COMPANY
4th Dimensional Façade Solutions

LOCATION
Australia

SOFTWARE
Autodesk® Inventor®
Autodesk® AutoCAD®
Autodesk® Navisworks®
Autodesk® Vault

Autodesk Inventor solves a 15,000 piece glass jigsaw

The power of Digital Prototyping enables 4th Dimensional Façade Solutions to design and construct a 21st century masterpiece

It speaks volumes with regard to the flexibility, sophistication and quality of the Autodesk Inventor mechanical design software, that it can accommodate a design project of this magnitude. It's true to say that without Autodesk Inventor this project could not have been built.

—**Jason Dent**
Founder of 4th Dimensional Façade Solutions

Image courtesy of Peter Barnes Photography

Project summary

The South Australian Health Medical research Institute (SAHMRI) headquarters building in Adelaide was commissioned by the South Australian Government as a prestigious, state of the art facility that reflected the confidence and capability within the Institute. SAHMRI is building a team of more than 600 researchers, who will work together in the search for better treatments and cures for some of the world's most challenging diseases.

The façade stands like a bubble around the building. It is the most complex steel structure ever built in the Southern Hemisphere being made up of 15,000 triangular glass facets and it is almost completely free-standing. The steel structure consists of 144,000 unique parts, all serial coded and embossed. Each triangle is made up of an aluminium frame, sealing gaskets, and a panel of which the majority are glass. The triangular assemblies are then mounted to a steel sub-frame. There are over 700 permutations and each individual part had to be drawn separately.

The whole supply and build contract for the façade alone was around AUD $35 million. iLogic, one of Autodesk Inventor's design automation utilities, gave designers the ability to automate much of the process by placing generic components and configuring them using a standard toolbox ensuring adherence to design standards and modelling consistency throughout the entire project. Despite intensive mathematical rationalisation, almost every piece of steel, aluminium and glass was unique.

The majority of the building structure was complete before any of the façade had been designed or detailed.

“The power of Inventor first came to our rescue in our collaboration with the rest of the design team - we could review any aspect of the design in 3D at any stage to show where the mismatches were occurring. Inventor iLogic components meant that infinite configurations of standard parts were placed with total confidence and there were no variations based on the operators personal modelling preferences,” says Dent.

The challenge

The architects had developed a 3D zero thickness surface model of the inside of the desired façade. The highest priority and the biggest challenge was ordering $10m of glass due to manufacturing lead times, before anything else was designed. Creating cutting details for the glass was the first challenge, followed by the details of the window frames and then the supporting steel. The design of the supporting steel between the glass and the existing building was particularly challenging as there was no possibility to change either the glass (as it was pre-ordered) or the supporting structure as it was already there.

Curving triangular structures are typically built using round hollow steel sections, but this façade design called for rectangular sections thereby dramatically increasing the complexity of the steel fabrication. Unlike a jigsaw where the challenge is to guess where every part goes, labelling over 250,000 components was vital to ensuring no guessing was necessary on the construction site.

The solution

All of the software vendors we spoke to shrank from this challenge, says Dent. “Autodesk Inventor had proven itself on several previous projects, but no one had tried anything this big, so we imported the surface model and the project just evolved from there.”

This evolution included a design team with nearly 30 individuals involved through 10 cities and 3 continents. “Being able to “speak 3D” was the only language that worked,” says Peter Crawley, 3D Consultant from Autodesk reseller CADPRO Systems Ltd. “If we hadn’t used Inventor it would have meant in excess of 200,000 2D drawings each taking an average of 20 minutes for each drawing.”

“In detailing the glass, we realised that you can’t just thicken the surface model because you get big gaps as the triangles move round the outside of a curve,” says Crawley. An intelligent iLogic part was developed that looked at each triangle and its angle to each of its neighbours, which then sized the glass accordingly. This “true shape” of all 15,000 triangles was then used to ‘profile cut’ the glass. “We decided to produce 2D drawings for checking purposes. A special program was developed inside Inventor that saved thousands of hours of repetitive 2D detailing work,” says Dent, who added “It’s just a shame we couldn’t check them as quickly!”

After managing to get the glass ordered, the window frames needed building.

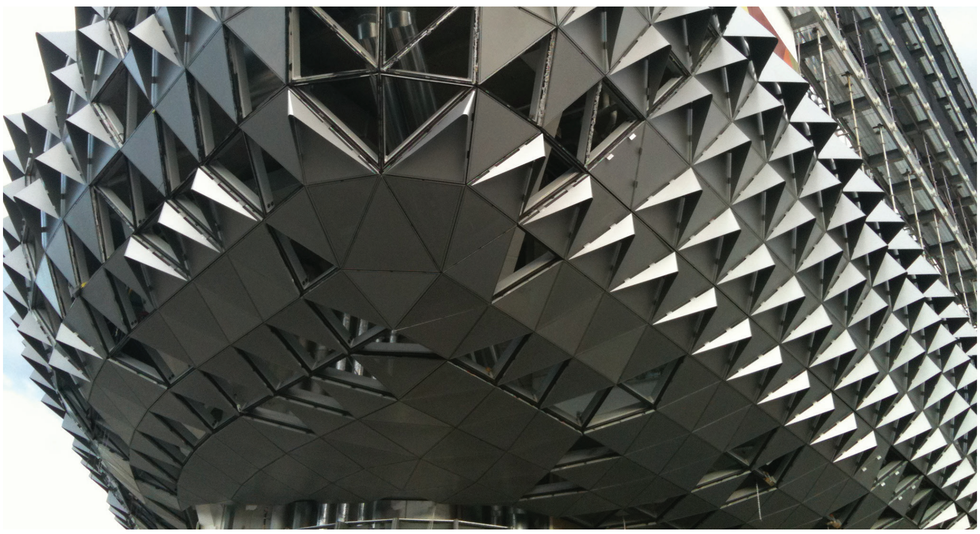

Image courtesy of 4th Dimensional Façade Solutions

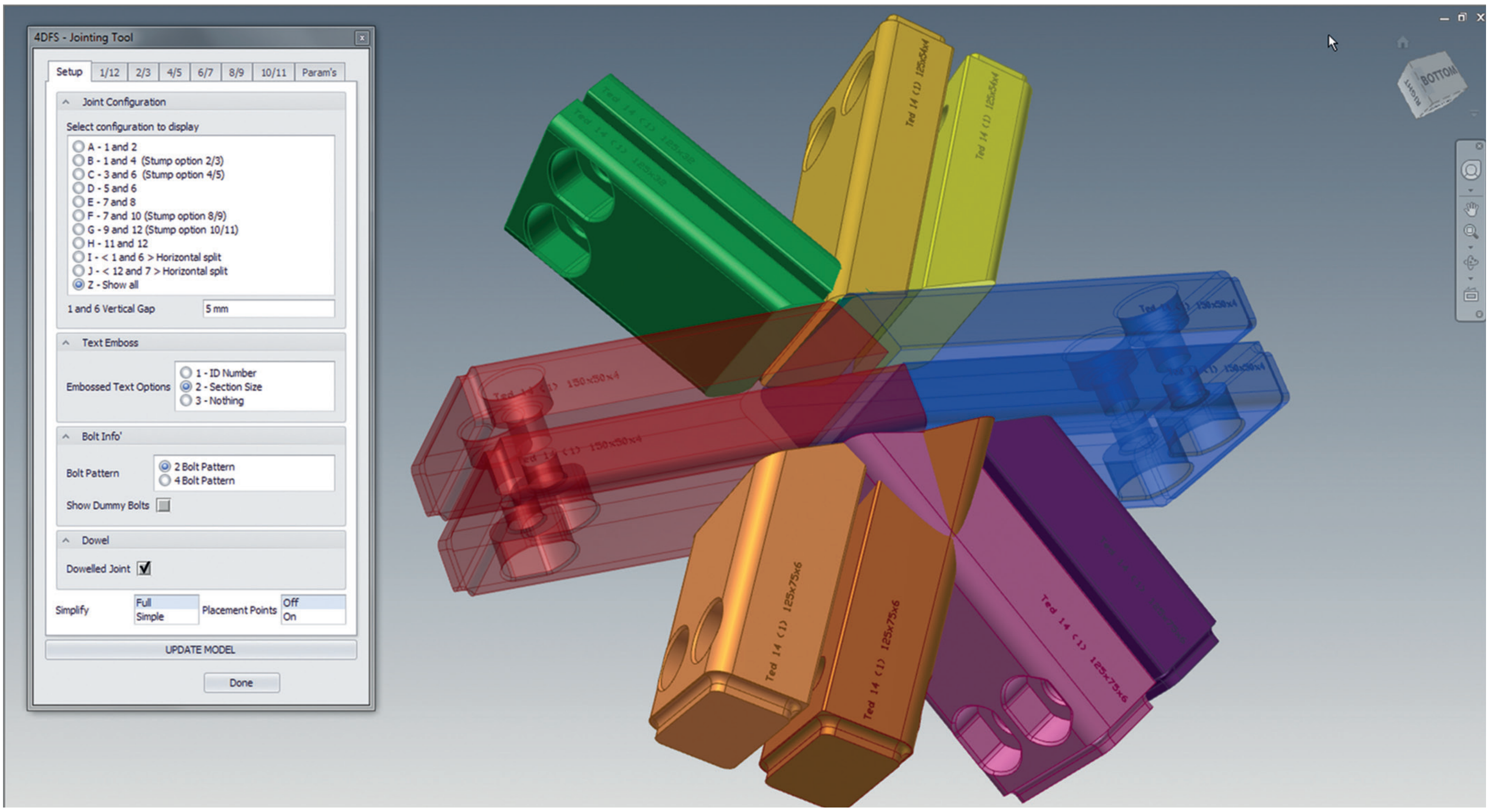

Image courtesy of 4th Dimensional Façade Solutions

The size of every triangle was automatically extracted to a spreadsheet, which fed a new Inventor iLogic window frame assembly.

"We didn't model every frame, there was no point," says Crawley. "We just created a few hundred for clash detection with the steel." Autodesk Inventor was particularly useful when it came to analysing how the various glazing components came together at a junction or a node point. The junction between the glazing triangles is essentially a six sided node like a hexagon. "A junction appears to work when it's illustrated on a 2D drawing," says Crawley. "But when you have a look at it in three dimensions then it suddenly doesn't work any more." It wasn't until people started to realise how complicated the geometry could become, especially as the façade goes round a curve, that the whole engineering design had to change. The steelwork junctions were equally complex. It was decided that the nodes should be simple hexagons that varied in shape to accommodate different steel section sizes.

One of the most difficult problems was to find the normal to 6 (or 7) triangles meeting at a single vertex or node, which would be valid in both concave and convex situations. This made the node design uncertain and gave rise to nodes that varied from a simple hexagon to unique six sided nodes whose sides varied in length depending on their orientation. Inventor's iLogic tool enabled designers to place a generic node, then configure it to suit the conditions.

"There were several occasions where we just ran into roadblocks and we couldn't figure out how to get round some of the problems," says Crawley. "And in most of the situations things were resolved by people having last-minute inspiration while they were taking a shower or similar. Once one problem was solved we just moved onto the next one until everything was fixed." "Almost by accident we discovered a repeatable technique to build complex manufacturable assemblies against a simple point cloud," says Crawley.

"With this technique, any shape made from triangular facets like this becomes surprisingly quick and easy to build. "One of the other features of Inventor, which saved considerable time for the designers, was the ability to emboss each component. In any given model you had maybe 20,000 components open, it took a finite period of time to interrogate each part by accessing its properties to identify it. To avoid having to do this, 4DFS embossed the part number and the grade of the material on each part.

When the designer was moving around in 3D space, he could interrogate the part by simply inspecting the embossing. "It's like engraving the part number and the material specification into the part," says Dent. The embossing was kept on the part and it was a considerable aid to the construction process in the workshops in China. This also enabled any 3rd party review process (like DWF™ and Navisworks) to work without any additional data being provided.

"The generic iLogic steel component was also designed to change colour if you changed the section size or grade of steel which made downstream inspection (in say Navisworks or DWF) so much easier," says Crawley. "On many occasions, new design criteria or steel sizes were added, and iLogic was able to update every single part already made."

"There are some new Autodesk tools like BIM 360™ Glue and Mockup 360™ that would have saved us weeks of time collaborating with stakeholders around the globe, but at the time we just made

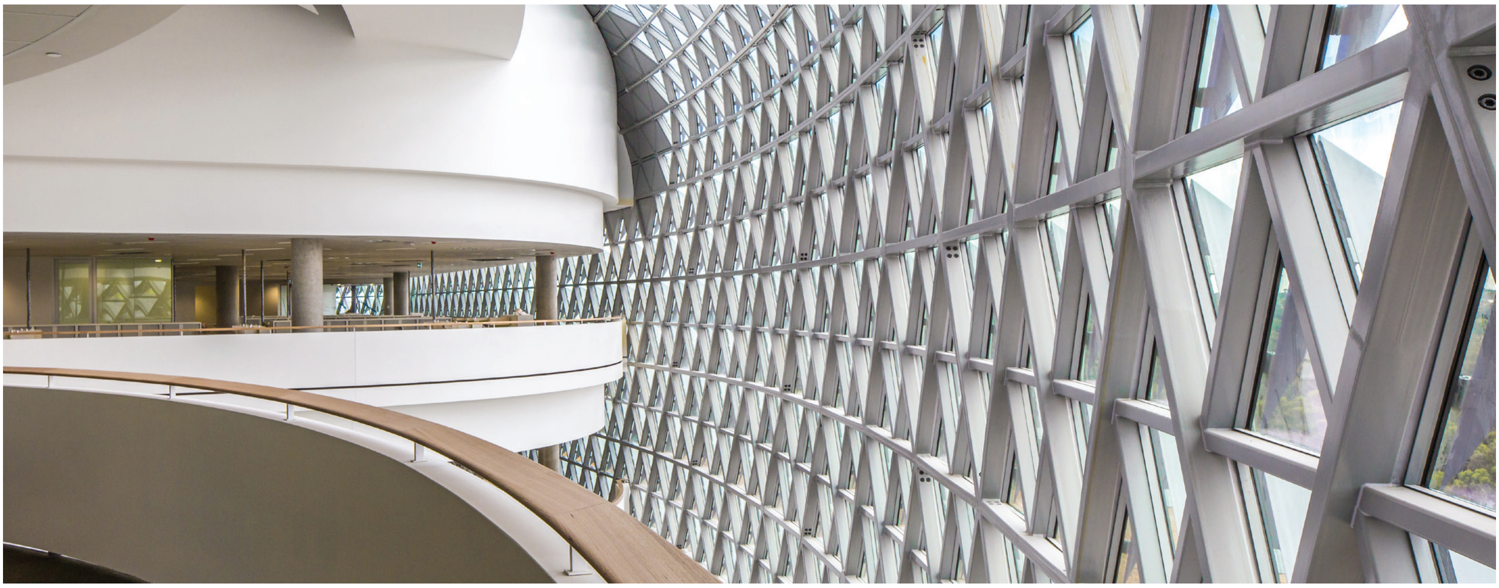

Image courtesy of Peter Barnes Photography

good use of Autodesk DWF files and some screen sharing software," says Crawley.

The iLogic tools and programming interface in Inventor simplified even the hardest problems. "Sure it took some effort, but who'd have thought Inventor would be able to export building survey data directly from the 3D model?" says Dent. "We were able to fabricate the steel without producing any drawings. All the steel junction pieces were CNC machined directly from our 3D Inventor models."

As the building was symmetrical about a central plane, Inventor simply mirrored every component. However, simply mirroring embossed text just reversed it. Making the text readable again (and changing the lettering) was another problem solved using more iLogic and Autodesk Vault which made very short work of renaming and renumbering thousands of parts and assemblies. "We didn't really have any other option other than to make the thing work otherwise someone was going to have an awful lot of glass for their greenhouse," says Dent. "And we had to order everything in batches so that we could get it all locked in with the supplier."

The results

The glass panels were made in China and assembled into their aluminium frames in North China. The steel was made in South China and then it was all shipped to Adelaide. The glass and aluminium was fitted to the steel in Adelaide.

"It all fit together without any specialised hand finishing," says Dent. "And the factory didn't need any fabrication drawings" The 2D design of the steel was still going on when 4DFS were doing the glass. "When you think about how separate all these different projects were, it's incredible that it ever came together," says Dent. In a situation where the whole design exercise was not following the logical design or manufacturing sequence and given the situation where some parts had to be ordered before the rest of the design was complete, it speaks volumes for the experience and ingenuity of those involved that the project was successful. It also speaks volumes with regard to the flexibility, sophistication, maturity and quality of the Autodesk Inventor software that it could accommodate an architectural design project of this magnitude. It's true to say that without Autodesk Inventor this project couldn't have been built.

Learn more

To find out more visit
www.autodesk.com/inventor

> The bottom line was satisfying the client and actually just building the project. The know-how of 4DFS, the ingenuity of the engineers and architects involved and the quality of world-class software from Autodesk meant that the prestigious SAHMRI building in Adelaide was completed with its high-tech multifaceted façade.
>
> — Jason Dent
> Founder of 4th Dimensional Façade Solutions

AUTODESK.