Introduction
In this article we look at how the approach outlined in document PAS 1192 Part 3 might be used by an organisation to develop their bespoke digital Asset Information Model to support decision making.

The publication of Publicly Available Specification PAS 1192 Part 3 provides a “Specification for information management for the operational phase of assets using building information modelling”. It is a companion document to PAS 1192 Part 2 which is a “Specification for information for the capital /delivery phase of construction projects using building information modelling”. The Part 3 document provides an approach to creating an asset information model to support the whole life of an asset from create/acquire, through use/maintain and on to renew/dispose.

Here we are using PAS 1192 Part 3 to explore how an organisation might go about establishing a digital asset information model to provide information for management.

Please note that hard copies of the two companion documents are available through the BSI Bookshop (PAS 1192-2 LINK) and (PAS 1192-3 Link) and free to download pdf versions were made available on the BSI Bookshop at the time of launch. The publication of both documents makes it clear that one of the main objectives of the application of information modelling in the capital delivery phase of an asset is to provide information to support the longer term activity of asset operation.
In Figure 2 we introduce the work stages associated with the life cycle of an asset. In 2012 the Business Innovation Skills Building Information Modelling (BIS BIM) Task Group worked with the publishers of existing “plans of work” to agree a standard set of work stages that would be applied across all roles and sectors associated with the creation and operation of assets in the built environment. The aim was to agree work stages that would be used across all roles and sectors to reflect a consistent level of development of information including non-geometric data, geometric data and documents. Note the significance of including Strategy and Operation and End of Life in the work stages. These stages had not been strongly recognised by previous plans of work. At the Strategy work stage an organisation seeking to create a new asset will be expected to define their required outcomes in terms of the social, environmental and economic measures that define sustainability. It is a stage that is about the business defining required economic, social and environmental outcomes and setting measurable targets.

The Operation and End of life work stage requires the organisation and their design/construction team to focus continuously on whole life considerations and in particular upon measuring how well the delivered asset meets the Strategy stage targets. Targets might not be met for a number of reasons, for example the targets may have been wrongly set and the use of the asset may have changed but it is important to measure performance, recognise positive and negative impacts upon performance and to optimise performance. These are the fundamental principles of “Soft Landings” for the government construction client.
A lot of people may be familiar with Figure No 3 as an overview of using BIM in the capital phase of asset delivery. The process of capital delivery begins on the right hand side in the operational phase of the above diagram with the organisation deciding that it needs to create or refurbish an asset and that decision of course is related to business need. The process then moves anti-clockwise around the diagram. The organisation will identify what information it already knows and what information it will want from the asset construction process to inform decisions – these will be called the Employer’s Information Requirements. The Employers Information Requirements are identified as the basis of construction/refurbishment/de-commissioning contracts and as part of the procurement process the organisation next seeks an execution plan that demonstrates that the supply chain can deliver what is required. Following contract award a delivery plan is produced by the supply chain to identify from within their team exactly who delivers what and when. This is referred to as the Master Information Delivery Plan. It should be noted that the TSB BIM Project “A digital tool for building information modelling” (insert link) is being established to create for all sectors a means of producing both a default and a bespoke digital Plan of Work using a Classification system that will be applicable to all construction sectors. The digital Plan of Work will effectively help to inform the Master Information Delivery Plan. After supply chain mobilisation the project starts and information is exchanged with the Employer at the agreed decision points. There are also likely to be many information exchanges between the design/construction team at each of the work stages. Digital documentation, graphical data and non-graphical data are produced progressively in support of the Employer’s decision points and eventually are transferred to the Employer organisation at the end of Handover and Close-out work stage. The organisation has to decide what happens to that digital information, how it benefits them and how it fits with the long term activity of asset management.

**Asset Management**

**Figure 4**

*Asset Management (Using PAS 55)*

This diagram from PAS 55:1 identifies the hierarchy of asset management. At the apex of the triangle it shows the key objective of supporting the purpose of the business. It introduces the layers of managing a diverse portfolio of assets and of managing asset systems that have an indefinite horizon of required usage and each contribute to the overall goals of the organisation.
As well as the layers dealing with strategic direction the diagram shows the day-to-day activities and realities of managing assets – Create/acquire, Use, Maintain and Renew/Dispose. The diagram goes some way to showing that over the long-term of asset management, the activities of Create/Acquire and Renew/Dispose might occur relatively infrequently. Of course it is these Create/Acquire and Renew/Dispose activities which require the information management approach identified in PAS 1192-2 whereas the information management approach identified in PAS 1192-3 applies to the much longer term of whole life asset management.

Figure 5
The Project Information Model in the asset life cycle?

Figure 5 introduces the BS ISO 55000 series of documents which is now published and sets an international standard for asset management. At the time of drafting PAS 1192 Part 3 the new standards had not been published.

The information management approach of PAS 1192 Parts 2 and 3 are shown here surrounded by the standards of asset management and the needs of operational management for the business need. It is perhaps a reminder that the short term construction/disposal activities which are the subject of a lot of publicity in the construction world are really a means to the long-term end of successfully operating a business supported by the practice of asset management. The diagram illustrates the work stages 0 (Strategy) to 6 (Handover and Close-out) associated with PAS 1192-2 and the multiplicity of activities (n) that occur during the much longer timescale associated with work stage 7 (Operation and End of Life)

Operational phase of an asset using BIM

Figure 6
Whole Life Information
PAS1192-3 2014
How does information generated by the day to day activities of asset management interface with the broader objectives of an asset information system? The bottom left of Figure 6 shows the broad principle of information exchanges from the multiple tiers of the supply chain on a Create and Acquire activity. These information exchanges will be managed in keeping with PAS 1192-2. It also shows that there will be similar information exchanges from the supply chain on a Renew/Dispose activity which will also be managed in keeping with PAS 1192-2. The development of information in the above activities is progressive and sequential in line with programmed work stages to align with key decision points by the Employer. The bottom centre of the diagram shows the information exchanges associated with the Use and Maintain activities and points out that during these activities which last for the greater part of the asset life cycle, the information exchange points and the decision points very rarely align so there needs to be a way to store “use and maintain” information so that the most up-to-date information is available to inform the decisions of corporate/organisation management when the need arises. Figure 6 introduces the Asset Information Model which can provide a repository for information.

Asset Information Model – Creating the case

Most organisations will probably say that they have an asset information model, after all they have probably been managing assets for years. Their models might be paper based, they might be digitally based and they might be a mixture of both. The models used might either be managed by the organisation or they might be managed by a supply chain provider. As asset portfolios become larger and more complex and as the world becomes more digitally biased, organisations will no doubt allocate more and more executive time to consider the need for a re-structuring of how they manage asset information to information better decisions. Whatever method is used by the executive team to analyse the performance of their current model and to inform the need for re-structuring the organisation, it will almost certainly need to identify benefits that it seeks to obtain from using and owning a digital asset information model.

Before embarking on the journey of producing the digital asset information model an organisation will develop and publish a business case. They will need to identify the benefits that they plan to obtain; how much time and money will be needed to create a data and file store; how much time and money will need to be allocated to identifying the information that will be required; how much time and money will be needed to collect that data; what sort of people and how many people will be needed to conduct the work and provide governance; what sort of software tools will be used to extract data from the asset information model and create reports. One of the first steps will be to identify the potential benefits of creating a digital information model. Some of the benefits might be as the following:

- Reduced costs due to the automated transfer of information from construction to operation. Less manual input of information.
- More complete information reducing management costs.
- Fewer problems and costs during early operation of a new or refurbished asset because of the availability of better information about the asset.
- The opportunity to reduce operation and maintenance costs. More focus on long term operational performance giving better informed decisions about operational expenditure and capital expenditure.
- Reduced remedial costs during early operation brought about by fewer construction defects.
- Savings from life cycle decisions informed by a single, integrated, up-to-date source of information. Better modelling of resilience and risk of failure.
- Improved expenditure decisions enabled by information to support asset investment planning.

A source of data records from dynamic metering and condition sensors to identify poor energy performance, faults and risk of impending failure.

The Organisation owns and retains all their asset information for future procurement.

The benefits to be sought are very personal to each organisation. Identifying the anticipated benefits is the critical stage of defining the required outcomes that the asset information model is to deliver. As with any project it is essential for the organisation to keep in mind the outcomes that it requires and to continuously monitor how well they are met.
Below is an example from the list of potential benefits that we will follow through this text:

“To improve expenditure decisions enabled by information to support asset investment planning.”

Preparing for an Asset Information Model

Figure 7

Organisation Information Requirements

The organisation will first identify what information it needs in order to answer the operational decisions that it will have to make. PAS 1192:3 refers to these as Organisation Information Requirements (OIR’s). Having an asset investment plan is an example.

- optimize asset management strategy and optimize/prioritize its asset management plan(s);
- assess the financial benefits of planned improvement activities;
- determine the operational and financial impact of asset unavailability or failure;
- make life cycle cost comparisons of alternative capital investments;
- identify expiry of warranty period and warranty;
- determine the end of economic life of assets/asset systems, e.g. the point in time when the asset related expenditure exceeds the associated income;
- determine the cost of specific activities (activity based costing), e.g. the total cost of maintaining a specific asset(s)/asset system;
- obtain/calculate asset replacement values;
- undertake financial analysis of planned income and expenditure;
- calculate the financial and resource impact of deviating from plans that might result in a change in asset availability or performance (e.g. what is the financial impact of deferring the maintenance of a specific generator by six months);
- assess its overall financial performance;
- undertake the on-going identification, assessment and control of asset related risks;
- comply with statutory and regulatory obligations.

Above are some organisation information requirements that might help to inform corporate/organisation decisions. These will be specific to each organisation. Organisations can have different needs for information. Identifying the OIR’s will require input from various departments within the organisation. Input will be needed in particular from the people involved in the strategic decision making associated with the asset portfolio and asset systems.
Asset Information Requirements

The next step will be to identify what pieces of information are needed to inform each OIR. PAS 1192:3 refers to these pieces of information as Asset Information Requirements (AIR’s). Asset Information Requirements are the detailed pieces of information about the asset that when placed in context can answer the questions raised in the Organisation Information Requirements. An OIR might be answered by a single piece of information but it usually requires an aggregation of several pieces of information about an asset. Continuing with our example it requires the replacement cost, the life expectancy and the business criticality of an asset to inform the asset investment plan.

To prepare the content required to answer an Organisation Information Requirement will often require the collection, aggregation and manipulation of multiple pieces of asset information – the Asset Information Requirements. A lot of these pieces of information will be drawn from the activities of day-to-day asset management (Create/Acquire, Use, Maintain and Renew/Dispose) and to identify the required information will need a lot of input from people engaged on those activities. There will be many Asset Information Requirements and the organisation will need to recognise the time and resource commitment required to identify every piece of data that is required.

Employers Information Requirements

If there is a decision to construct a new asset the organisation will need to identify which of the AIR’s will need to be identified as part of the Employer’s Information Requirements (EIR’s) for the new construction contract. In our example of creating an asset investment plan we might ask for the life expectancy and replacement cost to be identified as part of the EIR’s.

Sources of Asset Information

Information from the Create/Acquire Activity

Figure 8
Some Asset Information is provided from construction Project Information Models at Handover and Close-out

In the case of major works such as a new construction/refurbishment a new Project Information Model will be created and will feed in data to the Asset Information Model. In creating the Employers Information Requirements for a new create and acquire project the organisation will use some of the Asset Information Requirements. That information will be delivered by the design and construction team as they progress through work stages 0 to 6. The information will be a mix of graphical data, non-graphical data and documents and will ultimately need to be retained in a data store (data) and a file store (documents). The asset information will be provided to the Employer/Organisation during and at the end of the Handover and Close-out work stage (6).
Listed below are some typical Asset Information Requirements that might be delivered from a Project Information Model (PIM) at Handover and Close-out (A Project Information Model is generated using BIM during the Create/Acquire activity):

- descriptions of assets, their functions and the asset system they serve
- locations of assets, possibly using spatial referencing or geographical information systems
- engineering data, design parameters, and engineering drawings
- vendor data (details of the organisation that supplied the asset)
- operating instructions
- maintenance instructions
- fault finding instructions
- commissioning instructions
- commissioning dates and data
- health and safety files
- regular statutory test requirements
- working life expectancy of each asset

These will be written into the Employer’s Information Requirements at the beginning of the PAS 1192:2 process. Identifying these information requirements will require a lot of input from the people responsible for the Use, Maintain and Renew/Dispose activities associated with asset management.

Notice that in following the OIR to develop an asset investment plan we have identified the first Asset Information Requirement to have the: “Working life expectancy of each asset”

Over the long-term operation of the asset a lot of the asset information that is needed to inform the Organisation Information Requirement will come from activities such as inheriting an asset, maintenance, transfer of ownership, minor works, breakdowns, major works and end-of-life works. There will be multiple activities under these main headings and they are regarded as “triggers” that will require an update of the Asset Information Model. It has already been stated that the triggers do not often deliver information to coincide...
with the organisation decision points and rules have to be established with regard to the required currency of data and in that regard how frequently documents, graphical data and non-graphical data will be updated and who will do updates.

Listed below are some typical pieces of Asset Information that might be provided during operation of the asset;

- the condition and duty of assets
- condition and performance targets or standards
- key performance indicators
- asset related standards, processes and procedures
- access planning and work schedules
- details of tasks to be carried out
- work instructions together with diagrams and reporting requirements, legal obligations and safety/environmental considerations
- task risk assessments and control measures
- criteria of non-conformance and the actions to be taken
- when assets were last maintained/inspected and when these tasks are next due
- list of overdue/outstanding tasks
- historical record of planned and unplanned maintenance tasks performed
- details of historical asset failures, causes and consequences (if known)
- operational data including performance characteristics and design limits
- details of emergency plans including responsibilities and contact details
- financial data including, where available the cost of historical and planned future maintenance tasks
- asset related contractual information
- details of ownership and maintenance demarcation where assets interface across a system or network of assets
- identities and levels of spares held, inter-changeability specifications and storage locations
- cost of replacing each asset
- details of asset dependencies and interdependencies
- the criticality of each asset to the organisation
- the criticality of each asset to the organisation that together can contribute to the Organisation Information Requirement of having an Asset Investment Plan. By being able to extract these pieces of up-to-date information from the data store in the Asset Information Model the organisation can employ proprietary report writing tools to produce an asset investment plan.

**AIR’s in operational supply chain contracts**

The asset information above will have to be gathered to update the model during the long-term asset operation. The need for this information will be written into the contracts that are made with asset operators and asset maintainers and will be identified as Asset Information Requirements. As mentioned previously they are specific to each organisation and will need to identified by the whole asset management team.

Notice that in response to the OIR to develop an asset investment plan we have identified further Asset Information Requirements;

- cost of replacing each asset
- details of asset dependencies and interdependencies
- the criticality of each asset to the organisation
- unique identification for each asset

We have identified various pieces of asset information about Life Expectancy + Criticality + Details of asset dependencies and interdependencies + Replacement Cost + Unique Identifier can be analysed to create an Asset Investment Plan.
Figure 10 is used here to emphasise the complexity of sourcing required data from the organisation’s own internal sources and the multiple tiers of its supply chain.

Figure 10

**Identifying the internal sources and multiple supply chain tiers that provide asset information**

It should be remembered of course that the organisation may elect to be entirely dependent upon such outsourced information models as their source of information. In so doing they will assess the risk and reward associated with relying upon a contracted provider. They will consider various factors; the provider may not have an understanding of the strategic objectives, the provider may have a time limited contract, employing the provider in this way may reduce the in-house cost of data management, the ownership of data has to be established etc.

Other asset information might be exchanged to and from work that is commissioned either internally or with other supply chain providers and would include such things as digital surveys, performance evaluation, component replacements and minor works. These are referred to as Direct Supplier Inputs.

These are sources of data and file based information, and they include:

- **External Asset Information Models** that might exist as computerised management systems used by suppliers for example a computer aided maintenance management system.
- **Direct Supplier Inputs** which could reflect digital surveys, performance evaluation results, component replacements, minor works.

There may well be outsourced information models that will both receive and issue data to the organisation’s Asset Information Model. A Computer Aided Facilities Management (CAFM) system used by a Facility Management provider will be the source of much of the asset information such as information about access planning and work schedules, a list of overdue/outstanding tasks and details of historical asset failures, causes and consequences. The CAFM system will also be supplied with much of the detail provided through a construction/refurbishment project such as engineering data, design parameters, operating instructions and fault finding instructions.

**Information from Outsourced Information Models and direct Supplier Inputs**
Information from Integrated Organisation (Enterprise) systems

• document management systems
• work/programme planning and scheduling systems
• materials management systems
• spares inventory systems
• purchasing systems
• decision support systems e.g. maintenance optimisation, capital expenditure planning, whole-life costing models
• asset utilisation systems
• performance reporting systems
• geographical information systems (GIS) and spatial analysis toolkits (for the analysis of GIS data)
• asset possession/shutdown/outage planning systems
• SCADA (Supervisory Control and Data Acquisition Systems)
• condition monitoring systems
• automation systems
• knowledge management systems
• staff location, scheduling and despatch systems

Dependent upon their Organisation Information Requirements and the data needed to inform those requirements the organisation may need to link with Enterprise Systems such as those shown in the table above. Decisions about this potential “linkage” will very much depend upon the Organisation Information Requirements and the needs of the Asset Information System.

This diagram is used to simply illustrate the types of information exchange and the basic components that might contribute to an Asset Information Model.
An information model is only as good as the accuracy and currency of the information that is stored within it. The concept of the common data environment (CDE) was introduced in BS 1192:2007. The process of governance introduced in BS 1192 is critical to delivering the value of an information model. Information is treated as “Work in Progress” until it is given approval to be labelled as “Shared” information and becomes accessible to selected team members. When the information has been verified and validated to confirm that it meets the requirements of the EIR/AIR it can be identified as “Published” data within the data store and file store and can be used for report writing and exchange with external systems. When it is considered appropriate the information can be labelled as “Archive” material and the asset files and history are retained for knowledge, regulatory and legal requirements.
Governance of the Asset Information Model

Figure 13
Governance: Asset Information Model (CDE)

Shared
- Ongoing input and output documents and data shared with Asset Management and Maintenance Team

Work In Progress
- Survey, Performance Evaluation and other input documents & data subject to validation and acceptance

Published
- Co-ordinated & validated output documents & data published for management reporting and input to portfolio and other external partners or systems

Archive
- Asset document & data history maintained for knowledge, regulatory and legal requirements, and for historic asset information management & reporting

From PAS 1192-3

BS 1192:2007 was written with the design and construction process in mind. PAS 1192:3 adopts the concept of the CDE from BS 1192:2007 and this diagram refers to some of the asset management information to which it might be applied.

Figure 14
Asset Information Model: Governance Reporting

This diagram re-affirms the importance of the digital tool required to verify that the information required by the AIR has been delivered. By introducing acceptable limits for each piece of data the tool can also validate that the information provided is of the correct order of magnitude. The TSB BIM Project “A digital tool for building information modelling” is to develop a verification and validation tool.
Roles associated with the management of an Asset Information Model

This section looks at the human side of data/information management. There is a requirement to have in place people who will manage the governance on a day to day basis. The responsibility for the strategic use of data and the processes of governance will need to be vested in a senior appointee whose role will be to ensure that the data available is to the agreed standards of accuracy and currency and that report writing tools are extracting the correct data to deliver the organisation information requirements and answer the business questions of the organisation executive team.

- allocation of roles, responsibilities and authorities for the origination, generation, capture, maintenance, retention, transmission, access to, assurance, archiving and disposal of items of information;
- definition of the content, meaning, formats and medium for the representation, retention, transmission and retrieval for each information item;
- requirements for information maintenance, including version control and assurance activities;
- requirements for the generation, capture or importing of the identified items of information;
- requirements for the storage of information items according to integrity, security and confidentiality requirements;
- retrieval and distribution of information to designated parties as required by agreed schedules or defined circumstances;
- requirements for the archival of designated information, for example for the purpose of retaining audit records and knowledge preservation;
- requirements for the disposal of obsolete, unreliable or unwanted information in accordance with the organisation’s requirements and security and privacy requirements;

What might the Asset Information look like?

Figure 15
An Asset Information Model

Figure 15 provides an overview of an asset information model and how it relates to the asset management system. It is essential to emphasise that this is a very adaptable concept and that this diagram does not reflect what is required by every organisation. For example, this model could represent information about a single asset or about multiple assets. Another option would be that in using report writing tools an organisation might choose to draw information from just the “published” data or it might choose to also draw upon information from integrated enterprise systems.
The model may be owned and managed by the organisation as their own asset information model or they might choose to apply the approach through their supply chain provider of operation/maintenance. When the OIR/AIR (and any EIR) have been identified and the structure and use of the Asset Information Model has been agreed the organisation will have a functional brief which they can take to their IT provider(s) so that they can develop the model.

A recognised classification system will be essential to enable accurate data extraction from the data/file store. The TSB BIM Project “A digital tool for building information modelling” is to develop a classification system.

The needs of report writing will especially need to be reviewed to ensure that any proprietary report writing tools extract and aggregate the appropriate data.

It is hoped that the guidance in PAS 1192 Part 3 will assist organisations in considering the thought processes and activities associated with establishing a digital Asset Information Model. Starting with the need to identify costs and benefits the document illustrates the stages of identifying Organisation Information Requirements and Asset Information Requirements for asset operation. It also introduces the need to identify selected Asset Information Requirements that will be identified as Employers Information Requirements in the event that a new asset construction project is undertaken in keeping with the principles of PAS 1192 Part 2. Finally the guidance looks at governance and the principles of the Common Data Environment before indicating what an Asset Information Model might look like.

Adopting the guidance can place a management team in a position whereby they can clearly specify their requirements to software developers.

The guidance is probably most useful to those who wish to have an understanding of asset information management without understanding the technical detail about how the information is made available to support management decisions.

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