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Virtual Building

General Motors' design-build team perfects a digital design, then locks it and builds without changes. The result? Faster, better, cheaper, safer—and smiles all around.



By Tom Sawyer

Soaring into the Virtual World

Build It First

Owner knows what he wants, asks for it, gets it and the industry springs ahead

General Motors Corp.'s World Wide Facilities Group has taken the leap and rather than fall, it has flown. The GM staff who build the plants that make cars that roll all over the world decided to lock in plant designs as virtual models and then tell the contractors: "Go build THAT!"

"It's a breakthrough change in the way we do business," smiles August Olivier, GM's director of capital projects. He was talking about two automotive plants under construction in Michigan that take the idea of virtual design and construction roaring down the road.

"It's a schedule-driven innovation," Olivier says. Schedule for GM means time-to-market. That takes fast movement from decision to production—and not just of cars, but also of the dedicated plants to build them. Compressing plant design and construction cycles lets GM

hold off on facilities commitments as long as possible while the car culture decides what it wants. Shortening the cycle mows down the chaos inherent in predicting the market and designing and building plants to meet it.

"All the stars aligned," says Robert J. Mauck, vice president of advanced technologies at Ghafari Associates

LLC, Dearborn, Mich. Ghafari is an the architectural/engineering firm and technology integrator. It has worked with Detroit-based GM for four years to bring just-in-time supply chain technolo-

gies to facilities construction. Ghafari has helped vet technology, techniques and organization needed to turn the dream into reality. "GM laid the groundwork and then pulled the trigger on all the right things," Mauck says.

The gains realized are the classics sought by the industry: faster, better, cheaper—and safer—construction, claims Mauck and others on the team.

They say the gains are being delivered on the two signature projects in Michigan: a 2.4-million-sq-ft vehicle assembly plant in Lansing called Lansing Delta Township, or LDT plant, and a 442,000-sq-ft addition to a Global V6 engine plant in Flint.

The Flint plant has flown together in 24 weeks less than the typical 85-week design and construction time. It is finishing construction five weeks ahead of schedule with no change orders from building component interferences.

Of the two plants, Flint gets a lot of the glory for near perfect performance. But LDT has been the plowhorse for debugging the organizational techniques and integrating the critical 3-D design technology, says Jack Hallman, GM's director of manufacturing construction management. "Everyone likes to talk about Flint because it has been such a smooth job," Hallman says. "But I think LDT should get as much credit as Flint, with all the learning we did on that. We learned some tough lessons to make it work, and it is working now as well on LDT as it has on Flint."

What is working out well are design-build teams that are saving money and time and accomplishing the projects with



▲ V6. Comprehensive 3-D modeling cuts clutter and activity on site. Parts arrive cut to fit. No trash, no dumpsters.

PHOTO COURTESY OF GENERAL MOTORS



▲ **Just Talk.** Clash detection flagged issue when detailer flipped diagonal on last bay of truss.

the offsite fabrication and just-in-time delivery techniques of lean construction. They are each enabled by a commitment to build from comprehensive 3-D models that not only define facility geometry but have been refined by a team with fully incorporated structural, mechanical and electrical details.

In the case of V6, the design-build team perfected the 3-D model and mutually resolved every interference prior to starting construction. Then, they “locked the model” and all parties agreed to build it as planned. Any unapproved deviation would be on that subcontractor’s head.

“In 26 years I have never seen a project run with more collaboration and be so simple,” says Michael Neville, Ghafari vice president and project principal. Ghafari is the V6 project manager and model coordinator. Barton Malow Design, Southfield, Mich., is architect and Ideal Contracting LLC, Pontiac, Mich., a minority contracting firm in which of Barton Malow owns a 49% share, is general contractor.

Hallman says the lessons learned on LDT have made a tremendous difference with V6. “We got off to a rocky start at LDT, but that was the learning curve. If we hadn’t done LDT, Flint would have never been,” Hallman says.

“I think the integration is outstanding,” Hallman adds. “I have been a pro-

ponent of lean construction, of taking the lean techniques we have used to improve our efficiency in manufacturing, for a long time. I have seen these things work and work great, and I have been pushing through industry groups like the Construction Industry Institute and the Construction Users Round Table. What 3-D has done is be an enabler for lean construction, and it really started at LDT.”

The early stumbles at LDT came from a hesitancy to commit and from some software issues, he says. But once those problems were resolved, that proj-

“There is a way to model that works...and a way to model that goes nowhere.”

— SAMIR EMDANAT, ADVANCED TECHNOLOGY MANAGER, GHAFARI ASSOCIATES, LLC

ect—and V6 which followed—soared. “We didn’t trust the 3-D data,” Hallman admits. “We cut our teeth on LDT.”

Todd A. Pugh, estimator at John E. Green Co., Highland Park, Mich., mechanical contractor on both projects, agrees: “No one, quite frankly, really bought into the model when we started in that [LDT] job. But by the time the V6 project came around, that had all changed. We had the entire job detailed and coordinated before we stepped on the jobsite,” Pugh says. “It wasn’t perfect,

because of human errors we’d made, but they were very minor things.”

How It Works

By now the technology of 3-D modeling and data-rich design may be familiar, but Ghafari’s process for its use is not.

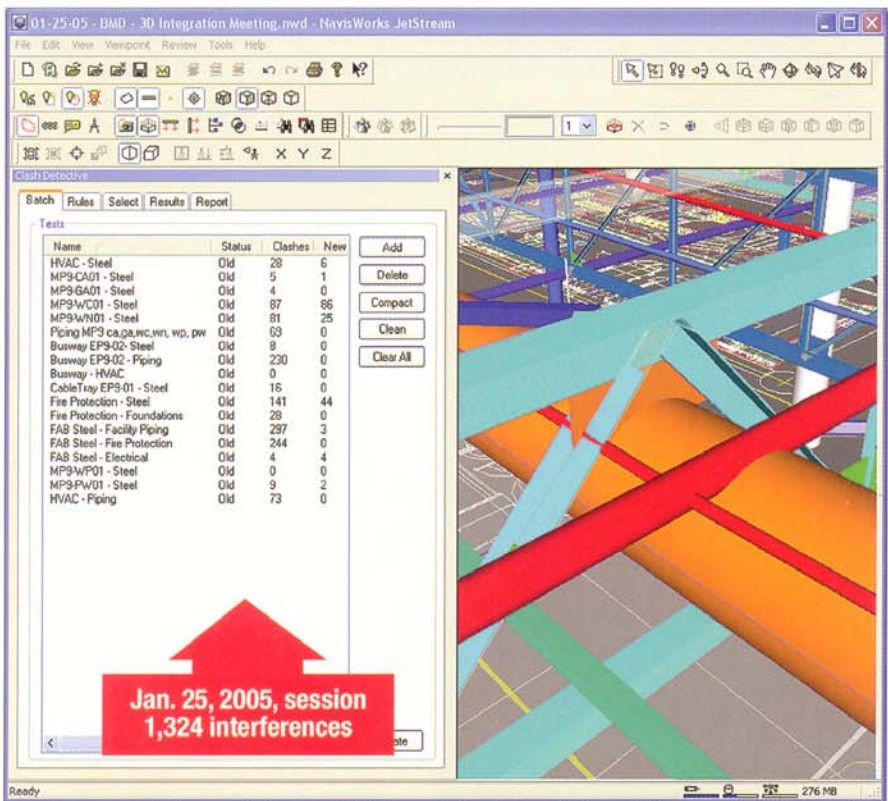
Bentley’s ProjectWise collaboration servers were used to circulate the architect’s Microstation model. Everyone could see it with a free viewer. NavisWorks design reviewer and 3-D model coordinator integrated new geometry developed by subcontractors in other

programs and ran collision detection on the results. Software included SDS/2 for steel detailing, QuickPen for mechanical planning, IntelCAD for HVAC and Autocad and various Autocad third-party products, says Samir Emdanat,

Ghafari’s manager for advanced technologies. He says NavisWorks doesn’t always bring in every bit of associated data, but it brings in enough. “It’s the best you can do with the supply chain right now,” he says.

“In the last few years we’ve been focused on the supply chain and what gets to the bottom line,” says Mauck. “It’s not technology for technology sake.”

“We could have done V6 two years ago,” adds Emdanat. “The technology hasn’t changed. The steel detailers were



▲ Resolving Issues. Mauck (above, right) in 3-D design review, where conflicts were solved.

already there....We might not have had the same level of sophistication for the piping and HVAC, but we could still have done the coordination piece.”

Emdanat says the key is making it all available to the full team. “It’s not simple. It’s not out-of-the-box. You need to know the standards really well. It all hinges on the structural steel data and it takes an intermediate format. There is not one technology to make it work,” he says. “There’s a way to model that works, and a way to model that goes nowhere.”

If the LDT project was the trial horse, V6 was the race. “GM’s facilities side had been watching the production side’s development cycle speed up and realized that soon the buildings were going to be on the critical path for new car development too,” says Mauck. GM decided to apply the lessons learned in the 1980s empowering production through what Olivier calls “math-data exchange.” It tightens production by using smart 3-D modeling to pass design data along the supply chain so each participant’s contri-

but ion can be incorporated faster, better and cheaper. In the building industry many are referring to the adoption of similar techniques as building information modeling, or BIM.

Proof

GM officials call the success with BIM at V6 “a momentous achievement” in itself. The proof is on the jobsite, Olivier says.

He recalls an exchange with HVAC contractor Dee Cramer, Holly, Mich. “Where’s your equipment?” he asked the contractor on the suspiciously sleepy worksite. “We pre-fab everything and bring it in and put it up,” was the answer as Cramer’s on-site work force of eight popped long runs of ductwork into place. Building components to the 3-D model means no fabrication or trimming on-site, almost no dumpsters and little waste.

“If it fits in the model, it fits in the field,” says Mauck

“It is different,” admits Dave Babcock, Dee Cramer project manager. “When you go there it’s, ‘where is everybody?’”

“One of the business issues we push is lean construction,” Olivier says. “We don’t think the industry has embraced it. Well, 3-D design is a huge enabler for lean.”

Getting the model completely correct, right from the beginning, is the key. Emdanat says that required some fundamental changes from everyone. But by last November, about the time LDT was getting over its growing pains, GM was ready to launch V6 and Ghafari knew what to do.

“On Nov. 7 we got the call...we co-located our teams and in three weeks placed the mill order and began fabricating steel,” Mauck says. By the end of December the initial 3-D model was complete. Co-locating the teams by bringing designers and estimators from all disciplines into one big bullpen jump started the collaboration. Then, the real fun began.

GM declines to share the construction budget on the \$300-million V6 plant expansion, but any GM-approved

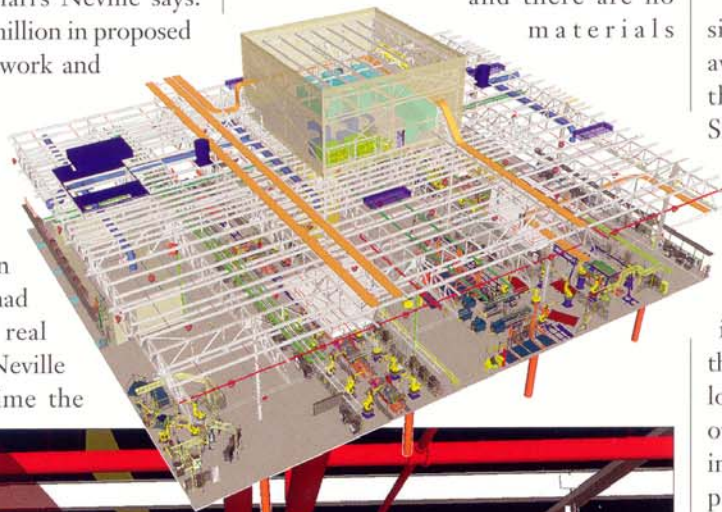


▲ **Tight.** Trimming on site is one thing, pre-fab to perfection is another.

design savings or schedule efficiencies were shared among the team. “We had three weeks of value-engineering sessions with architectural, mechanical, electrical and structural,” Ghafari’s Neville says. “We developed \$5.5 million in proposed savings, most in ductwork and mechanical, and electrical...We were throwing everything down that could be eliminated.”

By then the design was 90% done. “We had enough data to put real things on the table,” Neville says. At the same time the

through beams, trusses blocked piping in unexpected places. But in each case the issues were discussed, circled, and resolved. “When you catch them and there are no materials



▲ **No-Fly Zone.** Facilities owns the space a foot above the top chord, production owns the floor.

subs were pouring their designs into the model. On Fridays they would pass their work to Emdanat who would integrate it over the weekend and run the collision detection routines. On Monday they would meet as a team to view the results.

Initially, more than 3,000 collisions were found. For instance, fire lines ran through ducts, ducts ran

involved, it’s just talk, and we’ll move it,” Emdanat says. “All we did was circle it.”

The subcontractors loved it. “When you get the 3-D review with everybody associated in the room, in eight hours you do what you probably would have done in a month,” says Paul Sinelli, GM manager of capital projects. “The issues actually get resolved and people see progress.”

One of the cast-in-stone business practices that was jettisoned was GM’s rigid CAD standard, which would have interfered with the fluid integration of so much subcontractor specialty software. Another was GM’s requirement for paper plan submissions for 30, 60 and 90% design review. It was simply incompatible with the live model review process, and after one influential in-house mechanical engineer sat in on the sessions and saw the light, that too was quietly let go. “We made some real believers out of some of those crusty old guys,” says Sinelli.

Now, GM projects yearly savings on similar projects through interference avoidance of 3 to 5% per project, and that’s aside from schedule savings, Sinelli says. “3-D brings it home. If it doesn’t fit in the model, it won’t fit in the field.”

“I have never seen a project go through more efficiently,” says Steve Hart, estimator for Dee Cramer. “Seeing everybody’s conflicts and resolving them right there on the screen made it a lot easier. Our design in V6 went right over the coil line and cutting table and into the field. If we could only get every project like that. It’s astronomically more efficient for everyone.”

Adds Matthew Cramer, Dee Cramer president: “We had zero collisions with the other trades. The owner is getting a project delivered a heck of a lot quicker than they ever could have gotten, and it’s flat-out less expensive for them. It’s an easier job to work on, and it’s win, win, win.”

And the down-side? Hart has that pegged as well: “There’s not enough of them,” he says. ■



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