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Title: Draft BS 8536 Design, manufacture and construction for operability - Code of practice

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Introduction

Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international and European standards, comments will be reviewed by the relevant UK national committee before submitting the consensus UK vote and comments. If the draft standard is approved, it is usual for the resulting published standard to be adopted as a British Standard.

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UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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BS 8536, Design, manufacture and construction for operability – Code of practice

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This is a draft and not a typeset document. Anyone wishing to comment on the draft is advised not to comment on typographical and layout issues.

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Contents

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on XX XXXXX 202X. 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.

Supersession

This British Standard supersedes BS 8536-1:2015 and BS 8536-2:2016, which are withdrawn.

Information about this document

BS 8536-1:2015 and BS 8536-2:2016 were developed to promote a smooth transition from the design, manufacture and construction phase to the operational phase of a built asset by embedding soft landings, post-occupancy evaluation and information management, using building information modelling. BS 8536-1 focused on buildings and facilities management and BS 8536-2 focused on infrastructure and asset management. Both have been well received by industry, especially public-sector clients, and have formed an integral part of the UK BIM Framework [1] and are consistent with the mission of the Centre for Digital Built Britain (CDBB).

In order to accelerate the application of relevant practices in the delivery of sustainable buildings and infrastructure, and also to reflect developments in the UK BIM Framework [1], BS 8536-1:2015 and BS 8536-2:2016 have been consolidated into this single, revised code of practice. This British Standard promotes a smooth process through the life cycle for the delivery and operation of built assets. It covers:

- needs in design, manufacture and construction;
- requirements for safety, security, efficiency and net zero carbon delivery, operation and use; and
- awareness of end-of-life strategies for decommissioning, repurposing or demolition.

This British Standard emphasizes the importance of adopting a whole-life view of an asset/facility and the need to realize value from it; not solely its design, manufacture and construction, upgrading, repurposing or refurbishment. In this regard, it is important to recognize that a vast amount of information and data about an asset/facility are generated and exchanged during its lifetime and that a security-minded approach to the handling of such information and data needs to be adopted.

This is a full revision of the standard, and introduces the following principal changes:

- alignment with the requirements of the BS EN ISO 19650 series of standards on information management using building information modelling, and with PAS 1192-6 on health and safety using building information modelling;
- application of the principles for sponsoring, directing, managing and transitioning projects (see BS 6079) individually or as part of a programme or portfolio (see BS ISO 21500 family);
- greater consideration of risk management across the project life cycle (see BS EN ISO 31000); and
- further application of the principles and practices contained within The Soft Landings Framework [2] and *Government Soft Landings* [3] to the project context.

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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.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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Introduction

Design, manufacture and construction for operability 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 new, upgraded, repurposed or refurbished built assets. These aspects can include: net zero carbon operation and use; energy use; greenhouse gas emissions; water quality, abstraction, consumption and pollutant prevention; soil and landscape quality and remediation; waste prevention or reduction, reclamation, reuse, recycling, treatment and disposal; asset availability, utilization, access, inclusiveness, safety, capability, capacity, quality, resilience, serviceability/maintainability and adaptability; and indoor air quality, thermal comfort, noise and vibration, and user well-being..

This British Standard considers matters relating to projects for the delivery of built assets according to defined operational requirements, including maintainability and reliability, and performance outcomes. For the purpose of this British Standard, “delivery team” (see ISO 19650-1) applies to the lead appointed party and its appointed parties engaged in the delivery of a new asset/facility or the upgrading, repurposing or refurbishment of an existing asset/facility. A project team comprising coordinated delivery teams offers benefits in terms of design and problem solving, as well as constructability and operational impacts. The “delivery team” does not extend to asset management or facilities management.

Project decisions, including those related to design, have to be based upon accurate and relevant information and data, and their impact on operational and user needs has to be understood before they are finalized. The most effective way to comment on the suitability or effectiveness of design is through formal reviews carried out during design. Testing assumptions during design is necessary to understand how the asset/facility will perform in operation and use and achieve its expected performance. Whilst it is usually too late to comment on the design of the asset/facility during construction or once it is operational, systematic measurement, analysis, comparison and feedback can be useful in informing the design of future assets/facilities for both constructability and operational use.

This British Standard aligns with the principles and practices of *The Soft Landings Framework* published by BSRIA [4], which comprises three main elements:

- setting project success criteria at the outset;
- protecting and promoting the success criteria throughout the project; and
- evaluating performance against the set success criteria.

The aim is to achieve a smooth transition from design, manufacture and construction into operation and use of an asset/facility. Key to this is collaboration throughout the project between each delivery team and the operator, operations team or asset/facility manager, as appropriate, in matters affecting operations and asset/facility users.

1 Scope

This British Standard gives recommendations on design, manufacture and construction for operability in relation to built assets (e.g. buildings and infrastructure for energy, telecommunication, transport and water), taking account of the expected performance of the asset/facility in use over its planned operational life.

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

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

b) improving the focus of the project team on the performance of the asset/facility in use;

c) promoting programme and portfolio thinking by the asset/facility owner and, where applicable, the project sponsor to ensure that the asset/facility meets the wider requirements of the owner's operations;

d) providing feedback on the expected functional and operational performance of the asset/facility at each stage in the delivery process;

e) extending the commitment of each delivery team to defined periods of aftercare post-handover of the asset/facility and its safe, secure, efficient and cost-effective operation in line with environmental, social and economic performance outcomes and targets;

f) embedding information management, using building information modelling, in the processes for the delivery and operation of assets/facilities;

g) emphasizing the importance of information and data quality; and

h) highlighting the need to maximize both the investment value and resource value of the asset/facility (see BS 8210).

It is applicable to the provision of information and data supporting a) to e) in a manner that maximizes the value that the asset/facility owner can subsequently derive from the information and data over the planned life of the asset/facility.

This British Standard outlines the primary activities, information, issues and deliverables to be addressed by the project team and each delivery team to support their work and to provide the asset/facility owner and the operator, operations team and asset/facility manager, as appropriate, with as much certainty as possible in regard to the required functional and operational performance of the asset/facility.

The requirements of inclusive design, managing design in construction and managing assets/facilities and their environments inclusively when operational have been incorporated (see BS 8300-2). A defined project-managed approach to the delivery of the asset/facility is adopted throughout (see BS 6079).

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 organizations procuring a new asset/facility, owners upgrading, repurposing or refurbishing an existing asset/facility, and the designers, constructors, consultants, suppliers, operators, licensees, operations and maintenance teams, asset/facility managers and other specialists engaged in such activities.

This British Standard is not intended to provide recommendations for design or construction, but is concerned with information and data that are needed to determine operability and performance requirements for the new, upgraded, repurposed or refurbished asset/facility. It does not cover decommissioning or other end-of-life activities.

This British Standard does not give recommendations for:

1) asset management or facilities management in general (see BS EN 55000 series and BS EN ISO 41000 series respectively);

2) the procurement of design, construction, asset management or facilities management services (see BS 8534 and BS 8572); and

3) the maintenance of assets/facilities (see BS 8210).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document[1)]. For dated references, only the edition cited

[1)] Documents that are referred to solely in an informative manner are listed in the Bibliography.

applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 6079, *Project management – Principles and guidance for the management of projects*

BS 8300-2, *Design of an accessible and inclusive built environment – Buildings – Code of practice*

BS 9999, *Fire safety in the design, management and use of buildings – Code of practice*

BS EN ISO 19650-1:2018, *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 1: Concepts and principles*

BS EN ISO 19650-2:2018, *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 2: Delivery phase of the assets*

BS EN ISO 19650-3:2020, *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 3: Operational phase of the assets*

BS EN ISO 19650-5:2020, *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling – Part 5: Security-minded approach to information management*

PAS 1192-6, *Specification for collaborative sharing and use of structured health and safety information using BIM.*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

3.1.1 access
ability of reaching and using a service or facility

[SOURCE: BS ISO 16439:2014, **3.2**]

3.1.2 accessibility
ease of reaching and using a service or facility

[SOURCE: BS ISO 11620:2014, **2.2**]

3.1.3 activity
task that is needed to produce a deliverable

3.1.4 adaptability
ability to be changed or modified to make suitable for a particular purpose

[SOURCE: BS ISO 6707-1:2014, **9.3.78**]

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

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

3.1.7 asset
item, thing or entity that has potential or actual value to an organization

3.1.8 asset availability
metric used to measure the percentage of time that an asset can be used during operations after allowing for scheduled maintenance interventions and breakdowns

[SOURCE: BS ISO 55000:2014, **3.2.1**]

3.1.9 asset information model (AIM)
information model relating to the operational phase

[SOURCE: BS EN ISO 19650-1:2018, **3.3.9**]

3.1.10 asset information requirements (AIR)
information requirements in relation to the operation of an asset

[SOURCE: BS EN ISO 19650-1:2018, **3.3.4**]

3.1.11 asset management
coordinated activity of an organization to realize value from assets

[SOURCE: BS ISO 55000:2014, **3.3.1**]

3.1.12 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**]

3.1.13 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**]

3.1.14 asset portfolio
assets that are within the scope of the asset management system

[SOURCE: BS ISO 55000:2014, **3.2.4**]

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

3.1.16 asset system
set of assets that interact or are interrelated

[SOURCE: BS ISO 55000:2014, **3.2.5**]

3.1.17 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**]

3.1.18 benefits realization
deriving benefits from project outputs and outcomes

3.1.19 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**]

3.1.20 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**]

3.1.21 constructability
degree to which the design of a planned asset/facility facilitates its manufacture, construction and operability

3.1.22 building information modelling (BIM)
use of a shared digital representation of a built asset to facilitate design, manufacture, construction and operation processes to form a reliable basis for decisions

[SOURCE: BS EN ISO 19650-1:2018, **3.3.14**, modified]

3.1.23 building performance evaluation
setting of targets and monitoring of performance at any point in the life of a building project

[SOURCE: BS 40101, **3.3**, in preparation]

3.1.24 business case
justification for making an investment, usually through a project, programme or portfolio, underpinned by an evaluation of the time, cost and risks of competing options and their expected value or benefit against the business plan leading to a preferred solution

3.1.25 business plan
resource setting out the business objectives and the methods and timescales for achieving them

3.1.26 carbon emissions
polluting carbon substances released into the atmosphere

3.1.27 carbon metric
measure of the weight of carbon dioxide equivalent (CO_2-eq) emitted per square metre per annum (based on greenhouse gas emissions over a 100-year period), expressed as $kgCO_2$-eq/m^2/annum per building type

3.1.28 classification
process of data categorization into a common language to describe things, enabling content to be machine readable and associated

3.1.29 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**]

3.1.30 common data environment (CDE)
agreed source of information for any given project or asset for collecting, managing and disseminating each information container through a managed process

[SOURCE: BS EN ISO 19650-2:2018, **3.3.15**]

3.1.31 configuration management
application of procedures to control, correlate and maintain documentation, specifications and physical attributes

[SOURCE: PD ISO/TR 21506:2018, **3.12**]

3.1.32 cost-benefit analysis
process that assesses the relation between the cost of an undertaking and the value of the resulting benefits

[SOURCE: BS ISO 16439:2014, **3.10**, modified]

3.1.33 deliverable
product or service as an outcome of a process

3.1.34 delivery phase
part of the life cycle during which an asset is designed, manufactured, constructed and commissioned

[SOURCE: BS EN ISO 19650-1:2018, **3.2.11**, modified]

3.1.35 design responsibility matrix
document setting out responsibility for each element of the design at each stage of the design development process for a level of information need

3.1.36 delivery team
lead appointed party and its appointed parties

[SOURCE: BS EN ISO 19650-1:2018, **3.2.6**, modified]

3.1.37 design review protocol
procedure for performing a structured and systematic review of a design at defined points in the project life cycle

3.1.38 user (end user)
person or organization which uses products or services from a supplier

[SOURCE: BS EN ISO 41011:2018, **3.3.5**]

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

3.1.40 environmental indicator
sustainability indicator related to an environmental impact

[SOURCE: ISO 21929-1:2011, **3.11**]

3.1.41 exchange information requirements (EIR)
information requirements in relation to an appointment

[SOURCE: BS EN ISO 19650-1:2018, **3.3.6**]

3.1.42 extended project life cycle
addition of an adoption phase to a linear or iterative life cycle to ensure that the governance of, and accountability for, the project stays with the project team until change is fully embedded

3.1.43 facility
collection of assets which is built, installed or established to serve an entity's needs

[SOURCE: BS EN ISO 41011:2018, **3.2.3.2**]

3.1.44 facility management (facilities management)
organizational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business

[SOURCE: BS EN ISO 41011:2018, **3.1.1**]

3.1.45 facility service
support provision to the primary activities of an organization, delivered by an internal or external provider

[SOURCE: BS EN ISO 41011:2018, **3.1.3.1**]

3.1.46 flawless start-up
fault-free commencement of operations

[SOURCE: BS 8587:2012, **3.1.15**]

3.1.47 front-end loading
process focusing on the early stages of a project where the greatest influence on outputs and outcomes can be achieved without costly disruption

3.1.48 golden thread of information
recording, developing, collecting, organizing and sharing of information by dutyholders or accountable persons in accordance with prescribed standards to ensure building safety throughout the lifecycle of a building

[SOURCE: BSI Flex 8670:2021, **3.14**]

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

3.1.50 impact
any change that might be adverse or beneficial

[SOURCE: BS ISO 15392:2008, **3.13**]

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

3.1.52 information exchange
act of satisfying an information requirement or part thereof

[SOURCE: BS EN ISO 19650-1:2018, **3.3.7**]

3.1.53 information model
set of structured and unstructured information containers

[SOURCE: BS EN ISO 19650-1:2018, **3.3.8**]

3.1.54 integrated project delivery
unified process supporting an extended project life cycle

3.1.55 key performance indicator (KPI)
measure that provides essential information about the performance

[SOURCE: BS EN ISO 41011:2018, **3.8.4**]

3.1.56 level of information need
framework which defines the extent and granularity of information

[SOURCE: BS EN ISO 19650-1:2018, **3.3.16**]

3.1.57 ontology
formal, explicit specification of a shared conceptualization

NOTE An ontology typically includes definitions of concepts and specified relationships between them, set out in a formal way so that a machine can use them for reasoning.

[SOURCE: BS ISO 5127:2017, **3.1.2.03**]

3.1.58 operability
capable of being put into use as intended

3.1.59 operational phase
part of the life cycle during which an asset is used, operated and maintained

[SOURCE: BS EN ISO 19650-1:2018, **3.2.12**]

3.1.60 operational strategy
overall approach to managing the production or use of an asset/facility

3.1.61 operations team
functional group responsible for the day-to-day running and maintenance of an asset/facility

3.1.62 operator
organization responsible for the day-to-day operation of an asset/facility

3.1.63 opportunity shaping (opportunity framing)
business-led process in which the project sponsor evaluates the key attributes of the project, develops and gathers information needed for key decisions, then allocates the value of the project to various stakeholders to make the project environment sufficiently stable for successful implementation

3.1.64 organizational information requirements (OIR)
information requirements in relation to organizational objectives

[SOURCE: BS EN ISO 19650-1:2018, **3.3.3**]

3.1.65 owner
individual or organization owning or procuring an asset/facility

NOTE This can refer to both existing and prospective owners.

3.1.66 performance
measurable result

[SOURCE: BS EN ISO 41011:2018, **3.8.3**]

3.1.67 portfolio
collection of portfolio components grouped together to facilitate their management to meet strategic objectives

[SOURCE: PD ISO/TR 21506:2018, **3.42**]

3.1.68 portfolio component
project, programme, portfolio or other related work

[SOURCE: PD ISO/TR 21506:2018, **3.43**]

3.1.69 portfolio management
coordinated activities to direct and control the accomplishment of strategic objectives

[SOURCE: PD ISO/TR 21506:2018, **3.45**]

3.1.70 portfolio strategy
high-level approach for managing portfolio needs

3.1.71 post-implementation review
measurement of the outcomes of a project for the delivery of an asset/facility and the performance of that asset/facility in operation with the lessons to be learned for future projects

3.1.72 post-occupancy evaluation (POE)
process of evaluating an asset/facility after it has been completed and is in use to understand its actual performance against that required and to capture lessons learned

NOTE Also referred to as building performance evaluation (BPE) in use.

[SOURCE: BS EN ISO 41014:2020, **3.1.4**]

3.1.73 programme
group of programme components managed in a coordinated way to realize benefits

[SOURCE: PD ISO/TR 21506:2018, **3.50**]

3.1.74 programme component
project, programme or other related work

[SOURCE: PD ISO/TR 21506:2018, **3.52**]

3.1.75 programme management
coordinated activities to direct and control the realization of identified benefits and deliverables

[SOURCE: PD ISO/TR 21506:2018, **3.54**]

3.1.76 project
temporary endeavour to achieve one or more defined objectives

[SOURCE: BS ISO 21502:2020, **3.20**]

3.1.77 project controls
application of measures intended to monitor a project's status, give early warning of deviations from the baseline of expected performance and provide forecasts of the project's time and cost at completion

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

3.1.79 project execution plan
document that sets out how the project will be executed

NOTE The project execution plan is analogous to a project management plan.

3.1.80 project information model (PIM)
information model relating to the delivery phase

[SOURCE: BS EN ISO 19650-1:2018, **3.3.10**]

3.1.81 project information requirements (PIR)
information requirements in relation to the delivery of an asset

[SOURCE: BS EN ISO 19650-1:2018, **3.3.5**]

3.1.82 project management
coordinated activities to direct and control the accomplishment of agreed objectives

[SOURCE: ISO 21502:2020, **3.24**]

3.1.83 project sponsor
individual or organization initiating and promoting a project

3.1.84 quality
degree to which a set of inherent characteristics of an object fulfils requirements

[SOURCE: BS EN ISO 9000:2015, **3.6.2**]

3.1.85 repurpose
adapt for use in a different way

3.1.86 requirements management
process of capturing, assessing and justifying stakeholders' wants and needs

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

3.1.88 security-minded
understanding and routinely applying 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: BS EN ISO 19650-5:2020, **3.10**]

3.1.89 service level
complete description of requirements of a product, process or system with their characteristics

[SOURCE: BS EN ISO 41011:2018, **3.1.4.3**]

3.1.90 soft landings
building delivery process which runs through the project, from inception to completion and beyond, to ensure all decisions made during the project are based on improving operational performance of the building and meeting the client's expectations

[SOURCE: The Soft Landings Framework 2018 [2]]

3.1.91 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**]

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

3.1.93 steady state
stable operation and use

3.1.94 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**]

3.1.95 success criteria
requirements set at the beginning of a project against which the project will be evaluated at key stages to decide whether or not it has been successful from key stakeholders' points of view

[SOURCE: *Success Criteria for Soft Landings Projects* [5]]

3.1.96 target operating model
arrangement for delivering an organization's business strategy expressed in terms of the people, processes, data and technology required to deliver that strategy

[SOURCE: BS EN ISO 41014:2020, **3.1.7**]

3.1.97 trigger event
planned or unplanned event that changes an asset or its status during its life cycle, which results in information exchange

[SOURCE: BS EN ISO 19650-1:2018, **3.2.13**]

3.1.98 upgrading
major modification work on an asset/facility or part thereof that improves its overall performance

3.1.99 value improving practice
methodology with a demonstrated, statistically reliable connection between its use and a better outcome

3.2 Abbreviated terms

For the purposes of this British Standard, the following abbreviated terms apply.

AIM	Asset Information Model
AIR	Asset Information Requirements
ALARP	As Low As Reasonably Practicable
BAU	Business As Usual
BIM	Building Information Modelling
BPE	Building Performance Evaluation
BREEAM	Building Research Establishment Environmental Assessment Method
CAFM	Computer-Aided Facilities Management
CDE	Common Data Environment
CDF	Concurrent Design Facility
DQI	Design Quality Indicator
EIR	Exchange Information Requirements
GRIP	Governance for Railway Investment Projects
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	Project Information Requirements
POE	Post-Occupancy Evaluation
RASCI	Responsible, Accountable, Support, Consulted and Informed
RIBA	Royal Institute of British Architects
SAMP	Strategic Asset Management Plan
SMART	Specific, Measurable, Achievable, Relevant and Time-bound
TOTEX	Total Expenditure

4 Concepts and principles

4.1 Key principle

*COMMENTARY ON **4.1***

Design, manufacture and construction for operability takes into account the needs of the owner, operator, users and other key stakeholders in regard to a new, upgraded, repurposed or refurbished asset/facility. The asset/facility is likely to hold its value or benefit for the owner and users if it is trouble-free, efficient and cost-effective in terms of operation.
*This British Standard aligns with the principles of The Soft Landings Framework 2018 published by BSRIA [2] and the principles identified in Government Soft Landings [3]: see also Soft Landings and Government Soft Landings [4]. Soft landings is a key process for the successful delivery of assets/facilities. In essence, it sets success criteria at the outset, protects and promotes the success criteria throughout the project and evaluates performance against the criteria. The criteria are elaborated in BSRIA "Success Criteria for Soft Landings Projects" [5]. Examples include environment performance, social performance, user well-being, functional performance and financial (i.e. economic) performance [see e) below and **4.4.4**].*

The project for the delivery of a new, upgraded, repurposed or refurbished asset/facility should take account of operational requirements and the expected performance outcomes from the outset, through all work stages (see **4.3.3**) and into operations. Design, manufacture and construction should be guided by this principle and be followed by defined periods of aftercare to allow the owner, operator, users and other key stakeholders to derive the expected benefits and required operational performance from the asset/facility.

*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 users. This implies an emphasis on 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. Front-end loading 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 manage them holistically; notwithstanding, this British Standard focuses on projects, including sub-projects covering an asset system (see **4.3** and **5.1.1**).*

This principle should be supported by the following.

a) The project for delivering a new asset/facility or upgrading, repurposing or refurbishing an existing asset/facility should derive from the owner's strategic asset management plan (SAMP) or facilities management strategy (see **4.5** and **5.2.13**) and be aligned with business objectives and the business plan, as part of an asset/facilities management system (see BS ISO 55000, BS ISO 55001 and BS ISO 55002 [asset management] and BS EN ISO 41001 [facilities management]).

b) The owner, operator or a delegated authority on the owner's behalf, such as a project sponsor (see **4.2.3**), should be capable of defining the business case for the project, its objectives, constraints, expected benefits and the required operational performance of the asset/facility (see **4.2**). Appropriate professional advice should be sought where any aspect cannot be adequately defined.

c) The owner, operator or delegated authority should be capable of expressing the security needs for the project and the ongoing operation of the asset/facility in relation to both the physical asset/facility and information concerning it. Appropriate professional advice should be sought where any aspect cannot be adequately defined. Where the project relates to a sensitive asset/facility, a suitably qualified person should be appointed to assist in the development of an appropriate and proportionate security-minded approach.

d) An evidence-based approach to design, manufacture and construction should be adopted that is driven by outputs which are explicit and measurable, wherever possible, and that reflects the requirements of the owner, operator, users and other key stakeholders regarding the expected benefits and the required operational performance of the asset/facility (see **4.2**).

e) Clear targets should be set for the expected benefits and the required performance outcomes at the outset of the project (see **4.4.4**), which are aligned with the owner's or operator's business objectives, as reflected in the business case (see **5.1.2**), and capable of being cascaded through the supply chain. These targets should be reviewed at defined information exchange points within work stages (see **4.7**) and, finally, during operation of the asset/facility.

f) Decisions in regard to design, manufacture and construction should aim to maximize the value of the asset/facility based upon the desired balance between cost, risk and performance [see BS ISO 55000, BS ISO 55001, BS ISO 55002 (asset management) and BS EN ISO 41001 (facilities management)].

g) Appointments (see **4.2**) should incorporate a commitment to defined periods of aftercare (see **4.2.7**), where appropriate.

h) A post-implementation review and/or post-occupancy evaluations (POE) should be undertaken at prescribed intervals during a defined period of extended aftercare by an

independent body, with the involvement of the project team and each delivery team. The post-implementation review and/or POE, including the lessons learned, should be recorded and stored in the asset information model (AIM) so that it is available to the owner, operator, licensee, operations team or asset/facility manager, as appropriate, and other parties determined by the owner or operator (see **4.6.4** and **5.8.4.4.3**).

i) The transition from design through construction and into operation should include the staged and final transfer of project information and data for operational purposes from the project information model (PIM) to the asset information model (AIM) (see **4.7.2**).

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 [6] and the Value Toolkit [7].

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 **4.2.6**).*

The AIM should be created at the start of the project so that it can be operated alongside the PIM.

*NOTE 5 Operating the AIM alongside the PIM allows 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/facility (see **5.7**). Doing so provides more time for verification purposes and facilitates the training of operations personnel in readiness for the start-up of operations.*

NOTE 6 The owner and/or operator might utilize an enterprise system to support their asset/facilities management.

4.2 Roles, responsibilities and accountabilities

4.2.1 General

*COMMENTARY ON **4.2***

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 standard is concerned with a broader range of considerations that involve multiple entities, including asset/facility 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 **4.2.2**) should verify 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.*

A responsibility assignment matrix (e.g. RASCI chart) should be used to differentiate roles, responsibilities and accountabilities in all phases and stages in the project.

The appointment of the project team (see **4.2.4**) and, if applicable portfolio and/or programme teams (see **5.1.3.1**), each delivery team (see **4.2.5**) and the operator, operations team or asset/facility manager (see **4.2.8**), 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 operational phase extends the traditional involvement of each 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/facility 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 verify that expertise on asset/facilities management is available so that operational requirements and the expected performance of the asset/facility form an integral part of the decision making.

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

From the outset of the project, there should be 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 **4.7**). The basis upon which

decisions are to be made should be clearly defined and communicated to all involved parties from the earliest practicable point.

NOTE 2 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 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/facility is sensitive or the owner and/or operator has decided to implement more than baseline security measures, advice/guidance should be sought from a person suitably qualified on security aspects related to the design, manufacture, construction and operation of the asset/facility and the protection of asset information and data (see **4.4.4** and **5.2.6**).

4.2.2 Owner

*COMMENTARY ON **4.2.2***

*Soft landings [2], [3] is intended to assist owners and operators in getting the best out of their new, repurposed or refurbished asset/facility through greater involvement of each delivery team with the operator, operations team or asset/facility manager, as appropriate. Much of the information required to support soft landings is already collected in the normal course of delivering a project. The owner or operator, as appropriate, is expected to nominate a person with responsibility for ensuring that soft landings is developed to suit the project throughout design, manufacture and construction and into operation of the asset/facility. This person might be the "project sponsor" or be referred to as the "owner's representative" or another term of the owner's choosing. The term "project sponsor" has been adopted in this standard (see **4.2.3**) to cover this responsibility. The reliance upon soft landings could present a case for a "soft landings champion" and a "soft landings lead" or "soft landings leads" drawn from each delivery team to help coordinate meetings and gather information and data required for this purpose. It is, however, important to understand the distinction between a person acting as an agent for the owner in fulfilling day-to-day responsibilities and subject matter experts in respect of soft landings. The soft landings champion is appointed by the owner or project sponsor and the soft landings lead(s) is identified by each delivery team.*

The owner should appoint a project sponsor (see **4.2.3**) whose principal tasks are to own the business case for the project, verifying its alignment with the business plan, and to oversee the planning, implementation and control of design, manufacture and construction to achieve a smooth transition into operation and defined periods of aftercare. The project sponsor should have first-hand working knowledge of the owner's organization and an understanding of the asset/facility's future. Where an existing asset/facility is to be upgraded, repurposed or refurbished, the project sponsor should have an understanding of its history or acquire such understanding.

NOTE The project sponsor is not a project manager. The project manager leads the project team and is responsible for delivering the asset/facility to an agreed scope of work, schedule and cost/budget in accordance with the business case and, normally, has no involvement or interest once the project has been completed and the asset/facility is operational. Similarly, the asset/facility manager might have limited expertise or interest in the project's delivery other than the asset//facility, once delivered, performs as required. There is, therefore, the need for a person who understands the business rationale for the project and possesses a strategic interest in, and understanding of, an integrated process for asset/facility delivery and operations.

Where soft landings has been adopted, a soft landings champion should be appointed. Where the scale, complexity or other key factor is suggestive of a greater focus on soft landings, the additional role of soft landings leads should be introduced.

4.2.3 Project sponsor

*COMMENTARY ON **4.2.3***

*A project sponsor often acts as the owner's "internal client" to provide leadership during project development, to verify that the project is efficient and cost-effective, and if part of a portfolio and or programme, is effectively coordinated with other portfolio or programme components. The project sponsor is normally accountable for the business case, obtaining funding and determining performance and other requirements, and is supported by the project team, or delivery team(s), if appointed at this time (see **4.2.4** and **4.2.5**). The project sponsor maintains an overview of the project's progress towards delivering the required operational performance and achieving the expected benefits.*

The project sponsor should be appointed for the entire period from initiation of the business case through to operation of the asset/facility, including the full period of extended aftercare, to provide continuity of purpose and consistency of approach. The project sponsor should report to the owner and/or operator and consult with the representative(s) of users or other key stakeholders as appropriate. The role of the project sponsor should not duplicate that of the project manager.

The project sponsor should maintain the focus of all parties on the required project outcomes and operational performance. The role of the project sponsor should not be delegated to another party, but another person(s) may be engaged to deal with any day-to-day questions and issues that arise which would otherwise distract the project sponsor from more strategically important matters.

NOTE 1 Support for the project sponsor could be provided by the soft landings champion.

The project sponsor should make regular reference to the schedule or equivalent documentation that identifies the work activities of the project team, with their associated information requirements and deliverables. The project sponsor should facilitate input from the operator, operations team or asset/facility manager, as appropriate, and users to the work of the project team.

The project sponsor should facilitate feedback on the design from the operator, operations team or asset/facility manager, as appropriate, and users to the project team on the integration of operational objectives, specification and maintenance requirements into the design.

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

a) establishment of the information requirements (e.g. OIR, PIR, AIR and EIR);

b) establishment and validation of the expected benefits and required operational performance of the asset/facility (see **4.2**) and the operational budget;

c) verification through successive work stages that the expected benefits and required operational performance will be achieved (see **4.4.4**);

d) planning for operational readiness in advance of the start-up of operations and the phasing in of asset/facilities management (see **5.6**, **5.7** and **5.8**);

e) liaison with the owner's appointee on a security-minded approach to project delivery;

f) post-implementation review and/or POE to establish if the asset/facility is performing as expected (see **4.6.3** and **4.6.4**), including measurement of actual operational performance against the required performance from environmental, social and economic perspectives (see **4.4.4**) based on information and data taken from reliable sources during the extended period of aftercare; and

g) preparation of an advisory report by the operator, operations team or asset/facility manager, as appropriate, with input from each delivery team where required (see **5.8.6** and **4.2**), during the extended period of aftercare, covering the need for any corrective actions, the presentation of benchmarking data and the lessons learned (see **5.2.3**).

NOTE 2 The project sponsor is the primary risk taker and has ultimate accountability and overall responsibility for the project.

4.2.4 Project team

*COMMENTARY ON **4.2.4***

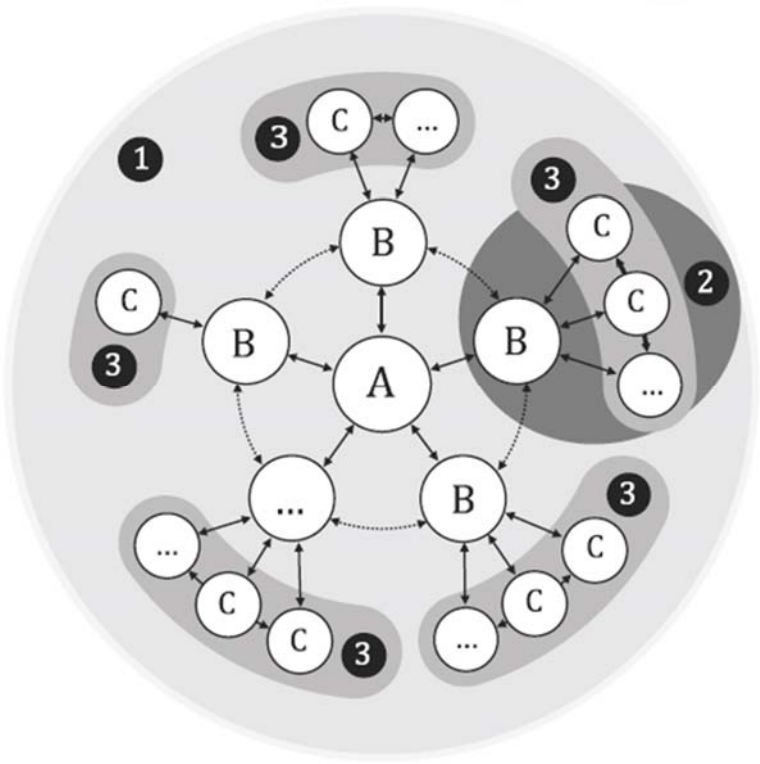
The project team comprises all demand-side and supply-side entities, groups and individuals, including those with design, construction, commissioning and start-up responsibilities, including each delivery team. Supply-side responsibility extends beyond the handover and start-up of the asset/facility to cover periods of aftercare within the operational phase.

The day-to-day management of the project based on an extended project life cycle should be vested in a project team under the direction of a project manager, where each delivery team is a subset of the project team (see Figure 1). In all cases, roles, responsibilities and accountabilities should be clearly defined.

*NOTE RASCI charts are useful for this purpose (see **4.2.11**).*

The project team should include personnel from the operator or operations team. Where no such arrangement presently exists, an asset/facility manager should be appointed to verify that operational requirements and performance outcomes (see **4.4.4**) are taken into account in each work stage.

Figure 1 – Relationships between the parties in the context of information management



Key

A	Appointing party	2	Delivery team
B	Lead appointed party	3	Task teams
C	Appointed party	↔	Information requirements and information exchange
….	Variable amount	⇿	Information coordination
1	Project team		

[SOURCE: BS EN ISO 19650-2:2018, Figure 2]

4.2.5 Delivery team

*COMMENTARY ON **4.2.5***

An integrated, collaborative approach to design, manufacture and construction is necessary to verify the constructability of the design and the operational performance of the asset/facility. The term "delivery team" is used in the context of information management to refer to each lead appointed party and its appointed parties as required to assist in transforming the owner's business objectives into an operational asset/facility or the upgrading, repurposing or refurbishing of one existing. An integrated project 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 each delivery team's supply chain. See **4.2.6** and **4.7.8** for exchange information requirements for supply chain entities.*

The project sponsor should promote collaborative working based on shared responsibilities and goals that are aligned with those of the owner and operator, where the latter is a separate entity (see **4.2.2**), and/or the operations team or asset/facility manager, as appropriate. The project sponsor should determine the composition of each 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 Use, maintaining continuity of purpose in regard to the owner's business objectives throughout (see **5.1.1**).

Each delivery team should support the project sponsor in pursuing an operational asset/facility that meets defined performance outcomes and targets. One member of each delivery team should be nominated to be responsible for coordinating all transition-related activities.

NOTE 1 This role may be fulfilled by the soft landings lead(s).

Each delivery team should align roles and responsibilities for the project to work activities and their associated information requirements and deliverables. A responsibility assignment matrix (e.g. RASCI chart) should be prepared by each delivery team for this purpose. The format of the matrix should be approved by the project manager and project sponsor in turn. The matrix should be aligned with an organization chart for the project, which should be prepared by the project team to show reporting/communication between all parties within the project organization and interfaces to external entities and other key stakeholders. Matrices should be updated as necessary in each work stage and in readiness for the subsequent work stage (see Clause **5**). Design responsibility matrices should complement the use of RASCI charts by providing a focus on assigned design responsibilities and the level of information need (see BS EN 17412-1).

NOTE 2 Annex A gives an example RASCI chart and a design responsibility matrix.

Each delivery team should advise the project sponsor of the need for any additional competences, skills and experience required as soon as any gap becomes apparent. Where the engineered systems are complex, the owner, operator or the project sponsor on their behalf, should appoint 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/facility, a suitably qualified person should be appointed at the outset of the project, if not already appointed, to assist in the development of an appropriate and proportionate security-minded approach.

4.2.6 Supply chain considerations

*COMMENTARY ON **4.2.6***

*In the course of delivering a new, upgraded, repurposed or refurbished asset/facility, much work devolves to suppliers and manufacturers. The success of the transition from design through manufacture, construction and into operation depends on the effective integration of the supply chain covering all the entities necessary for delivering the operational asset/facility. The management of multiple organizational, technical and contractual interfaces between these entities is part of the task and is a factor in that success. It is essential that all suppliers of services, products and materials are effectively integrated into the approach to be taken, including work activities, information requirements and deliverables in each work stage. There are implications for the exchange of information between appointees and the appointing party (see **4.7.5**, **4.7.6** and **4.7.7**).*

As far as practicable, suppliers and manufacturers should adopt an approach that supports the key principle (see **4.1**) throughout all work stages in which they are involved. Each supplier and manufacturer, as appropriate, should identify a person for the purpose of transition into operations and inform the transition coordinator (see **4.2.5**) within its delivery team, which should be the soft landings lead, where appointed. This person should attend meetings, 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.

Where highly specialized plant and equipment is involved, provision should be made to retain the services of the supplier to assist during handover and in monitoring performance during start-up and operation of the asset. These suppliers may be based on site full-time during an initial period of aftercare (see **5.8.3**) to assist with user queries and to undertake optimization of systems as necessary. In this case, the project manager should make these conditions clear and verify that they are embodied in the scope of work and subsequent agreements with the supplier.

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

Where suppliers of highly specialized plant and equipment are required to provide support for an extended period of aftercare (see **5.8.4**), the roles and responsibilities should be the same as those required in the Use work stage (see **5.8**). The applicable RASCI charts for this purpose should be updated where necessary to reflect these arrangements.

Suppliers should be required to contribute their information and data to the common data environment (CDE) (see **4.7.4**) in accordance with their exchange information requirements (EIR).

4.2.7 Aftercare team

An aftercare team should be appointed to manage interventions and provide solutions to problems identified in the normal operation of the asset/facility or as a result of post-implementation reviews and/or POE. This team should be staffed by representatives of each delivery team with sufficient coverage of the disciplines to cope with a wide range of potential interventions and solutions that might be required to optimize functionality and performance of the asset/facility.

NOTE The aftercare team does not manage, maintain or operate the asset/facility. Its role is to fine-tune and de-bug systems in the period of aftercare.

4.2.8 Operators, operations team and asset/facility manager

*COMMENTARY ON **4.2.8***

The asset/facility might be operated by the owner or another party where, for example, a licence is granted to operate a service based on the asset/facility as would occur in the case of a toll road, bridge or tunnel. It is necessary that the interests of the operator are taken into account from the outset. These interests extend to the needs of the users of the asset/facility. In a larger organization, an operations team, asset/facilities management team or, possibly, an asset/facility manager is responsible for the asset/facility 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.

Expertise is required on operational matters and this might be provided by a consultant engaged for this purpose. This person is necessary to provide comment and advice on the implications of design, manufacture and construction proposals from an operational perspective as they are developed from the Strategy work stage through to Handover and Closure.

The project sponsor should give the operator, operations team or asset/facility manager, as appropriate, authority to provide appropriate information and data to each delivery team concerning the operational strategy and operational requirements, including performance targets and outcomes, operational cost and budgets, and procurement of asset and facility-related services where applicable (see BS 8572). The applicable RASCI charts for these purposes should reflect these arrangements. The operator, operations team or asset/facility manager, as appropriate, should identify the owner's information needs in this regard as part of the organizational information requirements (OIR) (see **4.7.5**).

NOTE Annex A gives an extract from a RASCI chart.

4.2.9 Users

*COMMENTARY ON **4.2.9***

The occupants, visitors and other users of the asset/facility are a key stakeholder group and are collectively referred to as users because they are generally the ultimate beneficiaries of the services provided by the asset/facility in operation.

The project sponsor should verify that the interests and needs of the users of the asset/facility are taken into account through a process of stakeholder engagement on the part of the project manager (see **4.2.11**).

NOTE 1 Depending on the number and diversity of users, the project sponsor could arrange for representation on a group, rather than an individual, basis.

Personally-identifiable information and data should be collected, used and stored in a security-minded manner.

NOTE 2 Asset and facility-related systems might contain a range of information and data about users, for example, information about passes or access tokens and emergency contact details. Attention is drawn to duties under data protection legislation.

4.2.10 Other stakeholders

The project team should identify those parties that are external to the project organization but who can impact it in some way, either negatively or positively.

NOTE Example stakeholders external to the project can include local authorities and other public bodies, utility companies, non-governmental organizations and the general public. The latter might have little power on an individual level but, collectively, could exert influence over decision making.

A stakeholder impact analysis should be undertaken to identify those persons, groups and organizations that are external to the project but which have an interest in it. The power they might exercise in influencing outcomes should be assessed. This information should be available when classifying and prioritizing functional and operational needs as part of requirements management (see **4.4.4** and **4.5.5**).

4.2.11 Collaboration and alignment

*COMMENTARY ON **4.2.11***

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 each delivery team and the developing design with the expected benefits and required operational performance of the asset/facility.

The project sponsor should verify that each 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/facility manager, as appropriate. Each delivery team should provide evidence of its approach in the form of a schedule of work activities, with their associated information delivery plans, for each work stage (see Clause **5**). This should take the form of a RASCI chart covering the work activities and their associated deliverables for each work stage. The RASCI chart should be supplemented by design responsibility matrices covering assigned design and information delivery responsibilities.

NOTE 1 Annex A gives an example RASCI chart and a design responsibility matrix.

The project team should obtain early input about the interests and needs of owners, operators, users and other key stakeholders. To assist with this, the project manager should prepare a plan for stakeholder engagement (see **5.1.6**).

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. A participative stakeholder engagement process should be adopted wherever practicable.

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 in eliminating them. Value engineering is a common and proven methodology for this purpose and is, increasingly, incorporated into routine practice. It is important, however, to establish 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 constructability and operability studies, 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 project team and the operator, operations team or asset/facility manager, as appropriate, overseen by the project sponsor or another person with delegated responsibility for operational readiness, flawless

start-up and early optimization of operational performance. Users, or their representative(s), should be involved in this planning.

The project team, working through the aftercare team (see **4.2.7**), should be involved in post-implementation review and/or POE as a process for assessing the performance of the asset/facility over the first three years of its operational life, to establish actual outcomes and to record and share lessons learned (see **4.6.3**). Where actual performance of the asset/facility falls below expected performance, the aftercare team should be empowered to intervene and rectify any issue or propose a solution to the reasonable satisfaction of the owner, operator or project sponsor and users or their nominated representative. The POE should extend to measuring the impact of the operator's or operations team's asset/facilities management strategy on the performance of the asset/facility (see **4.2**).

NOTE 3 The advantages of this approach, including post-implementation review and/or a POE, are the optimization of operational performance of the asset/facility 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, manufacture and construction. Achievement of the required outcomes could be regarded as an indication of the operator's and users' likely satisfaction with the asset/facility and offers some assurance with respect to operational cost.

The project sponsor should verify that operational input is a continual, but controlled, contribution during design, manufacture and construction work to demonstrate that the design of the asset/facility 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 **5.3.3**). The project 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/facility are likely to be met. Confirmation of the associated capital and operational costs should be provided by the project team, with input from the operator, operations team or asset/facility manager, as appropriate, at points defined for the purpose of information exchange (see **4.7**).

4.3 Project-managed approach

4.3.1 Project life cycles

*COMMENTARY ON **4.3.1***

All projects pass through phases or stages in their life cycle, enabling the work involved to be broken down into manageable parts. A life cycle defines the interrelated phases or stages in a project and provides a structure for governing the progression of work. In the basic case, there are two overarching phases in the life cycle of built assets: the delivery phase and the operational phase. A linear life cycle is appropriate for most situations involving built assets. Derivative life cycles, typically involving iterative processes within phases, might be encountered as part of, for example, an agile project management methodology or a hybrid life cycle. Many organizations have devised their own life cycle to move projects through a sequence of phases and stages to delivery of the asset/facility and some have extended the approach into operations and the realization of benefits. Increasingly, time is devoted to shape (or frame) the opportunity that gives rise to the project as part of what is termed "front-end loading".

The owner, operator or project sponsor should define the life cycle for the asset/facility, including its phases and/or stages, and the extent to which they constitute the project life cycle.

NOTE An extended project life cycle recognizes the adoption phase of the project during which benefits realization takes place. The thinking here is to derive the required benefits from the outputs of the project. Often, the responsibility for operating the asset/facility and benefits realization falls outside a delivery team's remit and influence. An adaptation of the extended life cycle to incorporate operations and the terminal act of decommissioning and repurposing or dismantling the asset/facility establishes the product life cycle. This life cycle is relevant when determining the total cost of ownership (TCO) or whole-life cost of the asset/facility.

4.3.2 Phases and stages

The project should be split into phases or stages, as appropriate to the selected life cycle and its terminology, where each equates to a distinct period (or state) in the life cycle, to improve the effectiveness of its management.

NOTE 1 Each phase or stage of the project could be managed as a sub-project to ensure that it is started correctly, planned, monitored and closed with lessons learned documented for the next project.

Decisions should be made within the phase or stage in which they are planned and not be carried over to the next phase.

NOTE 2 These decision points are referred to variously as decision gates or gateways.

The owner, operator or project sponsor, as appropriate, should specify the phases (or stages), decision points, criteria for progression and deliverables and provide this information to the project team to organize and plan its work.

When planning work and deliverables, sufficient time should be allowed for review or evaluation of proposals prior to a decision gate or gateway so that decision-making is not at the very end of the phase or stage.

Each decision gate or gateway should be preceded by reviews as part of the project's governance and assurance and be accompanied by a simple question to which an affirmative answer is necessary to move the project forward to the next stage.

NOTE 3 Decision gates serve a business purpose, not a design or construction purpose. Decision gates check the progress of the opportunity and ascertain the likelihood of realizing the expected value for the benefit of the project's stakeholders. Changes, for example new or revised design proposals, have to be assessed in terms of their impact on cost and schedule. Allowing little or no time to evaluate changes before a decision gate or gateway can result in issues or problems being carried over to the next work stage, thereby undermining their purpose as a check and control mechanism.

4.3.3 Plans of work

*COMMENTARY ON **4.3.3***

A plan of work maps the project life cycle and defines the work stages, the work to be done and the level of information need (see BS EN 17412-1) with respect to each appointee. Progression depends on satisfying predefined criteria at decision gates or gateways that include requirements relating to environmental, social and economic performance. In this regard, it is important to recognize the iterative nature of some work, where the reassessment of assumptions is a normal feature. In the case of design, the process is not always linear and is likely to involve some degree of iteration within work stages to converge on an acceptable solution or deliverable.

The work stages should reflect the following suggested plan of work, which may be adjusted to suit the specific needs of the owner, operator or project sponsor.

0 Strategy – defines the owner's or operator's business objectives, plan and case for the project, including required outputs, outcomes and expected benefits, and the relationship of the project with any overarching portfolio and/or programme.

1 Preparation and Brief – develops the project objectives, including required project and performance outcomes from the asset/facility 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 Technical Design – prepares the technical design, including structural and engineering design information, detailed cost and operational data.

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

6 Handover and Closure – training of operations personnel and handover of the asset/facility to the owner or operator and start-up of operations.

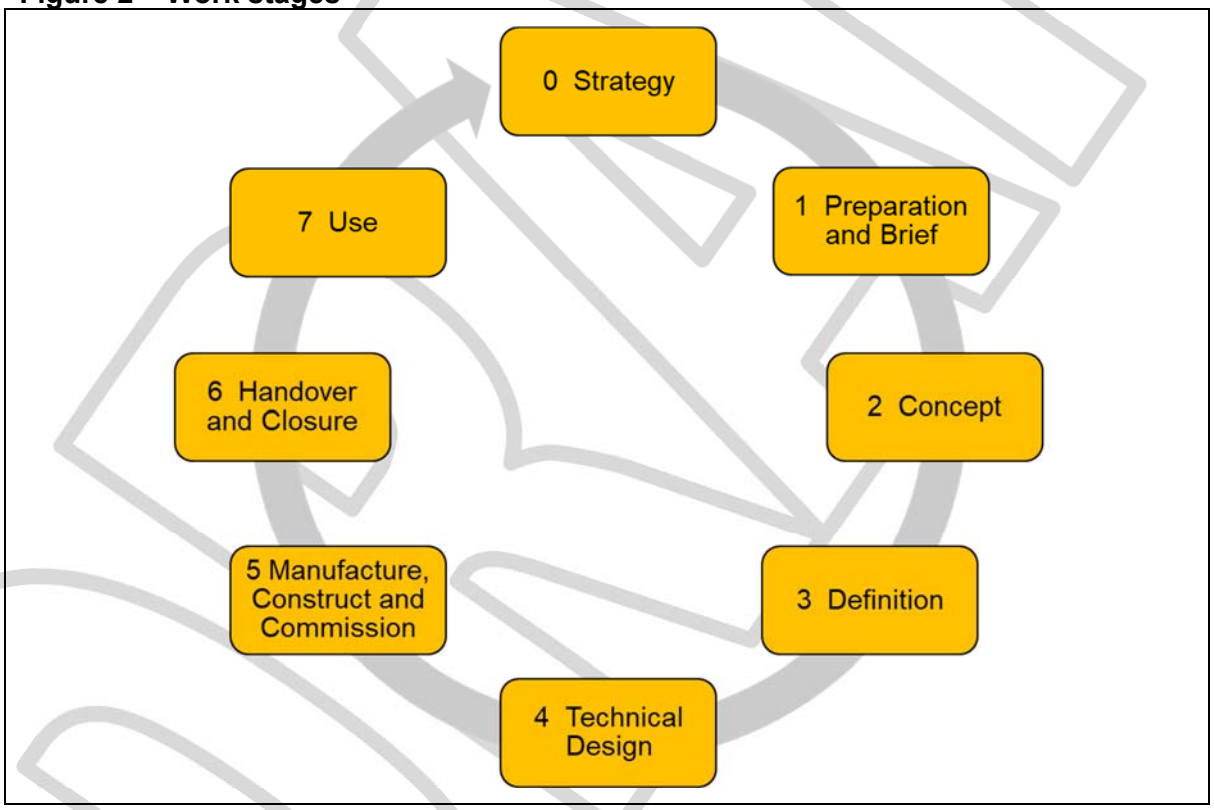
7 Use – steady-state operations, aftercare, post-implementation review and/or POE, as appropriate, including benchmarking and lessons learned.

The plan of work should be used to verify 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 and operating the asset/facility.

NOTE 1 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. These are additional to the decision gates or gateways at the end of each work stage. It would not be appropriate for a delivery team, when appointed, to determine such timing although it can communicate its expectations to achieve a workable plan. Discussion between the owner, operator or project sponsor, as appropriate, and each delivery team on the alignment of decisions and information exchanges would therefore be in all parties' interest.

Figure 2 illustrates the progression from the Strategy work stage through to Use, including end of life, where the decision to proceed from one work stage to the next depends upon the owner, operator or project sponsor, as appropriate, "signing off" key decisions. For this reason, decision gates or gateways 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 and economic performance of the asset/facility (see **4.2**). The owner, operator or project sponsor, as appropriate should determine the timing of decision points, information exchanges (see **5.3.3**) and the criteria to be satisfied, taking into account the adopted procurement method and arrangements for appointing each delivery team.

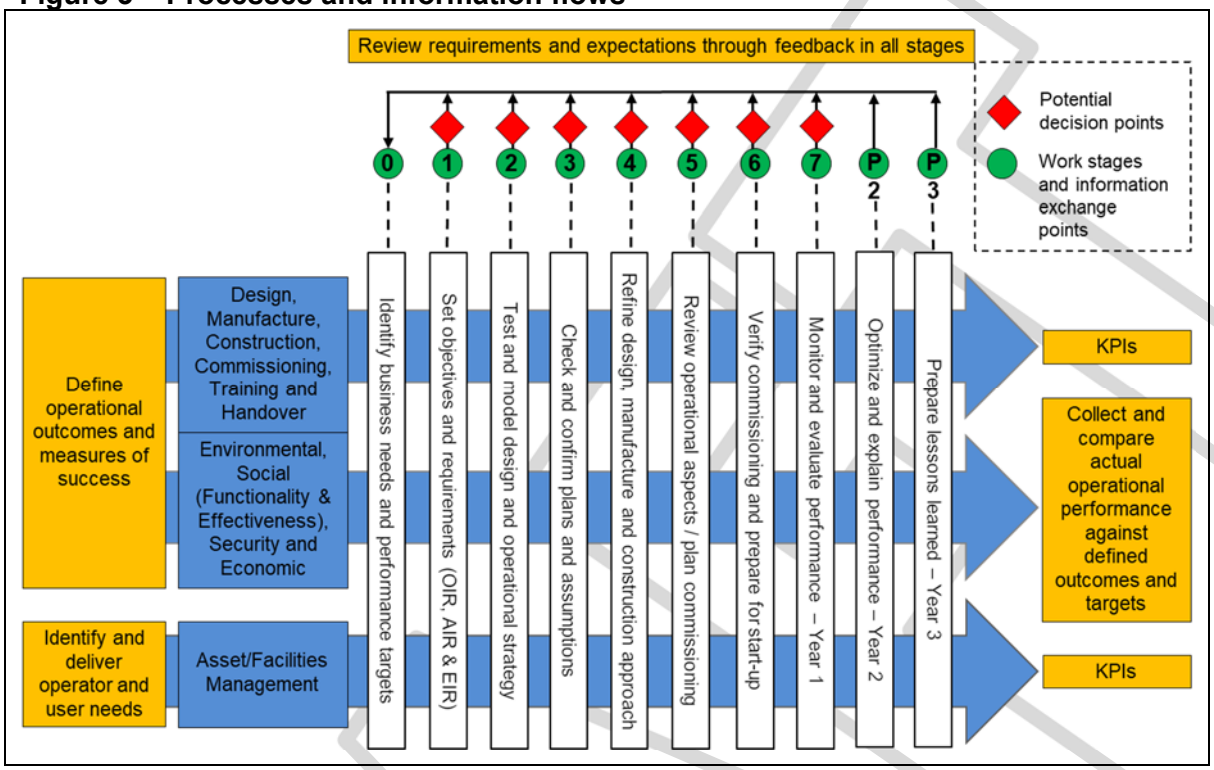
Figure 2 – Work stages



NOTE 2 Figure 3 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 and economic performance of the asset/facility (see **4.2**).

Figure 3 – Processes and information flows



NOTE 3 The approach shown in Figure 3 represents processes and information flows in a manner that is analogous to swim lanes.

*NOTE 4 Clause **5** is structured in accordance with the work stages outlined in the plan of work as the project progresses from its commencement to the operation of the asset/facility. The same or similar sub-clause headings are used in each work stage, wherever practicable, to ensure consistent treatment of both recommendations and guidance. In a number of cases, the latter are broadly similar, although might contain important differences.*

The requirements contained in each work stage (see Clause **5**) should be properly defined 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 exceed reasonable needs.

The owner or project sponsor should determine an appropriate plan of work, which should be digitally enabled and capable of supporting information management using building information modelling.

NOTE 5 Attention is drawn to the RIBA Plan of Work 2020 [8] and Toolbox [9] as a proven blueprint for project success for buildings and to The Construction Playbook [10]. In the case of infrastructure, a number of sector-specific plans of work exist, for example, Governance of Railway Investment Projects (GRIP) and the "V Cycle" model or process, each of which is reflective of the business objectives and practices of particular sub-sectors, owners and/or operators.

4.3.4 Project controls

Controls should be applied at key or critical points in the project life cycle and should extend to the programme and portfolio level, as appropriate. They should coincide with decision points and decision gates or gateways, but may also be applied at other points in the life cycle to help monitor progress and compliance with the project's governance and assurance. Project controls should focus on determining whether the required actions, tasks and decisions have been accomplished satisfactorily or if further action or adjustment is necessary before proceeding.

NOTE 1 Project control is a discipline with functions designed to control scope, quality, schedule, resources, cost and HSSE. The primary purpose is to inform the project's management of performance and progress so that the project's current status and forecast of completion is maintained continuously such that any deviation from the approved baseline of the project can be detected and corrective action taken, where necessary.

The owner, operator or project sponsor, as appropriate, should confirm the basis upon which costs and budgets are to be controlled, including limits on authorization for expenditure and supplementary budgets where, for example, scope changes are approved.

NOTE 2 Cost and budget are not the same. Typically, once a final investment decision has been reached, based on an estimate of the cost of delivering the asset/facility, a budget for the purpose of capital expenditure is authorized. This approved budget represents a cap on expenditure under which commitments can be entered into through the issue of purchase orders and the award of contracts. Commitments represent assigned budget, which is funds earmarked for expenditure, and so cannot be used for any other purpose.

4.3.5 Project risk management

The project team should implement a structured process of project risk management. The project manager should be accountable for the effective management of risks to which the project is exposed and verify that the consequences are reflected in the project's current status and forecast of completion date and cost.

NOTE 1 APM Mini Guide, "Project risk analysis and management" [11] offers a suitable basis for helping project teams to implement risk management.

The risks, both threats and opportunities, that could affect realization of the required functionality, expected performance and outcomes for the asset/facility should be systematically assessed and managed in each work stage. 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/facility and determine the actions necessary to manage them. The assessment should include identification and analysis of threats (downside risks) and opportunities (upside risks), treatment of those risks and the controls to be applied (see BS EN ISO 31000). Security risks, in particular, should be assessed at regular intervals and predefined points throughout the life cycle and when certain trigger-related events occur, with the security strategy updated accordingly.

NOTE 2 Downside risks are factors that can have a potentially negative impact on the asset/facility, 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 change in the economic or market environment or the re-examination of the scope of work against the business objectives and project objectives, e.g. change to take advantage of the likely availability of more energy-efficient equipment by a particular date.

For risks to be managed effectively they should be expressed in terms of a definite cause and the uncertain event that might occur, in terms of quantifiable probability, and its effect on project objectives if it were to occur together with a quantifiable consequence. The risk event should be connected with the project in terms of, for example, specific activities in the project schedule or cost estimate (or budget) that would be affected if the event were to occur.

NOTE 3 Risks should be identified as relating to defined activities or decisions in the project. A list of risks that states, for example, weather, labour shortages and material delays does not give many clues as to the event that might occur which, if it did, would have an impact on objectives. At best, these are likely to be issues to be resolved by the project manager and the project team in the normal course of construction project management.

Care should be taken to avoid confusing risks with issues. An issue is a certain event, or a risk that has materialized, that should be dealt with by whatever means reduces its impact negatively on the project.

NOTE 4 A risk is not a certain event; there is only a probability of its occurrence. If a risk event is going to occur then it is no longer a risk but an issue to be resolved by whatever means are available and appropriate.

NOTE 5 Effective project management deals with issues and, where appropriate, builds resilience into project plans.

NOTE 6 Issues might exceed the capacity to be resolved at the project level and might have to be escalated to the programme or portfolio level or to the project sponsor. Similarly, risks at the project level might have to be escalated to the project sponsor or the programme or portfolio level.

An up-to-date risk register is one of the key deliverables in the Strategy work stage and should be established and maintained from the outset (see **5.1.10**). 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 potential benefits. 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.

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

NOTE 7 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 materialize, others might disappear and new ones appear.

4.4 Objectives, outputs, outcomes and benefits

4.4.1 Projects, programmes and portfolios

*COMMENTARY ON **4.4.1***

This subclause addresses instances where organizations owning and operating assets/facilities might manage their projects collectively rather than individually as part of a programme or portfolio.

The project team should be aware of the project's possible relationship with any other project or projects. Where the project forms part of a programme or portfolio, governance and assurance matters should be clarified so that the project is best able to contribute to the overall success of the programme or portfolio. Arrangements and undertakings affecting the project, by the nature of its relationship with other projects or the interdependency of projects, should made explicit.

NOTE 1 It is essential that the project team and each delivery team within it have a clear understanding of the context within which the project fits within the organization that "owns" it. For instance, the project might be an enabler for later projects or, simply, be contingent upon the success of a project preceding it. In the public sector, the organization might have a set of predefined outcomes or objectives to which all projects within a programme or portfolio will contribute.

The owner, operator or project sponsor, as appropriate, should verify that arrangements to resource the project take into account demands on personnel, equipment and materials that might be shared by other projects.

NOTE 2 In multi-project organizations, sharing of resources is common and so plans to support the project might draw on resources that are supporting other projects concurrently, as would be the case with a matrix organizational structure for project work.

4.4.2 Project objectives and outputs

*COMMENTARY ON **4.4.2***

*Project objectives tend to be couched in terms of the broad scope of the asset/facility as the deliverable, its cost and the time required to deliver it safely, securely and efficiently. The defined scope, cost and time for completion of a deliverable can also be regarded as the outputs from the project. In many situations, project objectives are set in terms of either deliverables or outputs. For example, the delivery of a new 50-bed intensive care unit, within 18 months, for a cost of £x million captures both objectives and outputs. Detailed requirements are expected to support the objectives (see **4.5.5**).*

The owner, operator or project sponsor, as appropriate, should verify that the objectives for the project are stated clearly and in quantifiable terms.

4.4.3 Project outcomes and benefits realization

*COMMENTARY ON **4.4.3***

Stakeholders in the project, including external stakeholders, to varying extents expect to realize value or benefits from the project outputs (or deliverables). For example, a 50-bed intensive care unit is intended to improve access to specialist healthcare for patients, as one stakeholder group, and to the hospital trust as another stakeholder. There will be many individuals and organizations who have an interest in improved healthcare. In addition to the obvious benefits to patients and the hospital trust, gains could accrue to other stakeholders from shorter stays in hospital. The realization of benefits is, for many stakeholders, the ultimate goal and the project is the means to their achievement. It is important, therefore, to recognize the different perspectives and expectations that each stakeholder or group of stakeholders might possess and to treat these as value drivers for the project.

The owner, operator or project sponsor, as appropriate, should verify that the value drivers for the project are documented to inform design decision-making, required project outcomes and the expected benefits to be derived from the project outputs (or deliverables).

NOTE The Value Toolkit [7] provides a structured approach for value-based decision making across the lifecycle of a project, programme or portfolio.

4.4.4 Functional and operational performance

*COMMENTARY ON **4.4.4***

*The performance required or expected of an asset/facility can be regarded as measures of success. BSRIA Guide on "Success Criteria for Soft Landings Projects" [5] gives example measures that include environment performance, social performance, user well-being, functional performance and financial (i.e. economic) performance (see **4.1**). Importantly, success criteria are set at the outset of the project and used as a constant reference through all work stages (see **4.3.3**) to determine if the asset/facility is likely to be successful from key stakeholders' points of view.*

Performance outcomes should be set at the Strategy work stage (see **5.1**) and monitored during each subsequent work stage up to and including Use (see **5.8**), with post-implementation review (see **4.6.3**) and/or POE (see **4.6.4**) at prescribed intervals during a defined period of extended aftercare (see **5.8.4**). These should be used as the basis for measuring operational performance. The expected performance outcomes are as follows.

a) Environmental – the asset/facility should meet performance targets, such as those for net zero carbon operation and use, 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), waste (e.g. prevention or reduction, reclamation, reuse, recycling, treatment and disposal) and/or other environmental indicators defined by the owner, operator or project sponsor.

   NOTE 1 An indicator is a quantitative, qualitative or descriptive measure. See Annex B for an approach and typical measures forming a part of the post-implementation review and/or POE, BS EN 15643-2 on assessment of environmental performance and BS 40101[2] on building performance evaluation.

b) Social (i.e. functionality and effectiveness) – the asset/facility should be designed and constructed to meet functional performance targets, such as those relating to asset availability, utilization, access, inclusiveness, safety, capability, capacity, quality, resilience, serviceability/maintainability and adaptability, and internal environmental performance such as indoor air quality, thermal comfort, noise and vibration, user well-being and/or others defined by the owner and/or operator.

   NOTE 2 See Annex C for an approach and typical measures forming a part of the post-implementation review and/or POE, BS ISO 15686-2 for an approach to service life prediction, BS EN 15643-3 on assessment of social performance and BS 40101 on building performance evaluation.

[2] In preparation

c) Economic – the asset/facility should meet performance targets for capital cost and operational cost so that whole-life costs can be estimated and value and benefits can be assessed [see **4.4.3**].

NOTE 3 See Annex D for an approach and typical measures forming a part of the post-implementation review and/or POE and BS EN 15643-4 on assessment of economic performance.

d) Security – the asset/facility and the creation, use, storage and disposal of asset and facility-related information and data should meet the security requirements of the owner, operator, licensee, operations team or asset/facility manager, as appropriate, and users.

*NOTE 4 See **5.2.6** for the development of an appropriate and proportionate security-minded approach.*

Performance outcomes and targets should be specific to the project and should be verified in each work stage (see Clause **5**) as part of a formal review process. As far as practicable, a quantitative approach should be taken to measuring performance and value or benefits, as appropriate.

The outcomes should be differentiated 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, indoor air quality, thermal comfort, noise and vibration, and user well-being). Wherever possible, commitment to net zero carbon operation and use should be pursued 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 5 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) [12], 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 [13], 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 6 PAS 2080 specifies requirements for the management of whole-life carbon in infrastructure, both in the provision of new assets/facilities and the upgrading of existing infrastructure. It specifies requirements for establishing effective governance systems for reducing whole-life carbon through the use of a carbon management process.

NOTE 7 A new, upgraded, repurposed or refurbished asset/facility can help the owner meet the requirements of key stakeholders, such as regulators, and new legislation. The preparation and maintenance of a health and safety file throughout design, manufacture and construction and into operations is covered by legislation [14].

NOTE 8 It is important to recognize that the full impact of the new, upgraded, repurposed or refurbished asset/facility might not be seen for many years. For this reason, the evaluation of the asset/facility's performance over what might be regarded as the long term falls outside the scope of this British Standard.

NOTE 9 The realization of value from an asset/facility 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/facility 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/facility (see BS ISO 55000 and BS EN ISO 41001). Benefit and utility are synonymous with value and all three are linked to cost and risk.

4.4.5 Evidence-based approach

*COMMENTARY ON **4.4.5***

Evidence-based design, manufacture 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 and economic performance, including demonstration of the owner's, operator's and users' satisfaction with the asset/facility in operation.

An evidence-based approach to design, manufacture and construction should be adopted, in which decisions are based on the best available information from multiple sources, including

but not limited to the owner's business objectives and plan, current operations, 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 each delivery team. Information and data for these purposes should be handled, stored and protected in accordance with the owner's and/or operator's security requirements (see **5.2.6**).

NOTE 1 Information and data related to the owner's current and future business objectives and operations might include sensitive commercial and economic details, as well as intellectual property, that need to be afforded appropriate and proportionate protection.

NOTE 2 BS 7000-4 provides guidance on the management of design, including a general approach to briefing.

4.5 Processes

4.5.1 High-level processes

*COMMENTARY ON **4.5.1***

*This subclause makes recommendations on high-level processes. Other processes and sub-processes are addressed in subsequent subclauses, especially those covering work stages (see Clause **5**).*

The following recommendations should be met as the minimum.

a) Design, manufacture and construction – the asset/facility should be delivered to the required operational requirements to allow it to perform as expected for its planned life subject to an appropriate maintenance regime (see **5.3.4**, 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 adopted where necessary (see **5.5.1**). In this regard, the owner should determine whether or not specific processes for configuration management, system integration and verification are required during design, manufacture and construction (see **4.5.6** and BS ISO/IEC/IEEE 15288). Where deemed necessary, these processes should be incorporated in the relevant work stages (see Clause **5**).

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

   NOTE 2 The distinctions between requirements management, configuration management and change control can be misunderstood. Defining and separating the roles and responsibilities is therefore essential. In requirements management, the focus is on stakeholders, their needs and requirements; in configuration management, the focus is on functional relations within an asset system or an element of the facility. In change control, the focus is on an effective process that links needs and requirements with functional relations to achieve and maintain performance of the asset/facility.

b) Commissioning, training and handover – the commissioning and handover of the asset/facility should be supported by training to meet the needs of the operator, users and other key stakeholders (see **5.6** and **5.7**).

c) Asset/facilities management – the strategic asset management plan (SAMP) or facilities management strategy, as appropriate, should be aligned with the owner's or operator's business strategy (see **5.1**).

d) Information and security management – the management of information and security should be efficient and effective in terms that are quantifiable.

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

NOTE 3 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.

4.5.2 Integrated project delivery

*COMMENTARY ON **4.5.2***

*An integrated delivery team brings benefits in coordinating design and problem solving, as well as in determining constructability and operability impacts. A related principle is extending the commitment of each delivery team to defined periods of aftercare during operation and use (see **4.6.2**) as part of an extended project life cycle (see **5.7** and **5.8**). An integrated process and delivery team overcomes the potentially disjointed relationship between the process for delivering the asset/facility (i.e. project management) and its operation (i.e. asset/facilities management). A further advantage is that information management, using building information modelling, acts more effectively as an embedded set of coordinated procedures and practices.*

A unified process of design, manufacture, construction and operation should be adopted for the project and be supported by an adequately resourced, integrated project team under the guidance of a project team. The project team should be led by a project manager reporting to the owner, operator or project sponsor, as appropriate (see **4.2.4**).

*NOTE The owner, operator or project sponsor might have a specific model in mind for operating the asset/facility, which the operator or asset/facility manager will be expected to implement (see **4.5.2**).*

Where a target operating model for the asset/facilities management is necessary to support the delivery of the owner's or operator's business strategy, requirements should be expressed in terms of the personnel, processes, data and technology required for this purpose as part of the strategic asset management plan (SAMP) or facilities management strategy.

4.5.3 Front-end loading

*COMMENTARY ON **4.5.3***

*Front-end loading (FEL) focuses on those work stages that bring the project to a state of readiness for manufacture and construction. It is a process for addressing the robustness of the business case, developing the concept, determining its strategic fit, assessing the risks (threats and opportunities) and evaluating the project's feasibility. FEL aims to maximize the potential for success by committing appropriate resources to establish that the "right project has been selected". The front end of the project is where the greatest influence on the project and its outputs can be brought to bear. It is also the time during which expenditure is relatively low, typically representing around 3% to 5% of the total project cost. The quality of FEL is one of the most significant factors, if not the most significant, in determining project success. FEL typically comprises three phases: FEL-1, where the business case, overall feasibility and strategic fit of the potential investment are evaluated; FEL-2, where scope definition, alignment of stakeholder interests and scope, quality, time, cost and value trade-offs are determined; and FEL-3, where design is advanced to the point that technical design and execution planning are sufficient to move the project into manufacture and construction. FEL in these three phases maps directly to the project life cycle (see **4.3.1**) and work stages (see **4.3.3** and Clause **5**) to provide a framework within which work can be controlled.*

The project sponsor should adopt a three-phase, front-end development process to establish the project before committing major resources and their associated expenditure to manufacture and construction.

4.5.4 Opportunity shaping

*COMMENTARY ON **4.5.4***

Opportunity shaping (or framing) is a business-led process in which the project sponsor evaluates the key attributes of the project, develops and gathers information needed for key decisions, then allocates the value of the project to various stakeholders to make the project environment sufficiently stable for successful implementation. The format for this process is, typically, one or more workshops.

Design should commence only after opportunity shaping has closed. Formal "sign-off" by key stakeholders should be secured at this point.

NOTE 1 Closure of opportunity shaping occurs when those stakeholders with a claim on value or benefits are satisfied with the structure of project and agree to proceed. If the shaping process is not formally closed, there is the likelihood of scope change and scope creep, leading to misalignment between scope, quality, schedule, cost and value or benefits.

After closure of opportunity shaping, no scope changes should occur unless warranted for reason of HSSE risks, inoperability or where the project sponsor is satisfied that the value or

benefits expected to derive from the change outweigh any negative impacts on schedule, cost or other practical consideration (see **4.5.7**).

NOTE 2 There is no single document or activity that defines closure of opportunity shaping. It can be a set of formal contracts with stakeholders or memoranda of understanding.

NOTE 3 Shaping errors and omissions can occur from failure to achieve alignment among stakeholders (e.g. giving disproportionate value or benefits to some stakeholders so that the project loses its appeal to others), failure to develop clear project objectives and value drivers, or impractical scope, quality, time and cost trade-offs. In such cases, the opportunity might have to be re-shaped.

4.5.5 Requirements management

*COMMENTARY ON **4.5.5***

*There is a crossover between requirements management and information management (see **4.7**). Information and data have to be elicited from the owner and users, among other key stakeholders, concerning their needs and preferences, and there has to be a method for controlling this process. Requirements management is that process.*

Requirements management is the process of capturing, analysing, justifying and baselining needs then controlling change and maintaining communication with relevant stakeholders. If requirements are not adequately identified, justified, specified and maintained, substantial changes later in the project are inevitable leading to schedule and cost overruns. Requirements evolve and mature through the work stages of Preparation and Brief, Concept and Definition.

Requirements should be drafted to describe what the owner and/or operator and other key stakeholders need. Requirements should focus on what is necessary, not how they will be achieved.

NOTE Requirements developed during the Preparation and Brief work stage typically comprise a high-level view of "wants" although will not necessarily describe what is needed.

As the project moves into the Definition work stage and more is known about solutions, the requirements should be revisited, refined and validated to verify that they are realistic and can be satisfied. Later in the Definition work stage, the solution should be verified against the requirements.

4.5.6 Configuration management

*COMMENTARY ON **4.5.6***

Configuration management encompasses the activities concerned with the creation, maintenance, controlled change and quality control of the scope of work and its deliverables and other outputs. Configuration focuses on system integrity and is closely linked to change control.

Configuration management should be utilized to achieve consistency in the asset/facility's performance, functional and physical attributes in terms of requirements, design and operational performance. Before any change to the configuration of asset systems or elements of the facility is considered for approval, the full implications should be determined.

4.5.7 Change control

*COMMENTARY ON **4.5.7***

As the project moves progressively through the Definition work stage, the design becomes more detailed with numerous interdependencies "hardwired" into the project's development. Allowing a scope change, which by definition is on a higher level (of detail), means that many of these interdependencies will be impacted, with knock-on effects that might be difficult to identify and resolve.

A change control process should be implemented by the project team to control change (see **4.2.4**). All proposed changes to the approved baseline of the project should be evaluated. A distinction should be drawn between scope changes, for which there is no provision in the approved budget, and non-scope changes, where adjustments might have to be funded from the project's cost contingency.

NOTE It is unlikely that anyone would propose a change that was other than beneficial, at least from the perspective of the person proposing the change. Nonetheless, all changes to the approved baseline for the project will have consequences, such as potentially compromising system integrity, and might also affect the achievement of project objectives with negative impacts on schedule and cost.

4.6 Post-project actions

4.6.1 General

*COMMENTARY ON **4.6.1***

*Post-project actions fall within the extended project life cycle (see **5.7** and **5.8**) and include periods of aftercare (see **4.6.2**) that are an owner's requirement built-in from the outset to ensure that the functional requirements and expected performance of the asset/facility are realized. Two key practices in this regard are post-implementation review (see **4.6.3**) and POE (see **4.6.4**).*

Post-implementation reviews and/or POEs should form an integral part of aftercare with provision built into work stages from the Preparation and Brief work stage onwards.

4.6.2 Aftercare

*COMMENTARY ON **4.6.2***

Instead of operational requirements informing and, to a certain extent, driving design, manufacture 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 as these are the ends that the owner/operator is seeking, whilst the project is the means to those ends. Handing over the asset/facility can no longer be seen as, more or less, the final act for each delivery team. Ensuring that the asset/facility performs as required necessitates defined periods of aftercare that allow for the adjustment and optimization needed to achieve the required operational performance.

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

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

The period of extended aftercare should include an assessment of the functionality and effectiveness of the asset/facility through post-implementation review (see **4.6.3**) and/or POE (see **4.6.4**). A proven methodology should be selected for these purposes as opposed to *ad hoc* arrangements that might be devised more for expediency than systematic evaluation.

NOTE 2 Post-implementation reviews are applicable to all constructed assets irrespective of type. In addition, POEs are applicable to buildings and other occupied spaces. The latter could be incorporated within the former where more detailed assessment is needed by users on, for example, aspects of the working environment such as indoor air quality, lighting, noise and thermal comfort.

NOTE 3 BSRIA's Occupant Wellbeing (BOW) Survey [15] assesses user satisfaction and well-being, covering the physical environment, indoor facilities, functionality and accessibility. It provides qualitative information that allows the owner, operator, operations team and asset/facility manager to measure the impact of building services on user perception of well-being. The BUS methodology [16] is an example of a survey that quantifies occupant satisfaction, reveals features of value or concern in the asset/facility and provides feedback. The Design Quality Indicator (DQI) [12] is a five-stage method for evaluating the design over the project life cycle against three quality principles: functionality, build quality and impact.

NOTE 4 Long-term considerations, for example, ongoing optimization of the asset/facility's operational performance and planned maintenance, can extend for many years, necessitating a long-term view of the predicted design life and operational performance of the asset/facility.

4.6.3 Post-implementation review

*COMMENTARY ON **4.6.3***

Post-implementation review involves the measurement of the outcomes of a project for the delivery of an asset/facility and the performance of that asset/facility in operation with lessons learned for future projects.

A post-implementation review should not be a one-off exercise but should instead be a periodic control and check on asset/facility performance to determine if it continues to meet requirements and expectations (see **4.3.3**).

4.6.4 Post-occupancy evaluation (POE)

*COMMENTARY ON **4.6.4***

POE or building performance evaluation (BPE) is a process for evaluating an asset/facility after it has been completed and is in use to understand its actual performance against that required and to capture lessons learned.

A POE should not be a one-off exercise but should instead be a periodic check and control on facility performance to determine if the asset/facility continues to meet requirements and expectations (see **4.3.3**).

NOTE Attention is drawn to BS 40101[3] and to "Building Performance Evaluation in Non-Domestic Buildings" (BG 63/2015) [17] which contains important guidance on tests and methods that can provide information on the building fabric, building services and operating strategies, energy use, handover and commissioning processes, user satisfaction, well-being and thermal comfort.

The project team should be aware of the benefits of a pre-occupancy evaluation in the case of upgrading and refurbishment projects, where a systematic approach to understanding users' needs and expectations can provide valuable inputs for establishing targets and expected outcomes.

4.7 Information management

4.7.1 General provisions

*COMMENTARY ON **4.7.1***

Information management encompasses the definition and management of an information model from design, through construction, and into operation of the asset/facility. The use of information modelling in general and the creation and management of a project and/or asset information model in particular is seen in the context of the owner's information management system of which its asset/facilities management system forms a part.

The owner should verify that there is sufficient information technology, human resources and competence to support information management.

NOTE When communicating information and data, it is important to verify that there is absolute clarity of meaning. Information requirements are best established from questions and answers that are formulated, as far as practicable, in plain language in accordance with the exchange information requirements (EIR).

4.7.2 Information management framework

*COMMENTARY ON **4.7.2***

Asset information models (AIM) and project information models (PIM) are the structured repositories of information needed to make decisions during the life cycle of a built asset. This includes the design, manufacture and construction of new assets/facilities, repurposing or refurbishment of existing assets/facilities, and the operation and maintenance of the asset/facility. AIM and PIM can include structured and unstructured information. Examples of structured information include geometrical models, schedules and databases. Examples of unstructured information include documentation, video clips and sound recordings. Most projects involve work on an existing asset/facility, even if this is a previously undeveloped site. These projects would be expected to include pre-existing asset/facility information to support the preparation of the brief and to assist lead appointed parties working on the project (BS EN ISO 19650-1).

The owner or project sponsor, as appropriate, should define the information management strategy for the project (see **5.1.1**). This should include the exchange information requirements (EIR) (see **4.7.8**) and subsequent arrangements for the capture and phased and final transfer of project information and data for operational purposes from the PIM to the AIM (see **4.7.4**). The arrangements to support asset/facilities management through the use of the owner's defined enterprise system or equivalent should be defined. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements where requested by the owner or project sponsor on its behalf. The intended arrangements for the asset information model (AIM) should be confirmed.

[3] In preparation.

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/facility. The requirements should encompass people, processes, physical and technical aspects.

4.7.3 Relationship with defined processes

*COMMENTARY ON **4.7.3***

The AIM and PIM are produced throughout the information life cycle and are utilized across the asset/facility life cycle to support decision-making.

The owner or project sponsor, as appropriate, should ensure that there is alignment at all times between the information life cycle and the asset/facility life cycle.

4.7.4 Information and data requirements

The owner or project sponsor, as appropriate, should take account of the following with respect to information management:

a) the workflow and technology making up the common data environment (CDE);

b) the information to be delivered by each delivery team to support decision-making throughout design, manufacture and construction, and into operation and use of the asset/facility;

c) the format and means for information exchange;

NOTE 1 Various information exchange standards are available (see the UK National Annex to BS EN ISO 19650-2 and Annex E).

d) the structure and format of the asset information model (AIM) that is to receive the content from the project information model (PIM);

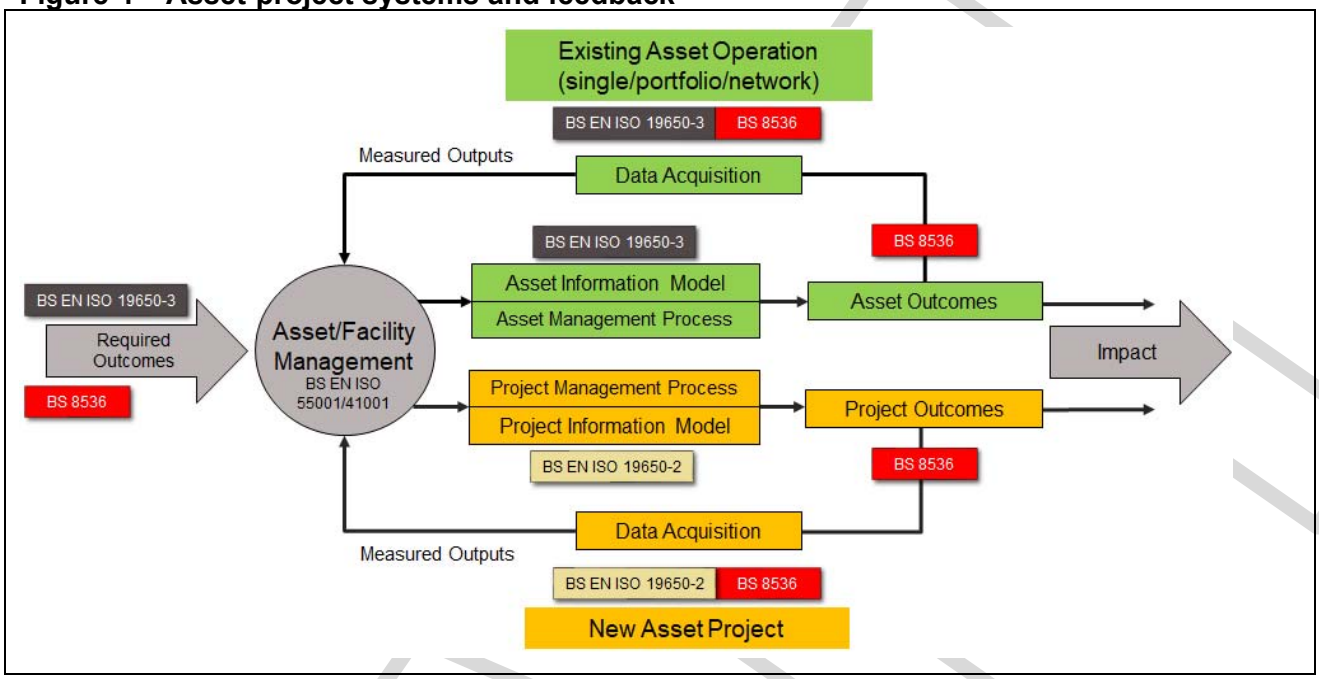
e) details of how content from the project information model (PIM) is to be transferred into the owner's asset information model (AIM);

f) requirements, policy, processes and procedures for the security of information and data, including the management of access, both physically and digitally; and

g) software to be used to meet operational and security requirements, such as the owner's defined enterprise system or equivalent (see **4.7**).

*NOTE 2 Figure 4 illustrates the relationship between assets/facilities and projects. A common failing in practice is that the systematic feedback that occurs in the asset/facilities 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/facilities management system. The figure also emphasizes the important relationship between this British Standard and those standards supporting information management, using building information modelling and which are cited as normative references (see Clause **2**).*

Figure 4 – Asset-project systems and feedback



4.7.5 Organizational information requirements (OIR)

*COMMENTARY ON **4.7.5***

"OIR explain the information needed to answer or inform high-level strategic objectives within the appointing party. These requirements can arise for a variety of reasons, including strategic business operation, strategic asset management, portfolio planning, regulatory duties or policy making" (BS EN ISO 19650-1). The appointing party would normally be the owner or the project sponsor on behalf of the owner.

The owner, operator or project sponsor, as appropriate, should prepare information requirements with respect to its organizational needs to inform the asset information requirements (AIR) and the project information requirements (PIR). These in turn inform the exchange information requirements (EIR).

4.7.6 Asset information requirements (AIR)

*COMMENTARY ON **4.7.6***

"AIR explain the information needed to answer or inform high-level strategic objectives within the appointing party in relation to a given asset. AIR are identified from the asset management process." (BS EN ISO 19650-3).

The owner or project sponsor, where appropriate, should define the asset information requirements (AIR) to be met in order that the organizational information requirements (OIR) can be satisfied.

4.7.7 Project information requirements (PIR)

*COMMENTARY ON **4.7.7***

"PIR explain the information needed to answer or inform high-level strategic objectives within the appointing party in relation to a given project. PIR are identified from both the project management process and the asset/facilities management process."' (BS EN ISO 19650-1).

The owner or project sponsor, where appropriate, should define the project information requirements (PIR) to be met in order that the organizational information requirements (OIR) can be satisfied. Where the project forms part of a programme or portfolio, a generic set of PIR may be developed and adopted, with or without amendment, for all projects.

4.7.8 Exchange information requirements (EIR)

*COMMENTARY ON **4.7.8***

"EIR set out managerial, commercial and technical aspects of producing project information. The managerial and commercial aspects include the information standard and the production methods and procedures to be implemented by each delivery team. The technical aspects of the EIR specify those detailed pieces of information needed to answer the PIR. These requirements are expressed in way that they can be incorporated into project-related appointments. EIR normally align with trigger events representing the completion of some or all work stages. EIR are identified wherever appointments are being established. In particular, EIR received by a lead appointed party can be sub-divided and passed on in any of its own appointments and so on along the supply chain. EIR received by appointed parties, including lead appointed parties, can be augmented with their own EIR. Some of the EIR can be passed to their own appointed parties, particularly where information exchange within a delivery team is necessary and this information is not to be exchanged with the appointing party. Several different appointments can exist in a project. The EIR from all these appointments is expected to form a single, coherent and coordinated set of information requirements, sufficient to address all the PIR."
(BS EN ISO 19650-1).

The owner should define its requirements adequately and clearly in terms of the information to be provided by each 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 information exchange points (see **4.3.3**). Each information requirement should have regard for the level of information need, which should be supported by an appropriate classification and data model (or ontology).

NOTE 1 Classification alone does not define the level of information need. A data model (or ontology) is necessary to show the properties of a subject area and how they are related, by defining a set of concepts and categories that represent the subject. By specifying both the classification and its associated data model or ontology, the owner or operator can be assured that the information provided by their delivery teams is well structured and machine readable, enabling it be consumed by the asset management system, for example. Annex E gives example classification systems.

The owner or operator, as appropriate, may create its own organizational ontology from the information it utilizes to bring together the taxonomies and terminologies across the organization to provide context and relationships to all data-related activities. This, in turn, provides a standardized way for all appointed parties and other stakeholders to promote a single source of information about the asset/facility and allow added-valued opportunities to be identified and exploited.

*NOTE 2 A closely-related document is the brief (see **5.2**), which is used for developing and, subsequently, evaluating design, manufacture and construction proposals (see **5.5.10**).*

The brief should be delivered in a digitally checkable form supplemented by the EIR.

4.7.9 Tender and appointment resources

The information to be provided by all appointees should be determined at the point of prequalification (see PAS 91) and incorporated in the invitation to tender as part of the EIR. Information requirements should be specified clearly so that each delivery team can understand, resource and deliver those requirements at the agreed information exchange points.

NOTE Resources extend beyond information and data to include personnel, equipment and materials.

4.7.10 Information acceptance and incorporation

Information and data should be authorized by each delivery team and accepted by the owner, operations team or asset/facility manager, as appropriate, before transfer between the PIM and the AIM. Once accepted by the operator, operations team or asset/facility manager, the status of the project information model should be "published".

5 Work stages

5.1 Strategy

5.1.1 General

*COMMENTARY ON **5.1.1***

The Strategy work stage involves defining the business case for the new or upgraded, repurposed or refurbished asset/facility, the project outcomes and required operational performance. It provides an essential baseline to assist in clarifying strategic intentions, not least the asset/facility's contribution to the business of the owner or operator. This stage can be thought of as one of strategic definition.

The owner, or the project sponsor on its behalf, should develop the business case and supporting arguments, including the expected benefits and the required performance of the new, upgraded, repurposed or refurbished asset/facility, in terms of its contribution to the business and alignment with the business objectives and plan. The work activities associated with this strategic definition (see **5.1.5**) should be identified together with the information and data required for this purpose (see **5.1.12**). Where the project is intended to cover an asset system and the needs of multiple stakeholders (see **5.1.6**), a formalized approach should be adopted for capturing and managing requirements (see **5.1.12** and BS ISO/IEC/IEEE 15288).

NOTE In the public sector, the development of the business case is highly prescribed. HM Treasury [19] defines a five-case model for a new, upgraded, repurposed or refurbished asset/facility. 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).

The information management strategy should be agreed between the project sponsor, each delivery team, and the operator, operations team or asset/facility manager, as appropriate, with the actions needed to collect, record and store information and data to support the primary activities (see **5.1.5**) of this work stage and subsequent stages.

A security triage process [see **5.1.5**b)] should be undertaken and where a security-minded approach is to be applied as a result, a security strategy, a security management plan and security information requirements should be developed by the owner for the asset/facility, taking advice as necessary.

5.1.2 Business case

*COMMENTARY ON **5.1.2***

*The business case provides justification for undertaking the project. The project sponsor owns the business case and the realization of benefits (see **5.1.10**). Normally, once the business case has been approved a project manager is appointed to take over leadership of the delivery phase. Sometimes, the project manager is given responsibility for preparing the business case, possibly with specialist support, because of access to key information and data.*

A business case should be prepared to answer the following questions as a minimum.

a) What is the justification for the project?

b) Does it align with the business objectives?

c) Does it align with the priorities in the business?

d) What are the business benefits?

e) Do the benefits outweigh the costs?

f) How well defined is the scope?

g) Are there constraints that could threaten the project objectives?

h) What can reasonably be assumed?

i) What are the risks?

j) Have the stakeholders in the project been identified?

k) Has the potential impact of stakeholders been assessed?

l) Have alternative development options been considered?

m) Is the rationale for the project sound?

n) Is approval for the project required and, if so, what is involved?

NOTE 1 The difference between business objectives and project objectives is not always understood and they are often considered incorrectly to be one and the same. All objectives can be considered against SMART (specific, measurable, achievable, relevant and time-bound) criteria to determine their fitness for purpose.

The business case should be formalized to include the following as a minimum:

1) description of the opportunity or problem to be solved;
2) formal statement of the business need and expected benefits;
3) relationship with other business requirements and interdependencies;
4) priority of need within the business;
5) high-level scope statement, project schedule and cost;
6) success criteria and how success is to be measured;
7) project objectives, constraints, assumptions and risks; and
8) definition and justification of chosen project option.

*NOTE 2 Success criteria are covered in **4.4.4** and the BSRIA Guide on "Success Criteria for Soft Landings Projects" [5].*

NOTE 3 It is recognized that an immediate concern is the delivery of the asset/facility and the realization of benefits and that limited consideration is given to decommissioning, dismantling or repurposing the asset/facility at the end of its service life. Having an end-of-life defined strategy for dealing with such eventualities could become a condition for development approval and compliance with legislation on HSSE.

The owner or project sponsor should state its position regarding the decommissioning, dismantling or repurposing the asset/facility at the end of its service life and how these activities can be accommodated in the business plan and brief for the asset/facility.

NOTE 4 Attention is drawn to the implications for HSSE and legislation in this regard [20].

Discussions around the choice of contractual approach in the context of procurement in general should align with the business case and business objectives, not just the project objectives.

5.1.3 Organizational context

5.1.3.1 Project, programme and portfolio

The relationship between the project and any programme or portfolio of which it is a part should be made clear by the owner, or project sponsor, to the project team and each delivery team, together with any additional or special requirements in terms of objectives, outputs and outcomes.

The project team, including each delivery team and its supply chain, should be informed of any additional or special requirements that apply to the project because of its place in a programme or portfolio.

NOTE 1 Where a project is managed as part of a programme or portfolio (see BS ISO 21500 family), it is necessary to verify alignment with the other projects and business as usual (BAU) activities across the organization. Important guidance is available in The Construction Playbook [10] and Project 13 [21], including a greater focus on the front end of projects and the thoroughness with which opportunities are shaped or framed in the wider business context to set-up projects for success.

NOTE 2 Programme and portfolio management techniques are outside the scope of this British Standard; however, if the asset owner adopts either or both it will be necessary for:

- *programme and or portfolio management teams to be established;*
- *the programme and/or portfolio management teams to be involved throughout the life cycle of their constituent projects; and*
- *the extent of the programme and/or portfolio management teams involvement in the projects to be defined in the programme and/or portfolio management plans.*

5.1.3.2 Programme and/or portfolio management plans

Where the project forms part of a programme and/or portfolio, the project team should work with the programme and/or portfolio management teams to align the project execution strategy or project management plan with the programme and/or portfolio management plans. Particular attention should be paid to understanding and shaping the CDE and expectations regarding the PIM and AIM to ensure consistency and facilitate programme or portfolio level data.

5.1.4 Feedback from previous projects

*COMMENTARY ON **5.1.4***

Documented case studies and lessons learned offer a useful starting point for project teams by helping to avoid needless issues and problems in the new project. Little point is, however, served by making such documentation available once the project is under way. While lessons learned from previous projects might provide confirmation of a particular approach or decision, it is likely to be too late to undo the work, actions and decisions that have led to the present state.

The project team should have access to documentation on previous projects that have relevance to the project before it is initiated.

5.1.5 Primary activities

The owner, operator or the project sponsor, as appropriate, should determine the extent to which the following work activities might apply to its strategic definition of the asset/facility and the project required to deliver it:

a) identifying the business-related activities and processes that the new, upgraded, repurposed or refurbished asset/facility will be required to support;

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

c) identifying the high-level needs of the owner, operator, users and other key stakeholders;

*NOTE 1 A formalized approach to capturing and managing requirements is available to assist in identifying and defining needs (see **5.1.12** and BS ISO/IEC/IEEE 15288).*

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

e) determining the environmental, social and economic performance outcomes and targets, as appropriate;

f) identifying the uncertainties and significant risks in the project and capture these in a risk register;

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

h) reviewing or identifying the particular competences, skills and experience necessary for each delivery team;

i) reviewing or determining the basis of the engagement of each delivery team and its relationship with the operator, operations team or asset/facility manager, as appropriate, users and other key stakeholders;

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

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

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

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

n) preparing 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) to arrive at a realistic estimate of the project's time;

NOTE 2 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. For example, 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) establishing an initial estimate of capital expenditure to include cost contingency and a statement of its accuracy;

NOTE 3 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 30% 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 the design, construction and risk exposure, a quantitative (i.e. probabilistically derived) cost risk analysis is likely to confirm the realistic view rather than the optimistic view. A similar approach applies to estimates of the project's time (i.e. schedule) [see n)].

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

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

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

The owner, operator or project sponsor, as appropriate, should determine which, if any, of the activities in a) to r), with the exception of the activity listed in b), are to be undertaken by the project team or a delivery team, if appointed at this stage. The owner or project sponsor should determine which, if any, of the following activities the operator, operations team or asset/facility manager, as appropriate, are to undertake:

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

2) identifying the approach to be taken to post-implementation review and/or POE, including the techniques and tools for these purposes;

3) establishing 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) identifying any existing strategic asset management plan (SAMP) or facilities management strategy, as appropriate, and supporting policy and procedures or, where none exists, preparing such a plan in outline;

5) identifying the extent of existing information modelling covering the owner's asset/facilities;

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

7) identifying a holistic approach to address security of people and process, as well as physical and technological security.

NOTE 4 BS ISO 55000, BS ISO 55001, BS ISO 55002 and BS EN ISO 41001 provide guidance on the factors to be accounted for by an organization when managing its asset/facilities.

5.1.6 Stakeholders

*COMMENTARY ON **5.1.6***

There is a direct relationship between the definition of stakeholders' needs and the definition of requirements for a new, upgraded, repurposed or refurbished asset/facility. First, stakeholders are identified and their likely impact upon the asset/facility over its life cycle are analysed. Second, stakeholder needs are assessed in terms of requirements for the asset/facility, which are then prioritized. Third, the stakeholder impact analysis is updated as progress is made in the project and where there are changes in stakeholders, their interests and/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, upgraded, repurposed or refurbished asset/facility 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 project sponsor and project manager should 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 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 [22].

Responsibility for eliciting the interests and needs of users of the asset/facility and other key stakeholders should rest with the project sponsor or the project manager, as appropriate. Stakeholder needs should be documented in a way that allows for assessment in terms of requirements for the asset/facility (see **5.1.12**).

NOTE 2 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 [14], [23].

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

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

5.1.7 Prioritization of needs

Performance targets should be determined by the owner, operator or project sponsor, as appropriate, based on a range that is recognized as achievable, and should be agreed with each delivery team involved in this work stage. 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 operator, operations team or asset/facility 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 **5.8.2**). Targets should be achievable and not aspirational.

*NOTE 1 Measures of the variance between actual and target performance enable the operations team to pinpoint the cause(s), allowing for adjustment and optimization of the asset/facility's operational performance as soon as possible (see **5.8.2**). 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.*

Where the owner, operator or project sponsor, as appropriate, determines that changes to the performance outcomes and/or targets are necessary, details should be communicated to the project team, including each delivery team involved in this work stage and the operator, operations team or asset/facility manager, as appropriate. These should then be recorded in the relevant part of the project information model (PIM).

NOTE 2 Performance outcomes and targets might need to be reconsidered if, during the prequalification of prospective appointees to each delivery team (see PAS 91), it becomes apparent that the required performance is unlikely to be met.

5.1.8 Whole life cycle approach

*COMMENTARY ON **5.1.8***

Total cost of ownership and whole-life costing are different but related concepts. The former seeks to minimize expenditure over the product life cycle, taking account of operational expenditure, capital expenditure and revenue expenditure. The combined concept of total expenditure (TOTEX) in some sectors and organizations is replacing the rigid separation of traditional cost centres as it helps to overcome the longstanding conflict between those who hold the capital budget for the asset/facility and those who hold the operational budget. Each generally wishes to minimize its budget, with consequences for the other. Whole-life costing attempts to balance current expenditure with future expenditure to achieve an optimal result and is, in the case of built assets, a technique that is focused largely on repair and replacement costs set against the original capital expenditure. Assets/facilities that have a high degree of engineered systems content are susceptible to expensive replacement costs, so maintenance regimes need to be sensitive to the risk of failure in critical systems and the consequences for the business and users.

A whole life cycle approach should be adopted for the project, utilizing whole-life costing.

5.1.9 Sustainable space provision

Where appropriate, the space efficiency of the asset/facility should be calculated and used to assess the owner's need for space over the planned lifetime of the asset/facility. The assessment should include allowance for growth and/or reduction in the demand for space and its phasing over the lifetime of the asset/facility, as well as the need for adaptability for uses different to those for which it might have been originally intended.

An assessment should, as far as practicable, be made of the extent to which space provision will be affordable into the future. Account should be taken in this assessment of the space necessary to achieve an inclusive design that anticipates the needs of people with mobility, sensory or cognitive impairment and others with equalities-related needs in accordance with design standards such as BS 8300-2 and BS 9999.

NOTE Attention is drawn to the Equality Act 2010 [24].

5.1.10 Issues and risks

Attention should be paid to the need to differentiate between issues and risks, where the former are certain events that have to be resolved and the latter are events that might or might not occur but, if they did, would have an effect on project objectives either negatively or positively.

Issues affecting the work in this stage and the planned deliverables (see **5.2.13**) should be identified and recorded, and the most appropriate response should be determined, including necessary changes in planning for the project and their time, cost and consequences for the achievement of the business objectives and realization of benefits.

The owner, or project sponsor on its behalf, should be aware of the issues 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. Other issues that might prevent or in some other way frustrate efforts to define the business case and associated matters of strategic importance should be recorded and steps taken to resolve them.

The risk register should be used to record:

a) threats to the achievement of the project objectives, expected benefits and required performance outcomes and targets; and

b) opportunities for improving the outcomes and the operational performance of the asset/facility.

A risk identification workshop should be conducted for this purpose.

The project team, and each delivery team involved in this work stage, 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 treatments (see **5.2.8**). The owner, operator or project sponsor, as appropriate, 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 treatments.

The owner, operator or project sponsor, as appropriate, should determine the most appropriate treatment for 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 each delivery team involved in this work stage or any other stakeholder.

Account should be taken of any potential for avoiding the threat or realizing the opportunity, reducing or increasing the extent of exposure for the owner and operator, and the likelihood of occurrence. The implications from whichever treatment is selected should be established with respect to the schedule, resources and cost.

NOTE No useful purpose is served by an action that involves transferring a particular risk to a party that is ill-equipped to handle it. As a specific risk treatment, "risk transfer" on smaller projects is likely to be possible because the risks (i.e. threats) might not be so great and the parties within each delivery team have the capability and capacity to respond to them without necessarily damaging their business. Exposure on projects above a certain size with the same owner is an important consideration for a contracted party's top management. This is no different to the owner expressing concern over its exposure to a single contracted party. If the contracted party fails on one project, it fails on them all.

5.1.11 Roles and responsibilities

The project team should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **4.2.5** and **5.1.5**) and their associated deliverables (see **5.2.13**) for this work stage.

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

The responsibility assignment matrix should be kept up to date and be used to inform the start of the Preparation and Brief work stage. Details of the information exchange requirements for this work stage should be summarized by the project team or each delivery team, where appointed (see **5.1.12**).

NOTE 2 Annex A gives an example RASCI chart and a design responsibility matrix.

5.1.12 Information and data assessment, needs and requirements

The following information should be taken into account for the purpose of supporting the work activities (see **5.1.5**) and contributing to the deliverables (see **5.2.13**) in this work stage:

a) the owner's business case for the new, upgraded, repurposed or refurbished asset/facility;

b) strategic fit;

c) project objectives, constraints and value drivers;

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

e) lessons learned from previous projects, as appropriate;

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

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

h) 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/facility 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/facilities management, including maintenance;

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

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

u) time frame and key dates;

v) details of any technical strategy;

w) details of any standardization or replication requirements;

x) strategic asset management plan (SAMP) or facilities management strategy;

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

z) owner's or operator's requirements for project governance.

*NOTE 1 Instead of accounting for capital expenditure and operational expenditure separately, total expenditure (TOTEX) could be adopted (see **5.1.8**).*

NOTE 2 For HSSE, there might be 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, the commitment might be to "no physical vulnerabilities".

Each of the information requirements in a) to z) should be obtained through a plain language question or questions to verify that the requirements are understood by the person or party receiving the request for information.

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

5.1.13 Common data environment

The owner, operator or project sponsor, as appropriate, 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/facilities management through the use of the owner's defined enterprise system or equivalent should be confirmed or revised. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements where requested.

5.1.14 Shared resources and reference information

The project sponsor should provide the project team, including 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 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 and/or POE in the Use work stage;

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

e) communication plan to support stakeholder engagement;

f) health and safety file, where the asset/facility is existing;

NOTE 1 The health and safety file for an existing asset/facility needs to be transferred from the AIM to the PIM for the new project, together with associated information for operations.

g) risk register;

h) format for presenting evidence to support subsequent design, manufacture and construction proposals; and

i) plan for the next work stage.

*NOTE 2 The emphasis on evidence-based design, manufacture and construction (see **4.4.5**) requires up-front agreement on the format of evidence for supporting assertions, assumptions and the decisions that stem from them.*

5.1.15 Key decisions and next steps

The project sponsor, in consultation with the owner and/or operator, should determine if the business case for the new, upgraded, repurposed or refurbished asset/facility is sufficient to progress to the Preparation and Brief work stage. The project team and the operations team or asset/facility manager, as appropriate, should be informed accordingly. Where the owner intends to proceed, the project team, including each delivery team involved in this work stage, should give the project sponsor the opportunity to review and approve the planned work activities and their associated information requirements and deliverables for the Preparation and Brief work stage prior to its commencement.

NOTE An appropriate plain language question 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.

5.2 Preparation and Brief

5.2.1 General

*COMMENTARY ON **5.2.1***

The Preparation and Brief work stage is concerned with developing project objectives, including operational requirements and performance outcomes and/or targets for the asset/facility over defined planning horizons (e.g. short, medium and long term or other period defined by the owner). It is a pivotal point in the life cycle of the asset/facility at which the project objectives, expected benefits, operational requirements and required performance outcomes and/or targets are defined, discussed and agreed between the owner, operator or project sponsor, as appropriate, and the project team including each delivery team and the operations team or asset/facility manager, as appropriate. The benefits, requirements and outcomes are revisited in subsequent work stages to verify that the teams continue to align themselves with the expected performance against which actual performance of the asset/facility, as well as their own performance, can be measured.

The owner, operator or project sponsor, as appropriate, should assemble the project team, including each delivery team, the operations team or asset/facility manager, as appropriate, and any other key stakeholder or specialist who can contribute to the preparation of the initial brief for the new, upgraded, repurposed or refurbished asset/facility. The project team should prepare this initial brief and should verify that the details of information exchanges between it and other parties are adequately defined (see **4.7.8**). The plan for information exchange should be used to define and control this work.

NOTE This task may be undertaken by each delivery team involved in this work stage with the assistance of the operator, operations team or asset/facility manager, as appropriate.

5.2.2 Primary activities

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

a) defining the scope and boundary conditions for the proposed asset/facility and project;

b) summarizing the relevant lessons learned from experience with previous projects and how they relate to the asset/facility and the project for its delivery;

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

e) determining the environmental performance outcomes and/or targets for the asset/facility over defined planning horizons (see **4.4.4**);

f) preparing 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) preparing a schedule of the named areas or zones and any named systems comprising the proposed asset/facility that are known at this time;

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

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

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

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

l) updating the risk register;

m) updating the project management schedule;

n) updating the estimate of capital cost;

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

NOTE 1 In the case of public sector projects, HM Treasury [25] calls for an adjustment to time and cost estimates to counter optimism bias by decision makers arising from the tendency for times and costs to be understated and benefits to be overstated. One 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 undertaking quantitative cost and schedule risk analysis are lacking.

p) determining how project information is to be transferred from the PIM to the AIM, asset register and the owner's defined enterprise system or equivalent (see **4.7.2**).

The project 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/facility manager, as appropriate, should undertake:

1) developing or updating the strategic asset management plan (SAMP) and policy or facilities management strategy and policy, as appropriate;

2) preparing a plan for measuring operational performance during the Use work stage;

3) identifying the need for any temporary transfer or relocation of personnel and/or equipment and outlining how this is to be managed;

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

5) preparing or updating the environmental management plan, as appropriate.

NOTE 2 Annex F provides an example of a "Brief checklist" to assist in matters of design.

5.2.3 Review of experience

*COMMENTARY ON **5.2.3***

The owner and the project benefit from the experience gained on previous projects and in managing existing assets/facilities. 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 project sponsor should assess the experience of the owner and operator, as appropriate, 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 project team, including each delivery team involved in this work stage, the project sponsor should conduct a review of the relevant experience. The project sponsor should allow for the participation of the operations team or asset/facility manager, as appropriate, in review meetings and may also permit the representative(s) of users and other key stakeholders to attend.

The project team, including delivery team, should study the owner's portfolio and/or undertake a review of published studies of similar existing assets/facilities to determine if there are worthwhile lessons to be learned. The project team, or delivery team on its behalf, should collate feedback and lessons learned from previous projects in which its members have been directly involved to allow the design to take account of constructability and operability criteria.

5.2.4 Intermediate reviews and verification

*COMMENTARY ON **5.2.4***

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 performance during start-up of operations. Peer reviews at key points during design development and in the Manufacture, Construct and Commission work stage reduce the likelihood of this occurrence.

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

The project 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, gates or gateways and reflect the adopted procurement method. The project 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 project sponsor may attend design reviews, but should leave the task of facilitation to the project team. Subsequently, the project team should inform the project sponsor of the topics to be peer-reviewed and verified, and capture and record the outputs to inform subsequent work stages up to and including the Use work stage.

NOTE A review and verification process termed "pitstopping" has been defined by BSRIA [26].

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

5.2.5 Environmental, social and economic performance

The project team should agree a set of performance outcomes with the owner and operator, as appropriate, or project sponsor on their behalf, and the operations team or asset/facility manager, as appropriate. These outcomes should provide the basis upon which the performance of the asset/facility is to be measured after handover (see **4.2** and **4.4.4**).

The outcomes should be continually referenced during peer review and verification (see **5.2.4**) 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/facility) approved by the owner or operator, as appropriate, or the project sponsor on its behalf. Each delivery team involved in this work stage should assist in the active monitoring of environmental, social and economic outcomes and targets. Progress towards meeting targets should be assessed and agreed at decision points, gates or gateways within the subsequent work stages.

The project sponsor should verify that an energy monitoring strategy is developed in collaboration between each delivery team involved in this work stage and the operator, operations team or asset/facility manager, as appropriate. The estimated energy use of the asset/facility should be measured at intervals during design, manufacture and construction coinciding with peer review and verification. Each delivery team involved in this work stage should verify that appropriate and sufficient equipment is specified and available to meet the owner's requirements for monitoring the environmental performance of the asset/facility once handed over. Similar provisions should be implemented to deal with monitoring water consumption and other environmental aspects (see **4.4.4**).

Each delivery team involved in this work stage should verify that energy use and water consumption data are based on metering and that any sub-metering is recorded, where applicable.

NOTE The principles of CIBSE TM39, Building energy metering [27], and the requirements of CIBSE TM31, Building log book toolkit [28], can assist in supporting data gathering. BS 8587 develops the concept of the

building log book into a facility handbook, which is a broader and more detailed collection of information about the asset/facility and its design, construction, operation and maintenance.

5.2.6 Security

The owner, operator or project sponsor should establish the required security-minded approach for the project, including appropriate steps for governance, accountability and responsibility.

Responsibilities should be defined for a person to be appointed by the owner, operator or project sponsor to verify that security risks are minimized through the collective efforts of all members of the project team, including each delivery team involved in this work stage and its supply chain.

5.2.7 Maintainability

A business-focused or risk-based model of maintenance should be adopted for the project, involving a review of business objectives and needs of the owner or operator, as appropriate, to ascertain the consequences of the failure of any aspect of the asset/facility on the business processes and activities. Critical systems and equipment should be identified and recorded to this effect. An assessment of the condition of engineered systems should be sought to support any available information available on the asset/facility's history, where upgrading, repurposing or refurbishment is involved.

NOTE BS 8210 recommends a business-focused and risk-based approach to facilities maintenance management.

5.2.8 Issues and risks

Issues affecting efficient and effective work in this stage should be identified at the start and actions taken to resolve them. Risks affecting the project and deliverables should be similarly identified and assessed and steps taken to treat them as appropriate.

NOTE Issues that can arise in this work stage include lack of stakeholder alignment on the project objectives and outcomes, and agreement on the scope definition.

The project should only proceed to the Concept work stage when objectives, outcomes and scope definition have been agreed among the project's key stakeholders.

The project team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and opportunities that might enhance outcomes. The project environment should be scanned for events that might constitute additional threats or opportunities.

The project team should proactively monitor and check the status of threats and opportunities recorded in the risk register, the events that might give rise to them and the results of risk treatment and any secondary risks that have arisen as a consequence. Where considered appropriate, the project sponsor should confirm that functional experts are available to address specific technical and non-technical risks.

5.2.9 Feasibility study

The owner, operator or project sponsor should determine if the business case and initial brief are sufficient to justify progression to the Concept work stage. A study should be undertaken by the project team to test the feasibility of the project, including its financial viability and the value or benefits that will result from the successful delivery of the asset/facility. The feasibility study should be a realistic attempt at quantifying both inputs in terms of cost and time, and the outputs and outcomes in terms of the deliverables and value or benefits for the project's stakeholders.

5.2.10 Roles and responsibilities

The project sponsor should request that the project team prepares a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **5.2.2**) and their

associated deliverables (see **5.2.13**) 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. A design responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design and the level of information need (see Annex A).

The owner, operator or project sponsor, as appropriate, 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.

5.2.11 Information and data

The following information should be taken into account for the purpose of supporting the work activities (see **5.2.2**) and contributing to the deliverables (see **5.2.13**) 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/facility;

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 design, manufacture or construction;

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

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

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/facilities management;

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

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

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

r) engineered system's philosophy;

s) details of specific requirements in asset/facilities 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 (see BS 8544 and BS ISO 15686-5);

u) information management plan;

v) extent to which building information modelling is to be used and who is to 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 or questions to verify that the requirements are understood by the person or party receiving the request for information and level of information need.

5.2.12 Common data environment

The owner, operator or project sponsor, as appropriate, 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/facilities management through the use of the owner's defined enterprise system or equivalent should be confirmed or revised. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements where requested by the owner or project sponsor on its behalf.

5.2.13 Deliverables and other outputs

*COMMENTARY ON **5.2.13***

The primary deliverable at the end of the Preparation and Brief work stage is the initial brief. The acceptability of the brief by the owner, operator or project sponsor, as appropriate, is likely to be dependent upon it confirming the required operational performance.

The project team should provide the owner, operator or project sponsor, as appropriate with the following as a minimum:

a) the response to the owner's, operator's, 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, manufacture 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 commitments by the owner to net zero carbon operation and use are likely to be satisfied by the design concept;

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

e) updated health and safety file;

f) updated risk register;

g) a draft environmental management plan; and

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

NOTE 2 Annex F provides an example of a "Brief checklist" to assist in matters of design.

5.2.14 Key decisions and next steps

The owner, operator or project sponsor, as appropriate, should reach a decision on whether or not there is a sufficient basis to proceed with the proposed project and inform the project team, including each delivery team and the operations team or asset/facility manager, as appropriate. Where the owner, operator or project sponsor, as appropriate, intends to proceed, the project team should give the project 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 plain language question to be considered here is: "Has enough been done to understand the needs of the owner, operator, users and other key stakeholders in regard to the project and its required outcomes?" The answer helps to inform each delivery team involved in this work stage on the approach to be taken in subsequent work stages.

5.3 Concept

5.3.1 General

*COMMENTARY ON **5.3.1***

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 and economic performance. It provides an opportunity for reviewing and, where appropriate, agreeing revisions to the initial brief which can then be finalized.

The project team should define the scope of work and its boundary conditions, its feasibility, areas of uncertainty and significant risks, and recommend the option most likely to achieve the expected benefits and required operational performance outcomes and/or targets. The owner, operator or project sponsor, as appropriate, 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/facility. Any adjustment to the concept should be confirmed with the owner, operator or project sponsor, as appropriate, following discussion and agreement between the project team and the operations team or asset/facility 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 F provides an example of a "Brief checklist" to assist in matters of design.

5.3.2 Primary activities

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

a) identifying and assessing uncertainty and significant risks (i.e. threats and opportunities);

b) updating the risk register;

c) preparing a project execution strategy;

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

e) preparing 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) reviewing design predictions against the expected benefits and required operational performance;

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

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

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

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

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

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

m) preparing a plan for satisfying training needs;

n) updating the project management schedule;

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

p) assessing the whole-life costs of major elements and systems (see BS 8544);

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

r) updating the required schedule contingency and cost contingency.

The operator, operations team or asset/facility manager, as appropriate, should undertake the following activities in consultation with the owner or project sponsor on its behalf and the project team:

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

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

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

4) outlining the initial period of aftercare and identifying those responsible for managing it;

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

6) identifying who is required from the operations team to support the aftercare to be provided by each delivery team involved in this work stage;

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

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

5.3.3 Design reviews

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

Design reviews should adopt a structured and systematic approach based on the agreed deliverables for this work stage (see **5.3.9**). Where found necessary and agreed with the owner, operator or project sponsor, as appropriate, the project team should update the performance outcomes and/or targets for energy use and greenhouse gas emissions, water consumption, waste reduction, noise and vibrations or other environmental indicators. The project team, or each delivery team on its behalf, where appropriate, 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 (see **4.6.3**) and/or POE (see **4.6.4**) are undertaken.

Where found necessary and agreed with the owner, operator or project sponsor, as appropriate, the project team should update the required social and economic performance outcomes.

The project team, or delivery team on its behalf, 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 **4.3.5**).

NOTE An important consideration is verifying that the asset/facility 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 an appropriate response.

5.3.4 Maintenance approach

*COMMENTARY ON **5.3.4***

It is important that the proposed arrangements for asset/facilities 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.

Each delivery team involved in this work stage should review and comment on the proposed arrangements for asset/facility maintenance in consultation with the owner, operator or project sponsor, as appropriate, and operations team or asset/facility manager, as appropriate. These arrangements should be reviewed at subsequent project decision points, gates or gateways up to and including the Handover and Closure work stage to verify that they remain appropriate.

NOTE Attention is drawn to BS 8210 for detailed guidance on facilities maintenance management.

5.3.5 Issues and risks

Issues affecting efficient and effective work in this stage should be identified at the start and actions taken to resolve them. Risks affecting the project and deliverables should be similarly identified and assessed and steps taken to treat them as appropriate.

The project team should maintain the risk register, updating this when necessary to reflect changes in risks that might threaten outcomes and 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/facility from specific events and vulnerabilities.

5.3.6 Roles and responsibilities

The project team should update the responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **5.3.2**) and their associated deliverables (see **5.3.9**) 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 Definition work stage. A design responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design and level of information need (see Annex A).

5.3.7 Information and data

The following information should be taken into account for the purpose of supporting the work activities (see **5.3.2**) and contributing to the deliverables (see **5.3.9**) in this work stage:

a) energy use 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 use and greenhouse gas emissions;

e) requirements for aligning with assessment methods (e.g. BREEAM and LEED), 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/facility;

j) required performance outcomes for use in post-implementation review and/or POE;

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 people with mobility, sensory or cognitive impairment and others with equalities-related needs, especially provisions for access, movement and emergency evacuation;

NOTE Attention is drawn to the Equality Act 2010 [24].

r) acceptable deviations from the initial brief;

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

t) risks to be reflected in 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) or facilities management strategy, as appropriate; 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 or questions to verify that the requirements are understood by the person or party receiving the request for information.

5.3.8 Common data environment

The arrangements to support asset/facilities management through the use of the owner's defined enterprise system or equivalent should be confirmed or revised. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements where requested by the owner or project sponsor on its behalf.

5.3.9 Deliverables and other outputs

*COMMENTARY ON **5.3.9***

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

The project team should provide the owner, operator or project sponsor, as appropriate, 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 the commitment to net zero carbon operation is likely to be achieved by the design concept;

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

e) updated health and safety file;

f) updated risk register;

g) project execution strategy; and

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

5.3.10 Key decisions and next steps

The owner, operator or project sponsor, as appropriate, should reach a decision on whether or not there is a sufficient basis to proceed following what amounts to a detailed feasibility study of the proposed asset/facility. Each delivery team involved in this work stage and the operator, operations team or asset/facility manager, as appropriate, should be informed accordingly. Where the owner or project sponsor, as appropriate, intends to proceed, the project team should give the owner, operator or project sponsor, as appropriate, 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 plain language question that can be considered here is: "Has each delivery team involved in this work stage 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, operator or project sponsor, as appropriate, has to reconsider the initial brief or, perhaps, the strategic definition and the business case for the new, upgraded, repurposed or refurbished asset/facility.

5.4 Definition

5.4.1 General

*COMMENTARY ON **5.4.1***

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 verify that the main aspects of the design have matured sufficiently to enable detailed, technical design to commence in the subsequent Technical Design work stage.

Each delivery team involved in this work stage should verify that the design proposal takes into account the needs of the owner, operator, operations team or asset/facility manager, as appropriate, and users in regard to the required operational performance of the asset/facility and that design assumptions are recorded and then tested in reviews of the design proposals (see **4.2**).

Each delivery team involved in this work stage should verify that the design proposal lends itself to safe, economical manufacture and construction and that it has been verified from an operability perspective for the level of information need at this point. In this regard, each delivery team involved in this work stage should assess the activities required to operate the asset/facility and reduce the associated risks to as low as reasonably practicable (ALARP). The owner, operator, operations team or asset/facility 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 each

delivery team involved in this work stage of any situation where there is the possibility of safety being compromised.

The owner, operator or project sponsor, as appropriate, should require each delivery team involved in this work stage and operations team or asset/facility 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/facility should be provided by the operator, operations team or asset/facility manager, as appropriate, to the owner, operator or project sponsor, as appropriate, and the project team.

The owner, operator or project sponsor, as appropriate, should clarify any uncertainty on the part of each delivery team involved in this work stage in regard to work activities, information exchanges or deliverables.

5.4.2 Primary activities

Each delivery team involved in this work stage should prepare the definition of the asset/facility, covering such work activities as:

a) exploring the design proposal by means of an information model or other method for explaining the asset/facility to the owner, operator or project sponsor, as appropriate, and the operations team or asset/facility manager, as appropriate, users and other key stakeholders;

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

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

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

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

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

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

h) preparing aftercare plans as agreed between the project sponsor and the operator, operations team or asset/facility manager, as appropriate, and the representative(s) of users;

i) undertaking an operational risk assessment, identifying any hazards, measures to eliminate or reduce the risks to as low as reasonably practicable (ALARP) and plans to control the risks during operation of the asset/facility;

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

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

l) updating the required schedule contingency and cost contingency;

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

n) identifying any controls for use by users and the steps to be taken to verify they can operate them safely and correctly;

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

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

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

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

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

3) reviewing and commenting on the updated estimate of operational cost;

4) identifying the parties needed to witness demonstrations;

5) updating the training plan for the operator, operations team or asset/facility manager, as appropriate, and users where necessary;

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

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

5.4.3 Option and solution 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 and economic performance, and comparison with the required outcomes (see **4.4.4**). In particular, each delivery team involved in this work stage should:

a) indicate when alternative solutions (e.g. designs, systems, products and materials), identified from a combined operational and inclusive perspective, are available;

b) inform the owner or operator, as appropriate, which solution (or combination of solutions) best meets the commitment to net zero carbon operation and use;

c) 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;

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

e) obtain current lead times for engineered systems and other manufactured 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/facilities to verify details before reaching a decision.

5.4.4 Issues and risks

Issues affecting efficient and effective work in this stage should be identified at the start and actions taken to resolve them. Risks affecting the project and deliverables should be similarly identified, assessed and steps taken to treat them as appropriate.

The project 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.

5.4.5 Roles and responsibilities

Each delivery team involved in this work stage should update the responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **5.4.2**) and their associated deliverables (see **5.4.8**) 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 Technical Design work stage. A design responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design and level of information need (see Annex A).

5.4.6 Information and data

The following information should be taken into account for the purpose of supporting the work activities (see **5.4.2**) and contributing to the deliverables (see **5.4.8**) 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 the commitment to net zero carbon operation and any related planning conditions and their implications; and

i) the design's conformity to standards, specifications and the final brief.

Each of the information requirements in a) to i) should be obtained through a plain language question or questions to verify that the requirements are understood by the person or party receiving the request for information.

5.4.7 Common data environment

The arrangements to support asset/facilities management through the use of the owner's defined enterprise system or equivalent should be confirmed or revised. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements where requested by the owner or project sponsor on its behalf.

5.4.8 Deliverables and other outputs

Each delivery team involved in this work stage should provide the owner, operator or project sponsor, as appropriate, 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/facility manager, as appropriate, 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 it has been accounted for in the design;

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

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

k) evidence that the design proposal as developed demonstrates principles in support of operational requirements, including the needs of people with mobility, sensory or cognitive impairment and others with equalities-related needs, especially provisions for access, movement and emergency evacuation;

l) updated health and safety file;

NOTE Attention is drawn to the Equality Act 2010 [24].

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

n) cash-flow forecast.

5.4.9 Key decisions and next steps

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

NOTE A plain language 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.

5.5 Technical Design

5.5.1 General

*COMMENTARY ON **5.5.1***

The Technical 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 each delivery team in finalizing the details of the design prior to construction.

Suppliers and manufacturers are involved where components and systems are subject to significant off-site fabrication. This work stage is one where the incidence of design changes is likely to rise, necessitating a strict, but effective, change control process. In this connection, it is important to recognize the potential for minor changes that are more in the nature of design development than a change in the scope of work.

The owner, operator or project sponsor, as appropriate, should review the technical aspects of the design and, where appropriate, visit suppliers and manufacturers to confirm the acceptability, or otherwise, of systems, components, products and materials. The owner,

operator or project sponsor, as appropriate, should determine whether or not specific processes for configuration management, system integration and verification (see **4.5.1** and BS ISO/IEC/IEEE 15288) are to be incorporated in this work stage and in the subsequent Manufacture, Construct and Commission work stage.

Any adjustment to the design should be approved by the owner, operator or project sponsor, as appropriate, before it is implemented as part of change control (see **4.5.6**), following discussion between each delivery team involved in this work stage and the operations team or asset/facility 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 change control should be implemented by the project team, where the authority for approving those changes classed as significant rests with the owner, operator or project sponsor, as appropriate. The criteria for classifying and approving design changes should be determined by the project manager, taking advice from the owner, operator or project sponsor, as appropriate, in the first instance.

5.5.2 Primary activities

Each delivery team involved in this work stage should prepare the technical design for the asset/facility, covering such work activities as:

a) implementing a change control procedure;

b) updating and verifying the accuracy and quality of the information model;

c) agreeing with the project sponsor the method of production and form of delivery for the information and data required to operate the asset/facility;

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

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

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

g) outlining the extent and content of the asset information model (AIM), including the health and safety file, operation and maintenance information, and a specification for extracting relevant data, where applicable;

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

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

j) updating the training needs' plan;

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

l) preparing the HSSE plan to cover construction and operations;

m) updating the risk assessments and the risk register;

n) preparing the project execution plan;

o) preparing a risk-adjusted estimate of capital cost and, where practicable, operational cost;

p) preparing a risk-adjusted estimate of time (i.e. probabilistically modelled schedule);

q) updating the integrated master schedule;

r) preparing a construction and system testing schedule and a commissioning and performance testing schedule, wherever practicable; and

s) updating the required cost contingency and schedule contingency from the probabilistic risk analyses in o) and p).

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

1) participating in reviews of the technical design and commenting on whether or not the design is capable of meeting the required environmental, social and economic performance;
2) identifying any changed operational requirements that are necessary to meet the commitment to net zero carbon operation and use;
3) providing an updated operational model, operational management plan and operational expenditure budget;
4) reviewing and commenting on the updated estimate of operational cost;
5) preparing an asset replacement and removal strategy, where applicable;
6) providing a definition of the requirements for the asset register and any specific maintenance plans;
7) providing a scope of work and specification for the procurement of maintenance services, where applicable;
8) advising on the need to recruit personnel for the operations team, where applicable;
9) advising on the need for procurement of service providers, where applicable; and
10) confirming the arrangements for the transfer of asset/facility data to the asset information model (AIM) or asset register, as appropriate.

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

5.5.3 Design change control

*COMMENTARY ON **5.5.3***

There is always the possibility that a proposed change, whilst attractive, might erode value in the asset/facility. 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 in terms of an alteration to the scope, quality, cost, schedule or 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 detail as a consequence of greater project definition.

Design changes should be avoided in this work stage unless considered necessary for reason of safety, security or inoperability.

NOTE 1 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 project sponsor so that the full implications for the safe, secure, efficient and cost-effective operation of the asset/facility can be verified.

This design change protocol should record details of the proposed change, including:

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 users of the asset/facility, including people with mobility, sensory or cognitive impairment and others with equalities-related needs, especially provisions for access, movement and emergency evacuation;

NOTE 2 Attention is drawn to the Equality Act 2010 [24].

e) impact on the whole-life cost and value of the asset/facility, 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 owner, operator or project sponsor, as appropriate, at intervals reflecting the extent and urgency of the change and the time required for design, redesign or other deviation from the project's baseline.

NOTE 3 Failure to consider and consult widely on the impact of a proposed change could result in unintended negative consequences.

5.5.4 Design information

Each delivery team involved in this work stage should allow for the review of the information model and supporting documentation, with comments from the owner, operator or project sponsor, as appropriate, and the operations team or asset/facility manager, as appropriate. Account should be taken of whether or not the design achieves the required environmental, social and economic performance outcomes and/or targets. Each delivery team involved in this work stage should verify that any monitoring and metering systems proposed by specialist contractors or suppliers are consistent with its own and that they satisfy the performance monitoring requirements of the owner, operator or project sponsor, as appropriate.

5.5.5 Maintenance needs

Each delivery team involved in this work stage should review and comment on the owner's and/or operator's arrangements for the procurement of maintenance services to verify that they are appropriate.

5.5.6 Issues and risks

Issues affecting efficient and effective work in this stage should be identified at the start and actions taken to resolve them. Risks affecting the project and deliverables should be similarly identified and assessed and steps taken to treat them as appropriate.

The project 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.

Each delivery team involved in this work stage should produce an updated 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 kept up to date. Details of this risk assessment should be provided to the operator, operations team or asset/facility manager, as appropriate, at the end of the Handover and Closure work stage.

5.5.7 Roles and responsibilities

Each delivery team involved in this work stage should update the responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **5.5.2**) and their associated deliverables (see **5.5.10**) 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 Manufacture, Construct and Commission work stage. A design responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design and level of information need (see Annex A).

5.5.8 Information and data

The following information should be taken into account for the purpose of supporting the work activities (see **5.5.2**) and contributing to the deliverables (see **5.5.10**) 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/facility manager, as appropriate, as defined in the OIR and AIR, the needs of users in terms of access, inclusiveness, safety, security, indoor air quality, thermal comfort and well-being, 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 fixed-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, upgraded, repurposed or refurbished asset/facility.

Each of the information requirements in a) to i) should be obtained through a plain language question or questions to verify that the requirements are understood by the person or party receiving the request for information.

5.5.9 Common data environment

The arrangements to support asset/facilities management through the use of the owner's defined enterprise system or equivalent should be confirmed or revised. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements.

Each delivery team involved in this work stage should provide its information model in accordance with the exchange information requirements. The model should be retained and utilized later for assisting in the optimization of operational performance and the whole-life cost of the asset/facility.

5.5.10 Deliverables and other outputs

Each delivery team involved in this work stage should provide the owner, operator or project sponsor, as appropriate, 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 and economic performance;

c) evidence that the calculations of energy use 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, manufacture and construction proposals satisfy construction, design and management (CDM) legislation and HSSE requirements for construction, operation and maintenance;

f) updated health and safety file;

NOTE Requirements under legislation for maintaining a health and safety file have been strengthened to establish a golden thread of information through the life cycle of higher-risk buildings.

g) updated project execution plan;

h) information models showing access provisions and method statements for maintenance activities;

i) simulations of energy use, greenhouse gas emissions, sound attenuation, public address and voice alarm performance;

j) fire and smoke modelling and user evacuation studies;

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

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

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

n) evidence that the automated transfer of asset/facility data content to the asset information model (AIM), the owner's defined enterprise system or equivalent can be achieved where this has been defined as a requirement;

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

p) updated budget estimates;

q) descriptions of controls for all engineered systems, including those controls intended to be operated by users; and

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

5.5.11 Key decisions and next steps

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

5.6 Manufacture, Construct and Commission

5.6.1 General

*COMMENTARY ON **5.6.1***

The Manufacture, Construct and Commission work stage is concerned with planning, organizing and coordinating off-site fabrication 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 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 for a smooth transition from construction to the subsequent Handover and Closure and Use work stages.

The project sponsor should require each delivery team involved in this work stage to provide a detailed schedule covering the construction work and the testing and commissioning of the asset/facility, 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 approved by the owner, operator or project sponsor, as appropriate, following discussion and agreement between each delivery team involved in this work stage and the operations team or asset/facility manager, as appropriate. Any approved 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 and/or POE and feedback to all stakeholders.

5.6.2 Primary activities

Each delivery team involved in this work stage should prepare for construction and commissioning of the asset/facility, which includes such work activities as:

a) verifying (e.g. by laser scanning) that the asset/facility is constructed, within the defined tolerances, in accordance with the virtual construction model;

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

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

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

e) updating the security plan for construction and commissioning;

f) updating the HSSE risk assessment;

g) updating the risk register;

h) updating the required schedule contingency and cost contingency;

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

j) updating the commissioning specification;

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

l) identifying any skills that users and other key stakeholders need to acquire before attending commissioning demonstrations;

m) preparing a schedule of pre-commissioning activities;

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

o) preparing and maintaining a 14-day look-ahead construction schedule;

p) updating the handover plan to include training requirements for the operator, operations team or asset/facility manager, as appropriate, and users;

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

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

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

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

1) determining 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) providing an operational HSSE risk assessment;
3) commenting on the construction and system testing schedule and the commissioning and performance testing schedule from the perspective of witnessing demonstrations; and
4) contributing to the updating of the handover plan.

5.6.3 Commissioning plan

Each delivery team involved in this work stage, in conjunction with the operator, operations team or asset/facility manager, as appropriate, should develop a plan for managing the commissioning of the asset/facility and the equipment and systems that it comprises.

NOTE 1 This process can be greatly assisted by a detailed schedule or schedules.

Each delivery team involved in this work stage should arrange for the commissioning to be witnessed by appropriate parties, including the project sponsor and the operator, operations team or asset/facility manager, as appropriate, and that the required performance outcomes are achieved to the satisfaction of the owner or the project sponsor on the owner's behalf.

NOTE 2 In the case of an asset/facility involving complex systems, it can be beneficial to define, as part of the brief, the steady operational state that is desired and then, when scheduling the project, to work back from the point at which the asset/facility enters full service (i.e. steady-state operation) to verify that all steps in systems' start-up are initiated in precisely the order in which they are required.

Details of testing and commissioning should be explicit in the project schedule so that design, manufacture and construction is progressed in a manner that facilitates on-time handover of the asset/facility.

5.6.4 Operations and maintenance requirements

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

5.6.5 Issues and risks

Issues affecting efficient and effective work in this stage should be identified at the start and actions taken to resolve them. Risks affecting the project and deliverables should be identified and assessed and steps taken to treat them as appropriate.

The project 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.

5.6.6 Roles and responsibilities

Each delivery team involved in this work stage should prepare a responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **5.6.2**) and their associated deliverables (see **5.6.9**) for this work stage. The RASCI chart should be kept up to date and be used to inform a similar requirement at the start of the Handover and Closure work stage.

A design responsibility matrix should be used for the purpose of assigning design responsibility for aspects of the design and the level of information need (Annex A).

5.6.7 Information and data

The following information should be taken into account for the purpose of supporting the work activities (see **5.6.2**) and contributing to the deliverables (see **5.6.9**) in this work stage:

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

NOTE Many new supply chain personnel are 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 verify 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) procedures for involving the owner, operator or project sponsor, as appropriate, 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 or questions to verify that the requirements are understood by the person or party receiving the request for information.

5.6.8 Common data environment

The arrangements to support asset/facilities management through the use of the owner's defined enterprise system or equivalent should be confirmed or revised. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements. Project information and data for operational purposes should be defined in the plan for information exchange, including operation and maintenance information supported by manufacturers' operating manuals to be transferred from the PIM to the AIM during this work stage.

Each delivery team involved in this work stage should verify that a robust project planning and scheduling tool is used to plan and schedule construction, coordinate organizational interfaces and sequence activities for commissioning and training, including the deployment of appropriate levels of resources.

5.6.9 Deliverables and other outputs

Each delivery team involved in this work stage should provide the owner, operator or project sponsor, as appropriate, and operations team or asset/facility manager, as appropriate, with the following as a minimum:

a) evidence that the asset/facility has been constructed, within the defined tolerances, in accordance with 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 provided to the owner and the operator, operations team or asset/facility manager, as appropriate;

e) updated health and safety file;

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

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

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

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

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

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

l) evidence that all commissioning activities have been conducted.

5.6.10 Key decisions and next steps

At the end of this work stage, the owner, operator or project sponsor, as appropriate, should:

a) 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/facility; and

b) inform each delivery team involved in this work stage and the operations team or asset/facility manager, as appropriate, of its decision.

Where the project sponsor determines that the project has met its objectives, each delivery team involved in this work stage, including those responsible for aftercare, should give the owner, operator or project sponsor, as appropriate, the opportunity to review and approve the planned work activities and their associated information requirements and deliverables for the Handover and Closure work stage before the conclusion of this work stage.

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

5.7 Handover and Closure

5.7.1 General

*COMMENTARY ON **5.7.1***

The Handover and Closure work stage is concerned with the training of the operations team, handover of the asset/facility to the owner or operator, as appropriate, and the start-up of operations. It can be highly advantageous for the owner, operator and project sponsor, as appropriate, to have users or their representative(s) included in discussions about expectations in regard to the use of the asset/facility. 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.

The owner, operator or project sponsor, as appropriate, should require the operations team or asset/facility manager, as appropriate, to provide a detailed plan for training those who have been, or will be, given responsibility for the day-to-day operation of the asset/facility and others who would benefit from direct observation of the operational aspects of the asset/facility. Each delivery team involved in this work stage should prepare a technical guide to assist the operator, operations team or asset/facility manager, as appropriate, in the day-to-day operation of the asset/facility (see **5.7.3**). 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 systems and products. The log should be reviewed by each delivery team involved in this

work stage and the operator, operations team or asset/facility manager, as appropriate, with their recommendations fed back to the owner or project sponsor, as appropriate.

5.7.2 Primary activities

Each delivery team involved in this work stage should prepare for handover of the asset/facility, covering such work activities as:

a) summarizing the changes that have been incorporated and advising on whether or not their implications have been brought to the attention of the owner, operator or project sponsor, as appropriate, and operations team or asset/facility manager, as appropriate, and the representative(s) of users;

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

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

d) recording all equipment and system settings and outputs from commissioning and informing the project sponsor and the operator, operations team or asset/facility manager, as appropriate;

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

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

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

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

i) creating the as-constructed information and data from the verified as-constructed model;

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

k) reviewing the updated operational information provided by the operator, operations team or asset/facility manager, as appropriate; and

l) preparing the forecast of outturn capital cost.

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

1) reviewing and commenting on all commissioning and handover-related information;

2) providing updated operational information to each delivery team involved in this work stage;

3) reviewing and commenting on all operation and maintenance information;

4) updating the estimate of operational cost;

5) transferring information and data from the PIM to the AIM;

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

7) preparing a cost breakdown of the asset/facility for the purpose of management accounting and capital allowances.

5.7.3 Operational readiness

Each delivery team involved in this work stage 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/facility 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 and the technical guide and the setting up of a helpdesk or other support system for users. The training needs of users and the arrangements for training sessions should form an integral part of this operational readiness plan.

Each delivery team involved in this work stage should organize training for the owner, operator or project sponsor, as appropriate, in regard to operation and maintenance before and after handover. Training for the operations team should be digitally recorded by each delivery team involved in this work stage for future use. A copy of the recording should be handed over to the owner or operator, as appropriate, during the initial period of aftercare (see **5.8.3**).

5.7.4 Commissioning check

Each delivery team involved in this work stage should check that commissioning records include energy use data, as far as practicable. Each delivery team involved in this work stage should review the commissioning records with the owner, operator or project sponsor, as appropriate, and operations team or asset/facility manager, as appropriate, and prepare a schedule for post-handover optimization of the asset/facility's performance in line with the requirements for the periods of initial aftercare (see **5.8.3**) and extended aftercare (see **5.8.4**). This schedule should be initiated during the Technical Design work stage (see **5.5.1**) and be finalized in this work stage.

Each delivery team involved in this work stage should verify that:

a) individual metering systems are functioning accurately, are adequately labelled according to end use; and

b) 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.

5.7.5 Engineered systems

Each delivery team involved in this work stage should, as appropriate:

a) provide a demonstration to the owner, operator or project sponsor, as appropriate, and operations team or asset/facility manager, as appropriate, of the asset/facility's engineered systems and control interfaces; and

b) demonstrate the methods for adjustment.

Each delivery team involved in this work stage should inform the operator, operations team or asset/facility manager, as appropriate, of the zoning strategies and modes of operation, where applicable.

User-controlled interfaces should be clearly legible and should be tested by each delivery team involved in this work stage and the operator, operations team or asset/facility manager, as appropriate, and a selection of users.

5.7.6 Start-up of operations

The owner, operator or project sponsor, as appropriate, should provide the project team with the detailed requirements for the start-up of operations. Each delivery team involved in this work stage should verify that the operational readiness plan (see **5.7.3**) takes into account,

where appropriate, the logistical arrangements for the owner or operator taking possession of the asset/facility to move in personnel, equipment and materials.

Where the asset/facility involves accommodation intended for occupation by either the owner's or operator's personnel, a move-in plan should be prepared by each delivery team involved in this work stage as part of the operational readiness plan (see **5.7.3**). Each delivery team involved in this work stage should liaise with the owner, operator or project sponsor, as appropriate, and operations team or asset/facility 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.

5.7.7 Aftercare team workplace

The owner, operator or project sponsor, as appropriate, should provide a prominent and accessible workplace for the aftercare team from the first day of start-up of the asset/facility for the defined periods of initial and extended aftercare.

5.7.8 Maintenance requirements

Each delivery team involved in this work stage should review and comment on the owner's proposed asset/facility maintenance arrangements to verify that they remain appropriate for the as-constructed asset.

5.7.9 Operations manuals and user guides

*COMMENTARY ON **5.7.9***

Building logbooks, building manuals and, increasingly, building user guides are prepared for users of assets/facilities. Ownership and management of assets/facilities bring with them the responsibility for safe and correct operation, which extends to user well-being. These undertakings go beyond concerns about the technical aspects of the asset/facility to cover manifold issues for which owners, and those acting on their behalf, have specific responsibilities and accountabilities.

Each delivery team involved in this work stage should prepare an operations 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 HSSE risk assessment. This complements the operation and maintenance information (see **5.7.14**) and should be transferred to the asset information model (AIM).

The project team should collate the documentation required under legislation such as logbooks and manuals in digital form for handing over to the operator, operations team or asset/facility manager, as appropriate, prior to Handover and Closure in sufficient time for the content to be assimilated and appropriate action to be taken.

A user guide for permanent and regular users of the asset/facility should be prepared by each delivery team involved in this work stage in a form that reflects the interests and needs of these users.

NOTE Attention is drawn to BSRIA's "Building Manuals and Building User Guides – Guidance and worked examples" (BG 26/2011) [29].

5.7.10 Issues and risks

Issues affecting efficient and effective work in this stage should be identified at the start and actions taken to resolve them. Risks affecting the project and deliverables should be similarly identified and assessed, and steps taken to treat them as appropriate.

The project 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.

5.7.11 Roles and responsibilities

Each delivery team involved in this work stage should update the responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **5.7.2**) and their associated

deliverables (see **5.7.14**) for this work stage. The RASCI chart should be kept up to date and used to inform a similar requirement at the start of the Use work stage.

5.7.12 Information and data

The following information should be taken into account for the purpose of supporting the work activities (see **5.7.2**) and contributing to the deliverables (see **5.7.14**) 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 expected to perform;

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

f) details of planned maintenance; and

g) applicable legislation regarding HSSE.

Each of the information requirements in a) to g) should be obtained through a plain language question or questions to ensure that the requirements are understood by the person or party receiving the request for information.

5.7.13 Common data environment

All information and data for operational purposes should be transferred from the PIM to the AIM not later than the end of this work stage, in accordance with the plan for information exchange. The arrangements to support asset/facilities management through the use of the owner's defined enterprise system or equivalent should be confirmed or revised. The operator, operations team or asset/facility manager, as appropriate, should assist with these arrangements.

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

5.7.14 Deliverables and other outputs

Each delivery team involved in this work stage should provide the owner, operator or project sponsor, as appropriate, with the following as a minimum:

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

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

c) evidence that the asset/facility as constructed is capable of delivering the required operational performance;

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

e) updated health and safety file;

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

g) a log of changes made to the design and information as recorded in the CDE with the implications of those changes;

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

i) evidence of an asset/facility operational readiness plan having been implemented;

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

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

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

m) records of the commissioning procedure and tests;

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

o) evidence that the asset/facilities management team attended the relevant commissioning meetings;

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

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

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

s) as-constructed information with fully-populated asset/facility data.

The operator, operations team or asset/facility manager, as appropriate, should provide each delivery team involved in this work stage with the following:

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

2) evidence of a communication plan to update users;

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

4) details of a helpdesk to support users;

5) evidence of the use of key performance indicators (KPIs) to assess the effectiveness of the asset/facilities management plan (see **4.5.1**);

6) cost breakdown of the asset/facility; and

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

5.7.15 Lessons learned

Closure should be undertaken to enable sharing of both the positive and negative lessons arising from the project to improve the quality of future design, specifications, decisions and work processes, and to verify that knowledge is shared across projects. The project team should allocate resources to enable transfer of experience to and perform closure, including the recording of lessons learned which should be verified by the owner, operator or project sponsor, as appropriate.

NOTE The benefits from capturing lessons learned include benchmarking of future projects against the delivered scope, schedule and cost, understanding trends and creating a feedback between the scope, schedule and cost, and estimating practices.

5.7.16 Key decisions and next steps

At the end of this work stage, the owner, operator or project sponsor, as appropriate, should decide whether or not operations should be started up and inform each delivery team involved in this work stage and the operations team or the asset/facility manager, as appropriate. Where the intention is to start up operations, each delivery team involved in this

work stage, including those responsible for aftercare, should give the owner, operator or project sponsor, as appropriate, the opportunity to review and approve the planned work activities and their associated information requirements and deliverables for the Use work stage before the conclusion of this work stage.

NOTE A question that can be considered here is: "Is the asset/facility 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 Use work stage.

5.8 Use

5.8.1 General

*COMMENTARY ON **5.8.1***

The Use work stage is concerned with achieving steady-state operation, involving aftercare, optimization of the asset/facility's performance, post-implementation review and/or POE, 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 owner, operator or project sponsor, as appropriate, on the extent to which the asset/facility provides the expected benefits and matches the required operational performance; it also provides valuable information and data for planning future projects. This work stage covers 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. The extended period of aftercare lasts for up to three years and covers asset/facility 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 to assess the asset/facility's environmental performance over the medium term.

The owner, operator, operations team or asset/facility manager, as appropriate, and users should be provided with information by each delivery team involved in this work stage to help them obtain the maximum benefit from the new, upgraded, repurposed or refurbished asset/facility, whilst making them aware of their duties and obligations with respect to HSSE. The operations guide (see **5.7.9**) should be provided for this purpose.

NOTE 1 The attitude of users to HSSE can be a significant factor in maintaining environmental, social and economic performance at the required levels, as well as maintaining compliance with legislation.

The operator, operations team or asset/facility manager, as appropriate, supported by each delivery team involved in this work stage, should verify the initial as-constructed information and note any deviations from the design. The as-constructed information should be processed through the status gates of the CDE in the PIM to enable review by the operator, operations team or asset/facility manager. Once verified by the operator, operations team or asset/facility manager, the information and 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 During the transition from Handover and Closure to operations, significant volumes of information and data might be transferred from the PIM into the AIM, increasing the risk that sensitive design or commercial details could be inappropriately handled or stored.

The owner should verify that appropriate and proportionate measures are adopted to deal with inappropriate handling or storage of information and data (see **5.2.6**); for example, 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/facility (see **4.7.2**).

5.8.2 Primary activities

Each delivery team involved in this work stage should prepare for operation of the asset/facility, including the initial and extended periods of aftercare, covering such work activities as:

a) conducting aftercare review meetings and post-implementation review and/or POE workshops as planned (see **4.6.3** and **4.6.4**);

b) recording user comments related to functionality and effectiveness;

c) maintaining records of tours and walkabouts, where appropriate, and informal inspections to detect emerging issues (see **5.8.4.2**);

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

e) optimizing the engineered systems;

f) recording and feeding back details of all optimization of systems;

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

h) updating the technical guide, where applicable.

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

1) recording and reviewing early energy use for comparison with predictions;

2) reviewing and recording any monitoring of other environmental indicators to detect emerging problems;

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

4) preparing and circulating newsletters or utilizing other media for communicating directly with users.

5.8.3 Initial aftercare

5.8.3.1 Aftercare team

Each delivery team involved in this work stage should appoint an aftercare team to represent it on post-handover aftercare duties for the initial period of aftercare to familiarize the owner, operator, operations team or asset/facility manager, as appropriate, and users with the operation of the asset/facility and to provide training and technical support where required. Each delivery team involved in this work stage, or the aftercare team on its behalf, should monitor the performance of the engineered systems with the participation of the commissioning manager (see **4.2.5**) and the operator, operations team or asset/facility manager, as appropriate. Any deviation from the expected performance should be identified, recorded and shared within the respective teams.

The aftercare team should include representatives from each delivery team involved in this work stage and the specialists 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 responsibility assignment matrix should be utilized for this purpose (see Annex A), with a copy provided to the operator, operations team or asset/facility manager, as appropriate, and the owner or project sponsor, as appropriate.

Consequent troubleshooting and optimization of the engineered systems should be carried out by each delivery team involved in this work stage working with the operator, operations team or asset/facility manager, as appropriate, reporting to the owner or project sponsor, as appropriate.

5.8.3.2 Support for operations and users

The aftercare team should provide technical help and support to the operator, operations team or asset/facility manager, as appropriate, for the full period of initial aftercare. The extent of this help and support should be determined by the project sponsor during the Definition work stage (see **5.4**).

Each delivery team involved in this work stage should provide the owner, operator, operations team or asset/facility manager, as appropriate, with all information and data including operations manuals prior to handover (see **5.7.9**).

Each delivery team involved in this work stage should organize, in consultation with the project sponsor, informal user meetings and discussions as soon as possible after the asset/facility has become operational.

Where it is not practical to involve all users directly in meetings and discussions with each delivery team and/or project sponsor, representatives of users should be nominated for this purpose.

5.8.3.3 Communications

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

5.8.3.4 Tours, walkabouts and informal inspections

The project sponsor should allow the aftercare team to access the asset/facility and, where practicable, talk and liaise with the users or their representative(s). Each delivery team involved in this work stage should verify that the individuals nominated for this role within the aftercare team have sufficient knowledge of how the engineered systems are intended to function.

5.8.3.5 Summary of initial aftercare

*COMMENTARY ON **5.8.3.5***

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

Each delivery team involved in this work stage, or the aftercare team acting on its behalf, should:

a) record issues that have arisen and discuss them with the project sponsor and the operator, operations team or asset/facility 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/facility manager, as appropriate, and users; and

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

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

1) take account of 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 each delivery team involved in this work stage or aftercare team on its behalf (see **5.8.3.4**);
4) record informal discussion with users;
5) maintain records of optimization of the asset/facility's operational performance and any adjustments undertaken; and
6) report to the project sponsor on how each delivery team involved in this work stage, or the aftercare team on its behalf, is dealing with technical queries relating to the asset/facility.

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.

5.8.4 Extended aftercare

5.8.4.1 General

Each delivery team involved in this work stage should carry out interviews with the owner, operator, operations team or asset/facility manager, as appropriate, and users three months after initial occupation to:

a) identify issues or concerns regarding the effectiveness of the asset/facility, including the engineered systems and their control interfaces; and
b) undertake adjustments as necessary to improve usability and system performance.

Where applicable, each delivery team involved in this work stage should conduct seasonal commissioning and 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.

5.8.4.2 Reviews

The owner, operator or project sponsor, as appropriate, 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. Each delivery team involved in this work stage should verify the attendance of representatives of the aftercare team, with the owner, operator or project sponsor, as appropriate, requesting the attendance of the representatives of the operations team or the asset/facility manager and user representative(s) so that emerging issues can be discussed and the appropriate actions agreed.

Each delivery team involved in this work stage should provide technical assistance to help the owner, operator, operations team or asset/facility manager, as appropriate, understand and utilize the energy metering system and other monitored systems during the periods of aftercare. Each delivery team involved in this work stage should work with the owner, operator, operations team or asset/facility manager, as appropriate, to review the overall systems' and energy use at a defined frequency and provide written reports on the findings.

5.8.4.3 Optimization of systems

The aftercare team should work with the owner, operator, operations team or asset/facility manager, as appropriate, to carry out optimization of engineered systems. Each delivery team involved in this work stage should record any alterations to systems and equipment, and any changes to standard control settings and operating schedules. These alterations should be processed through the status gates of the CDE in the PIM to enable review by the owner, operator, operations team or asset/facility manager. Once verified by the owner, operator, operations team or asset/facility 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.

The owner, operator, operations team or asset/facility manager, as appropriate, should determine the point at which the asset/facility transfers to the maintenance regime for the asset/facility and where the responsibility rests for scheduled maintenance work in the intervening period. Account should be taken of the need to update the AIM and the party responsible for this task.

5.8.4.4 Performance reviews

5.8.4.4.1 General

*COMMENTARY ON **5.8.4.4.1***

The expectation is that either a post-implementation review or a POE is undertaken, but not both. The former is more common for infrastructure projects and the latter for building projects. A post-implementation review and POE could, however, apply to the same asset/facility; for example, a railway station includes both transitory users accessing rail services and supporting facilities, and permanent users occupying offices and other spaces.

A post-implementation review should be undertaken (see **5.8.4.4.2**) to determine the degree of success of the project, in particular the extent to which the asset/facility meets its objectives and achieves the expected benefits and required operational performance. In the context of buildings and other occupied spaces, POE should be undertaken (see **5.8.4.4.3**) to establish the appropriateness of operating strategies and users' working environment, including user satisfaction and well-being.

NOTE The post-implementation review and/or POE can assist in optimizing the benefits from, and operational performance of, the asset/facility, through benchmarking performance, collating the lessons learned from the project to inform future projects, and updating the owner's information management system.

5.8.4.4.2 Post-implementation review

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

The project 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/facility manager, as appropriate, should request the attendance of a senior representative of each of the main disciplines within each delivery team involved in this work stage at a workshop with the project sponsor and the representative(s) of users.

The annual analysis report should be reviewed 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 Preparation and Brief work stages, subject to any subsequent, agreed modification. The workshop should identify recommendations for how the operational performance of the asset/facility 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) [12] is an example of a methodology for measuring three quality principles – functionality, build quality and impact – to provide objective evidence of achievement. BREEAM Communities [13] 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.

5.8.4.4.3 Post-occupancy evaluation (POE)

A formal POE of the building's performance should be conducted at the end of Years 1 and 3, and may be conducted at the end of Year 2 if the owner, operator or project sponsor deems this to be necessary. The evaluation should include a user satisfaction survey to understand users' working environment, the extent to which the asset/facility supports the users and where there might be room for improvement.

The project sponsor should compare actual performance with the required performance and comment on potential improvements, where appropriate, for the end-of-year review. When this annual analysis report has been completed, the operator, operations team or the asset/facility manager, as appropriate, should request the attendance of a senior representative of each of the main disciplines within each delivery team at a workshop with the project sponsor and the representative(s) of users.

The annual analysis report should be reviewed against the owner's business objectives, project objectives, expected benefits and operational requirements and required performance outcomes and/or targets as set in the Strategy and Preparation and Brief work stages. The workshop should identify recommendations for how the operational performance of the asset/facility can be optimized. The workshop should conclude with agreed actions necessary to achieve alignment with the objectives, outcomes and targets as closely and as quickly as possible.

NOTE The Design Quality Indicator (DQI) [12] is an example of a methodology for measuring three quality principles – functionality, build quality and impact – to provide objective evidence of achievement. BSRIA's Occupant Wellbeing (BOW) Survey [15] assesses user satisfaction and well-being, covering the physical environment, indoor facilities, functionality and accessibility. It provides qualitative information that allows the owner, operator, operations team and asset/facility manager to measure the impact of building services on user perception of well-being. The BUS methodology [16] is an example of a survey that quantifies occupant satisfaction, reveals features of value or concern in the asset/facility and provides feedback. BREEAM In-Use [30] is a scheme to help the owner, operator, operations team or asset/facility manager, as appropriate, reduce the operational costs and improve the environmental performance of existing assets/facilities.

5.8.4.5 Summary of extended aftercare

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

a) compare the post-implementation review and/or POE 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 energy use with targeted use and explain good or bad performance;

f) compare actual water consumption with targeted consumption and explain good or bad performance;

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

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

i) request the attendance of a senior representative of each of the main disciplines within each delivery team involved in this work stage at a workshop with the owner, operator or project sponsor, as appropriate, and the representative(s) of users; and

j) report to the owner, operator or project sponsor, as appropriate, on the first year of performance and the actions considered necessary to optimize performance of the asset/facility, 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 owner, operator, operations team or the asset/facility manager, as appropriate, should:

1) continue its performance evaluation;

2) prepare the annual reports on performance with explanation of improvements, risk treatments, 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 each delivery team involved in this work stage and the project 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 each delivery team involved in this work stage at a workshop with the owner, operator or project sponsor, as appropriate, and the representative(s) of users; and
7) report to the owner, operator or project sponsor, as appropriate, on performance during the year, the actions considered necessary to optimize performance of the asset/facility, the response to residual risks, where applicable, and the lessons learned.

5.8.5 Issues and risks

Issues affecting efficient and effective work in this stage should be identified at the start and actions taken to resolve them. Risks affecting the project and deliverables should be identified and assessed, and steps taken to treat them as appropriate.

The project team should maintain the risk and opportunity register, updating this where necessary to reflect changes in risks that might threaten normal operations and the opportunities that might enhance the performance of the asset/facility.

5.8.6 Roles and responsibilities

Each delivery team involved in this work stage should update the responsibility assignment matrix (e.g. a RASCI chart) to cover the work activities (see **5.8.2**) and their associated deliverables (see **5.8.9**) for this work stage.

The owner, operator, operations team or asset/facility manager, as appropriate, should conduct the measurement, evaluation, benchmarking and advisory reporting related to the environmental and social (i.e. functionality and effectiveness) performance at or near the end of Years 1 and 3 after the commencement of operations. Action at the end of Year 2 should be taken if interventions have occurred and solutions to operational problems have been necessary. Measurement, evaluation, benchmarking and advisory reporting should take place before the end of the period for making good defects for the asset/facility to enable remedial work to be carried out as necessary.

The owner, operator, operations team or asset/facility 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. Operational costs should be recorded on a periodic basis and not less frequently than every quarter.

5.8.7 Information and data

The following information should be taken into account for the purpose of supporting the work activities (see **5.8.2**) and contributing to the deliverables (see **5.8.9**) in this work stage:

a) for the initial period of aftercare:
    1) functionality and effectiveness of the asset/facility 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 and/or POE;

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/facility 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 and/or POE; 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 or questions so that the requirements are understood by the person or party receiving the request for information.

5.8.8 Common data environment

The operator, operations team or asset/facility 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, each delivery team involved in this work stage should take action immediately to transfer the required information and data.

5.8.9 Deliverables and other outputs

The operator, operations team or asset/facility manager, as appropriate, should provide the owner or project sponsor on its behalf with the following as a minimum:

a) evidence of the functionality and effectiveness of the asset/facility 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 and/or POE at the end of Years 1 to 3, as appropriate, to establish feedback to the owner and/or operator;

e) results from the post-implementation review and POE/or 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) updated health and safety file;

r) documented experiences and lessons learned; and

s) 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.

5.8.10 Key decisions and next steps

*COMMENTARY ON **5.8.10***

This work stage provides the opportunity for the owner, operator, licensee, operations team or asset/facility manager, as appropriate, and each delivery team involved in this work stage to consolidate valuable information and data about the performance of the asset/facility.

Adjustments to the operational parameters of the asset/facility and any subsequent changes to the design should be recorded. Alterations and changes should be processed through the status gates of the CDE in the PIM to enable review by the operator, operations team or asset/facility manager. Once verified by the operator, operations team or asset/facility 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 1 A question that can be considered here is: "Does the asset/facility measure up to requirements in terms of its environmental, social and economic performance?" The answer to this question determines the owner's next steps in asset/facilities management and any subsequent adjustments or alterations to the asset/facility.

NOTE 2 Annex G offers an activity checklist to assist in briefing for design, manufacture and construction and, in particular, reviews of progress in all work stages.

5.8.11 Data exchange

The management of information and data about the asset/facility should continue throughout the operational phase. As work in connection with maintenance, repairs and replacements is undertaken, details should be captured in the asset management model (AIM) within the owner's or operator's asset/facilities management system. Records should be kept with respect to:

a) as-constructed information prepared before the handover of the facility, such as construction details, layouts, floor plans and other perspectives showing the location of engineered systems; and

b) as subsequently altered information to be kept during the operational phase, such as details of defects, maintenance, alterations and redecoration work, where appropriate.

NOTE 1 The gathering of up-to-date information and data on the asset/facility is a necessary prerequisite to maintaining a digital likeness that is justified by the avoidance of errors and omissions when undertaking work at a future date.

The owner or operator should maintain the asset information model so that it represents the current state of the asset/facility at all times.

NOTE 2 The integration of operations and maintenance into the asset information model, together with real-time condition data on the performance of the asset/facility, moves closer to the realization of the digital twin as a dynamic model with which the asset/facility manager and others could interact to monitor and control conditions within the asset/facility. The incorporation of an ontological view would add a semantic capability by defining a set

of concepts and categories to represent the subject in a digital context. In this way, it would provide a common landscape of formal naming and definition of the categories, properties and relations between the concepts, data and entities in the subject matter.

5.8.12 Decommissioning, repurposing or dismantling

*COMMENTARY ON **5.8.12***

In its basic form, decommissioning is the act of removing something from service. Decommissioning falls outside the scope of this British Standard. In the case of the asset/facility, there will be implications from any mothballing or abandonment such as continuing liability for any acts or events involving the asset/facility that might put people, property or the environment at risk. Materials and products used in its construction might no longer be considered appropriate or safe and steps might have to be taken to dispose of them safely.

When establishing the business case for an asset/facility and in subsequent decision-making through the work stages covering design, manufacture and construction, the owner or operator, as appropriate, should take account of the implications of decommissioning, repurposing or dismantling it at the end of its service life and the risks this poses to people, property and the environment.

Annex A (informative)
Responsibility assignment matrix (examples)

An example of a RASCI chart is given in Table A.1.

Table A.1 – Typical tasks and allocated roles (extract)

Task	CEO	COO	CFO	CIO	AM/FM
Prepare information management strategy	Consult	Accountable	Support	Responsible	Support
Manage asset/facility contract information	Accountable	Consult	Consult	Support	Responsible
Prepare operational procedures	Inform	Accountable	Inform	Consult	Responsible
Maintain records of asset/facility performance	Inform	Accountable	Consult	Support	Responsible
Maintain asset register	Inform	Accountable	Consult	Support	Responsible

NOTE CEO = Chief Executive Officer; COO = Chief Operating Officer; CFO = Chief Finance Officer; CIO = Chief Information Officer; AM = Asset manager; FM = Facility manager.

An example of a design responsibility matrix is given in Table A.2.

Table A.2 – Typical design responsibility matrix indicating level of information need (extract)

Aspect of design		**Work stage 2: Concept Design team**	
Uniclass 2015 code	**Title**	**Design responsibility**	**Level of information need**
Ss_15_10_28_85	Steel sheet pile embedded retaining wall system	Drivedeal	2
Ss_20_05_65_41	In situ concrete bored piling system	Drivedeal	2
Ss_20_05_15_71	Reinforced concrete pile cap and ground beam foundation system	Drivedeal	2
Ss_20_10_75_35	Heavy steel framing system	Frambold	3
Ss_30_12_85_16	Composite steel and concrete floor	Frambold	2

NOTE The level of information need (see BS EN 17412-1) is expected to be predefined for each work stage and in this example is set as the default value (i.e. level 2), except for one aspect of the design. 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. In the table, "Ss" refers to a system.

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 to evaluate environmental performance. It is expected that they would need to be adapted to suit the characteristics and requirements of a specific project.

B.2 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 consistent with the target of net zero carbon operation and use. It might therefore cover:

a) assessment of annual energy use covering all individual energy sources;

b) analysis of half-hourly energy demand profiles;

c) assessment of the asset/facility's contribution to greenhouse gas emissions;

d) cross-references to the post-implementation review and/or post-occupancy evaluation (POE) 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 product performance;

h) review of the performance and usability of controls and metering;

i) safety, security, reliability, resilience, serviceability/maintainability of energy-using systems and components;

j) structured reviews with the operator, operations team or asset/facility manager, as appropriate, and the representative(s) of users;

k) review of how the owner's leadership, strategic asset management plan (SAMP) or facilities management strategy and user behaviour impact upon energy use;

l) suggestions for improvement; and

m) comparison with the results from other assets/facilities (from within a portfolio, programme or from a wider benchmark database).

B.3 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 and/or post-occupancy evaluation (POE) 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) review of rainwater harvesting equipment, where applicable;

m) structured reviews with the operator, operations team or asset/facility manager, as appropriate, and the representative(s) of users;

n) review of how the owner's leadership, strategic asset management plan (SAMP) or facilities management strategy and user behaviour impact upon water use;

o) suggestions for improvement; and

p) comparison with results from other assets/facilities (from within a portfolio, programme or from a wider benchmark database).

B.4 Waste reduction including reuse and recycling

This evaluation might typically include measurement of waste and an advisory report to suggest ways of reducing waste and opportunities for reuse and recycling. 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 and/or post-occupancy evaluation (POE) 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/facility manager, as appropriate, and the representative(s) of users;

h) review of how the owner's leadership, strategic asset management plan (SAMP) or facilities management strategy and user behaviour impact upon waste reduction and disposal;

i) suggestions for improvement; and

j) comparison with results from other assets/facilities (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 to evaluate social performance. 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 functional and internal environmental performance over the period under review, for example:

a) availability – the proportion of time the asset/facility was in a functioning state compared with the interval over which the asset/facility was expected to function;

b) utilization – the extent to which the asset/facility provided or directly supported the operations and the users for which it was designed;

c) capability – the ability of the asset/facility to achieve its objectives in relation to the expected benefits;

d) capacity – the measure of the asset/facility's ability to provide the full extent of expected benefits;

e) access – the ease with which users gain access to the asset/facility, including the use of amenities and other supporting features, where applicable;

f) inclusiveness – the extent to which the asset/facility supports the needs of people with mobility, sensory or cognitive impairment and others with equalities-related needs;

g) space – the size, layout and interrelationship of constituent spaces contributing to the efficient use of the asset/facility, where applicable;

h) safety – the number of reported incidents, including injury to persons and damage to property;

i) security – the number of breaches, near misses or other trigger-related events;

j) quality – the inherent quality of the asset/facility, its components and sub-systems;

k) reliability – the ability of the asset/facility to perform correctly and consistently in accordance with its operational specifications;

l) resilience – the capacity to recover quickly from an event impacting negatively on the asset/facility;

m) serviceability and maintainability – the ease and speed with which the asset/facility or a component of it can be adjusted/repaired and maintained;

n) adaptability – the extent to which the asset/facility allows for the functions it accommodates now and into the future;

o) measurability – the ease of metering and other measurement of energy, greenhouse gas emissions, water consumption and waste reduction;

p) form and aesthetics of materials – the physical composition, scale and configuration of the asset/facility within its boundaries;

q) construction – the functionality and durability of materials and the standard of construction;

r) durability – the ability to resist deterioration over time under normal use;

s) indoor air quality – the measure of the users' assessment of air quality afforded by the asset/facility;

t) thermal comfort – the measure of the users' assessment of the level of comfort afforded by the asset/facility;

u) well-being – the measure of the users' sense of well-being afforded by the asset/facility;

v) urban and social integration – the integration and coherence of the asset/facility with the surroundings;

w) character and innovation – the expression of users' appreciation of the asset/facility and what it means to them;

x) operational management – the degree to which users are satisfied with asset/facilities management and how it impacts on the performance of the asset/facility in meeting their needs; and

y) strategic management – what users think of the owner's business strategy and how it impacts upon performance of the asset/facility in meeting 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 to evaluate economic performance, 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 and/or post-occupancy evaluation (POE), 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 expressed as £/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.

D.3 Operational cost

Example cost centres include:

a) structural repair;

b) building services engineering repair and maintenance;

c) internal repair and maintenance;

d) reinstatement;

e) minor improvements;

f) internal re-organizations;

g) internal plans and decoration;

h) grounds maintenance;

i) water and sewerage; and

j) energy.

Annex E (informative)
Information and data classification (example)

Information and data classification plays an important role in information management if the information and data generated are to be transferred accurately and effectively between disciplines. Classification is the first step in standardizing information containers and datasets so that ontologies and mappings can be utilized to increase the automation of downstream business workflows.

Examples of current UK (Uniclass 2015) and international classification systems are given in Table E.1.

NOTE 1 Coding structures and descriptions can be expected to change over time.

Table E.1 – UK and international classification systems

Classification system	Coding structure						Comments
Uniclass 2015 (Unified Classification for the Construction Industry) Developed by NBS: https://www.thenbs.com/our-tools/uniclass-2015	Pr_60_60	60	60			Heating and cooling source products	Uniclass Products
	Pr_60_65_37	60	65	37		Heating and cooling coils	
	Pr_60_65_37_47	60	65	37	47	Low temperature hot water heating coils	
	Ss_60	60				Heating, cooling and refrigeration systems	Uniclass Systems
	Ss_60_30	60	30			Rail and paving heating systems	
	Ss_60_30_60	60	30	60		Pavement heating systems	
	Ss_60_30_60_27	60	30	60	27	Electric pavement heating systems	
	PM_10	10				Project Information	Uniclass Project Management
	PM_10_10	10	10			Project	
	PM_10_10_60	10	10	60		Project Description	
OmniClass Developed by CSI:	23-23 11 00	Vertical Transportation Equipment					OmniClass Products
	23-23 11 11	Elevators					
	23-23 11 11 11	Traction Elevators					

https://www.csiresources.org/standards/omniclass	23-23 11 11 11 11 23-23 11 11 11 13 23-23 11 11 11 15 23-23 11 11 11 17	Freight Traction Elevators Passenger Traction Elevators Residential Traction Elevators Service Traction Elevators	
	21-04 30 21-04 30 10 21-04 30 10 10 21-04 30 10 30 21-04 30 10 50 21-04 30 20 21-04 30 20 10 21-04 30 20 30 21-04 30 20 70 21-04 30 20 90	Heating, ventilation and Air Conditioning (HVAC) Facility Fuel Systems Fuel Piping Fuel Pumps Fuel Storage Tanks Heating Systems Heat Generation Thermal Heat Storage Decentralized Heating Equipment Heating System Supplementary Components	OmniClass Elements
UniFormat™ Developed by CSI and CSC: https://www.csiresources.org/standards/uniformat	D30 D3010 D3010.10 D3010.30 D3010.50 D3020 D3020.10 D3020.30 D3020.70 D3020.90	Heating, Ventilation, and Air Conditioning (HVAC) Facility Fuel Systems Fuel Piping Fuel Pumps Fuel Storage Tanks Heating Systems Heat Generation Thermal Heat Storage Decentralized Heating Equipment Heating System Supplementary Components	
MasterFormat Developed by CSI and CSC: https://www.csiresources.org/standards/masterformat	42 00 00 42 08 00 42 08 10 42 08 20 42 08 30	Process Heating, Cooling, and Drying Commissioning of Process Heating, Cooling and Drying Equipment Commissioning of Heating Equipment Commissioning of Cooling Equipment Commissioning of Drying Equipment	

NOTE 2 All tradenames and trademarks are acknowledged.

Annex F (informative)
Brief checklist for a building (example)

F.1 The following extract from a checklist represents typical considerations from a largely design perspective in regard to the work activities involved in briefing (see **5.2.2**), the information and data required to support those activities (see **5.2.11**) and the deliverables (see **5.2.13**) in the form of an initial brief. These considerations are not comprehensive and might not be appropriate for every situation.

a) Overall design concept:

1) vision and image of the organization and the extent to which these are to be reflected in the appearance and design of the asset/facility;

2) impact of the design on users as they approach, enter and move about the asset/facility, in particular the internal environment and provisions for assuring the health, safety and security of personnel;

3) inclusive design principles applying to the asset/facility, incorporating the needs of disabled people with mobility, sensory or cognitive impairment and others with equalities-related needs; and

4) extent of design for reduced environmental impact, including choice of principal materials and their eventual reuse, recycling or disposal, and the adoption of passive systems (e.g. natural means of lighting, cooling and ventilation).

b) Operational requirements: internal:

1) zoning, internal circulation and transportation (e.g. offices, service cores, lifts escalators, stairways and lobbies);

2) demands for space supporting different functions and activities (e.g. production, creative areas, private spaces, meetings and conferences, safety areas, social areas, dining and refreshment areas) and for ancillary services (e.g. waste segregation, recovery, reuse and recycling, and rainwater harvesting);

3) organizational structure (e.g. departments and other units), including the anticipated number of personnel and their roles;

4) communication between departments and with users;

5) descriptions of the functions, activities and processes to be supported in the asset/facility, including provisions for the isolation and segregation of space, by zone;

6) arrangements for enabling the access, use and emergency evacuation for all users, including people with mobility, sensory or cognitive impairment and others with equalities-related needs;

7) flexibility/adaptability in the internal design (e.g. reconfigurable space and expansion/reduction possibility);

8) energy use, water management and waste disposal;

9) security, safety, fire and resilience (e.g. measures in the event of a failure in an installation or system, or other incident and arrangements for business continuity);

10) carbon footprint, including calculation of carbon metric; and

11) support services (e.g. services such as cleaning and waste disposal and supplies such as consumables).

c) Operational requirements: external:

1) zoning of external areas and associated security (e.g. landscaping, parking, assembly in the event of emergency, fencing, lighting, sign-posting, security and surveillance);

2) entry to and from the asset/facility for occupants, visitors and other users, including emergency access and “means of escape” routes; and

3) access to public transport (e.g. modes of transport and their distance from the asset/facility).

F.2 The following checklist represents typical considerations from a largely operational (i.e. facilities management) perspective. These considerations are not comprehensive and might not be appropriate for every situation.

1) Internal spaces:
   a) types of surface (e.g. internal walls, partitions, floors and ceilings);
   b) surface areas (m^2) by type;
   c) planned lifetime of surfaces by type;
   d) estimate of initial cost of surfaces by type;
   e) provisions for cleaning and routine maintenance by type;
   f) restrictions in access; and
   g) activities to be performed in connection with the above (e.g. frequency, specialist skills, equipment and consumables) and acceptable service levels.
2) External envelope:
   a) orientation and form;
   b) types of surface (e.g. roof covering, external walls, windows and external doors);
   c) surface areas (m^2) by type;
   d) planned lifetime of surfaces by type;
   e) estimate of initial cost of surfaces by type;
   f) provisions for cleaning and routine maintenance by type;
   g) restrictions in access; and
   h) activities to be performed in connection with the above (e.g. frequency, specialist skills, equipment and consumables) and acceptable service levels.
3) External spaces:
   a) asset/facility plot size, layout, general operations and access for deliveries and maintenance work;
   b) restrictions in access and working height;
   c) equipment and permanent fixtures on the plot;
   d) types of surface and surface areas (m^2);
   e) planned lifetime of surfaces;
   f) estimate of initial cost of surfaces; and
   g) provisions for routine maintenance, including acceptable service levels.

Annex G (informative)
Activity checklist

The checklist given in Table G.1 is intended to assist in briefing and, in particular, reviews of progress through design, manufacture, construction and commissioning, and into the Use work stage. It does not purport to provide a complete or comprehensive summary of activities, but suggests an approach.

Table G.1 – Summary of main activities by focus area and work stage

Focus area	Work stage							
	0 Strategy	1 Preparation and Brief	2 Concept	3 Definition	4 Technical Design	5 Manufacture, Construct and Commission	6 Handover and Closure	7 Use
Environment Meeting the targets for net zero carbon (including energy use and greenhouse gas emissions), water consumption, waste disposal and other environmental factors.	Determine the targets for energy use, greenhouse gas emissions, water consumption, waste reduction and other environmental factors.	Determine the environmental performance outcomes for the asset/facility. 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 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.
Social (i.e. functionality and effectiveness) Meeting the needs of the owner, operator and users in regard to asset availability, utilization, access, inclusiveness, safety, serviceability/ maintainability, indoor air quality, thermal comfort and well-being, among others. **Security** Meeting the needs	Identify the business-related activities and processes to be provided by the new, upgraded, repurposed or refurbished 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,	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,	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	Explore the design proposals by means of an information model or other method for explaining the asset/facility 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	Undertake model-based design performance simulations. Identify any changed operational requirements essential for meeting the desired energy performance target. Prepare method statements covering operation, use and maintenance	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	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/facility safely, securely and efficiently, where applicable.	Conduct aftercare review meetings and workshops as planned. Record users' comments related to functionality and effectiveness. Maintain records of walkabouts, where applicable, to identify emerging issues. Update the technical guide, as appropriate.

Table G.1 – Summary of main activities by focus area and work stage

Focus area	Work stage							
	0 Strategy	1 Preparation and Brief	2 Concept	3 Definition	4 Technical Design	5 Manufacture, Construct and Commission	6 Handover and Closure	7 Use
of the owner, operator and users from the development of an appropriate and proportionate security-minded approach.	processes, support services, assets/facilities and personnel.	access, inclusiveness, safety, security capability, capacity, serviceability/ maintainability, adaptability, indoor air quality, thermal comfort and well-being, among others.	and operational requirements.	asset/facility that is safe to access, operate, use and maintain.	. Prepare aftercare plans.	design, structural design, and engineered systems needed to obtain statutory approvals.		
Economic 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. 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 G.1 – Summary of main activities by focus area and work stage

Focus area	Work stage							
	0 Strategy	1 Preparation and Brief	2 Concept	3 Definition	4 Technical Design	5 Manufacture, Construct and Commission	6 Handover and Closure	7 Use
Commissioning, Training and Handover Completing the asset/facility and preparing for handover, operation and use, including support for the operator and users.	Arrange for the project sponsor to oversee the soft landings process or appoint a soft landings champion or lead for this purpose. Determine the requirements and arrangements for the delivery of project information and asset information.	Determine how project information will be transferred from the project information model (PIM) to the asset information model (AIM) and owner's enterprise system or equivalent.	Outline commissioning needs, including those for engineered systems. Prepare a plan for operational readiness to include commissioning checks, training and handover. Determine the operational resources needed to support commissioning checks, training and handover.	Update the plan for commissioning, operational readiness, 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 commissioning, operational readiness, training and handover. Prepare a construction and system testing schedule and a commissioning and performance testing schedule. Confirm the arrangements for the transfer of information to the asset information model (AIM).	Update the commissioning specification. Update the commissioning, operational readiness and training plans in liaison with the commissioning manager. Prepare a schedule of activities for commissioning. Identify any skills that users need to have before attending commissioning demonstrations.	Verify the commissioning information provided by each delivery team. 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 model (AIM).	Maintain records of walkabouts, where applicable, to identify emerging issues. Optimize the engineered systems. Record and feedback details of performance optimization. Update the technical guide.

Table G.1 – Summary of main activities by focus area and work stage

Focus area	Work stage							
	0 Strategy	1 Preparation and Brief	2 Concept	3 Definition	4 Technical Design	5 Manufacture, Construct and Commission	6 Handover and Closure	7 Use
Asset/Facilities Management Providing an efficient and cost-effective strategy, policy and plans for operating and maintaining the asset/facility.	Identify the performance benchmarks for this type of asset/facility by establishing targets and the processes for subsequently measuring performance. Identify any existing strategic asset management plan (SAMP) or facilities management strategy and supporting policy or procedures and, where none exists, prepare the SAMP or facilities management strategy in outline. Identify the approach to be taken to post-implementation review and/or post-occupancy evaluation (POE).	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) or facilities management strategy and policy covering the Use work stage. Prepare a draft plan for measuring operational performance during the Use 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 and economic performance. Provide an updated operational model, operational management plan and operational expenditure budget. Identify the parties needed to witness demonstrations.	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. Prepare or update a schedule of assets to be maintained and a cost breakdown for accounting and taxation purposes.	Compare the post-implementation review 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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