"BIM isn't Geospatial" …. Or is it?

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Introduction

The purpose of this paper is to raise the awareness of the Geocommunity to "BIM", where significant contributions could be made within the wider sphere of the AECOO industry and civil infrastructure, if more traditional definitions of "GIS" and "geospatial", "CAD", "3D modelling" and "Information Management" could be laid aside, and greater integration and collaboration established. To accomplish such an outcome, this paper seeks to:

- establish a common understanding of the wider context of "BIM";
- determine how "BIM" is relevant to the Geocommunity;
- determine how the Geocommunity should contribute to the UK Government BIM Strategy – and engage with the AECOO industry as a whole.

What is all this fuss about "BIM"?

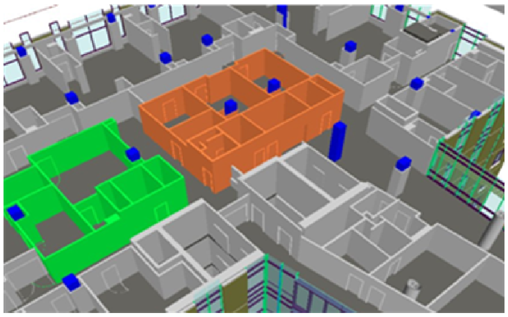
Why has there been a marked increase in interest and debate about BIM? What is the point? The point is improving the performance of our infrastructure – reducing waste; increasing resource efficiency; reducing risk; increasing resilience; increasing integration. What it should NOT be about is using the latest and whizziest 3D technology.

Effective and efficient design, construction, ownership, management and use of buildings and other civil infrastructure increasingly requires information exchange among all disciplines and professions that have a stake in those facilities. Around the globe, governments and clients are demanding improved services, including leaner construction, and carbon efficient design. In response, the AECOO (Architecture, Engineering, Construction, Owner and Operator) industry is undertaking major business transformation.

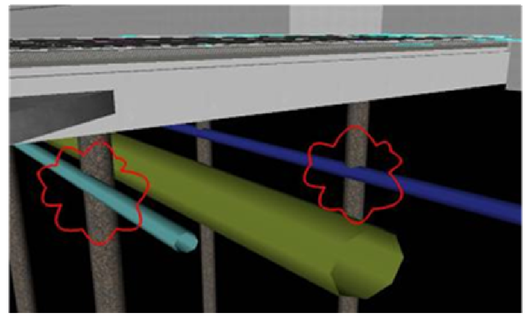
This transformation is manifest in the disruption around "BIM". Whilst a number of definitions exist, the requirements emerging from the AECOO industry coalesce to a common need for "BIM" as the process of generating, managing and modelling project information throughout the whole lifecycle of the infrastructure – not just for a building – from planning and design, through construction, to operation, maintenance and de-commissioning. Associated tools shift the primary method of working from traditional 2D workflows towards intelligent 3D modelling systems – and the creation of models. BIM describes the activity, *not an object*, and is much more than a single technology or tool - it's a quantum change in practice, processes and behaviours around the AECOO industry.

The acronym BIM (Building Information Modelling) evolved in the early 2000's to describe virtual design, construction and facilities management. BIM processes revolve around virtual models that make it possible to share information throughout the entire building industry. These virtual models are embedded with data which, when shared among stakeholders, greatly reduce errors and improve facilities. BIM offers owners the ability to become more efficient and effective by linking their business processes with their facilities.

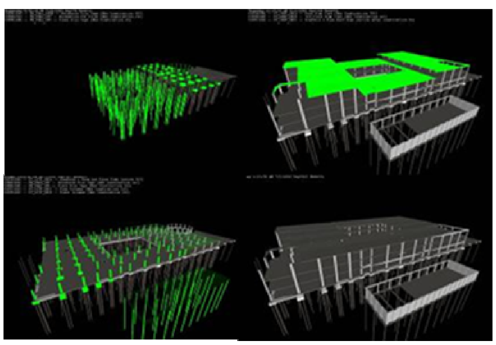
BIM tools create an assembly of objects with known properties. For example a 'pump' object is associated with its graphical and attribute data e.g. symbol, shape, cost or carbon performance characteristics, throughout its lifecycle. By modelling in multiple dimensions (e.g. spatial, temporal, cost) many parallel outputs are created from the same model. Models may be related across the different disciplines of architecture, engineering, construction and operation to analyse processes for resourcing and scheduling, and the information flow can facilitate integration with energy modelling, structural analysis etc. without requiring re-entry of data. The principles of BIM support the basic premise of information management – getting the right information, to the right person, in the right form, at the right time.



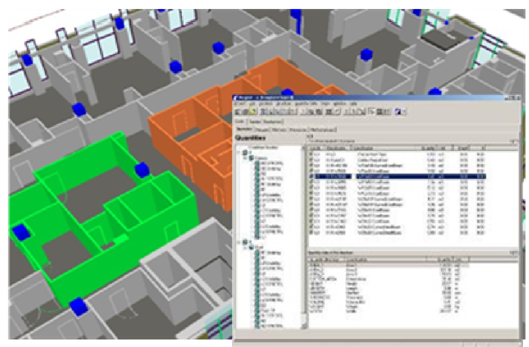
Design Visualisation: visualise building early in the process to support and accelerate decision-making



Design Validation: Integrate 3D models of all trades to identify interferences and constructability issues before they materialise in the field



Schedule Visualisation: Visualise construction process to review and optimise the construction sequence and the schedule



Estimating: Tie project scope to price, and manage scope changes more efficiently

Figure 1 – Applications of BIM

There remains contention around the meaning of BIM – illustrated by the fact that both the BIS Report (2011) and the Australian Guidelines for Digital Modelling (2009) refrain from providing a specific definition – and encapsulated in Jernigan's "BIG BIM, little bim" (2008). Suffice to say, the term is not well-liked, and may yet change. What is important is the need, the activity – and the opportunity – which is currently associated with "BIM" (yet may morph into PIM, IPD, …..).

So let's return to the impending and pressing need. The US Federal Government has predicted savings of over $15.8 billion per year from integrated processes. The UK Government is requiring all publicly funded infrastructure projects to move up the BIM curve within an overall push to introduce 20% savings across the construction industry by 2016 – based on evidence that projects today save 5-12% when BIM is properly used (BIS Report 2011). The BIM maturity model (figure 2) illustrates the expectations of Government for a roll-out of BIM to at least level 2, involving digital delivery of all project/asset information within a 3D collaborative BIM process.

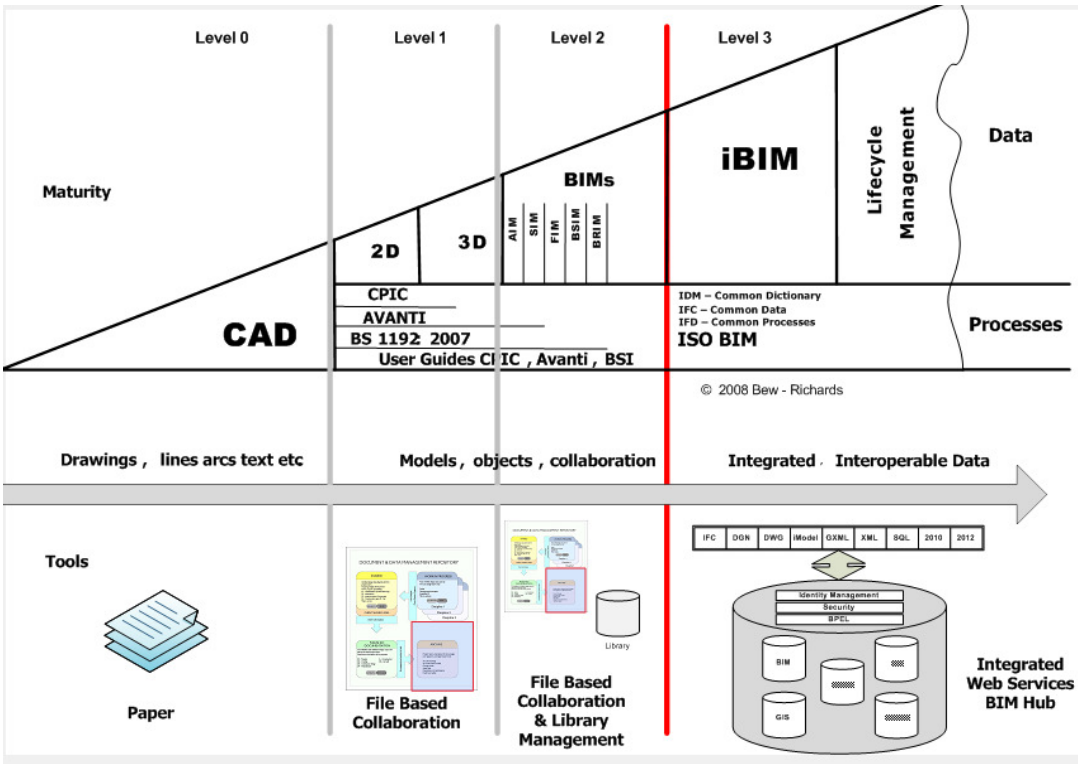


Figure 2: Bew-Richards BIM adoption scale

The aim in requiring improved supply-chain integration is to achieve:

- Performance improvement
- Greater project 'certainty'
- Reduced risk.

BIM – by requiring interoperability of information – encourages accuracy, effective flow, and intelligent use of information – throughout the whole life cycle. A major advantage of BIM is that following handover, BIM should enable optimised management of assets e.g. for space utilisation, programming, running costs, energy/carbon reduction. BIM enables design and configuration options to be analysed early and quickly in the project life cycle, against performance requirements, leading to cost reductions, and increased certainty in project outcomes.

What has this got to do with Geospatial?

Recall that the UK BIM Strategy addresses the needs of the UK Infrastructure – and because it is addressing infrastructure, sound information management and GIS is critical to its delivery. The Geocommunity have a significant role to play in meeting this challenge.

The convergence with GIS is a concept which recurs in the BIM literature and on-line discussions time and again. Casey et al 2010 describe BIM as … "a modelling technology that combines the design and visualisation capabilities of CAD with the rich parametric object and attribute modelling of GIS". In "Big BIM, Little BIM", Jernigan (2008) refers to Toffler's vision: the capture of integrated knowledge in an organised way should drive planning: …. "attempts to bring this knowledge together would constitute one of the crowning intellectual efforts in history – and one of the most worthwhile." Jernigan continues ……"BIM, coupled with GIS, relational databases, and the Internet all help us to achieve Toffler's vision. Building on these concepts, you can now use rules-based planning systems to capture and integrate knowledge at all levels. If you can describe something, it can be captured. If it can be captured, you can define its relationship to other knowledge. By applying the rules that govern how these bits of knowledge interact, you can assess options more quickly and more accurately than ever before. Where planning once relied on broad generalities and 'rules of thumb' you can now simulate 'real life' using BIM."

In this respect, BIM and GIS are in concept much the same, but perform on a different stage. It should be easy to see how such a concept can be extended from the realms of a single building, to a group of buildings or indeed an entire city – using combined CAD, database, 3D modelling and geospatial principles and technologies.

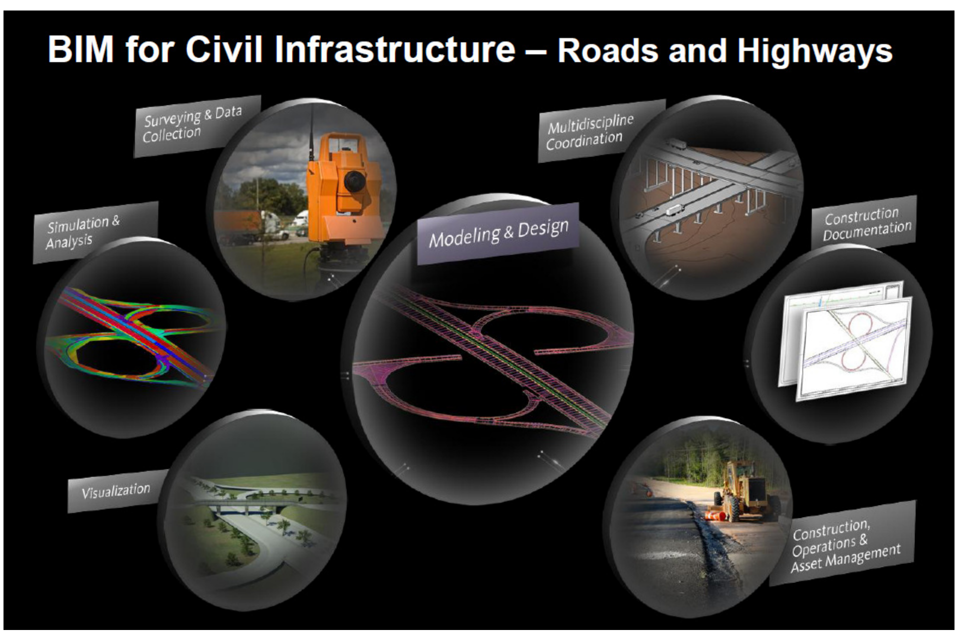


Figure 3: BIM for Civil Infrastructure (Atkins)

The major software vendors, such as Bentley, Autodesk, and ESRI, have recognised this, and are developing varying strategies to address the need (e.g. http://www.bentley.com/en-US/Solutions/Buildings/About+BIM.htm; http://usa.autodesk.com/building-information-modeling/about-bim/; http://www.esri.com/industries/facilities-management/business/bim.html).

However, a divide remains between how BIM is realised for buildings – and how it is realised for the wider civil infrastructure. This is where the "B" in BIM is a frustrating obstacle to the basic understanding of, and receptiveness to, BIM implementation beyond that of buildings – and is where the Geocommunity can make a significant impact.

The links between BIM and GIS

To understand how GIS and BIM can converge, let's consider the stage on which each has traditionally played. BIM models describe buildings or other facilities. They are typically initiated during the procurement phase of a facility lifecycle. They are used to organise the information with specific, often contractual, deliverables in mind. Since BIM models are valued for construction, the shape (3D) and time (4D) information is collected. BIM models usually represent the world as is forecast to be.

GIS models typically describe entire sites or regions. They tend to be less sophisticated geometrically, typically being plan-based. They may be more sophisticated in the connectivity information, so that infrastructure and services are represented as nodes and links. This then allows them to be used more extensively for analysis and operational controls. They often represent the world as is, but are also used during planning and for modelling outcomes.

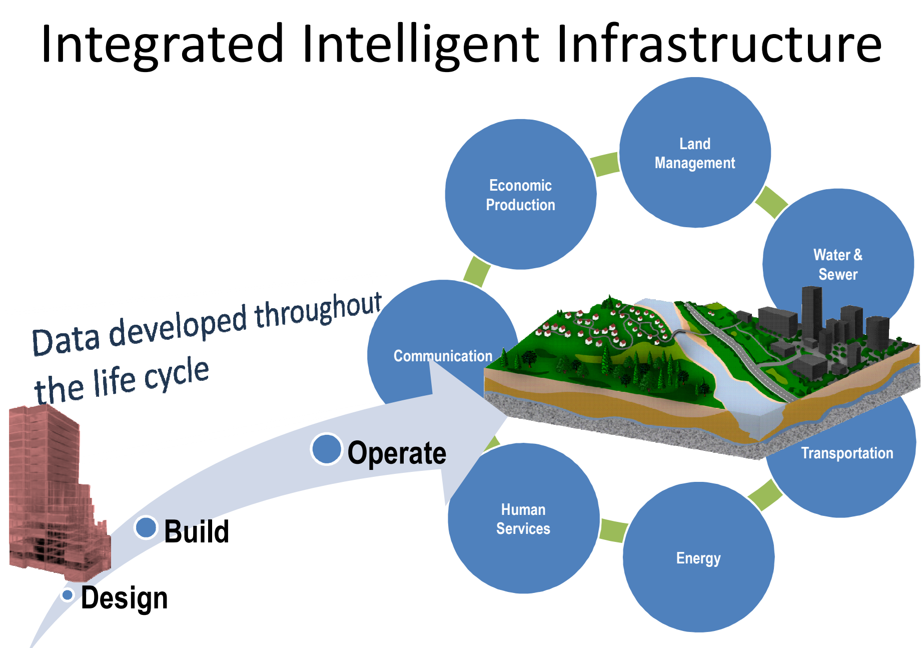


Figure 4: The overlapping stages of BIM and GIS (Steve Jolley, Bentley)

GIS supports the graphical mapping of information datasets, supporting various forms of analysis such as flood forecasting, space planning, asset management and hazard planning. BIM tools hold data and information relating to a facility, whereas GIS systems allow analysis to be reported and visualised at a geographical scale or level of detail. The synergy derived from integrating BIM with GIS tools can provide Owners with visual representation of facilities in the context of the surrounding environment. Designers and contractors can benefit through demonstrating design solutions on a broader level, increasing shared understanding. If the best of both were employed it could transform how civil infrastructure is managed through the life cycle.

Some might argue that they have been employing "BIM" in a broad sense for years. Examples where BIM is achieving considerable benefits in respect to cost, carbon and resource savings, lean construction, and environmental benefits include: Tyndall Air Force Base in the States, where BIM is a mandatory requirement for many States and for US Core of Engineer projects (http://usa.autodesk.com/adsk/servlet/pc/item?siteID=123112&id=16881271); M25 widening (see http://usa.autodesk.com/adsk/servlet/pc/item?siteID=123112&id=16884471), Figueiredo Ferraz Manaus Urban Renewal (http://usa.autodesk.com/adsk/servlet/pc/item?siteID=123112&id=16881470).

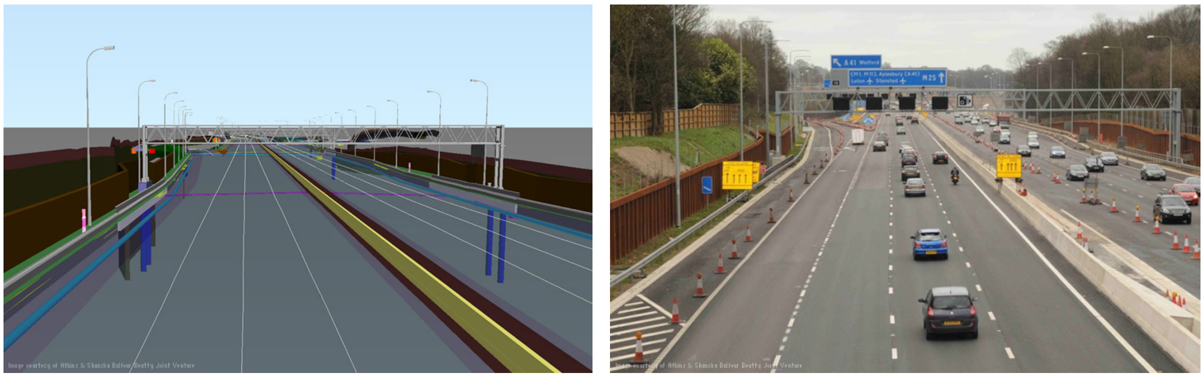


Figure 5: BIM on M25 Widening Project, UK (Balfour Beatty, Skanska & Atkins JV)

Examples of how the integration of CAD, GIS and Information Management is evolving to deliver the principles of BIM include Sellafield (Cottrill, 2010), and CrossRail (Arup/Atkins, 2010 Winner: AGI Private Sector Award).

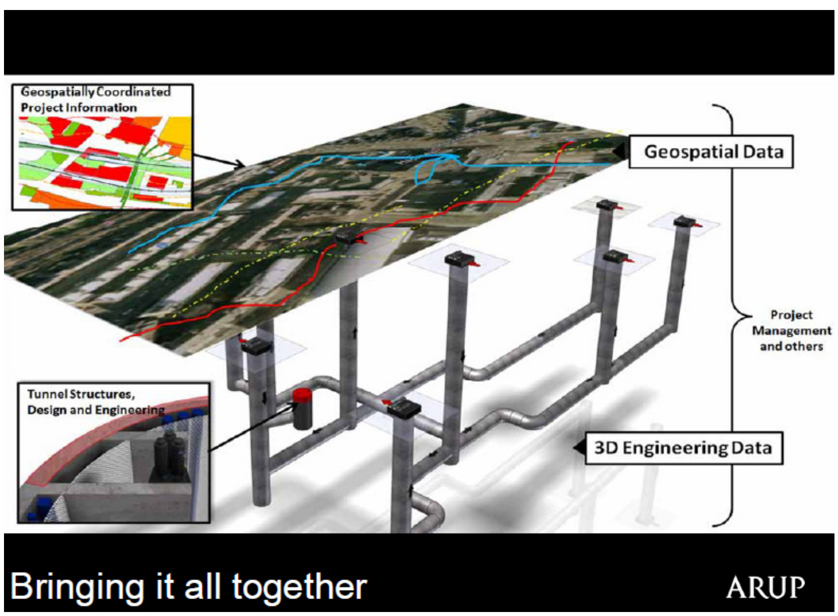


Figure 6: Exploiting CAD, GIS and Information Management to deliver BIM principles on Crossrail (Arup)

Based on experience generated on projects such as Crossrail, Highways Agency, Metronet and the Olympics, Atkins is currently running converged information management processes for the Etihad Rail project in Abu Dhabi. The services being provided are:

- Data management: to inform the concept and preliminary rail design process, a large amount of spatial data is being gathered from across the UAE, mainly relating to existing infrastructure e.g. utilities, land use, in hard copy, CAD, PDF, raster and GIS format. After being logged by document control, the GIS/data management team review, quality check and process the data, and pass it to the engineering team for integration into their data models. It is tracked and key metadata recorded to ISO standards, within a data register.

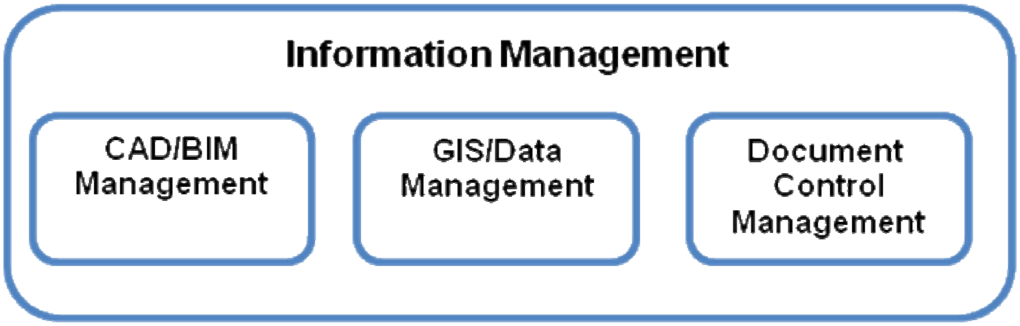


Figure 7: Merging of CAD/GIS/document control functions to deliver integrated Information Management on Etihad Rail

- Data processing: much of the received data does not conform to project standards e.g. spatial reference system, file format, accuracy, and is processed to ensure adherence e.g. by re-projecting data from a local grid system to UTM zone 40N.
- CAD/GIS integration: Using tools including AutoCAD Civil 3D and FME, data received in e.g. ESRI geodatabase/shape file, Intergraph GeoMedia, are provided in DGN or DWG format, as required.
- Web GIS: a web GIS portal for use across the project/stakeholder team, has been established, so that spatial data (both CAD and GIS) can be viewed and interrogated in context with other key information, within one system.

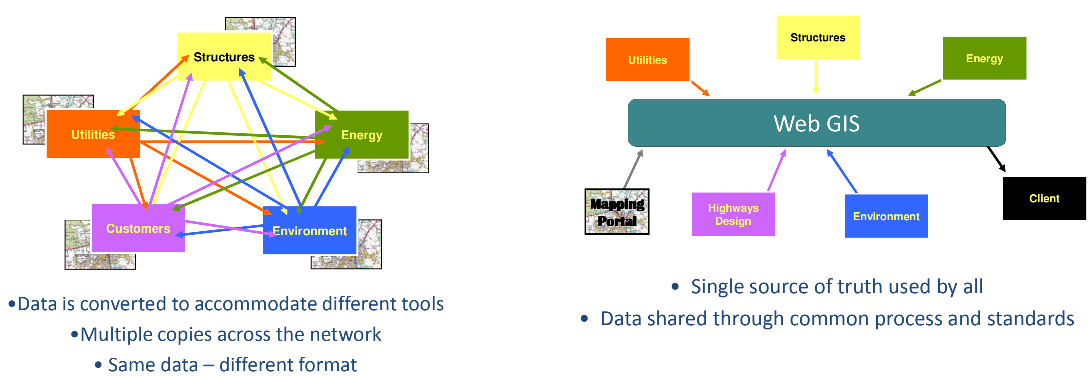


Figure 8: Impact of utilising web GIS – a single point of truth

- Data submission: much of the design data must be issued in GIS formats as part of formal deliverables, e.g. data for the Abu Dhabi Urban Planning Council must conform to their data submission standard i.e. in ESRI geodatabase format, with certain attributes and particular spatial reference system set. This data includes the rail alignments, facilities and stations data, and limits of deviation to assist with land ownership issues.
- Data handover: the collation and logging of all spatial data on the project will enable a smooth handover of information to the design and build contractor upon completion of Atkins' commission. All key information will be readily available and no data will be lost on transition between the different phases of the project.

The holistic approach to the management of data and information to be taken on the Etihad Rail project can be regarded as an early precursor to convergence of CAD and GIS to fulfil BIM aspirations. The approach has enabled the engineers to work more efficiently by providing access to data that they would otherwise have been unable to use due to format and spatial reference system differences, and the web GIS portal has allowed all of this information to be viewed in context. This has also proved to be a useful tool in engaging with stakeholders to discuss issues relating to the alignment.

More progress is being made as BIM becomes utilised at the data capture and design stages to produce 3D spatially referenced models. Once a defined BIM implementation plan is established at the onset of a project - which defines data structures and formats, along with information and workflow processes – such a project can move up the BIM maturity curve – and efficiencies introduced. Realistically, this is where a large part of the industry currently sits – probably at Level 1 or at best borderline 2 – and progress needs to be made on developing and implementing industry-wide standards and methodologies to enable a successful shift up the maturity curve.

One of the challenges is that the CAD and the GIS communities have been so culturally different – and much of the drive for BIM is from those related to the CAD community. The development of standard taxonomies and ontologies for CAD and GIS is still largely separate, but is evolving for semantic interoperability (Peachavanish et al 2006). The momentum around BIM makes convergence of the two a pressing need.

The bottom line is that BIM data is just like any other - it can be effectively handled in a larger database management system (DBMS), e.g. Oracle, Microsoft, IBM, Open Source - that cares little for what the data actually is, but is powerful enough to handle large quantities of it and receive, link, store, and output any subset of that data, on demand, in the way an end user needs it. Huge strides will be made once BIM tools can be routinely integrated with GIS systems in this way.

Common challenges: Data, Process, People and Technology

Data

Because BIM is about managing information through the whole life of an infrastructure, important concepts are that of continuous improvement, and of delivering the right information, to the right person, in the right form, at the right time. Creating and holding a mass of information at the preliminary design – and carrying this through to operation and maintenance is management of information for its own sake. The purpose has to be continually reviewed – and filtering employed.

A better understanding of what BIM can offer – across the supply chain – is much needed and defining more clearly the information which needs to be captured through the life cycle is vital. Owners need help in understanding how they can solve their problems through BIM deployment – and so a clear definition of requirement, and of the data drops for different types and levels of information through the life cycle is a priority. This is a challenge which should be very familiar to the Geocommunity.

Information needs change according to stakeholder and according to project stage – this impacts the level of motivation of different parties to take part in the gathering and management of information. If the motivation doesn't exist – the flow of information will not occur. Contracts are typically set up to put the onus on the current contractor to ensure that information is correct and accurate – this does not instil the best environment for information to be trusted as it moves from left to right through the project life cycle. This will have to be addressed if collaborative working is to be realised across the supply chain.

The following diagram from Jackson 2010 illustrates the mechanisms for defining differing levels of information at different gateways (or data drops):

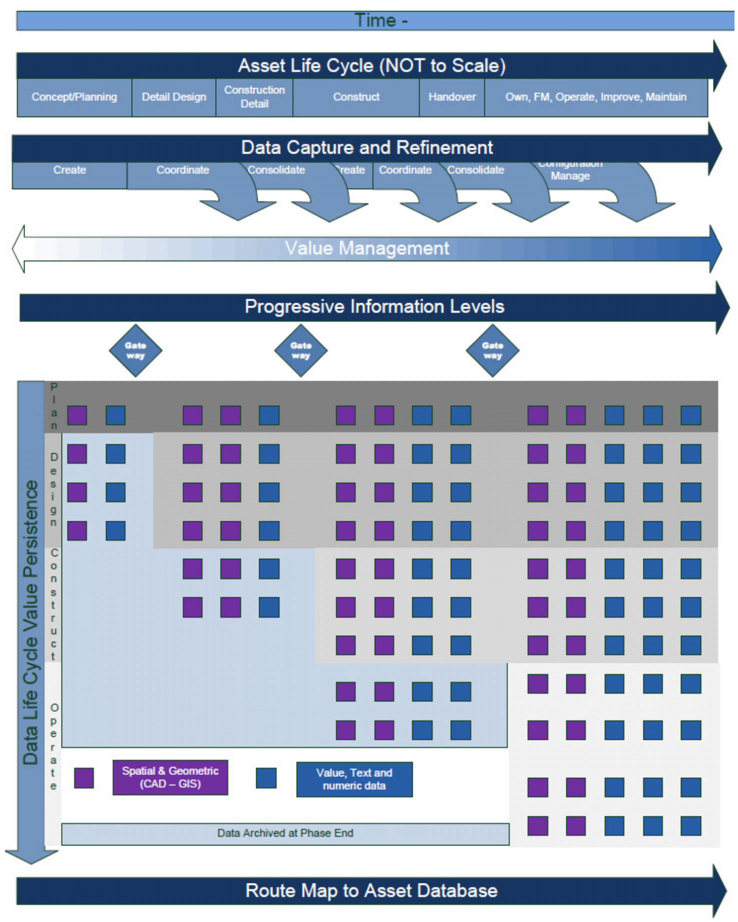


Figure 9: Data requirements through the life cycle (Jackson 2010)

Process and People

The core of effective BIM is the amalgam of processes which underpin how project teams collaborate effectively. The work of Avanti (2006) and the development of BS1192:2007 have been formative in establishing a pragmatic way forward which does not require the latest technology to work. Best practice has been developed over some years on a range of projects, with demonstrable benefits (Avanti, 2006). A useful manual has been produced to assist in implementation of this collaborative working (Richards, 2010). The Crossrail project is continuing to improve its approach, and is being used as a testbed for developing BS1192 within the setting of Projectwise. The project is also facilitating the further development of data schema addressing the rail, and wider civil, infrastructure.

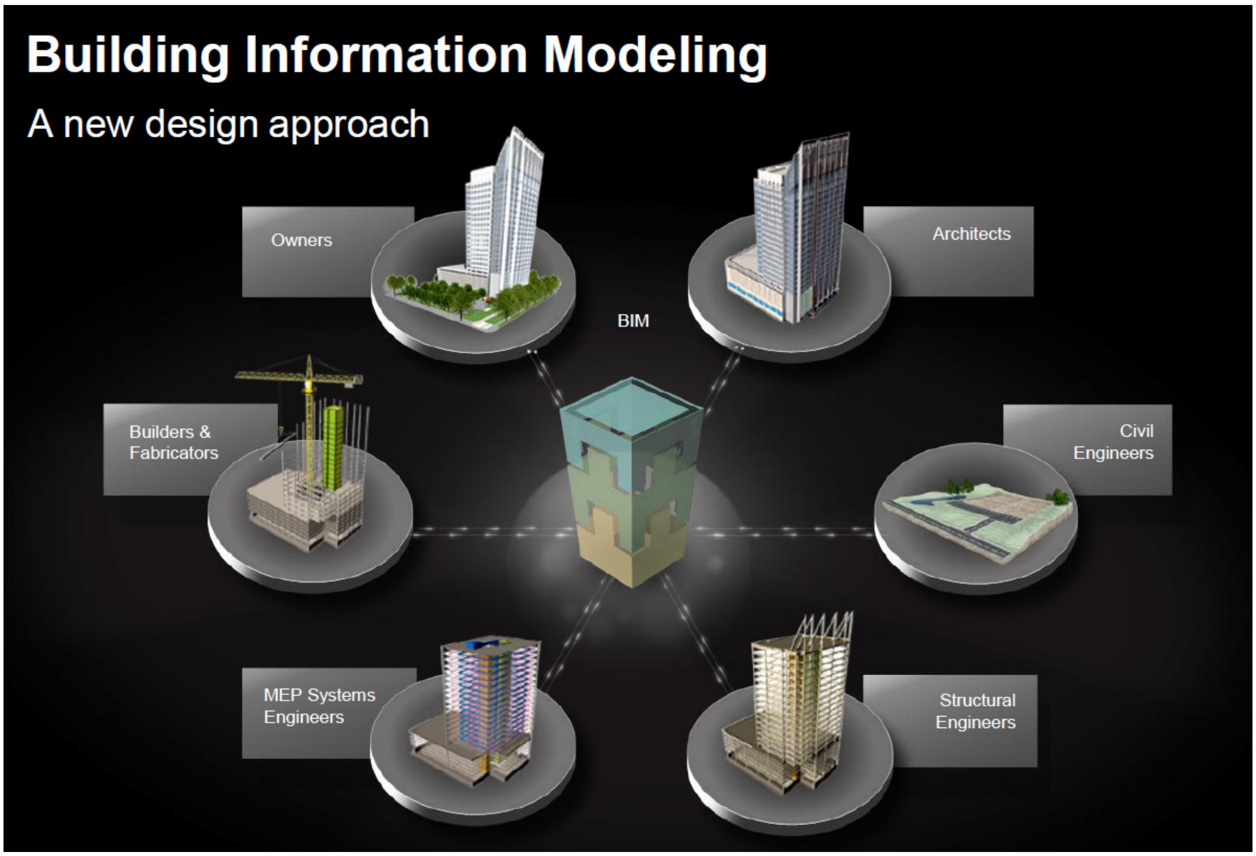


Figure 10: Multidisciplinary integration as a part of BIM implementation

Some kind of portal is commonly being adopted as a single source of truth which allows access to, processing of, and integration of, information which remain at their original – or most appropriate - location. This approach allows for flexibility and scalability of solutions – use of a single model is not sustainable for the majority of projects. Bentley refer to the principle of a Common Data Environment as a "Federated Single Point of Truth":

What is "Federated" Project Data?

Federated project data is stored in multiple locations and aggregated on an as-needed basis, rather than in one central, monolithic and cumbersome database.

Why "Federated" Project Data?

Federated data mirrors the way most inter-disciplinary project teams work—each with their own applications and operating in their own locations. It is the most efficient way to work.

Figure 11: The Federated Single Point of Truth – Bentley.

Atkins' SDI (Spatial Data Infrastructure)(2009) has been developed with these principles in mind. BAA has established its own Common Data Environment (CDE) and related the management of its information clearly to business requirements – the IM is seen to be an important part of the workflows – and is not established for its own sake. Work has been undertaken to integrate BIM with GIS to enable asset management across the BAA estate, providing spatial reference and coordination, and accessed through a single portal (utilising Autodesk MapGuide and Topobase) – launched in July 2011 as "Heathrow Map Live".

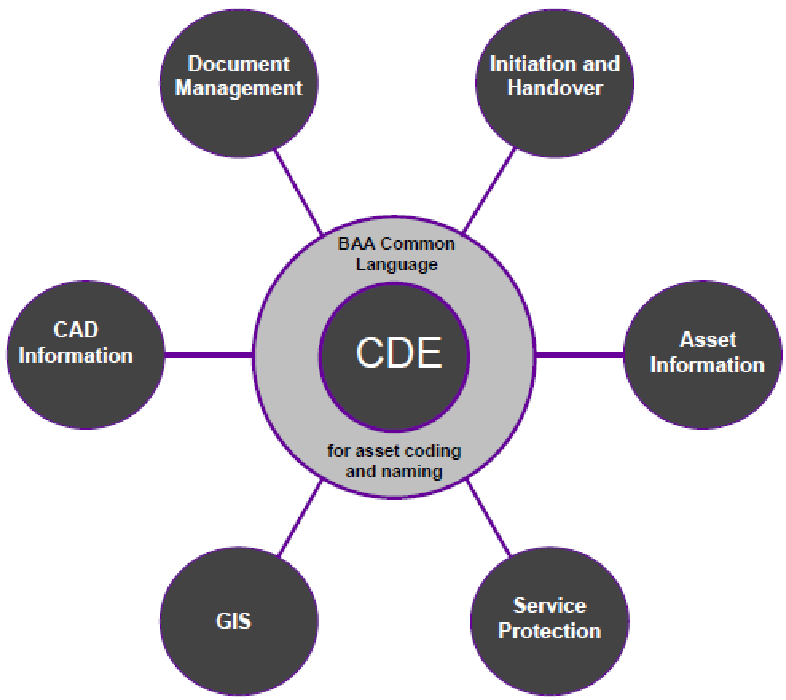


Figure 12: BAA's implementation of BIM and CDE (Nigel Stroud, BAA)

People and Technology

Significant cultural change will be necessary within the construction industry to enable successful BIM implementation. Much focus will be needed to facilitate a major behavioural change within an industry traditionally regarded as one of the most confrontational. A common language will be required to avoid misunderstandings – an obvious area of concern relative to data format is standardised definitions, terms and taxonomies, to enable data reuse and efficient collaboration and communication among all stakeholders.

The technologies themselves create silos – and there is a need to establish aligned staff, software, data, standards and workflows across these technologies to enable integration.

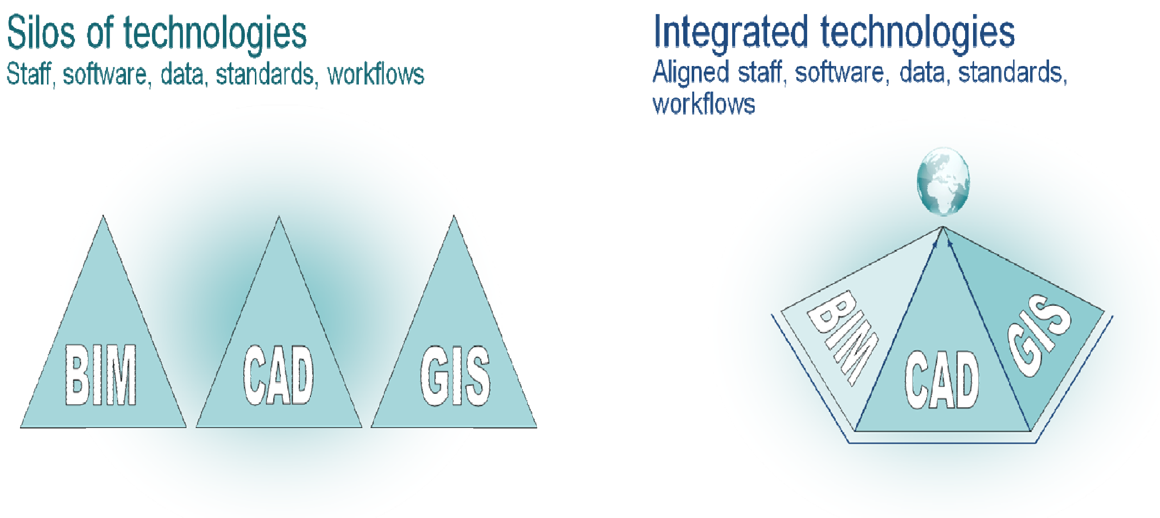


Figure 16: Integration of technologies

The speed of technology change often exceeds the capacity of the AECOO industry as a whole to adapt and accept the change. This is where it is important to understand that BIM is far more about data, process and people than it is purely about technology. To affect a change – there needs to be some stability.

The challenges of rolling out BIM across a reluctant user community are very similar to that which the geospatial community has faced with its own technologies. Business analysis, user requirements, process mapping, business cases, standards development, data modelling and xml development, education and training are common skills which can be translated across from geospatial application to BIM application to great effect. There is a wealth of experience in the GI community of the industry requirements for information management. This should be tapped into to facilitate a successful outcome to the UK BIM Strategy.

Conclusion

This paper has sought to establish that BIM and Geospatial are firmly inter-linked – and that the advancement of BIM relies, in part, on integrating geospatial skills and technologies into BIM solutions. This is not a trivial undertaking. A convergence of expertise and ideas is required – and a receptiveness to developing solutions in a collaborative way. Key issues identified are a common language, spatial reference, data schema and specifications, definition of requirements and deliverables, system integration and progression to integrated work and information flow.

Much work remains to be done to achieve the UK Government's demand for roll-out of BIM across the construction industry – which gives rise to great opportunities for the geospatial profession –

or at least for those prepared to adjust to market demands. A gap still exists between the BIM community and the geospatial community – this must be bridged if we are to fulfil the UK Government targets – and should be bridged if the geospatial community is to contribute to the demands and requirements of the AECOO industry around the globe.

In response, AGI has established the I-BIM (Infrastructure BIM) Special Interest Group (SIG), which aims to discuss and rise to the challenges and opportunities across the infrastructure industry in delivering BIM - within a geospatial context - to improve the performance of infrastructure. The SIG will seek to establish links and provide support to the main players in the BIM community – and to strengthen existing efforts to respond to the UK Government BIM Strategy.

Acknowledgements

This paper has drawn on the discussions that have occurred at the preliminary meetings of the AGI I-BIM SIG. In addition, thanks must go specifically to the Crossrail team, to BAA (Nigel Stroud), to colleagues on the ICE IS Panel - Phil Jackson (Bentley) and James Brayshaw (OS), to Mervyn Richards, and to Patrick Davis and Richard Budden (Atkins).

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