#### 4.7.2.8 Technical guide

The delivery team should prepare a technical guide to provide a succinct introduction for the operations team to help smooth the transition into operation and to outline duties and obligations in regard to operational HSSE. This complements the operation and maintenance information (see **4.6.4**) and should be transferred to the asset information model (AIM).

### 4.7.3 Risks

The delivery team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and the opportunities that might enhance outcomes.

### 4.7.4 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.7.2**) and contributing to the deliverables (see **4.7.7**) in this work stage:

a) the owner's security requirements, including the security of information and data;

b) a summary of design changes that have been incorporated;

c) the required basis for a valuation for insurance purposes;

d) details of how specific systems, components and products are to perform;

e) details of the day-to-day operation of the asset;

f) details of planned maintenance; and

g) applicable legislation regarding operational HSSE.

Each of the information requirements in a) to g) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

### 4.7.5 Roles and responsibilities

The delivery team should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.7.2**) and their associated deliverables (see **4.7.7**) for this work stage. The RASCI chart should be kept up to date and should be used to inform a similar requirement at the start of the Operation and End of life work stage.

### 4.7.6 Information systems and tools

All information and data for operational purposes should be transferred from the project information model (PIM) to the asset information model (AIM) not later than the end of this work stage, in accordance with the plan for information exchange. The arrangements to support asset management through the use of the owner's defined enterprise system (see PAS 1192-3 and PAS 1192-5) or other means should be confirmed or revised. The operator, operations team or asset manager, as appropriate, should assist with these arrangements.

*NOTE If the operator, operations team or asset manager, as appropriate, does not have possession of information and data for operational purposes at the start of the Operation and End of life work stage then it might be difficult to operate the asset safely, securely, efficiently and cost-effectively. In any event, it is inappropriate to hand over all information and data at the point of handover of the asset; instead, phased handover of a certain amount of information and data is necessary.*

### 4.7.7 Deliverables

The delivery team should provide the sponsor with the following, as a minimum:

a) details of the extent to which the asset aligns with the project objectives and expected benefits;

b) evidence of the integrity of the asset and the systems that it comprises;

c) evidence that the asset as constructed is capable of meeting the required operational performance;

d) evidence of the safe, secure and efficient operation of the asset in general and the engineered systems in particular;

e) evidence that the relevant owner's security requirements have been met;

f) a log of changes made to the design and information (where BIM is used) as recorded in the CDE with the implications of those changes;

g) details of any modification to the operational requirements and performance targets established in earlier work stages to reflect sponsor- or owner-initiated changes;

h) evidence of an asset operational readiness plan having been implemented;

i) evidence that the demonstrations of balancing, regulating and performance testing have been conducted successfully, where applicable;

j) evidence that the performance of products, components and systems has been reviewed with the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users;

k) evidence that the commissioning of equipment has been undertaken by the suppliers to the specified method, logic, programme and in accordance with the commissioning specification;

l) records of the commissioning procedure and tests;

m) evidence that the sponsor and operations team have seen the results of all tests;

n) evidence that the asset management team attended the relevant commissioning meetings;

o) updated operation and maintenance information and technical guide reflecting the settings at the time of commissioning;

p) evidence that test results and any updated operation and maintenance information have been transferred to the asset information management (AIM) model;

q) final predictions of energy use and greenhouse gas emissions based on simulation models of the as-constructed asset; and

r) as-constructed information with fully-populated asset data.

The operator, operations team or asset manager, as appropriate, should provide the delivery team with the following:

1) evidence of a move-in plan for people and/or equipment, where applicable;

2) evidence of a communication plan to update end-users;

3) details of an appropriate workplace, with data communication links, for the aftercare team;

4) details of a helpdesk to support end-users;

5) evidence of the use of key performance indicators (KPIs) to assess the effectiveness of the asset management plan (see **3.4** and **3.7**);

6) cost breakdown of the asset; and

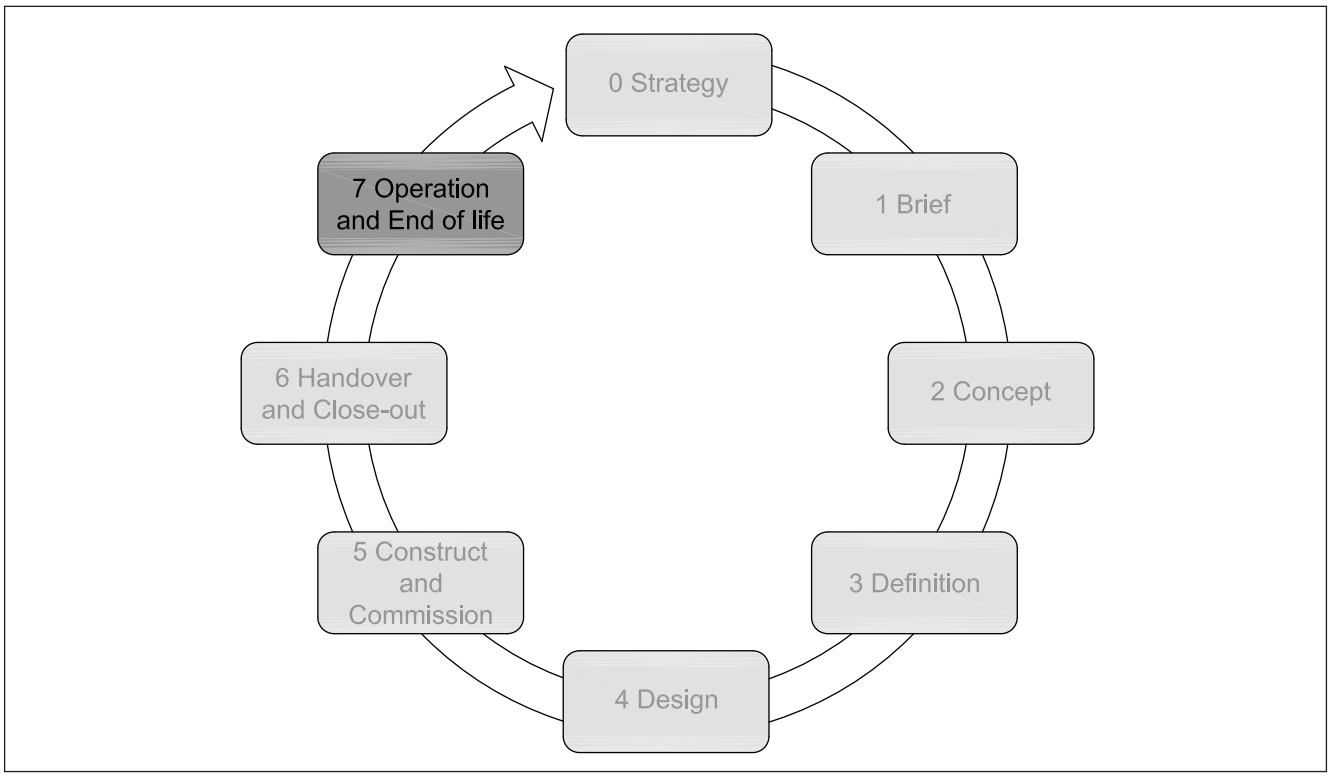
7) details of the method for recording and reporting on operational cost.

### 4.7.8 Key decisions and next steps

At the end of this work stage, the sponsor should decide whether or not operations should be started up and should inform the delivery team and the operator, operations team or the asset manager, as appropriate. Where the intention is to start up operations, the delivery team, including those responsible for aftercare, should give the sponsor the opportunity to review and approve the planned work activities and their associated information requirements and deliverables for the Operation and End of life work stage before the conclusion of this work stage.

*NOTE A question that can be considered here is: "Is the asset likely to measure up to the project objectives, expected benefits and the required operational performance?" The answer to this question largely determines the owner's actions in the Operation and End of life work stage.*

## 4.8 Operation and End of life




### 4.8.1 General requirements

*COMMENTARY ON **4.8.1***

*The Operation and End of life work stage is concerned with achieving steady-state operation, involving aftercare, optimization of the asset's performance and post-implementation review (PIR), including benchmarking and lessons learned. This work stage measures any gap between actual performance and required performance. It provides a vital link in a chain of feedback that provides evidence to the sponsor and owner on the extent to which the asset provides the expected benefits and matches the required operational performance; it also provides valuable information and data for planning future projects (see Figure 3). This work stage considers separately the immediate and short-term issues and those arising over the medium term. These are referred to as the periods of initial aftercare and extended aftercare respectively. The initial period of aftercare typically runs from six to eight weeks after handover, and the extended period of aftercare lasts for up to three years and covers asset performance-related activities and actions that are replicated in each year, although at a reducing intensity. In the case of environmental performance, it might not be possible to make a comprehensive assessment for many years into operation and, as such, these considerations are beyond the scope of this British Standard. There is, however, the extended period of aftercare, which might be sufficient in many cases to assess the asset's environmental performance over the medium term.*

The operator, operations team or asset manager, as appropriate, and end-users should be provided with information by the delivery team to help them obtain the maximum benefit from the new or upgraded asset, whilst making them aware of their duties and obligations with respect to operational HSSE. The technical guide (see **4.7.2.8**) should be provided for this purpose.

*NOTE 1 The attitude of end-users in regard to operational HSSE can be a significant factor in maintaining environmental, social, security and economic performance at the required levels.*

The operator, operations team or asset manager, as appropriate, supported by the delivery team, should verify the initial as-constructed information and note any deviations from the design. Where "BIM Level 2" has been adopted, the as-constructed information should be processed through the status gates of the Common Data Environment (CDE) in the Project Information Model (PIM) to enable review by the operator, operations team or asset manager. Once verified by the operator, operations team or asset manager, the data should be allowed to transition through the "verified gate" to the "published section" for use and, thereafter, to the "archive section" as appropriate.

*NOTE 2 PAS 1192-2 and PAS 1192-3 provide detailed guidance in this regard.*

During the transition from Handover and Close-out to operations, significant volumes of information and data might be transferred from the project information model (PIM) into the asset information mode (AIM), increasing the risk that sensitive design or commercial details could be inappropriately handled or stored. The owner should ensure that appropriate and proportionate measures are adopted to deal with this risk (see PAS 1192-5), e.g. phasing the transfer of information and data would help to minimize this risk and allow more time to verify requirements for the safe, secure, efficient and cost-effective operation of the asset (see **3.4**).

### 4.8.2 Primary activities

#### 4.8.2.1 Operations

The delivery team should prepare for operation of the asset, including the initial and extended periods of aftercare, covering such work activities as:

a) conduct aftercare review meetings and post-implementation review (PIR) workshops as planned (see **4.8.2.3.2** and **4.8.2.3.4**);

b) record user comments related to functionality and effectiveness;

c) maintain records of walkabouts, where appropriate, and informal inspections to detect emerging issues (see **4.8.2.2.5**);

d) optimize the structural monitoring and control systems, where applicable;

e) optimize the engineered systems;

f) record and feed back details of all optimization of systems;

g) update the asset information model (AIM); and

h) update the technical guide, where applicable.

The operator, operations team or asset manager, as appropriate, should prepare for operation of the asset, including the initial and extended periods of aftercare, based on the following activities:

1) record and review early energy use for comparison with predictions;

2) review and record any monitoring of other environmental indicators to detect emerging problems;

3) set up a helpdesk with a physical presence, at least initially; and

4) prepare and circulate newsletters or utilize other media for communicating directly with end-users.

#### 4.8.2.2 Initial aftercare

##### 4.8.2.2.1 General

The delivery team should appoint an aftercare team to represent it on post-handover aftercare duties for the initial period of aftercare to familiarize the operator, operations team or asset manager, as appropriate, and end-users with the operation of the asset and to provide training and technical support where required. The delivery team, or the aftercare team on its behalf, should monitor the performance of the engineered systems with the participation of the commissioning manager (see **3.6.6**) and the operator, operations team or asset manager, as appropriate. Any deviation from the expected performance should be identified, recorded and shared within the respective teams. Consequent troubleshooting and optimization of the engineered systems should be carried out by the delivery team working with the operator, operations team or asset manager, as appropriate, reporting to the sponsor.

##### 4.8.2.2.2 Aftercare team

The aftercare team should include representatives from the delivery team and the specialist contractor(s) responsible for the engineered systems. The aftercare team may, in addition, include the commissioning manager. These named individuals should take specific roles in the initial period of aftercare. A RASCI chart should be prepared by the delivery team for this purpose, with a copy provided to the operator, operations team or asset manager, as appropriate, and the sponsor.

##### 4.8.2.2.3 Support for operations and end-users

The aftercare team should provide technical help and support to the operator, operations team or asset manager, as appropriate, for the full period of initial aftercare. The extent of this help and support should be determined by the sponsor during the Definition work stage (see **4.4**).

The delivery team should organize, in consultation with the sponsor, informal end-user meetings and discussions as soon as possible after the asset has become operational.

##### 4.8.2.2.4 Communications

The delivery team, or the aftercare team on its behalf, should develop a plan for communicating operational issues to the operator, operations team or asset manager, as appropriate, and end-users. The delivery team should allow for technical input into the presentations, newsletters and other communications prepared by the operator, operations team or asset manager, as appropriate, for the benefit of end-users concerning the safe, secure, efficient and cost-effective operation of the asset and to address specific concerns or questions.

##### 4.8.2.2.5 Walkabouts and informal inspections

The sponsor should allow the aftercare team to access the asset and, where practicable, talk and liaise with the end-users or the representative(s) of end-users. The delivery team should ensure that the individuals nominated for this role within the aftercare team have sufficient knowledge of how the engineered systems are intended to function.

#### 4.8.2.2.6 Summary of initial aftercare

*NOTE 1 Attention is drawn to the example approaches to performance evaluation given in Annex B, Annex C and Annex D.*

The delivery team, or the aftercare team acting on its behalf, should:

a) record issues that have arisen and discuss them with the sponsor and the operator, operations team or asset manager, as appropriate, in regard to remedial action;

b) provide input to early performance evaluation, comparing actual values with required outcomes and targets;

c) record comments about how specific elements, systems and products perform, and prepare reports on their performance;

d) identify changes made by the owner or operator that might have caused any impaired performance;

e) maintain records of technical help given to the operator, operations team or the asset manager, as appropriate, and end-users; and

f) report to the sponsor on how the operator, operations team or the asset manager, as appropriate, is delivering the required performance outcomes.

The operator, operations team or asset manager, as appropriate, should:

1) consider any operational costs that might have arisen that were not predicted and maintain records to inform lessons learned;

2) record input to any performance evaluation during this period;

3) maintain records of walkabouts, where applicable, and informal inspections on the part of the delivery team or aftercare team on its behalf (see **4.8.2.2.5**);

4) record informal end-user discussion;

5) maintain records of optimization of the asset's operational performance and any adjustments undertaken; and

6) report to the sponsor on how the delivery team, or the aftercare team on its behalf, is dealing with technical queries relating to the asset.

*NOTE 2 Attention is drawn to BS ISO 15489-1, which provides detailed guidance on the creation, capture and management of records regardless of structure, form or media.*

### 4.8.2.3 Extended aftercare

#### 4.8.2.3.1 General

The delivery team should carry out interviews with the operator, operations team or asset manager, as appropriate, and end-users three months after initial occupation, to:

a) identify issues or concerns regarding the effectiveness of the asset, including the engineered systems and their control interfaces; and

b) undertake adjustments as necessary to improve usability and system performance.

Where applicable, the delivery team should conduct seasonal commissioning and should include for the cost of testing all engineered systems under full-load conditions (e.g. heating equipment in mid-winter and cooling/ventilation equipment in mid-summer) and under part-load conditions in spring and summer. Where applicable, testing should also be carried out during periods of high and low occupancy.

#### 4.8.2.3.2 Reviews

The sponsor should arrange aftercare review meetings during the extended period of aftercare. These should be quarterly for the first year and then annually for two further years. The delivery team should ensure the attendance of representatives of the aftercare team, with the sponsor requesting the attendance of the representatives of the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users, so that any emerging issues can be discussed and the appropriate actions agreed.

The delivery team should provide technical assistance to help the operator, operations team or asset manager, as appropriate, understand and utilize the energy metering system and other monitored systems during the periods of aftercare. The delivery team should work with the operator, operations team or asset manager, as appropriate, to review the overall systems' and energy performance at a frequency defined by the sponsor, and provide written reports on the findings.

#### 4.8.2.3.3 Optimization of systems

The aftercare team should work with the operator, operations team or asset manager, as appropriate, to carry out optimization of engineered systems. The delivery team should record any alterations to systems and equipment, and any changes to standard control settings and operating schedules. Where "BIM Level 2" has been adopted, these alterations should be processed through the status gates of the Common Data Environment (CDE) in the Project Information Model (PIM) to enable review by the operator, operations team or asset manager. Once verified by the operator, operations team or asset manager, the data should be allowed to transition through the "verified gate" to the "published section" for use and, thereafter, to the "archive section" as appropriate.

*NOTE PAS 1192-2 provides detailed guidance in this regard.*

#### 4.8.2.3.4 Post-implementation review (PIR)

*COMMENTARY ON **4.8.2.3.4***

*The post-implementation review (PIR) is intended to determine the degree of success of the project, in particular the extent to which it meets its objectives and achieves the expected benefits and required operational performance. The PIR has a role in determining if improvements can be made to optimize the benefits from, and operational performance of, the asset, in benchmarking performance and in collating the lessons learned from the project to inform future projects, as well as updating the owner's information management system (see Figure 3). In the context of buildings, it is synonymous with post-occupancy evaluation (see BS 8536-1).*

A formal post-implementation review (PIR) of the asset's performance should be undertaken at the end of Years 1, 2 and 3. The review should include an end-user satisfaction survey, an energy-use survey, where applicable, and an assessment of the overall performance of the asset against the agreed outcomes and/or targets and applicable benchmarks.

The sponsor should compare actual performance with the required performance and comment on potential improvements, where applicable, for the end-of-year review for each year of aftercare. Residual risks held in the risk register should be examined to determine the action, if any, to be taken.

When this annual review has been completed, the operator, operations team or the asset manager, as appropriate, should request the attendance of a senior representative of each of the main disciplines within the delivery team at a workshop with the sponsor and the representative(s) of end-users. The annual analysis report should be considered against the owner's business objectives, project objectives, expected benefits, operational requirements and required performance outcomes and/or targets as set out in the Strategy and Brief work stages, subject to any subsequent, agreed modification. The purpose of the workshop should be to consider recommendations on how the operational performance of the asset can be optimized. The workshop should conclude with agreed actions necessary to achieve alignment with the objectives, outcomes and/or targets as closely and as quickly as possible.

*NOTE The* Design quality indicator (DQI) *[4] is an example of a methodology for measuring three quality principles – functionality, build quality and impact – to provide objective evidence of achievement. BREEAM Communities [5] is a scheme for measuring and certifying the sustainability of large-scale development plans. It provides a framework to support planners, local authorities, developers and investors through the master planning process.*

#### 4.8.2.3.5 Summary of extended aftercare

*NOTE Attention is drawn to the example approaches to performance evaluation given in Annex B, Annex C and Annex D.*

At the end of the extended period of aftercare in Year 1, the operator, operations team or the asset manager, as appropriate, should:

a) compare the post-implementation review (PIR) results with expectations;

b) compare actual performance with the required performance and explain good or bad performance;

c) determine if any optimization of operational performance is required to rectify bad performance;

d) compare actual operational cost with the estimated operational cost and explain good or bad performance;

e) compare actual water consumption with targeted consumption and explain good or bad performance, where applicable;

f) compare actual waste reduction with targeted reduction and explain good or bad performance;

g) compare actual performance with required performance for all other identified environmental indicators;

h) request the attendance of a senior representative of each of the main disciplines within the delivery team at a workshop with the sponsor and the representative(s) of end-users; and

i) report to the sponsor on the first year of performance and the actions considered necessary to optimize performance of the asset, response to residual risks, where applicable, and the lessons learned.

At the end of the extended period of aftercare in Years 2 and 3, the operator, operations team or the asset manager, as appropriate, should:

1) continue its performance evaluation;

2) prepare the annual reports on performance with explanation of improvements, risk responses, changes and good or bad performance;

3) prepare reports on the performance of systems, components and products;

4) feed back the findings of performance evaluation to the delivery team and the sponsor;

5) retain data on measured performance to inform the benchmarking of required outcomes and performance targets for future projects;

6) request the attendance of a senior representative of each of the main disciplines within the delivery team at a workshop with the sponsor and the representative(s) of end-users; and

7) report to the sponsor on performance during the year, the actions considered necessary to optimize performance of the asset, the response to residual risks, where applicable, and the lessons learned.

### 4.8.3 Risks

The delivery team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten normal operations and the opportunities that might enhance the performance of the asset. Assessment of residual risks should be undertaken periodically (see **4.8.2.3.5**) and the actions needed in response to residual risks should be discussed with the sponsor.

### 4.8.4 Information requirements

The following information should be considered for the purpose of supporting the work activities (see **4.8.2**) and contributing to the deliverables (see **4.8.7**) in this work stage:

a) for the initial period of aftercare:

   1) functionality and effectiveness of the asset overall;

   2) functionality and effectiveness of the engineered systems;

   3) the owner's security requirements including the security of information and data;

   4) other required inputs to the post-implementation review (PIR);

   5) actual environmental performance compared to required performance for metered use of energy, greenhouse gas emissions, water consumption, waste reduction and other environmental indicators; and

   6) performance of specific systems, components and products;

b) for the extended period of aftercare:

   1) functionality and effectiveness of the asset overall;

   2) functionality and effectiveness of the engineered systems;

   3) the owner's security requirements including the security of information and data;

   4) extent to which stakeholders' needs are satisfied;

   5) other required inputs to the post-implementation review (PIR); and

   6) results of the analysis of actual performance against required performance for all defined environmental indicators.

Each of the information requirements in a) and b) should be obtained through a plain language question, supported by a prompt and, where applicable, an example, to ensure that the requirements are understood by the person or party receiving the request for information (see **3.9.3** and Annex G).

### 4.8.5 Roles and responsibilities

The delivery team should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.8.2**) and their associated deliverables (see **4.8.7**) for this work stage. The RASCI chart should be kept up to date.

The operator, operations team or asset manager, as appropriate, should conduct the measurement, evaluation, benchmarking and advisory reporting related to the environmental, social and security performance at or near the end of Years 1, 2 and 3 after the start-up of operations. Measurement, evaluation, benchmarking and advisory reporting should take place before the end of the defects liability period for the asset to enable corrective or remedial work to be carried out as necessary.

The operator, operations team or asset manager, as appropriate, should record data on energy use, water consumption and waste reduction and disposal on a continual basis so that it can be reported at any time. Similarly, data on operational cost should be recorded on a periodic basis and not less frequently than three months.

### 4.8.6 Information systems and tools

The operator, operations team or asset manager, as appropriate, should confirm that all project information and data for operational purposes have been transferred from the project information model (PIM) to the asset information model (AIM). Where this is not the case, the delivery team should take action immediately to transfer the required information and data.

### 4.8.7 Deliverables

The operator, operations team or asset manager, as appropriate, should provide the sponsor with the following, as a minimum:

a) evidence of the functionality and effectiveness of the asset overall;

b) evidence of the functionality and effectiveness of engineered systems including control interfaces;

c) evidence that the relevant owner's security requirements have been met;

d) details of the post-implementation review (PIR) at the end of Years 1, 2 and 3 to establish feedback to the owner;

e) results from PIR recorded with details of any required corrective action;

f) an annual review of energy use;

g) evidence of a recognized method of calculation being used to provide an estimate of the expected greenhouse gas emissions for the coming year;

h) records of any optimization or behavioural changes introduced to improve operational performance;

i) details of any operational changes, where applicable;

j) evidence that a comparison of actual and predicted operational costs is being maintained;

k) records of any procedural changes made to improve operational cost whilst still delivering the required service levels;

l) records of metered consumption of water, where applicable;

m) records of measured waste reduction and disposal, where applicable;

n) records of measurement of other defined environmental indicators, where applicable;

o) details of actual operational cost;

p) updated risk register;

q) documented experiences and lessons learned; and

r) evidence that the findings from the first year of measurement of performance have been coordinated with the sign-off of the first year of the defects liability period.

*NOTE Documenting experiences and lessons learned, together with feedback on performance, prevents valuable know-how disappearing when personnel leave the owner's or operator's organization. Attention is drawn to BS ISO 15489-1, which provides detailed guidance on the creation, capture and management of records regardless of structure, form or media.*

### 4.8.8 Key decisions and next steps

*NOTE 1 This work stage provides the opportunity for the owner, operator, licensee, operations team or asset manager, as appropriate, and the delivery team to consolidate valuable information and data about the performance of the asset.*

Adjustments to the operational parameters of the asset and any subsequent changes to the design should be recorded. Where "BIM Level 2" has been adopted, alterations and changes should be processed through the status gates of the Common Data Environment (CDE) in the Project Information Model (PIM) to enable review by the operator, operations team or asset manager. Once verified by the operator, operations team or asset manager, the data should be allowed to transition through the "verified gate" to the "published section" for use and, thereafter, to the "archive section" as appropriate.

*NOTE 2 PAS 1192-2 provides detailed guidance in this regard.*

*NOTE 3 A question that can be considered here is: "Does the asset measure up to requirements in terms of its environmental, social, security and economic performance?" The answer to this question determines the owner's next steps in asset management and any subsequent adjustments or alterations to the asset.*

*NOTE 4 Annex J offers an activity checklist to assist in briefing for design and construction and, in particular, reviews of progress in all work stages.*

Annex A (informative)

# Brief checklist (example)

**A.1** The following example checklist represents typical considerations as part of an initial brief for a highway scheme comprising roads, footpaths, cycleways and other features on a large commercial development. These considerations are not comprehensive and might not be appropriate for every situation:

a) site characteristics and features;

b) access, site gradients and crossfalls;

c) highway characteristics in the area;

d) connections with existing highways;

e) vehicle crossings;

f) maintenance and service margins;

g) pending highway schemes;

h) relationship with off-highway facilities and works;

i) public rights of way and diversions;

j) footpaths and cycle paths;

k) verges and landscaping;

l) pedestrian crossings;

m) extent of public transport and provisions;

n) speed limits and speed restriction zones;

o) traffic calming measures;

p) building lines;

q) parking;

r) access visibility;

s) street lighting;

t) signs and road markings;

u) traffic signals;

v) public utilities;

w) highway drainage;

x) salt bins;

y) adoption of public open space; and

z) advance payment code.

**A.2** The following checklist represents typical considerations for the design of the highway scheme outlined in **A.1** and adapted from [11]. These considerations are not comprehensive and might not be appropriate for every situation:

a) Carriageways:

   1) in plan – width, alignment, crossfall/camber, junction layout, radius and visibility, forward visibility, speed restrictions (spacing) and gullies; and

   2) in section – vertical alignment, construction, kerb detail, ramp detail and speed restriction detail.

b) Footways:

1) in plan – width, alignment, crossfall/camber, junction layout, radius and visibility, forward visibility, speed restrictions (spacing) and gullies; and

2) in section – gradient, crossfall, construction, edging, vehicle crossing construction and pedestrian barrier detail.

c) Maintenance and service margins:

1) in plan – width, pedestrian crossings, vehicle crossings, service routes and boundaries; and

2) in section – gradient, crossfall, construction, edging, vehicle crossing construction and pedestrian barrier detail.

d) Drainage:

1) in plan – surface water outfall, route and manholes, gully connections, foul water route and manholes, outfall consent; and

2) in section – surface water outfall, pipework and manholes, foul water manholes, trench bedding and backfill, and depth of cover.

e) Boundaries:

1) in plan – retaining walls, boundary fences/walls, embankments, cuttings and overhang; and

2) in section – embankment slopes, cutting slopes, retaining walls, and wall and fence details.

f) Footpaths:

1) in plan – width, alignment, route, vehicle crossings, barriers, bollards, maintenance/service routes and gullies; and

2) in section – gradient, crossfall, construction, edging, vehicle crossing construction, barrier and bollard details, embankment slope, cutting slope and retaining wall(s).

g) Off-highway facilities

1) in plan – parking spaces and garaging (number and proximity), alignment, garage set-back, drainage, vehicle turning area, pedestrian and vehicle access visibility; and

2) in section – access road construction, parking space gradient and construction, and drainage details.

*NOTE There is an important distinction between a footway and a footpath. The former is a right of way for pedestrians within the boundaries of a public highway, usually adjacent to a carriageway, and the latter is a separate right of way provided exclusively for pedestrians, being part of a public highway that does not include a carriageway.*

# Annex B (informative) Environmental performance evaluation (example)

## B.1 General

This annex gives an example of an approach to be adopted and typical measures to be taken by an owner. It is expected that they would need to be adapted to suit the characteristics and requirements of a specific project.

## B.2 Annual energy use and emissions

This evaluation might typically include energy measurement, calculation of greenhouse gas emissions and an advisory report to suggest ways of improving energy performance and reducing greenhouse gas emissions. It might therefore cover:

a) assessment of annual energy use with regard to all individual energy sources;

b) analysis of half-hourly energy demand profiles;

c) assessment of the asset's contribution to greenhouse gas emissions;

d) cross-references to the post-implementation review (PIR) in regard to environmental performance;

e) investigation of issues arising (especially where there is unusually good, poor or variable performance);

f) spot checks and recording measurements as necessary;

g) technical review of structures, systems, components and products performance;

h) review of the performance and usability of controls and metering;

i) safety, security, reliability, resilience, serviceability and maintainability of energy-using systems and components;

j) structured reviews with the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users;

k) review of how the owner's leadership, strategic asset management plan (SAMP) and user behaviour impact upon energy use;

l) suggestions for improvement; and

m) comparison with the results from other assets (from within a portfolio, programme or from a wider benchmark database).

## B.3 Annual water consumption

This evaluation might typically include measurement of water consumption and an advisory report to suggest ways of reducing water consumption. It might therefore cover:

a) assessment of annual water use;

b) assessment of annual water abstraction by source;

c) analysis of water demand profiles;

d) analysis of water quality, in particular pollutants in surface water discharges;

e) cross-references to the post-implementation review (PIR) in regard to environmental performance;

f) investigation of issues arising (especially where there is unusually good, poor or variable performance);

g) spot checks and recording measurements as necessary;

h) technical review of engineered systems' and standalone equipment performance;

i) review of the performance and usability of controls and metering;

j) safety, security, reliability, resilience, serviceability and maintainability of water systems;

k) review of water-saving equipment;

l) structured reviews with the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users;

m) review of how the owner's leadership, strategic asset management plan (SAMP) and user behaviour impact upon water use;

n) suggestions for improvement; and

o) comparison with results from other assets (from within a portfolio, programme or from a wider benchmark database).

### B.4 Annual waste reduction and disposal

This evaluation might typically include measurement of waste and an advisory report to suggest ways of reducing waste. It might therefore cover:

a) assessment of annual solid and fluid waste disposed (to include effluent discharged to drains, where applicable);

b) analysis of pollutants discharged to drains, where applicable;

c) analysis of waste disposal profiles;

d) cross-references to the post-implementation review (PIR) in regard to environmental and engineered system performance;

e) investigation of issues arising (especially where there is unusually good, poor or variable performance);

f) spot checks and recording measurements as necessary;

g) structured reviews with the operator, operations team or asset manager, as appropriate, and the representative(s) of end-users;

h) review of how the owner's leadership, strategic asset management plan (SAMP) and user behaviour impact upon waste reduction and disposal;

i) suggestions for improvement; and

j) comparison with results from other assets (from within a portfolio, programme or from a wider benchmark database).

## Annex C (informative) Social performance evaluation (example)

This annex gives an example of an approach to be adopted and typical measures to be taken by an owner. It is expected that they would need to be adapted to suit the characteristics and requirements of a specific project. A scoring system could be used to ascribe a numerical value to a qualitative assessment of aspects of performance over the period under review, for example:

a) availability – the proportion of time the asset was in a functioning state compared with the interval over which the asset was expected to function;

b) utilization – the extent to which the asset provided or directly supported the operations and the end-users for which it was designed;

c) capability – the ability of the asset to achieve its objectives in relation to the expected benefits;

d) capacity – the measure of the asset's ability to provide the full extent of expected benefits;

e) access – the ease with which end-users gain access to the asset, including the use of amenities and other supporting facilities, where applicable;

f) inclusiveness – the extent to which the asset supports the needs of disabled persons and others with equalities-related needs;

g) space – the size, layout and inter-relationship of constituent spaces contributing to the efficient use of the asset, where applicable;

h) safety – the number of reported incidents, including injury to persons;

i) security – the number of breaches, near misses or other trigger-related events;

j) reliability – the ability of the asset to perform correctly and consistently in accordance with its operational specifications;

k) resilience – the capacity to recover quickly from an event impacting negatively on the asset;

l) serviceability/maintainability – the ease and speed with which the asset or a component of it can be maintained or repaired;

m) adaptability – the extent to which the asset allows for the functions it accommodates now and into the future;

n) measurability – the ease of metering and other measurement of energy, greenhouse gas emissions, water consumption and waste reduction;

o) form and aesthetics of materials – the physical composition, scale and configuration of the asset within its boundaries;

p) durability – the ability to resist deterioration over time under normal use;

q) quality – the inherent quality of the asset, its components and sub-systems;

r) comfort – the measure of the end-users' assessment of the level of comfort afforded by the asset, where applicable;

s) construction – the functionality and durability of materials and the standard of construction;

t) urban and social integration – the integration and coherence of the asset with the surroundings;

u) character and innovation – the expression of end-users' appreciation of the asset and what it means to them;

v) operational management – the degree to which end-users are satisfied with the asset's management and how it impacts on the performance of the asset in meeting their needs; and

w) strategic management – what end-users think of the owner's business strategy and how it impacts upon performance of the asset in meeting end-users' needs.

# Annex D (informative) Economic (cost) performance evaluation (example)

## D.1 General

This annex gives an example of an approach to be adopted and typical measures to be taken by an owner, which might need to be adapted to suit the characteristics and requirements of a specific project.

*NOTE The purpose of economic performance measurement is to enable effective post-implementation review, including benchmarking and lessons learned.*

## D.2 Capital cost

A number of approaches are possible for measuring and comparing capital cost performance. The following are example benchmarks that could be used.

a) *Type 1 – Global measures*: these metrics are used by owners and cost consultants to benchmark total construction cost, for example: £/km, £/km$^2$, £/m$^3$, £MW and £/tonne. They are related to key parameters such as kilometres of carriageway and track or megawatts of power delivered by the project.

b) *Type 2 – Functional measures*: these align with functions and business outcomes, for example: £/passenger km and £/MW or £/tonne of production output.

c) *Type 3 – Ratios*: these are used to benchmark costs that are related to the total capital cost, for example, design fees or project management as a ratio (or percentage) of total construction cost. They can help in understanding efficiency in the project delivery process.

d) *Type 4 – Elemental measures*: these are similar to Type 1 benchmarks and are applied at the elemental (quantity) level, for example, foundation costs £/m (e.g. piles), £/m$^2$ (e.g. floor slabs) or £/m$^3$ (e.g. ballast). They are meaningful only when there is a clear relationship between the element and the spatial measure.

*NOTE Many infrastructure costs are estimated with the support of cost models developed by owners and specialist consultants with extensive experience of the assets concerned. For example, railway costs are estimated from cost models developed by the owner (i.e. rail authority) or specialist consultants for asset systems (i.e. network infrastructure and trains) on the one hand and separate cost estimates for the infrastructure on the other hand. Locomotive and rolling stock cost models are also developed by the manufacturers.*

## D.3 Operational cost

### D.3.1 General

Methods are available for measuring and comparing operational cost performance of various infrastructure. Many are specific to the infrastructure in question, for example railways and telecommunications. This subclause provides an example for railways.

### D.3.2 Example cost centres for network infrastructure

Example cost centres include operation and maintenance of:

a) track;

b) structures (e.g. bridges and tunnels);

c) roadways;

d) signalling and communication;

e) power supply for electrified sections;

f) intermodal equipment;

g) passenger stations and terminals;

h) fuel stations; and

i) train yards and stores.

### D.3.3 Example cost centres for train operations

Example cost centres include:

a) electricity and diesel fuel;

b) locomotive capital depreciation or leasing cost;

c) locomotive maintenance;

d) driving crew;

e) on-board crew for passenger trains;

f) rolling stock wagons depreciation or leasing cost;

g) rolling stock maintenance;

h) terminal operations; and

i) commercial costs (i.e. passenger ticketing and freight booking).

### D.3.4 Example cost centres for management

Example cost centres for management include:

a) managerial, technical, financial, legal, security and other personnel functions;

b) timetable information and helpdesks (online and physical); and

c) outsourced services and supply-only contracts.

## Annex E (informative) Responsibility assignment matrices (examples)

An example of a RASCI chart is given in Table E.1 and an example of a detailed responsibility matrix incorporating information exchanges is given in Table E.2.

Table E.1 **Typical tasks and allocated roles (extract)**[A)]

| Task | CEO | COO | CFO | CIO | AM |
|---|---|---|---|---|---|
| Prepare information management strategy | Consult | Accountable | Support | Responsible | Support |
| Manage asset-related contract information | Accountable | Consult | Consult | Support | Responsible |
| Prepare operational procedures | Inform | Accountable | Inform | Consult | Responsible |
| Maintain records of asset performance | Inform | Accountable | Consult | Support | Responsible |
| Maintain asset register | Inform | Accountable | Consult | Support | Responsible |

[A)] SOURCE: BS 8587:2012, Annex A, modified.

*NOTE CEO = Chief Executive Officer; COO = Chief Operating Officer; CFO = Chief Finance Officer; CIO = Chief Information Officer; AM = Asset Manager.*

Table E.2 **Typical detailed responsibility matrix incorporating information exchanges (extract)**

| Aspect of design | | Work stage 2: Concept Design team | | |
|---|---|---|---|---|
| **Uniclass2015 code** | **Title** | **Design responsibility** | **Level of model detail** | **Level of model information** |
| Ss-15-10-28-85 | Steel sheet pile embedded retaining wall system | Drivedeal | 2 | 2 |
| Ss-20-05-65-41 | In situ concrete bored piling system | Drivedeal | 2 | 2 |
| Ss-20-05-15-71 | Reinforced concrete pilecap and ground beam foundation system | Drivedeal | 2 | 2 |
| Ss-20-10-75-35 | Heavy steel framing system | Frambold | 3 | 3 |
| Ss-30-12-85-16 | Composite steel and concrete floor | Frambold | 2 | 2 |

*NOTE 1 The level of model detail and level of model information are expected to be predefined for each work stage and in this example are set as the default value (i.e. level 2), except for one element. The heavy steel framing system is a long-lead item and requires more detail and information in order to procure it; hence, it is shown as level 3.*

*NOTE 2 The BIM Toolkit [6] provides a source of default level of model detail and level of model information and a means for producing a digital Plan of Work (dPoW). Level of model detail ranges from 1 (i.e. visual representation of proposals at the Concept work stage, including general spatial coordination) to 5 (i.e. dimensionally accurate information to reflect the final design, primary performance characteristics and installation details). Level of model information likewise ranges from 1 (i.e. a description of the type of object to detail any design intent) to 5 (i.e. information relevant to the specific child products of the deliverable to allow for purchasing). Uniclass2015 is a unified classification for the UK industry covering all construction sectors. It contains consistent tables classifying items from an asset such as a railway down to products such as fixed seating in a railway station. In the table, Ss refers to a system.*

**Annex F (informative)**

# Risk (threat and opportunity) assessment (examples)

Table F.1 records the threats (downside risks) and opportunities (upside risks) identified for a new offshore wind farm. Opportunities can be handled outside the risk register, but monitored in the table as shown. Each item is held in the risk register, where closer scrutiny and further evaluation is recorded. Scores can be assigned (high = 3, medium = 2 and low = 1) to each item for both impact and probability. Summation of impact and probability for each item allows them to be ranked, enabling attention to be directed towards those having the greatest potential impact and probability of occurrence.

Table F.1 **Threats and opportunities**

| Identified threat/opportunity | Threat (-) | | Opportunity (+) | |
|---|---|---|---|---|
| | Impact | Probability | Impact | Probability |
| **Technical** | | | | |
| New, unproven generators | H | L | | |
| Requirement for fewer turbines | | | H | M |
| Insufficient power generation capacity | H | L | | |
| Design life of gearboxes shorter than expected | M | M | | |
| **Environmental** | | | | |
| Seabed conditions worse than expected | M | M | | |
| Prolonged adverse winter weather | H | M | | |
| Objection to visual impact from environmental groups | M | L | | |
| Adverse impact on marine ecology and objection from environmentalists | M | L | | |
| Adverse impact on migratory birds and objection from environmentalists | M | L | | |
| Collision from maritime traffic | M | L | | |
| **Socio-political** | | | | |
| Increased local employment during project execution | | | M | H |
| Shortages of skilled labour during project execution | H | M | | |
| Demand for local (temporary) housing for construction workers | M | H | | |
| Demand on local businesses | | | M | M |
| **Commercial** | | | | |
| Cost of imported materials exceeding budgets | H | M | | |
| Need for additional port facilities [A)] | H | M | | |
| Change in energy tariffs | H | M | | |
| Unexpected rise in tender prices | M | M | | |
| Difficulty attracting competitive tenders | M | M | | |

[A)] Transportation to and from the wind farm might necessitate an expansion of existing port facilities to cope with increases in the transhipment of components.

*NOTE H = High, M = Medium, L = Low.*

# Annex G (informative) Plain language questions (examples)

## G.1 General

This annex gives examples of questions that might be asked by the owner of the delivery team and are based on plain language questions adapted from the Building Information Modelling (BIM) Task Group [6] for the purpose of this British Standard. These examples are illustrative of the approach and are likely to vary from project to project.

## G.2 Strategy

**Question 1:** What is the proposed information management strategy?

**Prompt:** BIM strategy and standards to be used across the portfolio.

**Question 2:** What does the master plan require to be developed?

**Prompt:** Master plan development sequence for the portfolio, programme and project.

**Question 3:** What are the characteristics of the site for the current phase of development?

**Prompt:** Laser and/or radar survey generated solid model and CDF grid, including ground conditions and existing structure.

**Question 4:** What are the technical strategies of the portfolios for which this project forms a part?

**Prompt:** Master plan model information and representations relating to the strategies, e.g. distribution network for electricity, water, gas, fuel and waste water.

**Question 5:** What performance benchmarks are available?

**Prompt:** Analyses of existing assets and facilities using a standard coding system, e.g. Uniclass2015.

**Question 6:** What are the performance objectives of the portfolio for which this project forms a part?

**Prompt:** Relevant extracts of information from the strategy.

**Question 7:** Has a design standardization policy been defined?

**Prompt:** Library of standard design elements defined in terms of BIM objects.

**Question 8:** Have stakeholders' high-level needs been captured?

**Prompt:** List of key deliverables and requirements, where needed, supported by measures. These might be captured in a model or a system for managing requirements.

**Question 9:** What is the initial view of capital cost?

**Prompt:** Type 1 or 2 capital cost measures and comparators.

**Question 10:** What is the initial view of revenue income or benefits, as appropriate?

**Prompt:** Economic measures and benefit-cost ratios as appropriate.

**Question 11:** How will security requirements be met?

**Prompt:** Physical boundaries and evidence of how information and data security arrangements defined in the EIR will be met.

*NOTE A list of security-related PLQs are available on the CPNI website: http://www.cpni.gov.uk/advice/Cross-cutting-advice/Digital-built-assets-and-environments/ [viewed 2016-10-05].*

**Question 12:** Have lessons been learned from previous projects?

**Prompt:** Identify lessons learned from similar, completed projects.

**Question 13**: Have requirements for the delivery of asset information and data been identified?

**Prompt**: Asset register for other projects in the portfolio.

## G.3 Brief

**Question 1**: Have the purposes for which the model will be used been defined?

**Prompt**: Purposes documented to inform designers as to their inputs.

**Question 2**: How are stakeholder needs captured?

**Prompt**: A digital initial brief in a format that can be used for automated validation of proposals.

**Question 3**: How will BIM be managed and exploited in this project?

**Prompt**: An information exchange plan with levels of model detail and levels of model information for each work stage.

**Question 4**: What is the available site?

**Prompt**: Updated laser and/or radar survey generated solid model and CDF grid, including ground conditions and existing structure.

**Question 5**: What physical constraints are there on and around the site?

**Prompt**: Details of existing structures to be retained and other infrastructure.

**Question 6**: What public utilities' constraints exist?

**Prompt**: Existence and current utilization parameters available for inclusion in the model.

**Question 7**: Will the development meet availability and capacity requirements?

**Prompt**: Evidence that the proposals would be sufficient.

**Question 8**: What information and data do the operator, operations team or asset manager, as appropriate, need to manage the asset?

**Prompt:** Strategic asset management plan (SAMP) and asset register.

## G.4 Concept

**Question 1**: What is the concept design?

**Prompt:** Rendered block diagram in site context, including significant equipment layout to the level of model detail and level of model information defined in PAS 1192-2 and supporting documents.

**Question 2**: Does the design's performance meet the portfolio's requirements?

**Prompt:** Early stage simulations, calculations and costs.

**Question 3**: What is the outline proposal for structural design?

**Prompt:** Structural design sufficient for simulation modelling.

**Question 4**: If the project represents an addition or upgraded asset, how is it to be integrated and coordinated with existing assets?

**Prompt:** Survey of existing assets and their interfaces.

**Question 5**: Can the owner's BREEAM or LEED objectives be met?

**Prompt:** Evidence of a compliant design.

**Question 6**: What targets are to be used for the post-implementation review (PIR)?

**Prompt:** Data from model to be referenced with the required outcomes and/or targets relating to environmental, social, security and economic indicators.

**Question 7**: Has the aftercare process been outlined?

**Prompt:** Planned interventions, including maintenance intervals.

**Question 8**: Has a method for measuring energy in use and calculating greenhouse gas emissions been incorporated into the design?

**Prompt:** Model derived schedule of metering facilities.

**Question 9**: How will any owner-specific performance needs be met?

**Prompt:** Model based simulations as appropriate.

**Question 10**: Has a commissioning strategy been integrated into the design?

**Prompt:** Optimized asset commissioning logic.

**Question 11**: Can the designers show that the project can be delivered safely?

**Prompt:** Construction logic demonstrated, highlighting how high-risk elements have been avoided or controlled.

*NOTE The BIM Toolkit [6] provides default plain language questions and a tool to enable authoring of project-specific Plain Language Questions.*

**Annex H (informative)**

# Stakeholder identification

A new offshore wind farm of 80 turbines off the east coast is planned, for which a licence is expected to be granted to an energy company. The numbers in parenthesis in the following list of stakeholders relate to the matrix in Figure I.1.

Internal stakeholders:

- board of directors (1);
- senior executives (2);
- business development department (3);
- finance department (4);
- project steering group (5);
- engineering department (6);
- project manager (7);
- project management office (project services) (8); and
- auditor (9).

External stakeholders:

- Department for Business, Energy and Industrial Strategy (10);
- Department for Environment, Food and Rural Affairs (11);
- National Grid plc (12);
- local port authority (13);
- local planning authority (14);
- local land owners (15);
- EPC contractor (16);
- major vendors (17);
- operator (18);
- neighbouring operators (19);
- local fishermen and other maritime operators (20); and
- environmental groups (21).

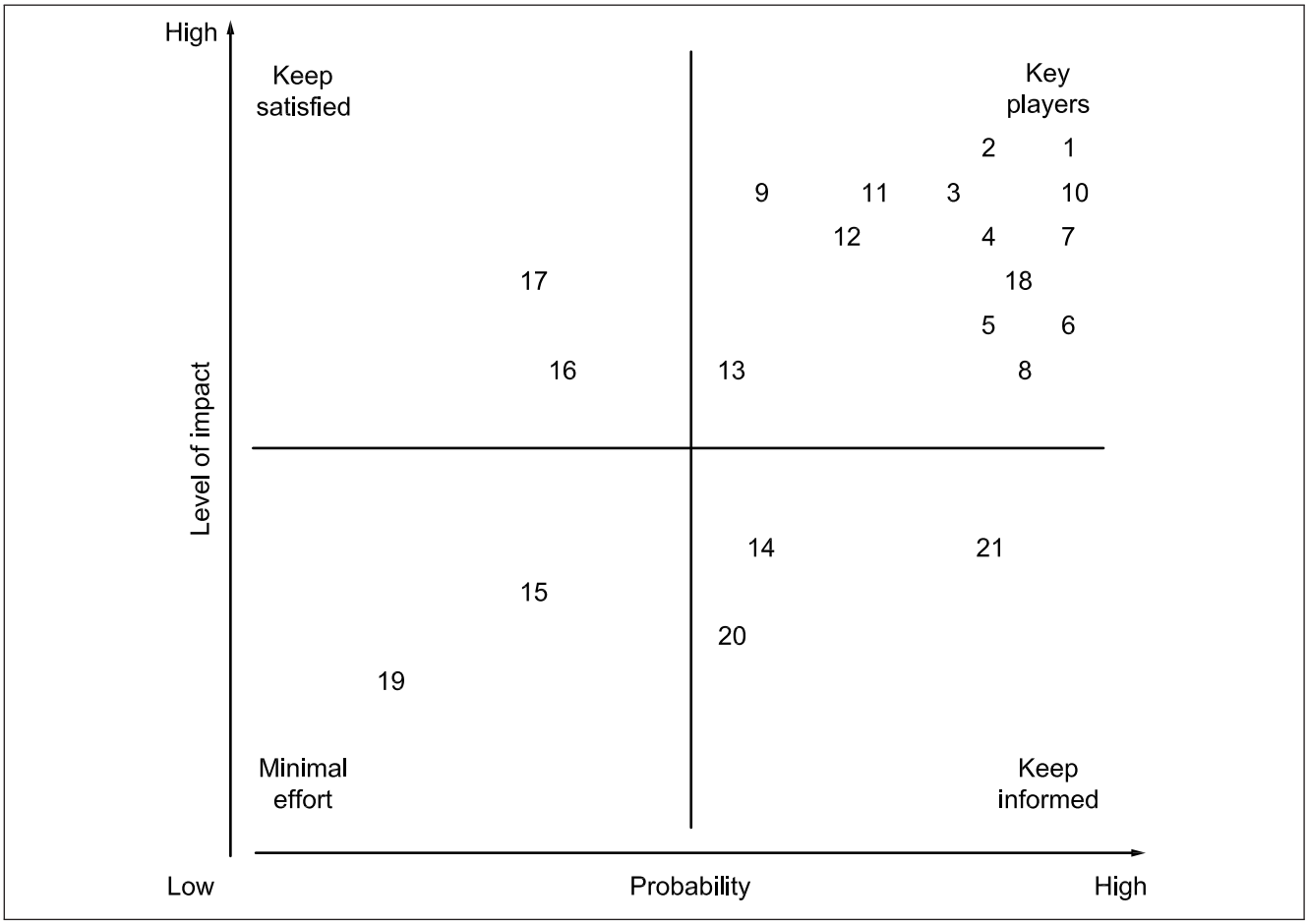
*NOTE No ranking of importance or other means of differentiating stakeholders (than dividing into internal or external) is implied by these lists. Preliminary assessment of stakeholder impact is covered in Annex I.*

Annex I (informative)

# Stakeholder impact analysis

Stakeholders' interests in the asset may be assessed in a number of ways, including the use of an impact/probability matrix (see Figure I.1). Individual stakeholders and groups of stakeholders are positioned in the matrix according to the level and probability of impact they have on the design and construction of the asset and its subsequent operations. It is a form of risk assessment. Since stakeholders and their interests could change over time reassessment is necessary. The overall aim of the matrix is to focus attention on the nature and degree of stakeholder engagement and communication, as indicated by the terms applied to the four quadrants, and actions that might then be necessary. The matrix is not intended to provide a complete solution to the assessment of stakeholders.

Figure I.1 **Stakeholder impact/probability matrix**




Annex J (informative)

# Activity checklist

The checklist given in Table J.1 is intended to assist in briefing for design and construction and, in particular, reviews of progress through design, construction and into operation. It does not purport to provide a complete or comprehensive summary of activities, but suggests an approach.

Table J.1 **Summary of main activities by focus area and work stage** *(1 of 5)*

| Focus area | Work stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0<br>Strategy | 1<br>Brief | 2<br>Concept | 3<br>Definition | 4<br>Design | 5<br>Construct and Commission | 6<br>Handover and Close-out | 7<br>Operation and End of life |
| **Environment**<br>Meeting the targets for energy use, greenhouse gas emissions, water consumption, waste disposal and other environmental indicators. | Determine the targets for energy use, greenhouse gas emissions, water consumption, waste reduction and other environmental indicators. | Determine the environmental performance outcomes for the asset. Prepare an environmental management plan. | Devise a plan for recording energy and other environmental performance, and the comparison of actual performance against required performance. | Identify any additional operational requirements necessary for achieving the required energy performance. | Undertake model-based design performance simulations that take account of the accuracy of prediction achieved in the past from similar simulations. | Review all installation details and correct any that will impact negatively upon the actual performance relative to the required performance. | Finalize the plan for environmental and energy metering. Prepare a plan to identify the responsibilities and extent of energy metering reviews. | Record and review early energy use for comparison with predictions. Review and record monitoring of environmental conditions to detect any emerging problems. |

Table J.1 **Summary of main activities by focus area and work stage** *(2 of 5)*

| Focus area | Work stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0<br>Strategy | 1<br>Brief | 2<br>Concept | 3<br>Definition | 4<br>Design | 5<br>Construct and Commission | 6<br>Handover and Close-out | 7<br>Operation and End of life |
| **Social (i.e. functionality and effectiveness)**<br>Meeting the needs of the owner, operator and end-users in regard to asset availability, utilization, access, inclusiveness, safety, serviceability/ maintainability and comfort, among others.<br>**Security**<br>Meeting the needs of the owner, operator and end-users from the development of an appropriate and proportionate security-minded approach. | Identify the business-related activities and processes to be provided by the new or upgraded asset. Assemble lessons learned from previous projects, including feedback based on documented case studies and other reliable sources. Identify the range of potential security issues that are applicable to the owner's business, processes, service provision, assets and personnel. | Prepare a statement on the general design philosophy and how it will address the project objectives, operational requirements and performance outcomes and/or targets. Prepare a draft strategy for determining the performance evaluation of functionality and effectiveness, considering features such as availability, utilization, access, inclusiveness, safety, security capability, capacity, serviceability/ maintainability, adaptability, quality and comfort, among others. | Prepare high-level simulation models to examine the alignment of the proposed design with the required operational performance outcomes and/or targets. Review design predictions against the required operational performance. Prepare an analysis of the fit between the concept design and operational requirements. | Explore the design proposals by means of an information model or other method for explaining the asset to the owner and other stakeholders. Report on the extent to which any operational constraints have been advised. Determine if the design will deliver an asset that is safe to access, maintain and use. | Undertake model-based design performance simulations. Identify any changed operational requirements essential for meeting the desired energy performance target. Prepare method statements covering operation and maintenance. Prepare aftercare plans. | Review all installation details and correct any that will impact negatively upon the actual performance relative to the required performance. Highlight any unavoidable changes in design that might give rise to a change in the required performance. Collate information on the general design, structural design, and engineered systems needed to obtain statutory approvals. | Identify where any operational details and performance targets have been adjusted to reflect commissioning results. Determine how non-technical users will know how to operate the asset safely, securely and efficiently, where applicable. | Conduct aftercare review meetings and workshops as planned. Record end-user comments related to functionality and effectiveness. Maintain records of walkabouts, where applicable, to identify emerging issues. Update the technical guide, as appropriate. |



Table J.1 **Summary of main activities by focus area and work stage** *(3 of 5)*

| Focus area | Work stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0<br>Strategy | 1<br>Brief | 2<br>Concept | 3<br>Definition | 4<br>Design | 5<br>Construct and Commission | 6<br>Handover and Close-out | 7<br>Operation and End of life |
| **Economic**<br>Meeting the targets for capital and operational expenditure and reflecting whole-life cost assessment. | Establish an initial view of capital expenditure and operational expenditure, or total expenditure, covering operations, maintenance, capital replacement costs and costs relating to energy use, water consumption and waste disposal. | Prepare an estimate of capital cost and a methodology for whole-life cost assessment. Prepare an estimate of operational cost, including a simple model of energy performance, maintenance and capital replacement costs. | Update the estimates of capital cost and operational cost and determine if they are within the agreed expenditure limits.<br>Update the assessment of whole-life costs. | Update the estimates of capital cost and operational cost. | Update the estimates of capital cost and operational cost. | Prepare forecasts of the outturn capital cost and operational cost. | Update the forecast of outturn capital cost. Prepare a detailed cost analysis of the outturn capital cost. Update the estimate of operational cost. | Consider any operational costs that might have arisen that were not predicted and maintain records to inform lessons learned. |

Table J.1 **Summary of main activities by focus area and work stage** *(4 of 5)*

| Focus area | Work stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0<br>Strategy | 1<br>Brief | 2<br>Concept | 3<br>Definition | 4<br>Design | 5<br>Construct and Commission | 6<br>Handover and Close-out | 7<br>Operation and End of life |
| **Commissioning, Training and Handover**<br>Ensuring that the project is delivered and the asset is handed over and supported to meet the needs of the operator and end-users. | Appoint sponsor to oversee the soft landings process.<br>Determine the requirements and arrangements for the delivery of project information and asset information. | Determine how project information will be transferred to the asset information model (AIM) and owner's defined enterprise system. | Outline commissioning needs, including those for engineered systems. Prepare a plan for commissioning, training and handover. Determine the operational resources needed to support commissioning, training and handover. | Update the plan for commissioning, training and handover. Identify the commissioning needs for each system and the related standards and methods. Update the handover plan, as necessary. | Update the plan for commission-ing, training and handover. Prepare a construction and system testing schedule and a commissioning and performance testing schedule. Confirm the arrangements for the transfer of asset information to the asset information model (AIM). | Update the commissioning specification. Update the commissioning and training plan in liaison with the commissioning manager. Prepare a schedule of pre-commissioning activities. Identify any skills that end-users need to have before attending commissioning demonstrations. | Verify the commissioning information provided by the suppliers. Prepare a schedule for coordinating on-site activities and witnessing of balancing, regulating and performance testing, where applicable. Record all equipment and system settings and outputs from commissioning. Update the asset information mode (AIM). | Maintain records of walkabouts, where applicable, to identify emerging issues. Optimize the engineered systems. Record and feedback all optimization performance. Update the technical guide. |

Table J.1 **Summary of main activities by focus area and work stage** *(5 of 5)*

| Focus area | Work stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0<br>Strategy | 1<br>Brief | 2<br>Concept | 3<br>Definition | 4<br>Design | 5<br>Construct and Commission | 6<br>Handover and Close-out | 7<br>Operation and End of life |
| **Asset Management**<br>Providing an efficient and cost-effective strategy, policy and plans for operating the asset. | Identify the performance benchmarks for this type of asset by establishing targets and the processes for subsequently measuring performance. Identify any existing strategic asset management plan (SAMP) and supporting policy or procedures and, where none exists, prepare the SAMP in outline. Identify the approach to be taken to post-implementation review (PIR). | Prepare an estimate of operational cost, including a simple model of energy performance, maintenance and capital replacement costs. Update or confirm the strategic asset management plan (SAMP) and policy covering the Operation and End of life work stage. Prepare a draft plan for measuring operational performance during the Operation and End of life work stage. | Prepare an operational model, operational management plan and operational expenditure budget. Outline the initial aftercare and extended periods of aftercare, including annual reviews as a basis for optimizing operational performance. Prepare a plan for the removal and replacement of equipment, fabric and debris, where applicable. | Participate in reviews of the design proposals and comment on whether or not the design is capable of meeting the required environmental, social, security and economic performance.<br>Provide an updated operational model, operational management plan and operational expenditure budget. Identify the parties needed to witness demonstra-tions. | Provide a scope of work and specification for the procurement of appropriate maintenance services, where required. Provide details of any specific maintenance plan. Advise on the need to recruit personnel for the operations team, where applicable. Advise on the need for procurement of other services, where applicable. | Determine whether or not the engineered systems and other major components and systems can be maintained safely in compliance with relevant legislation. Provide an operational risk assessment. Comment on the construction and system testing schedule and the commissioning and performance testing schedule from the perspective of witnessing demonstrations. | Provide updated operational information to the delivery team. Review and comment on all operation and maintenance information. Review and comment on all commissioning and handover-related information.<br>Prepare or update a schedule of assets to be maintained and a cost breakdown for accounting and taxation purposes. | Compare the post-implementation review (PIR) results with expectations. Compare actual performance with the required performance and explain good or bad performance. Compare actual operational cost with estimated operational cost, actual water consumption with predicted consumption and actual waste reduction with predicted reduction, then explain good or bad performance. |

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**Further reading**

BS 7000-6, *Design management systems – Part 6: Managing inclusive design – Guide*

BS 8300, *Design of buildings and their approaches to meet the needs of disabled people – Code of practice*

BS 8544, *Guide for life cycle costing of maintenance during the in use phases of buildings*

BS 8587, *Guide to facility information management*

BS EN 15221-1, *Facility management – Part 1: Terms and definitions*

BS EN 15221-2, *Facility management – Part 2: Guidance on how to prepare facility management agreements*

BS EN 15221-3, *Facility management – Part 3: Guidance on quality in facility management*

BS EN 15221-4, *Facility management – Part 4: Taxonomy, classification and structures in facility management*

BS EN 15221-6, *Facility management – Part 6: Area and space measurement in facility management*

BS EN 15221-7, *Facility management – Part 7: Guidelines for performance benchmarking*

BS EN 15265, *Energy performance of buildings – Calculation of energy needs for space heating and cooling using dynamic methods – General criteria and validation procedures*

BS EN 15331, *Criteria for design, management and control of maintenance services for buildings*

BS EN 15643-2, *Sustainability of construction works – Assessment of buildings – Part 2: Framework for the assessment of environmental performance*

BS EN 15643-3, *Sustainability of construction works – Assessment of buildings – Part 3: Framework for the assessment of social performance*

BS EN 15643-4, *Sustainability of construction works – Assessment of buildings – Part 4: Framework for the assessment of economic performance*

BS EN ISO 9001, *Quality management systems – Requirements*

BS EN ISO 14001, *Environmental management systems – Requirements with guidance for use*

BS ISO 11620, *Information and documentation – Library performance indicators*

BS ISO 15686-1, *Buildings and constructed assets – Service life planning – Part 1: General principles and framework*

BS ISO 19208, *Framework for specifying performance in buildings* [3)]

BS ISO 37500, *Guidance on outsourcing*

BS ISO 55001, *Asset management – Management systems – Requirements*

BS ISO 55002, *Asset management – Management systems – Guidelines for the application of ISO 55001*

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