BIM takes off

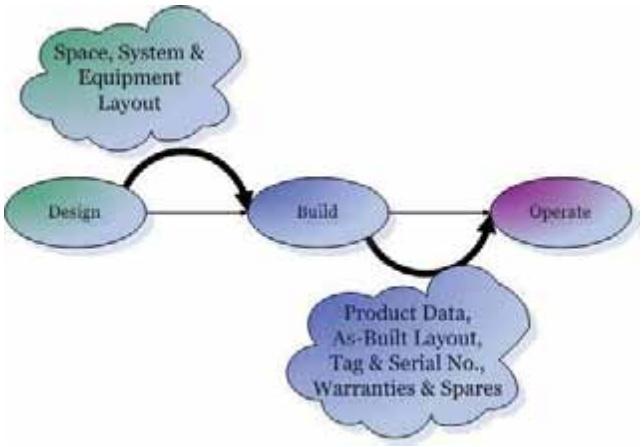
Information modelling for roads and highways is taking off. But why now, and what is it anyway? Adrian Greeman

After half a decade of slow development in road engineering, everyone suddenly wants to talk about Building Information Modelling: the use of electronic models in construction. Consultants have got "BIM champions", software sellers are branding their products upfront as crucial "BIM tools," and clients are beginning to insist on BIM "deliverables". These include some governments, notably in Scandinavia, Australia, and lately the UK, and various states and federal bodies in the US such as the US Corp of Engineers. Others are working on it too.

The reason for this according to numerous experts in the field is partially technological and partially economic. BIM offers major efficiencies in the construction process at a time when the economic crisis is making that vital, competition is growing and clients becoming ever more demanding. "And meanwhile the maturing of the software products has reached a critical mass point," said Adam Mathews, European and Middle East business development manager for AutoDesk, one of the sector's leading vendors.

But pinning down just what BIM is, and is not, is more complex than it might appear. Understanding what is required and what software tools might be needed by contractors, designers and the supply chain is even more complex. As one expert in the field, UK consultant to software producer Bentley Systems Phil Jackson said, there is a kind of "fog" around the subject and a host of competing definitions. "At present what BIM is really depends who you are in the construction chain and what you want to do with the software tools," he said.

Using BIM effectively offers major efficiencies in the construction process at a time when the economic crisis is making that vital



So, variously, it can be seen as a 3D design tool; a tool for multi-disciplinary collaboration in design; a tool for collaboration in construction, bringing various subcontract disciplines together to coordinate work; a planning and sequencing tool; a clash detection tool for both spotting overlaps in physical space and in project sequencing; a communication tool for engineers to speak to each other and also to the client; a publicity tool using visualisations; an information transfer tool, which is possibly one of the most important aspects; a life cycle information tool where the greatest benefits could be achieved; a design costing tool and construction financing tool, and importantly too, a health safety tool allowing site works to be run through and organised with reduced risks.

Such a wide range of functions, and others, is inevitably hard to get a grip on. It draws on and uses all kinds of software from structural and road design packages and data federation tolls like Navisworks to relational databases. But as speakers at the Institution of Civil Engineers conference in London recently, were keen to emphasise, it is not focussed around particular kinds of software or even the output from software. One speaker, Rachel Arulraj, the director of virtual construction at US consultant Parsons Brinckerhoff said that the firm uses over 45 different software tools to enable BIM.

Instead it is really about the process of design, construction, and maintenance. "Building in BIM is a verb, not an object," was a point repeatedly made at the ICE conference and that means building roads as much as it does office blocks. But despite that, to grasp what BIM is, it is helpful to focus on one type of software to start with, which emerged in the building and architectural sector. This is the object-based 3D "intelligent" model.

Such models started as computers exponentially grew more powerful, and the increased sophistication of CAD allowed 3D models of a structure to be drawn. "Pretty rapidly people realised that this was not enough and they needed software that worked in object-based terms," said Nick Nesbit, from AEC3, an Anglo-German consultancy specialising in BIM. He is also a leading figure in the development of international data standards for BIM.

"What that means is that a 3D design is not just adding a Z coordinate to drawn lines, but that there is a complete reorganisation of the software to use a set of parametric objects. Such objects have all kinds of properties and attributes. Most of all they can 'relate' to each other," he said.

The archetypal programs of this type are those like Revit, now owned and developed by AutoDesk in two flavours: for architecture and for civil structures, or the equivalent Bentley Architect, ArchiCAD and others. In these, designers use objects they set up and define themselves, or draw in from a library, or as the market develops even from outside sources like manufacturers.

To a greater or lesser extent these will automatically, or with changes to the dimensions, "self-fit" into a structure. A "window" for example will have adjustable dimensions and information

about properties such as thermal insulation capacity.

It will also be moveable and as it is dragged and dropped, a walls and corners will "heal" themselves", with a space made elsewhere to accommodate the object. Offsets and clearances will be seen too.

An equivalent program in civil engineering would see perhaps the capacity to select a "roundabout" from a pallet of junctions which could be dropped into position, said Mark Bew, technical director at consultant URS-Scott Wilson in the UK and a leading figure in the British government's BIM working party. It would automatically connect onto the road and all necessary cut and fill would be done.

Object based design is the "Holy Grail," he said and others agree. Arulraj for example said, "Full BIM will mean programs where objects will have attributes".

That is some years off. Major problems have to be sorted out, not least in international setting of standards for what objects are, what information they should contain and so on. Software has to develop.

The international "Building Smart" groups have done major work producing such specifications which are known as Industry Foundation Classes, or IFCs, which are not proprietary software specific. But they are not well defined in the infrastructure sector. "Most vendors do not yet include them," said Nesbit.

Road design programs like Inroads or Bentley MX, have long had three-dimensional surfaces and can cut through these and calculate road cuts and embankments. They are data based and volumes and quantities can be produced. But the objects within them do not "know what they are". Even Autodesk's Civil 3D which is partly constructed along object lines, and can quickly readjust and rebuild alignments and all the elements attached to them when they are dragged and moved, is not an object-based program in the full sense.

"But pay attention," said UK Autodesk civils expert Jack Srongitharm, "We have recently introduced a new category of items to its design libraries called 'solids' which are a bit more than lines and surfaces. Currently solids deal with a specific design problem such as designing overhangs on bus or train platforms. But they might indicate future development.

Novapoint in Norway is making more head-on progress towards full BIM with a new version of its road design suite being built around object-based principles and a full 3D model held in a database rather than as design files (see box). It could be the first civil engineering "Revit".

Even in the structural sector there are advances to be made in object-based software before the full concept is realised.

But attaining this level does exhaust what BIM is by any means, far from it. Many other elements of what a full 3D model will allow can be done now, and by different means. Some of these have taken on a life of their own which is now almost more important than the original design function of the models. As a result BIM has expanded away from the design sector into the complete construction chain. "It is no longer 'lonely BIM' but 'collaborative BIM," said AutoDesk's Mathews. A final stage will be, "…whole life BIM," he said, when the model data is seamlessly passed on into the asset management stage.

First of the additional aspects is the use of a single model as a repository for the design work of others to be added to. It becomes a "single source of truth" for data and measurements and the location where all the elements of a design gradually build up, which allows different designers to coordinate and work together collaboratively. Using the ability of a three dimensional model to be represented on screen, visualisations can be made which are millimetre accurate and allow clashes to be spotted, and the design outcome to be rethought after walking or driving a "virtual construction".

The cumulative appending of design data to the model objects – which are defined to allow such additions, - also becomes one of the most important new capacities of BIM, because the "design intent" can be carried over to the construction phase said Richard Shannon, BIM "Champion" for UK international consultant Mott MacDonald. By querying the model, information can be provided to reduce site errors, and reduce RFIs.

Even more importantly, the data is carried on to the eventual commissioning and operations phase of a project. Not just design data is added; during construction further details are added in, such as reinforcement, and perhaps for the first time even completely accurate "as built" data. It all constantly feeds back into the design model as well perhaps allowing adjustments to reflect the FM team's requirements better.

Other information is easily added as well such as specific details about components like drains or lampposts, beyond simply their alignments and dimensions. Each item can have its own particular serial number recorded and with that a host of information about what it is, where it was made and which batch, what maintenance it ▶

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Innovative BIM package

Causeway says that its latest software package offers intelligent 3D modelling capabilities and powerful integration functionality for civil engineers. Called the Professional Design Suite (PDS), the package is said to cover all aspects of earthworks design and quantification, development site infrastructure design and highway design. Modules are available for digital modelling, alignment design and drainage design. The latest generation also features a visual reality module that generates walk-throughs and fly-throughs within just a few minutes of finishing a design.

The digital modelling BIM capabilities of PDS include borehole modelling, calculations from multiple models, automatic generation of formation models and quantities, storage pond modelling, dynamic cut and fill analysis and surface design tools. These are combined with horizontal and vertical route alignments, intelligent 3D junction design and dynamic integration with micro drainage.

When the design is complete the visual reality module uses gaming technology to generate designs faster than with conventional methods. Causeway has also made a free viewer available to help clients view the designs.

PDS is said to be intuitive to use and can be learned with minimal training and with no requirement for specialist CAD skills. PDS users, who include the majority of the UK's top 100 consulting engineers, typically report time-savings of 50% compared to traditional methods.

Causeway
www.causeway.com

requires, and so forth, all sitting in the model. Delivering this accumulating information in the BIM model to the client, means that projects will arrive with their own very specific electronic "user manual". Data can then be fed directly into maintenance and facilities management, beginning to realise the dream of "whole life cycle" design and construction.

Many of the experts spoken to by *World Highways* put this aspect of BIM development at the top of the list. It is being driven especially by the rise of design-build-operate and perhaps own, contracts.

"The point of BIM in the end is outcomes," said Shannon. "The client is interested in a better product and saving money."

Part of that is better understanding of the design, which can be created in virtual form for discussion and modification, so that client-designer misunderstandings and misdirected expectations can be eliminated, and with them the need to change or re-do projects later.

But the biggest savings come in the use and maintenance lifespan of the project. Building up facilities management or road pavement maintenance information and data is expensive and if much of it is present at the start, including manuals, serials and place of manufacture for components, substantial effort could be saved. Rescans and resurveys which are routine now, could be ruled out.

"At present," said Shannon, "by the end of a project everyone is tired or looking to move on. So the data, if it is passed on at all, comes as a great pile of photocopies and scraps."

But the rigorous accumulation of electronic data which an object model facilitates, can also be done now with existing design and other software tools, even without the object-based model.

Developing a system to collect data and its attachment to design drawings and models is already in train. In the United States a protocol called COBie, the Construction Operations Building information exchange has been originated by the US Corp of Engineers which sets out how and what information should be gathered and presented in a text based form and it is gathering momentum. The UK government is building part of its own BIM strategy on COBie for example.

Early stages of BIM see this information collection running in parallel with 3D design work, with the capacity to automate it being carried out more and more by software. One thread of this development is the consistent naming and organisation of documentation to rules of military precision, which is particularly represented by the UK standard, BS1192(2007). A tailored version of Bentley Systems' ProjectWise works to this.

Another major aspect of BIM models is that they incorporate design work and information from a host of different disciplines in the one place, all coordinated with each other and again BS1192 2 procedures help achieve this.

But perhaps the "killer app" for this is Autodesk Navisworks, and to some extent equivalent tools like Bentley Navigator which all bring together disparate designs in one place for virtual model display, matching files or in Bentley's case holding them in a single "container". Novapoint has its Virtual View module which draws road surface, lighting, signage, drains, cabling and lighting all into one model.

By "federating" data, matching up assorted 3D models and

Twin lane structure

The two lane Crussell Bridge in Helsinki, opened in June this year was a complete BIM project by design consultant WSP's Finnish operation. The complex 175m long dual span assymetric cable stay structure, which links Ruohalahti and Jätkäsaari on the western shore of the city centre and carries vehicle traffic as well as having facilities for cyclists and pedestrians will also feature a tramway in the future. The City of Helsinki was the client and it was built by the contractor Skanska Civil.

WSP used a BIM set up for both concrete and steel design of longitudinally pre-stressed concrete beams including time and management dimensions. It was the consultant's first experience of modelling concrete with reinforcement. The bridge was a pilot for both WSP and the client, and also software provider Tekla Corporation via its bridge design software, which has been further refined as a result of the scheme.

Tekla's software is one of the few true BIM products around, believes WSP infrastructure BIM leader David Stone, "…in as much as it uses a full data-object methodology".

Client, designers, contractor and major subcontractors all used the same primary BIM tool and the construction model was published on the WSP server. Extensive use was made of the BIM model for the fabrication of steel girders and concrete reinforcement, for monitoring and management of the supply chain of fabricated components, for formwork and temporary support structure design, for quality control using laser scanning and for construction planning using 4D animation.

Tekla Software
www.tekla.com

The new Crussell Bridge in Finnish capital Helsinki was a complete BIM project by WSP and was built by Skanska, while the structure improves connectivity to the western shore area of the city - image courtesy of WSP's Nicola Evans

sometimes 2D drawings as well, into a single view around a common reference, these programs replicate elements of what a full object BIM model will do and allow several key aspects of BIM working to be carried out.

Top of the list is clash detection and it is no surprise that the automated detector for overlaps and spatial intrusions in Navisworks, which alone can save tens of thousands of dollars, if not millions, in avoiding later physical conflicts, comes only in the premium version of the program.

But Navisworks in its viewing capacities has particularly taken off for contractors and on-site construction. Its ability to show the various elements of the design in a single walk through visualisation has been proving invaluable for site meetings, design exploration, subcontractor coordination, construction sequence run-throughs, and spatial planning for detailed site operations.

"It helps that although federating all the data requires the full program the result can be displayed in a free viewer," said major UK and international contractor Balfour Beatty's technical manager, David Philp.

Using the virtual views, drainage installers can make clear that they do not have sufficient working space, or concreters that the skip will not be able to lift over nearby falsework.

Extending Navisworks' value for on-site work is the capacity to create sequence simulations and attach them to a timeline which can be run through with a slider. Further dimensions of financial costings such as payments received against outgoings, and lately the carbon usage of a project, are growing in importance too.

Other programs can add to these capacities too. Synchro for example can link a 3D visualisation to Gant charts, and to Primavera or Microsoft project manager timelines and calendars, and can allow quick resequencing of operations by dragging out critical path elements and so forth, with the result reflected in the 3D view. Some major contractors worldwide are taking to this.

One important aspect of this type of program is emphasised by Balfour Beatty and that is safety. Philp says that pre-visualisation has a major impact on safety for complex sites, allowing virtual construction to be carried out and obstacles to be identified before anyone can get hurt. The contractor, and partner consultant Atkins, have been using it on the huge widening and upgrade to London's M25 ring motorway in advance of the Olympic Games.

"This is only partly down to the software," Philp underlined. "A lot more of BIM is through the procedures and methods that the software facilitates."

For this physical side of construction these site coordination aspects are more or less what they mean by BIM at present, highlighting Phil Jackson's point that BIM has multiple meanings for different participants.

A further element that feeds into BIM at present is the general coordination of design work construction management and project managements, again around BS1192. Stuart Spencer, Bridge Information Model manager for Bentley Systems says the importance of that can be overlooked.

But others underline the fact that BIM has grown to embrace a lot more than software and object-based design models.

It is a transformation in ways of working, believe many in the industry. "It is very challenging," said Jeff Stephens, a technology manager at the UK construction division of French firm Vinci, "and will be a disruptive change".

So important is it that the UK government has set up a five year programme to introduce BIM working, drawing on these elements. The aim is to draw all firms, including the "trailing edge" of smaller supply firms and subcontractors, into using the technology.

Bew, who chaired the working party which advised the British Government, said that the aim is to achieve the use of assorted types of existing 3D modelling softwares, along with electronically managed file based collaboration, by 2016. The so-called Level 2 BIM in a hierarchy defined by the working group which ends with the "Holy Grail" level 3, of object-based systems in which all the data, both spatial and textual is held in one place.

The way that has to be achieved is left open in the British strategy to avoid plumping for any particular types of software. But a key element is the interoperability of data transfer, probably around IFC standards, and the development of COBie.

"Level 3" itself is still a future vision and there are some in the field who argue it can be achieved without producing the all-encompassing single model, which could become so large it is unwieldy. Federating the data may be all that is needed say some, with advances in the kinds of programs that bring in disparate data. Others are more certain the way to go is the object-based model, including Bew. Norway and Finland are both already well advanced on that path, and Norway's government already requires delivery of models built around IFC standards.

Software producer Novapoint has been working on the development of a database mediated 3D model software for about six years and is about to launch a first version. This will tie in with a giant model held by the Road Administration itself, to which future projects will be added, gradually building up a single representation of the country's entire road network and the terrain around it.

The Norwegians say this is not unwieldy because any particular designer will only check out as much of the database as he needs for his project. But he will have access to all the past data on the road system, saving huge amounts of survey and other work.

Finland too is heading in this direction. For buildings, the government property agency has been requiring the submission of BIM models since 2007, again with inter-operability achieved through using IFC, said Jaakko Jauhainen, sales director for Solibri which makes software to verify BIM models and their rich information content before submission.

"The standards for infrastructure are less well developed but are on the way too," he said.

One of Solibri's big markets is the US which is pushing ahead with BIM usage. Several DoTs are now passing 3D models on directly to contractors for use in machine guidance systems, another major area of BIM development.

BIM is an idea whose time has come, a speaker told the London ICE conference. It seems so. ■

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Autodesk
www.autodesk.com

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