Chapter 4

BIM and Infrastructure

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4.1 Introduction

It is perhaps unfortunate that BIM (Building Information Modelling/Management) includes the word 'building' and that much early discussion on BIM has concentrated on its use for design of 'buildings'. If we are to realise the full benefits of BIM then its utilisation needs to be seen in a much wider context, and the term 'building' viewed as the verb 'to build' rather than the noun 'building'. If we understand 'infrastructure' to be the physical structure needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function, then it is clear that 'buildings' are a subset of infrastructure as a whole and infrastructure gives the overall built environment context. The often repeated adage that infrastructure is the horizontal rather than vertical aspect of the built environment is grossly incorrect and distinctly unhelpful in our implementation and use of BIM. Furthermore, linking infrastructure to just the civil engineering aspects of construction limits the application and use of BIM in the built environment. Infrastructure is the setting for the whole built environment and not just roads and railways.

A useful definition of infrastructure is: 'the set of interconnected structural elements that provide a framework supporting an entire structure of development'. As such it has direct interaction with its surrounding environmental context and its boundary conditions must integrate with that context.

4.2 In infrastructure the asset is the business

In general, in infrastructure the asset is the business rather than containing a business. As such, any information-led strategy must cover the full lifecycle of the asset being considered.

Rather than being a linear process, infrastructure asset owners' information can jump in at any part of this cycle and does not necessarily start with a 'new project'; indeed, most infrastructure construction starts with an existing asset and some demands to update and improve its performance. Many infrastructure asset owners spend significantly more on operational asset management than they do on new

Construction Manager's BIM Handbook, First Edition. John Eynon.

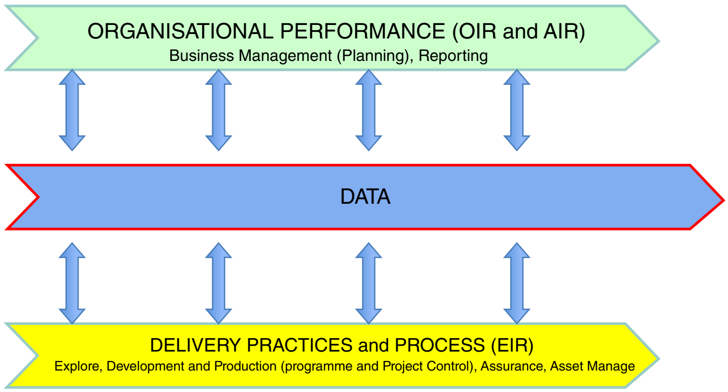


Figure 4.1 Data spine for organisation operation.

projects. Hence, any BIM for infrastructure must incorporate the changes that occur in operation – as well as those larger ones that occur in new projects.

Early BIM examples have centred around the creation of new assets and projects to undertake this, hence it is not surprising that most BIM thinking has focused on the 3D modelling aspects of design and construction. This is, of course, an important aspect of BIM and delivers many benefits; however, to reap the full rewards of BIM we need to see it as information through the whole lifecycle.

The approach, therefore, is one of capturing data throughout the lifecycle of an asset to support Organisational Information Requirements (OIR) that drive strategic and business decisions, Asset Information Requirements (AIR) that drive operational management performance and decisions, and Employers Delivery Information Requirements (EIR) that drive project delivery and handover (Figure 4.1). This data capture and management acts as an 'information spine' for the asset lifecycle.

This BIM 'spine' captures, manages and provides information not just about the components and assets that comprise a project but also provides information to support corporate business decision making, asset owning and maintenance, and project delivery management (Figure 4.2).

While these principles apply to all construction, they are particularly significant in infrastructure where there are few 'new projects' and even those that are new have to fit into existing infrastructure.

4.3 Infrastructure is messy

Infrastructure deals with the landscape in all its infinite variety and often is messy, moving and re-sculpting the earth surface – involving lots of mud, dirt and water – making discrete object definition difficult if not impossible. Rather than the tidy defined edges of buildings, in infrastructure it can be difficult to distinguish where one thing starts and another ends. While it does contain discrete components, it is often continuous and linear and not quite so easy to break down into logical chunks.

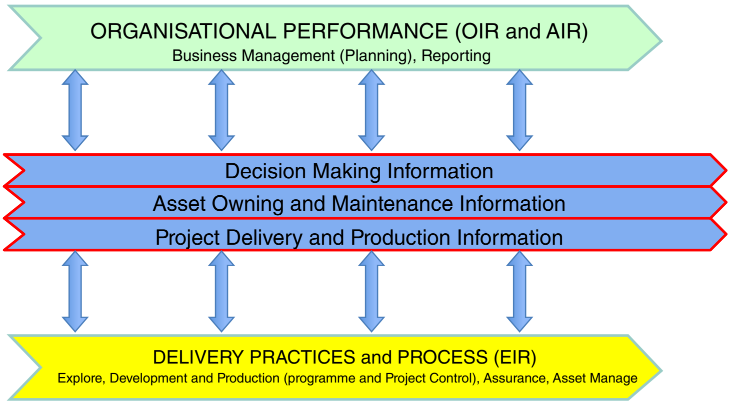


Figure 4.2 Data spine for AIR and OIR.

Infrastructure projects not only add new construction to the landscape, but also modify the existing landscape. Hence, in most cases, the first models encountered in a project are survey models – be they topological, ground surface, geological, environmental, land ownership or prediction models, such as traffic and flood modelling. And the final model handed back to operations is also a topological and surface model. It usually forms a new surface that sits within a contiguous landscape, which it intersects and interacts with to form new components by cutting away or adding to existing formation.

It will usually have multiple geological surface layers, regular and irregular, continuous and non-continuous. It must take into account geological faults, small intrusions like sand lenses and underground spaces. This impacts on the measured quantities, construction, structural integrity and performance of the asset, hence accurate modelling of surfaces is essential.

Many components are buried and form part of a wider network, often outside the site with wider connections, and can interfere with existing networks of underground assets with the related clash potential. Anecdotal evidence suggests that discovery and recording of existing underground assets accounts for a significant risk and cost to new projects and becomes very important when upgrading existing facilities.

While infrastructure has discrete components, these are often networked and continuous, requiring segmentation. The network aspect is important as it gives all components context, and actions on one element can impact others that are remote but connected. A good example is track possessions for railway work or traffic diversions. In some disciplines, these networks are expressed as schematic diagrams rather than geometrically correct representations. These representations of components need to relate to the real world ones and connect to the same data. Typical of these might be signalling schematics.

Many deliverables are defined as polygonal features, such as land ownership, noise contours, planting, drainage and catchment areas, ponds and environmental protection areas. Some of these component features are required for project delivery but are not physical objects as such, rather geographic features that hold essential delivery and permission information such as might be required during public participation exercises, environmental studies, traffic or water flow modelling or simply for gaining access.

Infrastructure projects fit into a wider landscape of features including geography, landform, environmental, geological, archeological, drainage, flood plains, tidal ranges, vegetation, transport corridors, utilities and so on. While it might be easy to dismiss these as mere mapping, they are important components of an infrastructure BIM. Often characterised as Geospatial Features in GIS, they are part of the BIM model. Additionally, and to add complexity, some of these features are transient – that is they change with time and conditions. Good examples are flood plains or balancing ponds.

While buildings do have to deal with these issues, they are usually more a matter of planning and clearance rather than an integral part of the project, unless they are part of a campus such as an airport – though it could be argued that the nature of a campus is much more related to infrastructure than to individual buildings, which are part of the whole.

Introducing these infrastructure components into BIM in a coherent way is necessary but clearly not quite as straightforward as the components of a building.

4.4 Federated infrastructure models

Infrastructure suits the Level 2 BIM approach in that any model, be it 3D geometry or pure data, is made up of layers and distinct sets of information. So the building fits into the overall landscape, and to model the information that makes up the whole each layer adds data that can be combined (federated) to give the overall view.

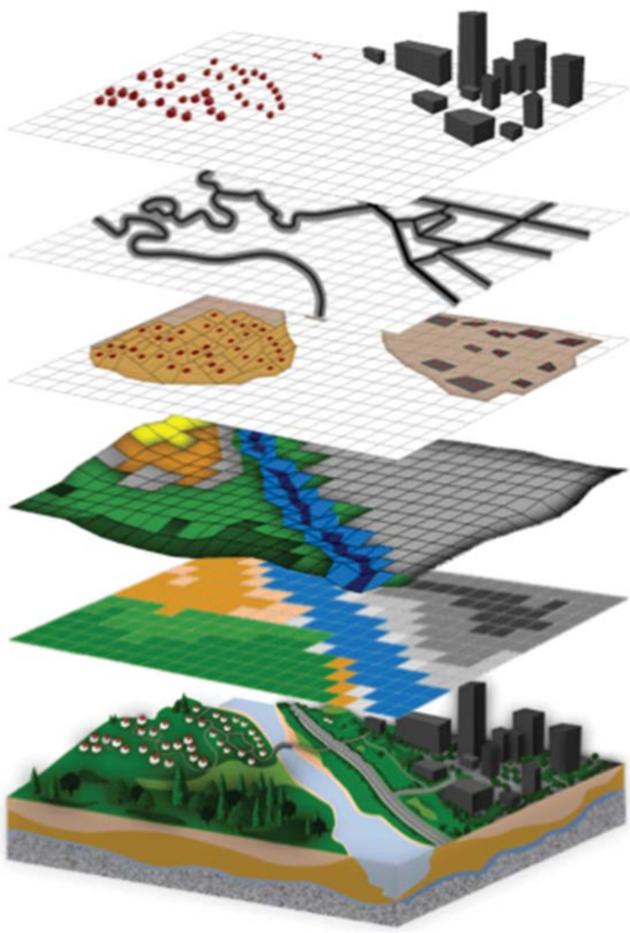
Hence an infrastructure BIM dataset may be made up from many different models, each coordinated and contributing to the whole.

Typical information models might include:

- survey model
- ground surface model
- utilities model
- geological surface models
- network and route models (traffic or water modelling)
- environmental model
- land-ownership model
- alignment model
- continuous linear entities model
- linear component model
- point entities/component model
- utility and drainage network model
- structural models – bridges, tunnels and retaining walls
- building models – structural, architectural, M&E

- rail signalling model
- asset information model.

The list here is not exclusive but drawn to show the principle of multiple models interacting with multiple applications to make a complete data picture. It follows that there is not, at least at present, a single application of modelling tool that can handle all the complexity and diversity required to meet the infrastructure world. Our approach, therefore, is one of creating 'open' federated and linked datasets created and edited by individual tools. In fact, our whole BIM solution must provide the capability of federating data from multiple sources to enable new solutions and applications to develop in the market, rather than plug-ins to proprietary solutions.



4.5 Specific infrastructure issues

There are a number of specific issues that arise within the infrastructure world that need to be addressed when data modelling.

- Geospatial location – infrastructure resides in a round world not a flat project site, hence particular attention needs to be given to:
  – World positioning and map projection systems with known translation methods.
  – Common coordinate systems.
  – A common grid with common origins:
    - not the building grid but a grid suitable for the project or its location (e.g. in London perhaps the London Survey Grid);
    - any specialist project grid must be related to and be capable of being federated with other models.
- Must be capable of locating and defining polygonal components, for example planting zone, catchment area and so on.
- Capable of defining a linear location – base line measurement – defining points where measured, require an LRM (Linear Referencing Method) and offset method for location.
- Definition of and subdividing continuous objects – segmentation – where a road starts and ends depend on use-case view. For example traffic engineering sections are different to design sections, signalling sections and maintenance sections.
- Handling variable asset values – attributes can vary along length.
- A consistent methodology for defining discrete objects from multiple surface models:
  – Many objects are defined by multiple surfaces, lines and vertices, not all of which intersect but need edge conditions to form objects.
- Definition of a discrete object will differ depending on at what stage of a project lifecycle the current action is being considered. For instance, a road design may break down in early stages to road sections between interchanges; whereas at construction it may break down into earthwork sections relevant to geology (rock, clay, sand etc), construction type or mass haul calculations; and at asset management and operation stage to cutting or embankment. So we need a model that can be recut to suit but retain its pedigree information.

- Of course, for many construction objects in infrastructure there are well-defined objects, such as bridges, tunnels, kerbs, safety fences and so on. These can be defined as Building Smart international foundation classes (IFCs); however, caution needs to be exercised as many IFCs tend to be able to define regular objects but complex shapes are not catered for.

4.6 Tools and data management issues

In general, GIS and infrastructure BIM tools lag behind those of building BIM. Many of these tools deliver line-based or surface-based, rather than object-based, information. Most certainly do not deliver structured data.

Many infrastructure design tools lock the user into a proprietary solution, which ultimately will restrict the wider use of BIM information. Some software tools are not conducive to federating data and try to work as a 'single' model, which leads to lock in. So care needs to be taken in software and data management choice.

While there are a number of defined, open standard objects for buildings, there are fewer that have been established for infrastructure. Some work is being done on this by Building Smart, creating road and rail alignment IFCs – but this work is in its infancy.

There is no common data dictionary definition for infrastructure components, although there is some work going on in this area by Building Smart.

In general, the best solution for an open approach is to adopt existing standards and modify them for infrastructure. These include:

- Open Geospatial GML for polygons and map features.
- Land XML – for modelling nondiscrete infrastructure.
- Open Building Smart IFCs for discrete structural objects – but with great care.

Top things to consider

- Start with your end in mind.
- Be clear about your information requirements, your clients and your specialist subcontractors.
- Be clear who is delivering what information. And their roles.
- Identify the information requirements that you are fulfilling and model appropriate to those requirements. Do not over-model too early.
- Make sure you model in a geographic context and not a local or building grid context.
- A good volume model breakdown structure is key to good federation – spend time on this.
- A clear BIM Execution Plan laying these things out is essential for good BIM.
- Your first model is a survey – make sure it is captured and stored in open formats; do not use CAD formats and layers to model survey objects, rather use GML formats. CAD drawings in DWG and DGN diminish capabilities to manage data.

- Choose software carefully and ensure that results can be easily federated without major reformatting.
- Follow the BS and PAS 1192 processes and don't cut corners: the process is designed for federation and collaboration in a controlled way. Some software does this better than others.
- Create and model using best software tools but capture and manage using the principle of holding geometry and data as linked but separate. The concept of a single modelling environment rarely achieves the goals software vendors promise and often can be restrictive.
- Use 'open' data principles and refrain from proprietary formats. A mixture of GML, LandXML and IFC will cover most things.