

DENVER'S AIRPORT EXPANSION PRIMES A PUSH TOWARD **BIM** FOR FACILITY MANAGEMENT

BY MATT BALL

Denver's Hotel and Transit Centre Programme is an ambitious project that combines a commuter rail transit centre and a 519-room Westin hotel to create a new gateway to the main terminal that incorporates sustainability goals. § The building information modelling (BIM) process employed for the design and construction of the Hotel and Transit Centre Programme at the Denver International Airport (DIA) is a unique and forward thinking effort that kicks off an even more ambitious airport-wide BIM conversion that will greatly improve ongoing facility management and maintenance. DIA is the fifth busiest airport in the

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Maintaining the anchoring for the white tension fabric roof provided a challenge in the early planning and design stages. This photo/model composite shows the detail of the temporary grounding tower. Precise measurement of the existing building was essential for the engineering of this tricky transition.

United States, and the largest in terms of area (85 square km), which means that there's a lot to manage, and a lot to maintain at this international airport.

Mark Hughes, BIM Manager at AECOM for DIA explained, "53 million passengers pass through the airport on a yearly basis, and about half of those passengers are origination/destination passengers, which means they're coming and going from the airport. That's a lot of wear and tear on roads and infrastructure."

Any airport project poses challenges given the need for added security, the need to report precise building location for the oversight of the Federal Aviation Administration (FAA), and the need to minimise inconvenience to travellers. DIA's BIM model-based approach aids a faster construction pace with coordinated project timelines and impressive collaboration around a central model, but this project is just the start for the airport's broader vision.

To achieve the facility-wide BIM effort, the airport first contracted with AECOM to scope and manage an overall airport BIM plan. The airport expansion with the Hotel and Transit centre provided a great test project for a fully integrated BIM effort. This programme-specific BIM management work is being spearheaded by HNTB. Both the airport and programme-based BIM managers and design and construction teams work together to aggregate and integrate the model with other core systems.

REDUCING WASTE

DIA is now nearing 20 years in age which means the facility has increasing maintenance needs. Noting the benefits of BIM on the Hotel and Transit Centre Programme, DIA moved to implement BIM for use in the day-to-day asset management of the entire airport facility. When fully implemented, DIA hopes the BIM system will make maintenance of the airport infrastructure more efficient, which in turn saves time and money, and improves quality.

"For DIA, it was really about reducing redundancy and carrying the building model throughout the whole lifecycle of the project," said Eddy Krygiel, AIA, LEED AP, Director of Design Technology, HNTB. "I know that sounds so cliché, because everyone says it, but they want to do it, and they're actually doing it."

DIA's push toward BIM for maintenance is strategic for long-term benefits. This building effort is the first step in a conversion of the whole airport into using the BIM model as the primary source of data for facility management. For example, when fully implemented, DIA personnel will be able to access through BIM, information on when an item was purchased, the cost, the item's specific location, when it was installed, the maintenance schedule for the item and other information important to maintaining the airport facilities. The airport is implementing an automated, bi-directional information

exchange between the BIM model and the Facilities Management platform that will greatly reduce risk, and will result in time and cost savings on accuracy alone.

"When BIM first became available, the airport saw the benefits of connecting to the facility management process. The goal in mind was to establish a fully integrated facility management workflow, and avoid the dreaded failure management pitfalls," said Dennis



Rodríguez, AIA, project manager Transportation, Aviation at AECOM, and the first in on the airport's BIM implementation team. "This new process provided an opportunity for some housekeeping and content management."

METICULOUS PLANNING

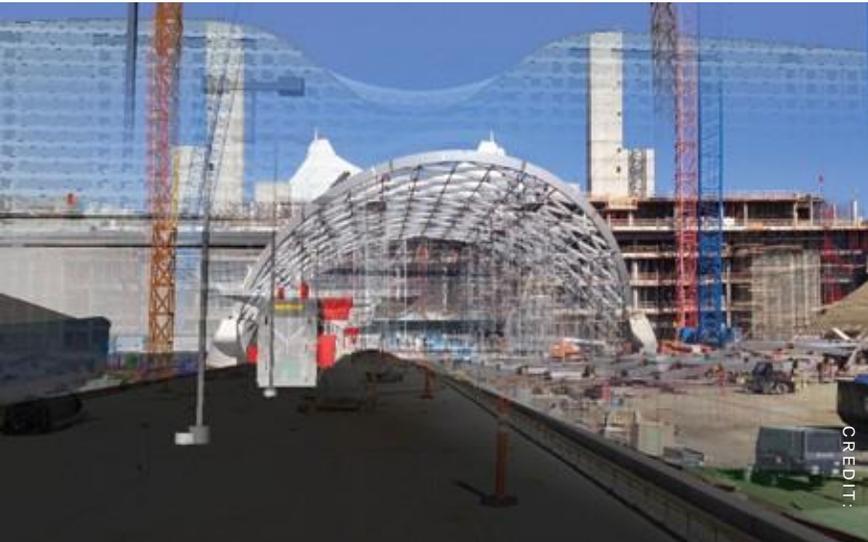
When the airport was built in the early 1990s (opening in 1995), the move from hand drawing to CAD was still fairly new. As a result, there are a great many drawings, but they were all on various disks, drives and file cabinets. A first step to the overall BIM project was bringing more than 9 million CAD files together in one place so that they can be catalogued.

Unfortunately, because of the limitations of this prior technology, there is no ability to identify which files are the most accurate. This points to a key benefit of a model-based approach where the model is updated continuously and becomes the central point of truth. Getting to the point of coordination, and integration with other systems, took a good deal of staging, with 18 months of planning before any project documentation began.

"We knew it was going to be a very large project team, and we would need to do some planning to keep things organised. We tried to predict the obvious issues and create a number of workflows to help solve those problems

before they arose.” said Krygiel. “One of the biggest problems that you have on projects is that team members don’t model enough, or they model too much. Our goal was to create guidelines on what would be modelled and what wouldn’t, so the process was predictable for everyone.”

Getting to consensus wasn’t the easiest process, as the team needed to talk to all the firms involved about collaboration on the BIM process. At first, many companies



With the concrete for the platform in place, this model/photo composite provides context for the completed structure. Note that the stairwells provide a reference point for the completed height.

held back because they had the feeling that their process was too unique.

“We’d invite the companies to collaborative meetings between design teams and construction teams, and some initially said they couldn’t participate,” said Rodriguez. “But when they realised the priority this held with the client, they started to participate. Getting them engaged ensured their authorship through the process, and a deliverable that they participated in.”

REALITY CAPTURE

Part of the early effort involved capturing the existing conditions, above and below ground, for the interface of this new construction project with the existing building. The integration of the point cloud into the model, along with survey data, assured an accurate building location.

The data capture of the Terminal Building included LiDAR scanning of the first three bays, from the roof down to the ground. The scan assisted modelling the building to a high level of detail, with everything modelled down to 15.6cm in size.

Using LiDAR to model the interior took place over three evenings (1 a.m. to 4 a.m.) with 18 to 24 meter scans. The scan data was compiled into a digital image, and from there it took four to six weeks to create the full model of the existing building.

COMPLEX WORKFLOW

On the design side 25 different firms created models and content, with some of those firms having multiple models, for well over 40 models total. On the construction side, there are ten firms creating content across 25 different disciplines. The train is another element with its own models that are coordinated by the Regional Transportation District (RTD).

“I don’t think anyone, design or construction, was used to an owner that has this level of engagement,” said Will Lineberry, Design Technology Manager, HNTB. “The significant integration, and airport-wide scope, is much greater than most owners would tackle.”

Essentially, the workflow starts when the designer creates a Revit model, which is then reviewed in Autodesk Navisworks Manage project review software where spatial coordination takes place, and it becomes a construction document that goes to the contractor. The contractor uses the model to create their own shop drawings with detail. The shop drawings contain the greatest amount of detail, such as with the ductwork for fabrication. These files include duct joints, turn locations in ductwork, valve locations in piping, and how all the connections are made.

Early in the design there were weekly design review meetings, where any problems were discussed and resolved. Later in the process the move was toward spatial coordination, where the model was analysed for design or construction conflicts. Now the project has moved to construction model coordination, where all the trades are modelling how it will be installed, down to hangers and flanges. The teams meet twice weekly to check for conflicts on upcoming work.

“A design model may not show hardware for hanging hydronic piping, but the construction model does. If you have four pipes with hangers next to each other supported from an 21cm post-tensioned slab, it’s nice to know where the areas of interest are on that slab,” said Lineberry. Additionally, having that level of detail will inform the design of future building modifications.”

The construction fabrication model comes back into the Revit model and gets justified and inspected to verify that everything is within tolerances that are spelled out in the BIM plan. If there’s a discrepancy, an RFI is generated and the Revit model gets re-aligned so that it always reflects what happens out in the construction site.

At the end of the project, the client will have an as-constructed Revit and Navisworks model and that will connect to DIA’s commissioning data. The building will be commissioned, and that commissioning data will go into an SQL database. The Revit model will be linked to the SQL database, and also linked to the Maximo facility management system.

“Designers really need to think as if they own it, they can’t just create a set of documents,” said Hughes. “You



The detailed and comprehensive model of the South Terminal Redevelopment Programme includes both above- and below-ground infrastructure as illustrated in this photo/model composite of the West Platform, which is seen again below in the final rendering.

have to have the mindset that you'll need to come back to the model, and it will inform all that you do in the future. We're in the process of originating the perpetual as-built."

DIGITAL TRANSITION

The all-digital approach was a challenge for some firms, as it meant a change in how they had been doing work up to this point.

"Our approach all along was that we needed to engage all disciplines (civil, infrastructure and vertical design, as well as construction groups for each of those), and they all have had very isolated views of how they do work," said Hughes. "The infrastructure guys really focused on that, and had no perception of how to integrate with vertical design, and vice versa. There has traditionally been an isolated approach that each would get their job done independently, but BIM requires everyone to engage all disciplines, all the way through."

Another problem beyond the need to educate different groups of the whole design process were issues around ownership and liability. With a seamless flow of models, the disconnects between the design and the final finished building go away. Significant issues of building performance have occurred in isolation in the past, without validation from engineers, and without simulating the impacts of mechanical changes.

Traditionally, documenting that change would happen in an RFI process, but often it would never get returned to the engineer, and it wouldn't get recorded back in a drawing. Most times, job-site changes don't impact mechanical performance when they aren't fully constructed as designed. Another issue, however, is when clashes in ductwork or piping occur, leading to a time consuming and costly fix.

"On another project, the mechanical engineer said they weren't going to do the clash detections, stating that was the means and the methods of the contractor," said Rodriguez. "What they were literally saying is that they were used to drawing lines that represented ducts, and the contractor had to make it fit. For years, they've been able to offload the responsibility of making it fit, even though as engineers they have always had the responsibility to make it fit."

The owner understands that paying for changes during construction is the most expensive point in the process. Clashes balloon into a huge cost, so if you can handle that during design, it has cost benefits. When you implement BIM, there are cost savings in reduced work and reduced change orders that are hard to quantify, as the money that isn't spent can't be tallied.

Another area of industry change has to do with the role of engineers and drafts-people. The lead engineer needs to participate in modelling, but they resist because they associate it with drafting. This change presents a paradigm shift on who and how the work is done.

"Engineers can model and simulate, and save a good deal of time, rather than going back to their master spreadsheets to make each calculation," said Hughes. "The platforms of today are based on a database and have a lot of internal calculation capability. They will help prevent drawing things that won't work. The key is getting the spread-sheet owners to trust the software over spreadsheets."

JOB-SITE MODEL ACCESS

With such a large job site, and a coordinated central model, making the model accessible to the workers had always been a goal. Given the issues with unwieldy plan sets, the contractors were willing to try electronic file sharing with iPads.

Without this digital device there would have been a need to coordinate, store, share and secure thousands of paper plans on-site. Instead, there are daily updates on all the iPads, and each of the trades can have a copy of the

most current model in their hand.

A worker can be looking at their iPad and a detailed model for tying re-bar. This is done with Autodesk's BIM 360 Glue, that allows them to easily visualise the 3D model, pan around and see the plan in context to where they are standing. With so many workers actively using the model on the site, it's not uncommon to see 15 to 20 people holding an iPad. The feedback has been very positive for its ease of use and quick up-to-date access.

The time saved, and safety gains of not having workers walking across an active job site, are further factors that are hard to quantify in terms of their dollar value.

"Just think of the guy checking re-bar up on level five, and the amount of time it takes to walk down five flights of scaffolding, walk 460 meters over to the trailers, try to sort through plans to find the one with the detail he is looking for, think through it, and then make that return trip," said Hughes. "He has that model in his hand on an iPad, with the detail he needs, looking right at the install and seeing if it matches the model, and doing that within minutes. Simple analysis like that bears a lot of witness to the benefit of the integration of technology in our everyday work."

An additional benefit is that everyone involved in the process has access to the model, where they can see it and use it to visualise the building in a way that makes sense to them. Having that detail, they can understand the points of assembly and how their work fits into the overall process, identifying any problems well in advance.

"With all the graphical representations and notations, everyone doesn't know what the notations mean in the model, but they won't admit that in a meeting," said Rodriguez. "But, if we link it to a model and a graphic representation where they can see it getting built, it's communicating, and they can speak to it from the executive level all the way down to the guy with boots on the ground. They then truly understand the schedule, and then we have time to plan and get input on how to correct any problems."

POINT OF TRUTH

The airport uses CAD, BIM and GIS on a regular basis for a number of different operations. GIS is the 'repository of truth' for deliverables to the FAA, and to provide the less granular view of the world. New information is provided by BIM platforms (Civil 3D or Revit) for authoring. In addition to being the authoring tool, BIM is also a platform used to integrate all building infrastructure. Maximo is used for facility management. To continue to maintain the sync of these systems, there are bi-directional updates to all systems on a regular scheduled basis.

"Up until the point of BIM becoming the primary authoring tool, maintenance were generating their own information in Maximo from construction documents that was 100 percent manually entered," said Rodriguez. "GIS was similar, because everything had to be manually entered from CAD tools, and the technician had to manually attribute the drawing. In both, the criticality of the data depends on how much the data entry person knows or cares, and that's how that system started falling apart." BIM has the benefit of coming from the authors of the information in either the design or construction process. The designs are created by the experts of the information, with the model corresponding to the exact location through survey input. The models are detailed with attributes and specifications that can be pushed to both Maximo and GIS, with no manual data entry at any of the integration points.

The model is just a starting point for some of the more detailed facility management tasks.

"Think about the warranty on mechanical systems — they all have different maintenance and trigger points," said Rodriguez. "The owner wants to make use of the warranty, but there are different requirements for regular maintenance. All that information needs to be entered into the system in order to get the most out of it."

ONGOING ADVANTAGE

BIM has become the primary author tool for new and ongoing projects at DIA. The model will be used for maintaining the critical systems that run the airport — mechanical, electrical, plumbing and security. The process is about creating a detailed model that informs all ongoing actions, and not on creating visualisations.

Whilst this major expansion illustrated the full scope of a BIM project with transition to operations, DIA has also been using this approach to capture information in other parts of the airport on smaller projects. It wouldn't be cost effective to create a highly detailed as-built for the whole facility, but by expanding the model with each project they will slowly fill in the gaps in the model.

Where there are gaps, there is an overall skeletal model

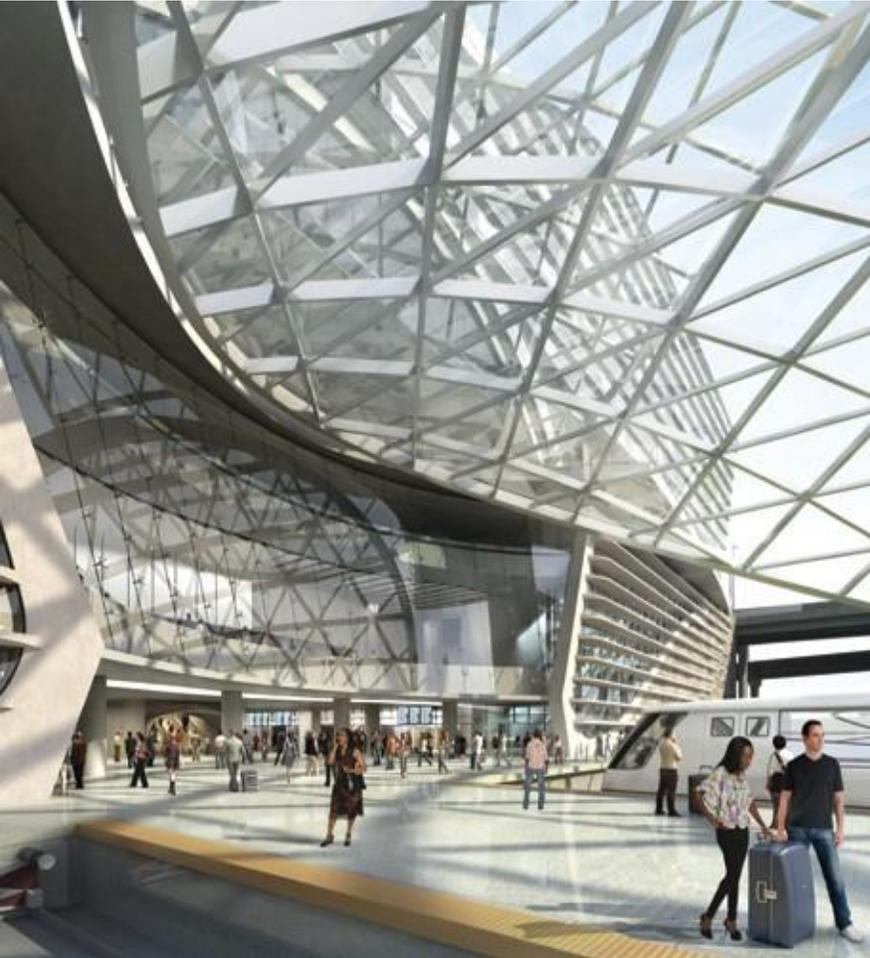


The scale of the base of the light-rail station canopy can be seen in this model/photo composite. The complexity of the rebar enforcement is something that craft workers can view on their iPads with models speeding the work.



for the entire facility that then accepts the greater detail as it becomes available.

One of the benefits ongoing is the ability to do detailed feasibility studies with the model. You can quickly design and scope a new element, based on a detailed model of what is currently there. If the project is approved, then the early conceptual feasibility work helps to jump-start the design. Having the model to do



The new dramatic gateway to the main terminal incorporates sustainability goals.

the study eliminates the need to survey and measure, and capture what's there. Avoiding lengthy and expensive consultant time on feasibility studies adds up to big savings over time.

This effort is truly at the forefront of BIM model adoption for this scale, scope, and integration with operations. Whilst there are clear benefits, there are also many hurdles.

"If you're not comfortable with the education process, it won't work," said Rodriguez. "It's not just education to get everyone on-board with the process, you have to stay engaged as things develop, and of course technology changes. A lot of owners want to do this, but over the two or three year project timeline things could fall apart if there isn't someone to advocate for them and follow through."

PROJECT DETAILS:

HNTB compiled the virtual composite model for the project and worked in collaboration with Parsons, Gensler, AECOM, and Mortenson, Hunt and Saunders (MHS) Tri-Venture

- ❑ *HNTB refined the BIM process and is charge of managing the BIM process for the project*
- ❑ *AECOM is working with DIA on the overall BIM for facility management*
- ❑ *Parsons Transportation Group serves as programme manager*
- ❑ *Gensler is the Architect of record for the Hotel*
- ❑ *Anderson Mason Dale is the Architect of record for the Public Transit Centre (PTC)*
- ❑ *Kiewit is providing all the earthwork, enabling, and horizontal work*
- ❑ *MHS Tri-Venture manage the vertical work*

Autodesk solutions for BIM employed by DIA include Autodesk Revit software (Architecture, Structure and MEP), Autodesk AutoCAD Civil 3D, Autodesk Navisworks, Autodesk AutoCAD, Autodesk Design Review, Autodesk ReCap, Autodesk Buzzsaw, Autodesk BIM 360 and Autodesk BIM 360 Field.

Be sure to check out the on-line version of this article on www.InformedInfrastructure.com for videos with the BIM managers, and animations of the construction.



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