INTERNATIONAL STANDARD

ISO 19650-1

First edition
2018-12

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

Organisation et numérisation des informations relatives aux bâtiments et ouvrages de génie civil, y compris modélisation des informations de la construction (BIM) — Gestion de l'information par la modélisation des informations de la construction —

Partie 1: Concepts et principes

Reference number
ISO 19650-1:2018(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 59, *Buildings and civil engineering works*, SC 13, *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM).*

A list of all parts in the ISO 19650 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

To improve future editions of the ISO 19650 series, national asset owners, public clients and authorities are recommended to gather information and experiences about its implementation and use.

The ISO 19650 series can benefit from a formal process for managing assets, for example as in the ISO 55000 series. The ISO 19650 series can also benefit from a systematic approach to quality within an organization, for example as in ISO 9001, although certification to ISO 9001 is not a requirement of the ISO 19650 series. Other standards that relate to information structures and delivery methods are also listed in the Bibliography.

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

1 Scope

This document outlines the concepts and principles for information management at a stage of maturity described as "building information modelling (BIM) according to the ISO 19650 series".

This document provides recommendations for a framework to manage information including exchanging, recording, versioning and organizing for all actors.

This document is applicable to the whole life cycle of any built asset, including strategic planning, initial design, engineering, development, documentation and construction, day-to-day operation, maintenance, refurbishment, repair and end-of-life.

This document can be adapted to assets or projects of any scale and complexity, so as not to hamper the flexibility and versatility that characterize the large range of potential procurement strategies and so as to address the cost of implementing this document.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 General terms

3.1.1
responsibility matrix
chart that describes the participation by various functions in completing tasks or deliverables

Note 1 to entry: A responsibility matrix can indicate accountability, consultation and informing, alongside the obligation to complete tasks or deliverables.

[SOURCE: ISO 37500:2014, 3.16, modified — The word "roles" has been replaced with "functions"; the words "for an outsourcing arrangement" have been removed; Note 1 to entry has been added.]

3.1.2
space
limited three-dimensional extent defined physically or notionally

[SOURCE: ISO 12006-2:2015, 3.1.8]

3.2 Terms related to assets and projects

3.2.1
actor
person, organization or organizational unit involved in a construction process

Note 1 to entry: Organizational units include, but are not limited to, departments, teams.

Note 2 to entry: In the context of this document, construction processes take place during the *delivery phase* (3.2.11) and the *operational phase* (3.2.12).

[SOURCE: ISO 29481-1:2016, 3.1, modified — The words "such as a department, team, etc." have been removed; Note 1 and 2 to entry have been added.]

3.2.2
appointment
agreed instruction for the provision of *information* (3.3.1) concerning works, goods or services

Note 1 to entry: This term is used whether or not there is a formal appointment between the parties.

3.2.3
appointed party
provider of *information* (3.3.1) concerning works, goods or services

Note 1 to entry: A lead appointed party should be identified for each *delivery team* (3.2.6) but this can be the same organization as one of the *task teams* (3.2.7).

Note 2 to entry: This term is used whether or not there is a formal written *appointment* (3.2.2) in place.

3.2.4
appointing party
receiver of *information* (3.3.1) concerning works, goods or services from a lead *appointed party* (3.2.3)

Note 1 to entry: In some countries the appointing party can be termed *client* (3.2.5), owner or employer but the appointing party is not limited to these functions.

Note 2 to entry: This term is used whether or not there is a formal *appointment* (3.2.2) between the parties.

3.2.5
client
actor (3.2.1) responsible for initiating a project and approving the brief

3.2.6
delivery team
lead *appointed party* (3.2.3) and their appointed parties

Note 1 to entry: A delivery team can be any size, from one person carrying out all the necessary functions through to complex, multi-layered *task teams* (3.2.7). The size and structure of each delivery team are in response to the scale and complexity of the asset management or project delivery activities.

Note 2 to entry: Multiple delivery teams can be appointed simultaneously and/or sequentially in connection with a single asset or project, in response to the scale and complexity of the asset management or project delivery activities.

Note 3 to entry: A delivery team can consist of multiple task teams from within the lead appointed party's organization and any appointed parties.

Note 4 to entry: A delivery team can be assembled by the *appointing party* (3.2.4) rather than the lead appointed party.

3.2.7
task team
individuals assembled to perform a specific task

3.2.8
asset
item, thing or entity that has potential or actual value to an organization

[SOURCE: ISO 55000:2014, 3.2.1, modified — Note 1, 2 and 3 to entry have been removed.]

3.2.9
project information
information (3.3.1) produced for, or utilized in, a particular project

[SOURCE: ISO 6707-2:2017, 3.2.3]

3.2.10
life cycle
life of the *asset* (3.2.8) from the definition of its requirements to the termination of its use, covering its conception, development, operation, maintenance support and disposal

[SOURCE: ISO/TS 12911:2012, 3.13, modified — The words "stages and activities spanning the life of the system" have been replaced with "life of the asset"; NOTEs 1 and 2 have been removed.]

3.2.11
delivery phase
part of the *life cycle* (3.2.10), during which an *asset* (3.2.8) is designed, constructed and commissioned

Note 1 to entry: Delivery phase normally reflects a stage-based approach to a project.

3.2.12
operational phase
part of the *life cycle* (3.2.10), during which an *asset* (3.2.8) is used, operated and maintained

3.2.13
trigger event
planned or unplanned event that changes an *asset* (3.2.8) or its status during its *life cycle* (3.2.10), which results in *information exchange* (3.3.7)

Note 1 to entry: During the *delivery phase* (3.2.11), trigger events normally reflect the ends of project stages.

3.2.14
key decision point
point in time during the *life cycle* (3.2.10) when a decision crucial to the direction or viability of the *asset* (3.2.8) is made

Note 1 to entry: During a project these generally align with project stages.

3.3 Terms related to information management

3.3.1
information
reinterpretable representation of data in a formalized manner suitable for communication, interpretation or processing

Note 1 to entry: Information can be processed by human or automatic means.

[SOURCE: IEC 82045-1:2001, 3.1.4, modified — The term has been changed from "data" to "information": in the definition, the word "information" has been replaced with "data".]

3.3.2
information requirement
specification for what, when, how and for whom *information* (3.3.1) is to be produced

3.3.3
organizational information requirements
OIR
information requirements (3.3.2) in relation to organizational objectives

3.3.4
asset information requirements
AIR
information requirements (3.3.2) in relation to the operation of an *asset* (3.2.8)

3.3.5
project information requirements
PIR
information requirements (3.3.2) in relation to the delivery of an *asset* (3.2.8)

3.3.6
exchange information requirements
EIR
information requirements (3.3.2) in relation to an *appointment* (3.2.2)

3.3.7
information exchange, verb
act of satisfying an *information requirement* (3.3.2) or part thereof

3.3.8
information model
set of structured and unstructured *information containers* (3.3.12)

3.3.9
asset information model
AIM
information model (3.3.8) relating to the *operational phase* (3.2.12)

3.3.10
project information model
PIM
information model (3.3.8) relating to the *delivery phase* (3.2.11)

Note 1 to entry: During the project, the project information model can be used to convey the design intent (sometimes called the design intent model) or the virtual representation of the asset (3.2.8) to be constructed (sometimes called the virtual construction model).

3.3.11
federation
creation of a composite *information model* (3.3.8) from separate *information containers* (3.3.12)

Note 1 to entry: The separate information containers used during federation can come from different *task teams* (3.2.7).

3.3.12
information container
named persistent set of *information* (3.3.1) retrievable from within a file, system or application storage hierarchy

EXAMPLE Including sub-directory, information file (including model, document, table, schedule), or distinct sub-set of an information file such as a chapter or section, layer or symbol.

Note 1 to entry: Structured information containers include geometrical models, schedules and databases. Unstructured information containers include documentation, video clips and sound recordings.

Note 2 to entry: Persistent information exists over a timescale long enough for it to have to be managed, i.e. this excludes transient information such as internet search results.

Note 3 to entry: Naming of an information container should be according to an agreed naming convention.

3.3.13
status code
meta-data describing the suitability of the content of an *information container* (3.3.12)

3.3.14
building information modelling
BIM
use of a shared digital representation of a built *asset* (3.2.8) to facilitate design, construction and operation processes to form a reliable basis for decisions

Note 1 to entry: Built assets include, but are not limited to, buildings, bridges, roads, process plants.

[SOURCE: ISO 29481-1:2016, 3.2, modified — The word "object" has been replaced with "asset"; the words "including buildings, bridges, roads, process plants, etc." have been removed; original Note 1 to entry has been replaced with a new one.]

3.3.15
common data environment
CDE
agreed source of *information* (3.3.1) for any given project or *asset* (3.2.8), for collecting, managing and disseminating each *information container* (3.3.12) through a managed process

Note 1 to entry: A CDE workflow describes the processes to be used and a CDE solution can provide the technology to support those processes.

3.3.16
level of information need
framework which defines the extent and granularity of *information* (3.3.1)

Note 1 to entry: One purpose of defining the level of information need is to prevent delivery of too much information.

3.3.18
capability
measure of ability to perform and function

Note 1 to entry: In the context of this document, this relates to skill, knowledge or expertise to manage *information* (3.3.1).

[SOURCE: ISO 6707-1:2017, 3.7.1.11, modified — Note 1 to entry has been added.]

3.3.19
capacity
resources available to perform and function

Note 1 to entry: In the context of this document, this relates to means, resources and procedures to manage *information* (3.3.1).

4 Asset and project information, perspectives and collaborative working

4.1 Principles

Asset information models (AIM) and project information models (PIM) are the structured repositories of information needed for making decisions during the whole life cycle of a built environment asset. This includes the design and construction of new assets, refurbishment of existing assets, and the operation and maintenance of an asset. It should be expected that the amount of information stored in information models, and the different purposes it will be used for, will mostly increase during project delivery and asset management.

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. Physical sources of information, such as soil and product samples, should be managed using the information management process described in this document through appropriate cross-references, for example sample numbers.

Most projects involve work on an existing asset, even if this is a previously undeveloped site. These projects should include some pre-existing asset information to support the development of the project brief and be available for lead appointed parties working on the project.

Information management processes within this document include the transfer of relevant information between an AIM and a PIM at the start and end of a project.

Asset and project information has substantial value to appointing, lead appointed and appointed parties involved in asset management and project delivery. This includes where no formal appointments exist. Appointing, lead appointed and appointed parties include the owners, operators and managers of built assets, and those delivering design and construction projects. Asset and project information is also valuable to policymakers, regulators, investors, insurers and other external parties.

The concepts and principles contained within this document should be applied in a way that is proportionate and appropriate to the scale and complexity of the asset or project.

4.2 Information management according to the ISO 19650 series

The recommendations and requirements for information management in the ISO 19650 series are based on appointing, lead appointed and appointed parties working collaboratively together, and all parties should participate in the implementation of the ISO 19650 series.

Information management can be represented as a sequence of maturity stages, shown as Stages 1, 2 and 3 in Figure 1. This Figure shows that development of standards, advances in technology and more sophisticated forms of information management all combine to deliver increasing business benefit. The ISO 19650 series has application mainly at Stage 2 maturity, but also can be partly applied at Stages 1 and 3.

Stage 2 maturity is also identified as “BIM according to the ISO 19650 series”. This is where a mixture of manual and automated information management processes are used to generate a federated information model. The information model includes all information containers delivered by task teams in relation to an asset or a project.

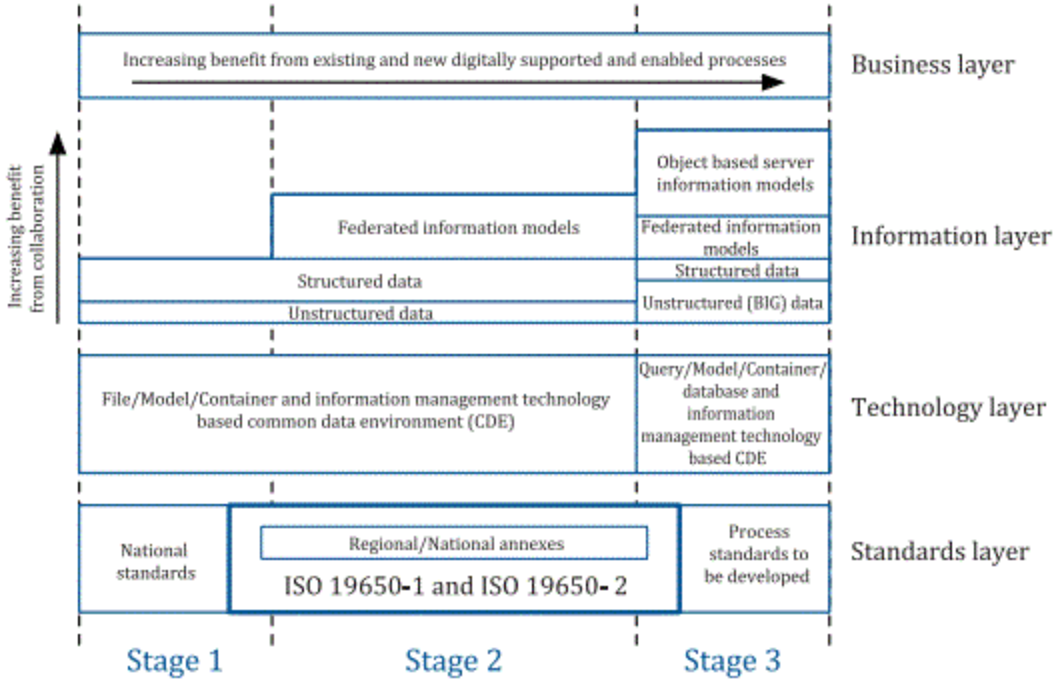


Figure 1 — A perspective on stages of maturity of analogue and digital information management

4.3 Information management perspectives

Different information management perspectives should be recognized by the information management process and should be incorporated in the process in the following ways:

— in the specification of information requirements;

— in the planning for information delivery; and

— in the delivery of information.

Information management perspectives should be defined on a case-by-case basis, but the four perspectives described in Table 1 are recommended. Other perspectives can also be helpful, depending on the nature of the asset or project.

include continuous development of the following impacts and beneficial aspects of the asset from the earliest deliverable onwards:

— management of capacity and utilization: documentation of the intended capacity and utilization of the asset should be provided as it is required to support comparisons of actual use and utilization and portfolio management;

— management of security and surveillance: information should be required or suppressed to support the management of the security and surveillance of the asset and neighbouring or adjacent sites in line with security requirements;

— support for renovation: renovation of each space or location and the whole asset should be supported with detailed information about the capacity, in terms of areas, spaces, occupancy, environmental conditions and structural load bearing;

— predicted and actual impacts: the appointing party should require information relating to the impacts from quality, cost, scheduling, carbon (CO_2e), energy, waste, water consumption or other environmental effects;

— operations: information necessary for the normal operations of the asset should be provided to help the appointing party anticipate the cost of asset operation;

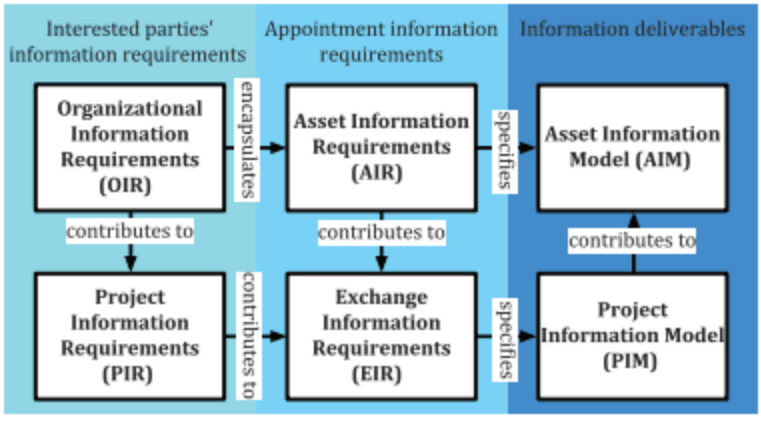
— maintenance and repair: information on the recommended maintenance tasks, including planned preventative maintenance, should be provided to help the appointing party to anticipate and plan for costs of maintenance;

— replacement: information on the reference or expected replacement service life and costs should be available to the appointing party to anticipate the costs of replacement; recycling of the physical assets should be supported with detailed information relating to the principal constituent materials; and

— decommissioning and disposal: information on the recommended decommissioning should be provided to help the appointing party anticipate and plan for end-of-life costs.

Information requirements associated with the delivery phase of an asset should be expressed in terms of the project stages that the appointing party or lead appointed party intends to use. Information requirements associated with the operational phase of an asset should be expressed in terms of foreseeable life cycle trigger events such as planned or reactive maintenance, fire equipment inspection, component replacement or change of asset management provider.

The different types of information requirements and information models are shown in Figure 2 and explained in 5.2 to 5.7.



NOTE In this figure, "encapsulates" means "provides the input to", "contributes to" means "provides an input to", "specifies" means "determines the content, structure and methodology".

Figure 2 — Hierarchy of information requirements

5.2 Organizational information requirements (OIR)

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.

OIR can exist for reasons other than asset management, for example in relation to submitting annual financial accounts. These OIR are not considered further in this document.

5.3 Asset information requirements (AIR)

AIR set out managerial, commercial and technical aspects of producing asset information. The managerial and commercial aspects should include the information standard and the production methods and procedures to be implemented by the delivery team.

The technical aspects of the AIR specify those detailed pieces of information needed to answer the asset-related OIR. These requirements should be expressed in such a way that they can be incorporated into asset management appointments to support organizational decision-making.

A set of AIR should be prepared in response to each trigger event during asset operation and where appropriate should also refer to security requirements.

Where there is a supply chain, the AIR received by a lead appointed party can be sub-divided and passed on in any of its own appointments. AIR received by a lead appointed party can be augmented with its own information requirements.

Across an asset management strategy and plan there can exist several different appointments. The AIR from all these should form a single coherent and coordinated set of information requirements, sufficient to address all the asset-related OIR.

5.4 Project information requirements (PIR)

PIR explain the information needed to answer or inform high-level strategic objectives within the appointing party in relation to a particular built asset project. PIR are identified from both the project management process and the asset management process.

A set of information requirements should be prepared for each of the appointing party's key decision points during the project.

Repeat clients may develop a generic set of PIR that can be adopted, with or without amendment, on all of their projects.

5.5 Exchange information requirements (EIR)

EIR set out managerial, commercial and technical aspects of producing project information. The managerial and commercial aspects should include the information standard and the production methods and procedures to be implemented by the delivery team.

The technical aspects of the EIR should specify those detailed pieces of information needed to answer the PIR. These requirements should be expressed in such a way that they can be incorporated into project-related appointments. EIR should normally align with trigger events representing the completion of some or all project stages.

EIR should be 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.

Across a project there can exist several different appointments. The EIR from all these appointments should form a single coherent and coordinated set of information requirements, sufficient to address all the PIR.

5.6 Asset information model (AIM)

The AIM supports the strategic and day-to-day asset management processes established by the appointing party. It can also provide information at the start of the project delivery process. For example, the AIM can contain equipment registers, cumulative maintenance costs, records of installation and maintenance dates, property ownership details and other details that the appointing party regards as valuable and wishes to manage in a systematic way.

5.7 Project information model (PIM)

The PIM supports the delivery of the project and contributes to the AIM to support asset management activities. The PIM should also be stored to provide a long-term archive of the project and for auditing purposes. For example, the PIM can contain details of project geometry, location of equipment, performance requirements during project design, method of construction, scheduling, costing and details of installed systems, components and equipment, including maintenance requirements, during project construction.

6 The information delivery cycle

6.1 Principles

The specification and delivery of project and asset information follows four overarching principles, each of which is the subject of more detailed discussion in this document:

1. Information is needed for decision-making during all parts of the asset life cycle, including when there is an intention to develop a new asset, modify or enhance an existing asset, or decommission an asset, all as part of the overall asset management system.

2. Information is specified progressively through sets of requirements defined by the appointing party, and the delivery of information is planned and progressively delivered by the delivery teams. In addition, some reference information can also be provided by the appointing party to one or more appointed parties.

3. Where a delivery team contains more than one party then information requirements should be passed to the most relevant party or the point at which the information can be most easily provided.

4. Information exchange involves the sharing and coordination of information through a CDE, using open standards whenever possible and clearly defined operating procedures to enable a consistent approach by all organizations involved.

These principles should be applied in a way that is proportionate to the asset management or project delivery context.

6.2 Alignment with the asset life cycle

AIM and PIM are produced throughout the information life cycle. These information models are used during the asset life cycle for making asset-related and project-related decisions.

Figure 3 shows the asset life cycle for operational and delivery phases of an asset (the green circle) and some information management activities (points A to C). In addition to the three points shown in the figure, verification of designers' intentions should take place through review of asset performance during the operational phase. Timing will depend on when and how frequently tests after completion and performance review are done. If the verification fails then remedial works can be required. During the operational phase, trigger events take place that can require an information management response, resulting in one or more information exchanges.

Figure 3 also shows that the ISO 19650 series for information management takes place within the context of an asset management system, such as ISO 55000, or a project management framework, such as ISO 21500, which itself takes place within organizational management according to a quality management system, such as ISO 9001. Other standards such as ISO 8000 (data quality) and ISO/IEC 27000 (information security management) and ISO 31000 (risk management) are also relevant but are omitted from the figure for clarity.

The following key principles (as set out in ISO 55000) are important for asset information management as set out in the ISO 19650 series:

— the appointing party specifically links asset management to the achievement of its business objectives through asset management policies, strategies and plans;

— appropriate and timely asset information is one of the fundamental requirements for successful asset management; and

— leadership and governance in relation to asset information management comes from the top management within the asset owner/operator.

The following key principles (as set out in ISO 9001) are important for asset information management as set out in the ISO 19650 series:

— there is a focus on the customer (the recipient or user of asset or project information);

— a Plan-Do-Check-Act cycle is used (to develop and provide asset or project information);

— engagement of people and the encouragement of appropriate behaviours is central to the delivery of consistent outputs; and

— there is a focus on sharing of lessons learned and continual improvement.

Key

A start of delivery phase — transfer of relevant information from AIM to PIM

B progressive development of the design intent model into the virtual construction model (see 3.3.10, Note 1 to entry)

C end of delivery phase — transfer of relevant information from PIM to AIM

Figure 3 — Generic project and asset information management life cycle

6.3 Setting information requirements and planning for information delivery

6.3.1 General principles

All asset and project information that is to be supplied during the asset life cycle should be specified by the appointing party through sets of information requirements. The relevant information requirements should be issued to each prospective lead appointed party as part of the procurement process. This also applies when work instructions are issued by one part of an organization to another part of the same organization. A response to each requirement should be prepared by the prospective lead appointed party and reviewed by the appointing party before appointment. The response to the information requirements is then managed and developed by each lead appointed party and included in the plan for their asset management or project delivery activities. Information is managed and delivered by each lead appointed party and accepted by the party specifying the requirements. Feedback loops provide for information deliverables to be revised if necessary. The generic flowchart for this process is shown in Figure 4.

A documented risk assessment for delivery of asset or project information should be included in the overall asset or project risk assessment, so that the nature of the information delivery risks, their

consequences and likelihood of occurring are understood, communicated and managed. The concepts and principles in this document should be considered in the information delivery risk assessment.

Information requirements are defined to address the questions that have to be answered to make key asset-related decisions at different points during the delivery and operation of the asset. Information delivery plans are made every time a lead appointed party is appointed in relation to asset management or project delivery activities. This includes the parallel appointments made by the appointing party in relation to design, construction or any other services, and the sequential appointments made to form a supply chain, for example, within a construction team.

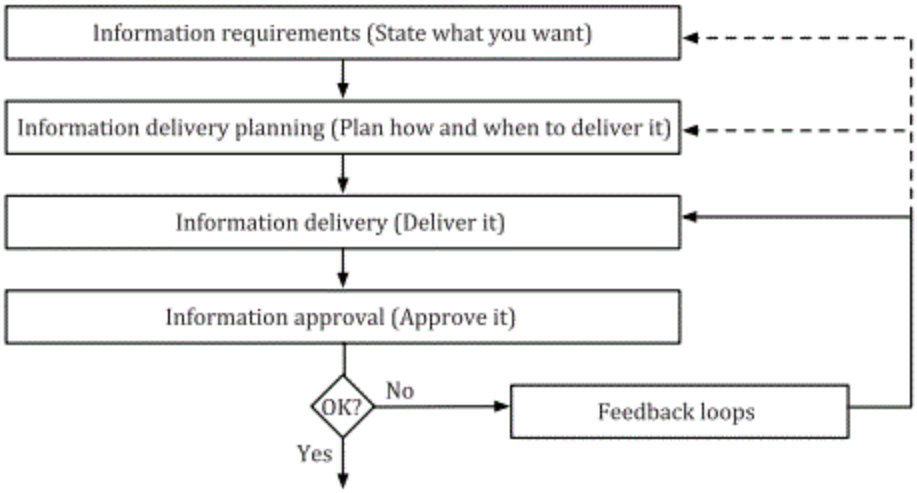


Figure 4 — Generic specification and planning for information delivery

Figure 5 illustrates the sub-division of information management processes and how they apply to each appointment within a project. A similar sub-division of processes should apply for each appointment during asset management.

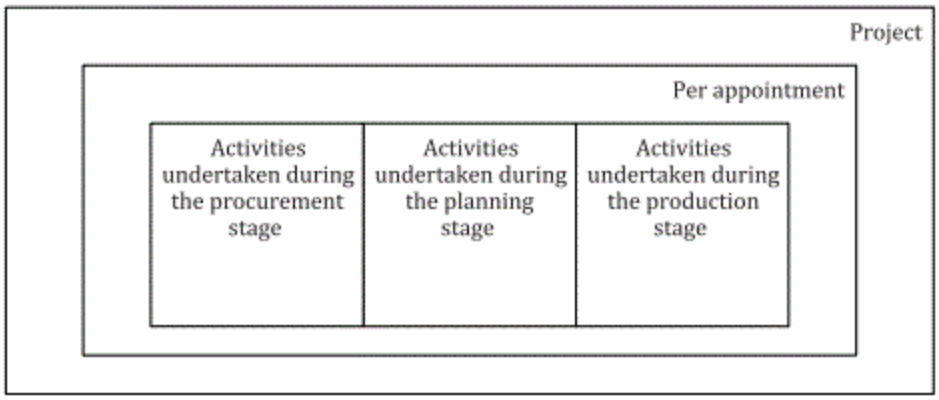


Figure 5 — Illustration of the sub-division of processes

The cascade of information requirements and the supply of information have some key features that are explained in 6.3.2 to 6.3.5 and illustrated for one particular form of procurement.

Further principles concerning information management functions, collaborative working and appointed party capability are set out in Clauses 7, 8 and 9. Further principles concerning information delivery planning are set out in Clause 10. Further principles concerning information production and delivery are set out in Clauses 11 and 12.

6.3.2 Delivery team provides information for asset owner/operator or client decisions

Figure 6 shows one instance of a key decision to be made by the appointing party. That decision is made at a key decision point, the diamond, where a set of information requirements is defined and cascaded to the delivery team (lead appointed party and appointed parties as appropriate). The information is delivered through information exchange, the solid circle.

The appointing party should define the occasions or times when they have to make key decisions, and precisely what information they require from the delivery team to make each decision. Any significant changes to the information requirements should be discussed and agreed between the appointing party and the lead appointed party, either of whom may make such a request.

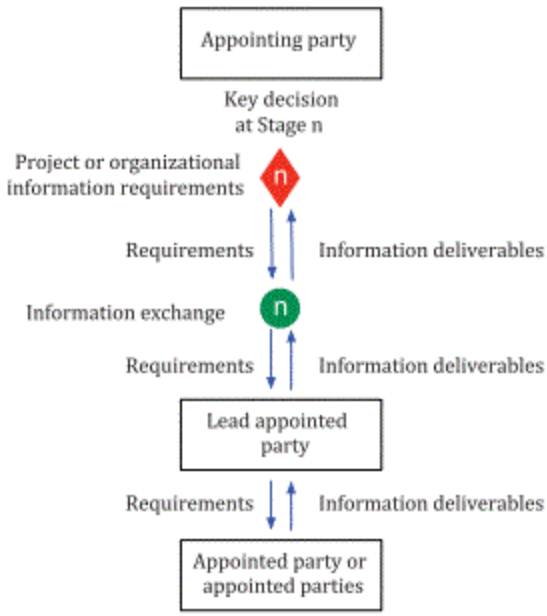


Figure 6 — Relationship between key decision and information from a lead appointed party

6.3.3 Information verification and validation at start and end of project stages

Figure 7 shows information exchange occurring between the end of one project delivery stage and the start of the next project delivery stage.

The solid circle represents the information exchange. The vertical arrows represent information requirements and information deliverables flowing between appointing party and lead appointed party. The circular arrows to the left of the vertical arrows represent the delivery of information by the lead appointed party, the checking of that information by the appointing party against the requirements, and any iteration that is needed to complete the information exchange (for example where required information is missing or not supplied to the required quality). The circular arrows to the right of the vertical arrows represent the provision of information from the appointing party to the lead appointed party, the checking of that information against what is needed to start the next project stage, and any iteration to complete the information exchange.

Within the validation and verification methods it is vital that the approval and acceptance procedures should be agreed and documented before any information exchange takes place.

It is particularly important that a second information check, to start a project stage, is made where there is a change of appointed party between one stage and the next, with particular attention to the usability of the information received. The second check should also take place when there is a delay before the next project stage starts. There can be some situations where the second information check is not needed, for example when the same lead appointed party is delivering both project stages and no delay in the project schedule occurs between these stages.

Information should also be checked if there is a change of lead appointed party during a project stage. In these circumstances, any limitations on the use of the previously appointed party's information should be taken into account.

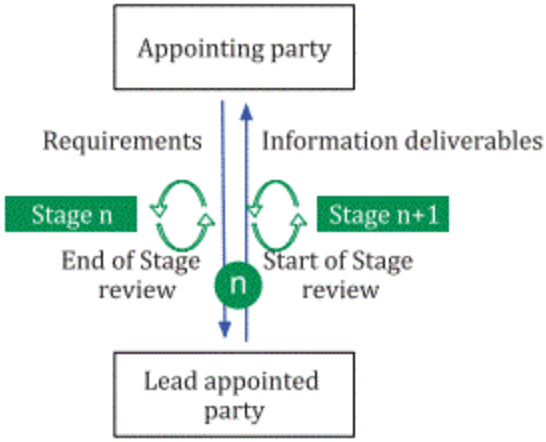
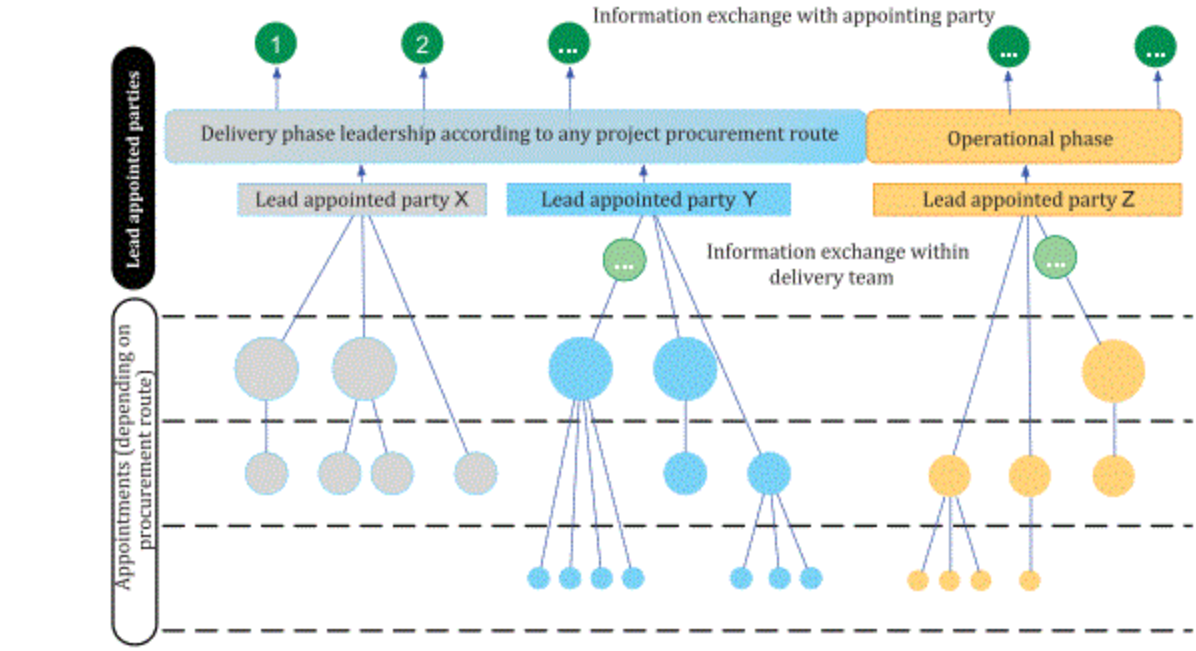


Figure 7 — Information checking during information exchange

6.3.4 Information is drawn from the whole delivery team

Figure 8 shows how the information delivered at information exchange is collated from extended delivery teams for design work, on the left, and for construction work, on the right. For the form of procurement being illustrated, the horizontal dotted lines represent, as an example, levels of appointment. Each lead appointed party may delegate all or part of the information requirements received from their appointing party and may also add information requirements of their own. The role of each lead appointed party in satisfying the AIR or EIR, as appropriate, should be defined in the delivery plans. Information is collated by each lead appointed party from their delivery team and delivered to the appointing party, with checking and possible re-submission as explained in Figure 7.

If new parties join the delivery team, the delivery plan should be updated to include and confirm the information they will be contributing to future information exchanges.



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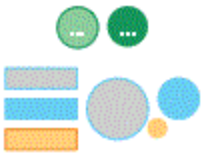


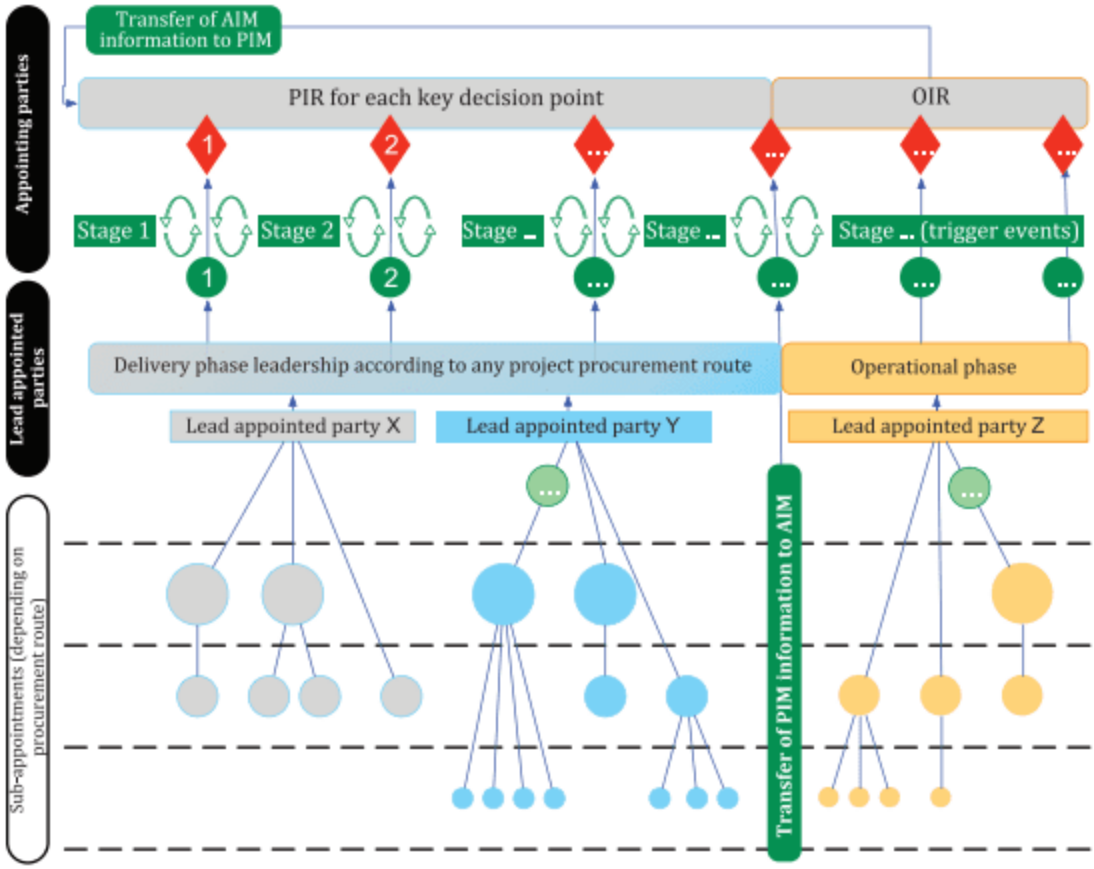
information exchange within delivery team, into PIM or AIM

lead appointed parties and appointed parties (task teams and delivery teams)

Figure 8 — Example of information being provided by whole delivery teams

6.3.5 Summary of information delivery from project and asset delivery teams

Figure 9 illustrates the cascade of requirements and the delivery of information for one particular type of procurement. It is possible to use different arrangements of project stages, different key decision points and different information exchanges from those illustrated. One example is the supply of progress information from the construction lead to the client during construction. However, the key features explained in 6.3.2, 6.3.3 and 6.3.4 should apply to all arrangements of project delivery and asset management.



Key

asset owner or project client key decision points

information exchange within delivery team, into PIM or AIM

lead appointed parties and appointed parties (task teams and delivery teams)

information verification and validation

flow of information deliverables

NOTE In certain situations information exchanges can also occur between appointed parties. For simplicity these have not been shown in the Figure.

Figure 9 — Example of information delivery through information exchange to support key appointing party decisions

7 Project and asset information management functions

7.1 Principles

Clarity of functions, responsibility, authority and the scope of any task are essential aspects of effective information management. Functions should be embedded into appointments, either through a specific schedule of services or by referring to more general obligations.

This document identifies the types of information management functions that should be considered and their responsibilities, and should be read in conjunction with other appointment documentation. Information management functions, responsibility and authority should be allocated to parties on the basis of their appropriateness and ability to perform them. In smaller businesses or projects, multiple functions may be performed by the same individual or party.

Information management functions should not refer to design responsibilities. However, for smaller or less complex assets or projects, information management functions may be performed alongside other functions such as asset management, project management, design team leadership or construction leadership.

It is important not to confuse functions and responsibilities with job titles or with professional or other designations.

In complex asset management or project delivery activities, it is possible to define a specific function of information facilitation or information process management to support team-working and collaboration. This should enable better focus on these different aspects of information management for the efficient implementation of the information management process.

7.2 Asset information management functions

The complexity of asset information management functions should reflect the scale and complexity of the asset or portfolio of assets being managed. It is important that functions are assigned at all times during the asset life cycle. However, given the long-term nature of asset management it is almost certain that functions will be fulfilled by a succession of organizations or individuals. It is therefore important that succession planning is properly addressed in the information management process.

In relation to assets, asset information management can be assigned to one or more individuals from the appointing party's staff. Asset information management involves leadership in validating information supplied from each appointed party and leadership in authorizing it for inclusion in the AIM. The function of asset information management should be assigned from the earliest stage of asset management.

At the end of any project, the key information to be handed over should include information required for operation and maintenance of the asset. Therefore asset information management should be involved in all stages of project delivery as defined in Table 1.

7.3 Project information management functions

The complexity of project information management functions should reflect the extent and complexity of project information. It is important that functions are assigned at all times during the project, but the sequence of appointments and their scope should reflect the procurement route being used.

Project information management involves leadership in establishing the project's information standard, the production methods and procedures, and the project's CDE.

The appointing party allocates responsibility for the delivery of information to the lead appointed parties as appropriate. Allocation of these responsibilities should be project specific and should be documented in the appointment document(s).

7.4 Task information management functions

Where delivery teams are sub-divided into task teams, information management functions should be assigned for each task team. Information management at a task team level is concerned both with the information associated with that task and with the requirement to coordinate information across multiple tasks.

8 Delivery team capability and capacity

8.1 Principles

The appointing party should review the capability and capacity of the prospective delivery team to meet the information requirements. This review can be done by the appointing party, by the prospective delivery team themselves or by an independent party. The scope of the review should be made available to the prospective delivery team. The review can be completed in more than one step, for example where prequalification is being used, but should be completed before the appointment is made.

Capability refers to being able to perform a given activity, for example by having the necessary experience, skill or technical resources. Capacity refers to be able to complete an activity in the required time.

When a new appointment is made during a framework agreement or similar long-term arrangement, then the scope of the review may be reduced to just the relevant aspects of capability and capacity. For example, in a project framework agreement the experience of the prospective delivery team and the access to information technologies need not be assessed for each new project unless the requirements are significantly different from previous projects. In an asset maintenance framework agreement, the capability of the prospective delivery team need only be reassessed at pre-defined intervals during the framework rather than before every maintenance activity.

8.2 Extent of capability and capacity review

The review of prospective delivery team capability and capacity should include at least the following:

— the commitment to comply with this document and the information requirements;

— the ability of the prospective delivery team to work in a collaborative way, and their experience in information container-based collaborative working;

— access to and experience of the information technologies specified or envisaged within the information requirements, or proposed by the delivery team; and

— the quantity of experienced and suitably equipped personnel within the prospective delivery team with availability to work on the proposed asset or project tasks.

9 Information container-based collaborative working

The collaborative production of information should be defined in general terms of structured information to allow the fundamental principles of information container-based collaborative working to be achieved. These fundamental principles are as follows:

a) authors produce information, subject to intellectual property agreements, which they control and check, only sourcing approved information from others where required by way of reference, federation or direct information exchange;

b) provision of clearly defined information requirements at high level, by interested parties associated with the project or asset, and at detailed level by the appointing party;

c) consideration of the proposed approach, capability and capacity of each delivery team prior to appointment by an appointing party against the requirements;

d) provision of a CDE to manage and store shared information, with appropriate and secure availability to all individuals or parties who are required to produce, use and maintain that information;

e) information models to be developed using technologies that are able to conform to this document;

f) processes related to security of information should be put in place during the whole life time of the asset to address issues such as unauthorized access, information loss or corruption, degradation and, as far as is practicable, obsolescence.

10 Information delivery planning

10.1 Principles

Planning for information delivery is the responsibility of each lead appointed party and appointed party. Plans should be formulated in response to the information requirements set out by the appointing party and should reflect the scope of the appointment within the overall asset life cycle. Each information delivery plan should state:

— how information will meet the requirements defined in the AIR or EIR;

— when information is going to be delivered, initially with respect to project stages or asset management milestones and later with respect to actual delivery dates;

— how information is going to be delivered;

— how information is going to be coordinated with information from other relevant appointed parties;

— what information is going to be delivered;

— who is going to be responsible for delivering the information; and

— who the intended recipient of the information will be.

At least some of the planning for information delivery should be carried out by the lead appointed party or appointed party before appointment, as this should form part of the review carried out by the appointing party. More detailed planning can then be required after the appointment is made as part of mobilization. Additional information delivery planning should take place if changes are made to the information requirements or to the delivery team.

The delivery team should review the information management solution before any technical design, construction or asset management tasks start. This should include the following:

— the necessary appointment conditions and amendments have been prepared and agreed;

— the information management processes are in place;

— the information delivery plan takes account of the delivery team's capacity;

— the delivery team has the appropriate skills and competencies; and

— the technology supports and enables the management of information according to this document.

Allowance should be made in the schedule for training in relation to skills and competencies.

Information should be delivered through pre-defined information exchanges. Information exchange can take place between the appointing and lead appointed parties, as well as between lead appointed parties.

The delivery of information in accordance with the information requirements should be one of the criteria for completion of a project or asset management activity. Each information container should be directly related to one or more pre-defined information requirements.

10.2 Timing of information delivery

An information delivery plan should be defined for the whole project or for the short and medium term of asset management according to the schedule and appointment of the parties. In complex situations, this can be generated by merging the delivery plans for each project or asset management task.

The timing of each information delivery should be included in each information delivery plan, with reference to project and asset management schedules when these are known.

10.3 Responsibility matrix

A responsibility matrix should be generated as part of the information delivery planning process in one or more levels of detail. The axes of a responsibility matrix should identify:

— information management functions; and

— either project or asset information management tasks, or information deliverables as appropriate.

The content of a responsibility matrix should show the appropriate detail relevant to the axes.

10.4 Defining the federation strategy and breakdown structure for information containers

The purpose of the federation strategy and the information container breakdown structure is to help plan the production of information by separate task teams to the appropriate level of information need as described in 11.2.

The federation strategy should be developed during information planning activities. It should explain how the information model is intended to be divided into one or more sets of information containers. Allocation can be done by viewing the information model in different views, such as functional, spatial or geometrical. The functional allocation concept is supported by a semantic model view. The geometrical model view is commonly used during the delivery phase.

The federation strategy should be developed into one or more information container breakdown structures during detailed planning to explain in more detail how information containers relate to each other. The federation strategy and the information container breakdown structure explain the methodology to manage interfaces associated with the asset during its delivery phase or operational phase. Different arrangements of information containers should be defined for different purposes, such as functional compatibility, spatial coordination or geometrical interfaces. This should be proportionate to the complexity of the asset or project. Explanations and examples of different applications of federation and information container breakdown are given in Annex A.

The federation strategy and information container breakdown structure should be updated as new task teams are appointed. Updates can also be required as the nature of the work being carried out changes, especially when this changes from asset management to project delivery and vice versa.

Information containers within the information container breakdown structure should be cross-referenced to task teams. Where the federation strategy and information container breakdown structure define only one set of information containers, each task team should be allocated one or more information containers from within the set and each information container should be allocated to only one task team.

The definition of the federation strategy and the information container breakdown structure are both strategic activities related to the project or asset and they should be agreed collaboratively. They should be owned and managed by functions that understand the strategic approach to project delivery and asset management.

The federation strategy and the information container breakdown structure should be communicated to all organizations involved in project or asset activities. It can be helpful for illustrations or detailed descriptions to be prepared and circulated. The security implications of communicating the federation strategy or information container breakdown structure should be considered and this can restrict their circulation.

11 Managing the collaborative production of information

11.1 Principles

A CDE solution and workflow should be implemented to allow information to be accessed by those who require it to undertake their function. The solution can be implemented in several ways and using a range of different technologies. In "BIM according to the ISO 19650 series" the CDE solution and workflow enable the development of a federated information model. This comprises information models from different lead appointed parties, delivery teams or task teams. Security and information quality should be considered and, where appropriate, integrated into the definition of or the proposals for the CDE. More detailed concepts and principles regarding the CDE solution and workflow are in Clause 12.

Issues in the information model should be avoided during the production of information rather than detected after the delivery of information. Issues could be spatial, for example structural elements and building services occupying the same space, or functional, for example fire protection materials being incompatible with the required fire rating of a wall. Spatial coordination issues can be of different kinds, for example "hard" where two objects are occupying the same space or "soft" where one item occupies the operating or maintenance space of another item, or "time" where two objects are present in the same place at the same time. This principle reinforces the requirement for a federation strategy (see 10.4).

Generic information should be used before the final product has been selected or manufactured, indicating the space required for installation, connection, maintenance and replacement, and be replaced by specific information as soon as this is available.

All rights relating to information should be governed by agreements made between the relevant parties.

11.2 Level of information need

The level of information need of each information deliverable should be determined according to its purpose. This should include the appropriate determination of quality, quantity and granularity of information. This is referred to as its level of information need and this can vary from deliverable to deliverable.

A range of metrics exist to determine levels of information need. For example, two complementary but independent metrics can define the geometrical and alphanumerical content in terms of quality, quantity and granularity. Once these metrics have been defined, they should be used to determine the levels of information need across the whole project or asset. All this should be described clearly within the OIR, PIR, AIR or EIR.

The levels of information need should be determined by the minimum amount of information needed to answer each relevant requirement, including information required by other appointed parties, and no more. Anything beyond this minimum is considered as waste. Lead appointed parties should consider the risk that importing object information automatically into information models can introduce a higher level of information need than is required.

The relevance of an information deliverable is not always correlated to its granularity. Level of information need is, however, closely linked to the federation strategy (see 10.4).

The granularity of alphanumerical information should be considered to be at least as important as that of geometrical information.

11.3 Information quality

Information managed in the CDE should be understandable by all parties. The following should be agreed to support this:

— information formats;

— delivery formats;

— structure of the information model;

— the means of structuring and classifying information; and

— attribute names for metadata, for examples properties of construction elements and information deliverables.

Classification of objects should be in accordance with the principles in ISO 12006-2. Object information should be in accordance with ISO 12006-3, to support object exchange.

Automated checking of information in the CDE should be considered.

12 Common data environment (CDE) solution and workflow

12.1 Principles

A CDE solution and workflow should be used for managing information during asset management and project delivery. During the delivery phase, the CDE solution and workflow support the information management processes in ISO 19650-2:2018, 5.6 and 5.7.

At the end of a project, information containers required for asset management should be moved from the PIM to the AIM. Remaining project information containers, including any in the archive state, should be retained as read-only in case of dispute and to help lessons to be learned. The timescale for retaining project information containers should be defined in the EIR.

The current revision of each information container within the CDE should be in one of the following three states:

— work in progress (see 12.2);

— shared (see 12.4); or

— published (see 12.6).

Current information containers can exist across all three states, depending on their development.

There should also be an archive state (see 12.7) providing a journal of all information container transactions and an audit trail of their development.

These states are shown in the conceptual diagram in Figure 10. Figure 10 deliberately does not illustrate the complexities of the CDE workflow, involving multiple iterations of information container development, multiple reviews, approvals and authorizations, and multiple journal entries into the archive recording information containers in any of the other states.

The transition from one state to another should be subject to approval and authorization processes (see 12.3 and 12.5).

Each information container managed through the CDE should have metadata including:

1. a revision code, in accordance with an agreed standard for example IEC 82045-1; and

2. a status code, showing the permitted use(s) of information.

Metadata is initially indicated by its author and then amended by the approval and authorization processes. Using an information container for anything other than the use indicated by its status code is at the risk of the user.

The CDE solution can include both a database management capability to manage information container attributes and meta-data, and a transmittal capability to issue update notices to team members and to maintain the audit trail of information handling.

The whole information model is not always held in one place, particularly for large or complex assets or projects, or widely dispersed teams. Information container-based collaborative working allows for CDE workflow to be distributed across different computer systems or technology platforms.

The advantages of adopting such a CDE solution and workflow include:

— responsibility for the information within each information container remains with the organization that produced it, and although it is shared and reused only that organization is allowed to change the contents;

— shared information containers reduce the time and cost in producing coordinated information; and

— a full audit trail of information production is available for use during and after each project delivery and asset management activity.

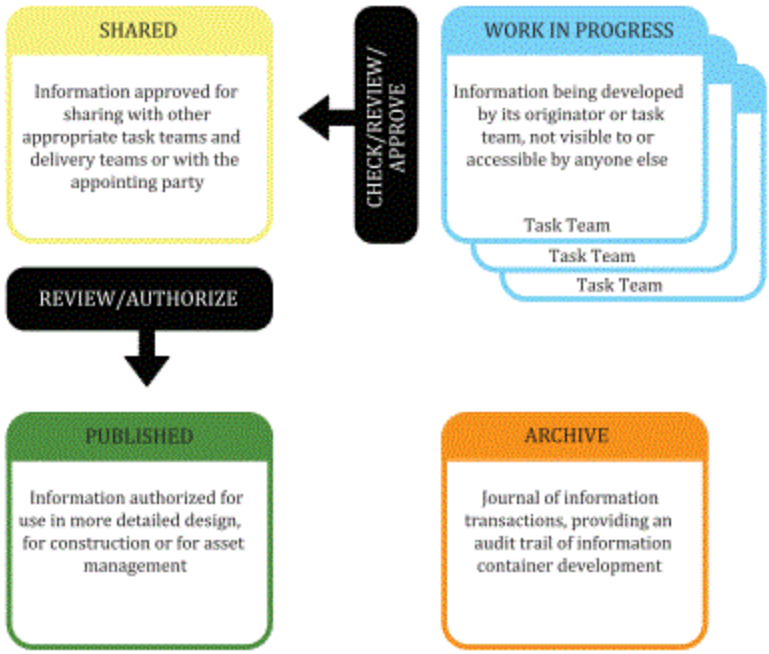


Figure 10 — Common data environment (CDE) concept

12.2 The work in progress state

The work in progress state is used for information while it is being developed by its task team. An information container in this state should not be visible or accessible to any other task team. This is particularly important if the CDE solution is implemented through a shared system, for example a shared server or web-portal.

12.3 The check/review/approve transition

The check/review/approve transition compares the information container against the information delivery plan and against the agreed standards, methods and procedures for producing information. The check/review/approve transition should be made by the originating task team.

12.4 The shared state

The purpose of the shared state is to enable constructive and collaborative development of the information model within a delivery team.

Information containers in the shared state should be consulted by all appropriate appointed parties (including those in other delivery teams) for the purpose of coordination with their own information,

subject to any security-related restrictions. These information containers should be visible and accessible but should not be editable. If editing is required, an information container should be returned to the work in progress state for amendment and resubmission by its author.

The shared state is also used for information containers that have been approved for sharing with the appointing party and are ready for authorization. This use of the shared state can be termed the client shared state.

12.5 The review/authorize transition

The review/authorize transition compares all the information containers at information exchange against the relevant information requirements for coordination, completeness and accuracy. If an information container meets the information requirements, its state is changed to published. Information containers not meeting the information requirements should be returned to the work in progress state for amendment and resubmission.

Authorization separates information (in the published state) that may be relied on for the next stage of project delivery, including more detailed design or construction, or for asset management, from information that can still be subject to change (in the work in progress state or the shared state).

12.6 The published state

The published state is used for information that has been authorized for use, for example in the construction of a new project or in the operation of an asset.

The PIM at the end of a project or the AIM during asset operation contains only information in the published state or the archive state.

12.7 The archive state

The archive state is used to hold a journal of all information containers that have been shared and published during the information management process as well as an audit trail of their development. An information container referenced in the archive state that was previously in the published state represents information that potentially has been used for more detailed design work, for construction or for asset management.

13 Summary of "building information modelling (BIM) according to the ISO 19650 series"

Information management is distinct from information production and delivery, but is closely linked to them. Information management should be applied during the whole life cycle of the asset. Information management functions should be assigned to the most appropriate organizations (appointing party, appointed parties, lead appointed parties) and should not necessarily require appointment of new organizations.

The quantity of information being managed generally increases both during the delivery phase and during the operational phase. However, only relevant information should be made available or transferred between operational phase and delivery phase activities and vice versa.

An information management process is started each time a new delivery phase or operational phase appointment is made, irrespective of whether this appointment is formal or informal. This process involves preparation of information requirements, review of prospective appointed parties in relation to information management, initial and detailed planning for how and when information will be delivered, and review of information deliverables against the information requirements before they are integrated with operational systems. The information management process should be applied in a way that is proportionate to the scale and complexity of the project or asset management activities.

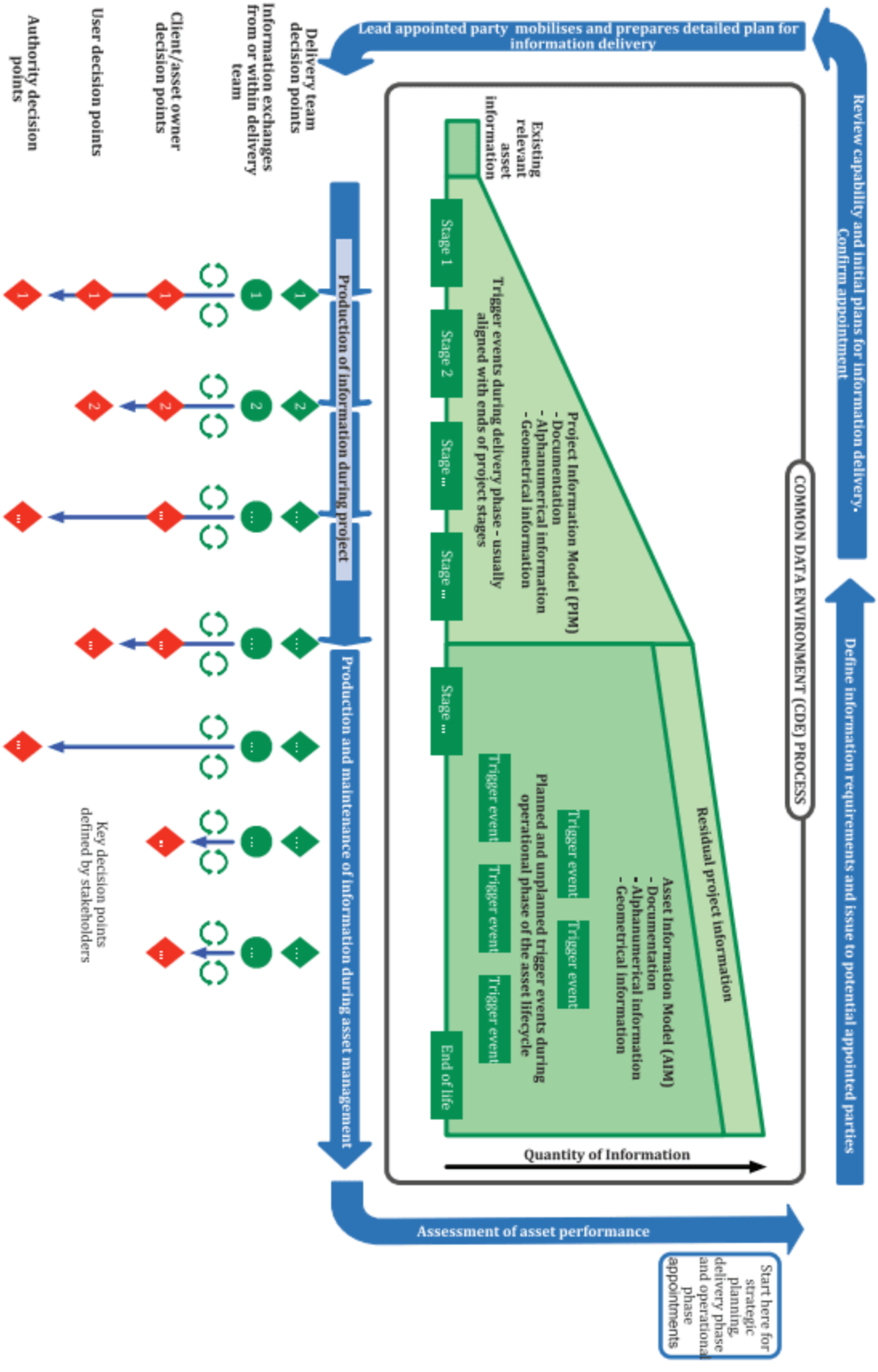
Information requirements are cascaded to the most relevant appointed party within a delivery team. Information deliverables are collated by the lead appointed party before delivery to the appointing party through information exchange. Information exchange is also used to transfer information between lead appointed parties where this has been authorized by the appointing party.

The CDE workflow is used to support collaborative production, management, sharing and exchange of all information during operational and delivery phases.

Information models containing federated information deliverables are produced as a result of the CDE workflow to address the perspectives of all interested parties.

Within the information management process, the number and description of sub-divisions of the asset life cycle (solid rectangles), points of information exchange (solid circles) and decision points for delivery teams, interested parties or appointing party (diamonds) should reflect local practice, interested party and appointing party requirements, and any agreements or requirements specific to project delivery or asset management.

These concepts and principles are summarized in Figure 11.



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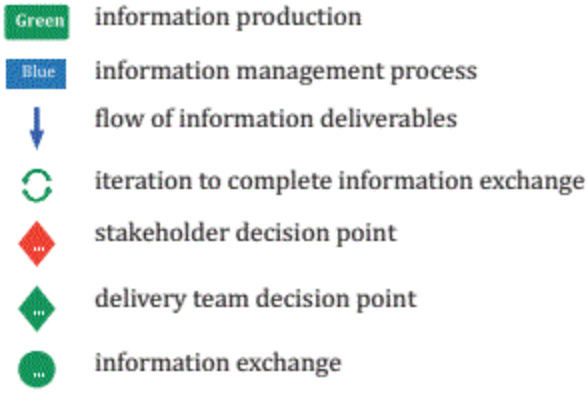


Figure 11 — Overview and illustration of the information management process

Annex A
(informative)

Illustrations of federation strategies and information container breakdown structures

A.1 General

Federation strategies and information container breakdown structures are important concepts in managing federated information models in "BIM according to the ISO 19650 series".

Federation and information container breakdown should be used to:

— allow different task teams to work on different parts of the information model simultaneously without introducing coordination issues, for example spatial clashes or functional incompatibilities;

— support information security;

— ease information transmission by reducing the sizes of individual information containers.

Federation and information container breakdown can also be used to help define scopes of service for task teams.

A.2 Simultaneous working

A federation strategy to allow simultaneous working should define the spatial boundaries within which each task team should locate the systems, components or construction elements it is responsible for.

For an asset that is primarily linear, such as a rail tunnel, the federation strategy can be defined by a dimensioned cross-section of the tunnel. This is illustrated in Figure A.1 and in this case the strategy is linked to different types of systems to be accommodated in the tunnel.

For an asset such as a building, the federation strategy can be defined through a set of interlocking spaces. This is illustrated in Figure A.2. An information container breakdown is illustrated in Figure A.3. Both of these are linked to different design disciplines.

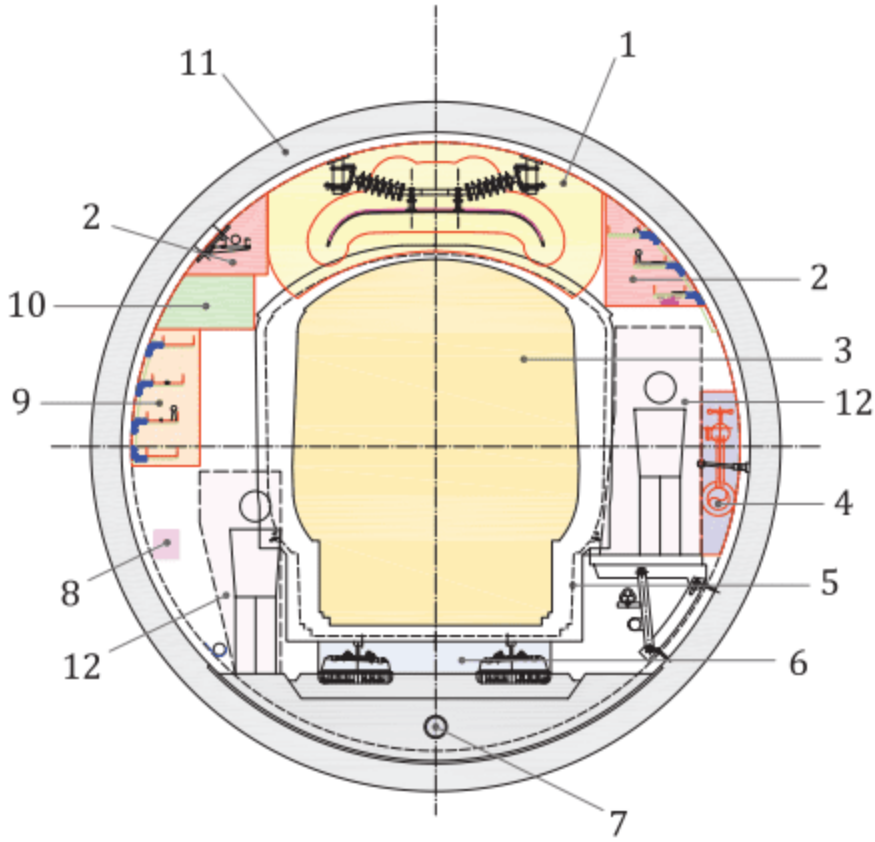
A.3 Information security

A federation strategy or information container breakdown structure to support information security should separate containers or spatial sections of the asset according to the permissions for accessing information.

For an asset related to criminal justice, such as a prison, different levels of restriction can be placed on general site information (such as location, vehicle access routes), on general design and construction information (such as floor plans, space adjacencies, heating and ventilation treatments) and on security-specific information (such as details of cell and wing locks, details of surveillance systems, evacuation or containment procedures). This is illustrated in Figure A.4.

A.4 Information transmission

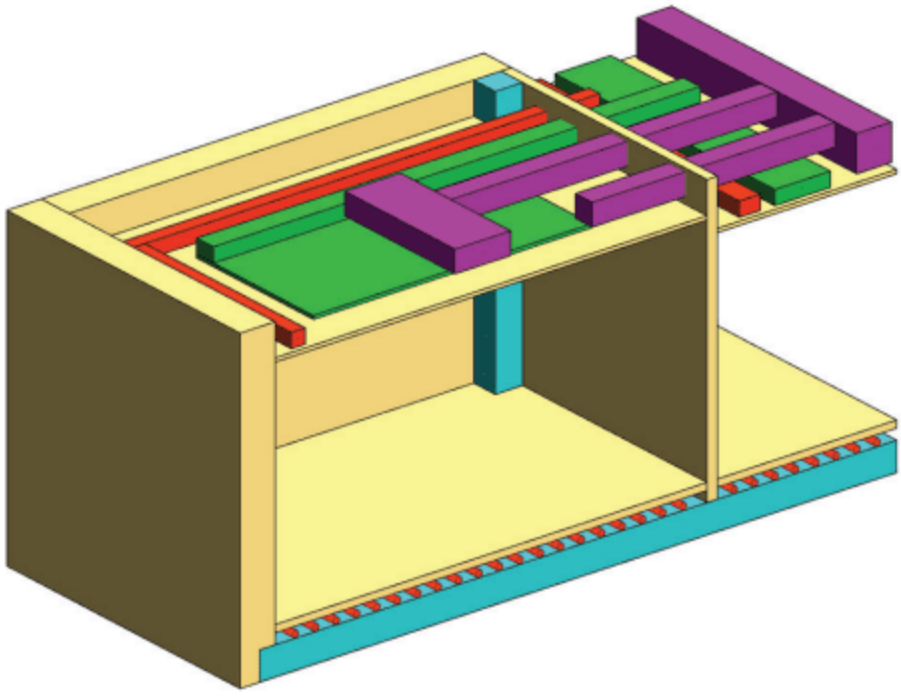
A federation strategy to assist with transmission of information containers within a delivery team or to and from an appointing party should consider the maximum file size that is practicable for upload and download with the specified IT infrastructure, for example 250 Mb. The information model should then be sub-divided so that no single information container is larger than 250 Mb.



Key

1	overhead line electrification	7	drainage system
2	electrical system	8	communications system
3	train	9	signaling system
4	water system	10	signage
5	kinetic envelope	11	tunnel structure
6	track system	12	emergency walkway

Figure A.1 — Illustration of federation of tunnel cross-section systems in a rail project



Key

yellow	architecture
blue	structure
green, red, purple	mechanical, electrical and plumbing systems

Figure A.2 — Illustration of spatial federation strategy by discipline in a building project

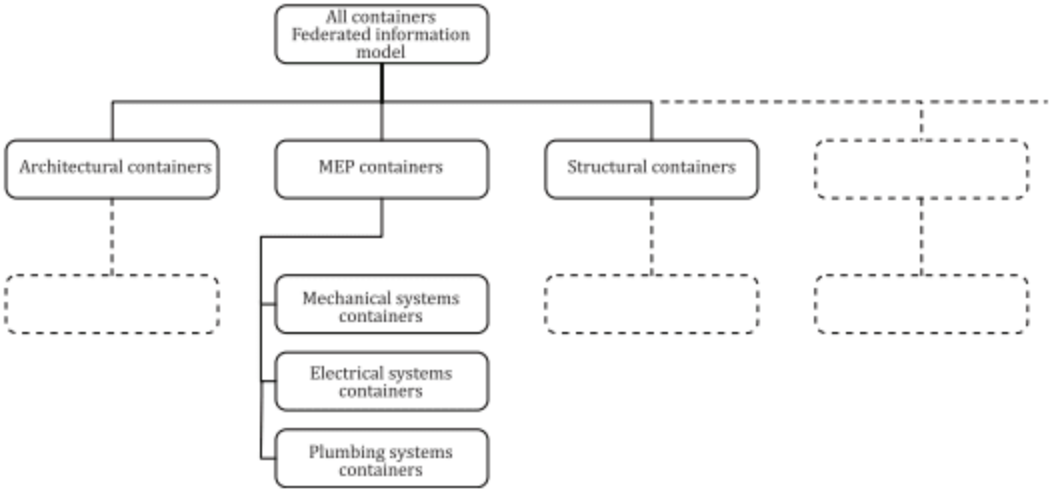


Figure A.3 — Illustration of information container breakdown structure for simultaneous working

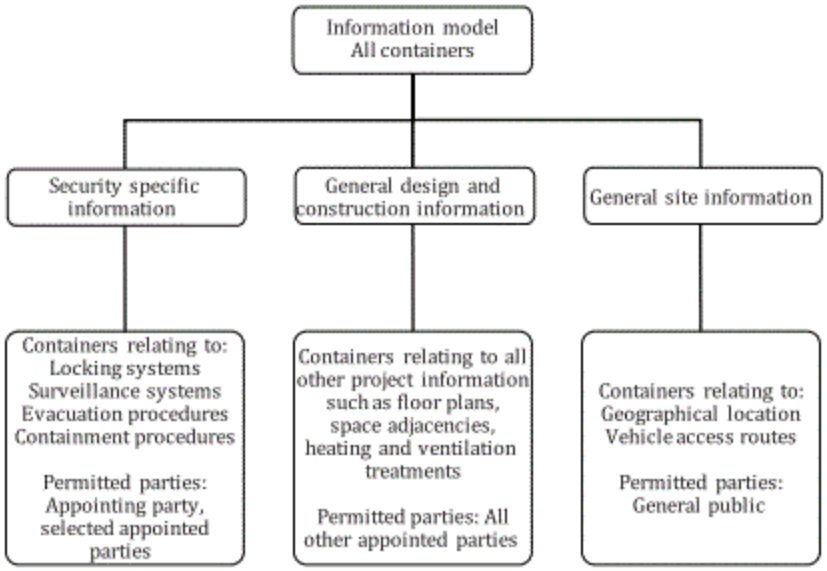


Figure A.4 — Illustration of information container breakdown structure for information security

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ICS 35.240.67; 91.010.01

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