

3D/Lean Enabled Integrated Project Delivery**Feb. 25, 2008**

This submission is based on breakthrough results achieved in a series of six Design/Build projects (two more in progress) that prove that the combination of 3D-Enabled Lean and integrated project teams can consistently deliver projects approximately 20% below cost and schedule (for time-to-market advantages), while improving quality and job site safety.

GHAFAARI has collaborated with General Motors Corporation for several years on its "Virtual Factory" initiative to bring the same lean (waste-eliminating) and 3D advantages to construction that were achieved in manufacturing (where waste accounts for 26% of the value stream versus 57% for construction based on CII data)

In 2000, GM executives mandated a 25% improvement of key metrics for schedule, cost, quality, and safety. This required out-of-the-box initiatives, including: lean best practices, lessons learned from product colleagues; math based 3D and Direct Digital Exchange (DDE) across the supply chain; and collaborative, Integrated Project Delivery with shared objectives, incentives and risks.

In 2003, after proof of concept pilots, 3D-Enabled Lean was deployed on the first large-scale project, Michigan's Lansing Delta Township Assembly Plant (2,300,000 sq. ft.). According to GM, the schedule was accelerated by 19% and cost reduced by 5-8%, validating potential for breakthrough results – now averaging 20% reductions in cost & schedule. Refer to Exhibits A1,2.

Subsequent projects have been a collaboration of GM, GHAFAARI, key subcontractors such as John E. Green, Dee Cramer, Superior and the general contractor, Barton Malow, with GHAFAARI led automated collision detection/coordination sessions repeated until collision-free status is achieved and models transition from design-data to build-data, allowing contractors to increasingly "build-to-the-model". Collision-free status is tracked on each project. Exhibits B & C.

Traditional 2D, paper-based exchange is loaded with wasteful hand-offs between supply chain partners where output from one partner becomes a source of take-off and re-input by another and repeated thousands of times in each project. Submitted projects regularly use DDE with structural steel fabricators to accelerate steel mill orders and improve model-based automated collision detection. Structural steel mill orders that took 10+ weeks to prepare and issue now take 10 days, and the generation/mailling/handling of thousands of paper-based steel shop drawings has been eliminated in favor of faster, in-model 3D reviews and approvals.

Collision-free solutions open several downstream opportunities including: off-site fabrication; Just-In-Time delivery and installation of pre-assembled subassemblies; reduced schedule leading to reduced fuel/emissions from transportation & temp heat/lighting; greener work site (since tear-out/rework are eliminated & scrap significantly reduced); improved trades morale (since the approach is collaborative and re-work is minimized). Refer to Exhibit D for more complete list.

Optimizing workflow across the value stream by squeezing out waste in hand-offs not only reduces costs and accelerates schedule, it also allows supply chain partners to maintain (or increase) profitability while improving quality for a win/win approach.

GM/GHAFAARI have presented at Georgia Institute of Technology, Stanford, Harvard, most SE Michigan Universities, and at several National Conferences. Results have attracted other sectors and GHAFAARI has been engaged by GSA, Marriott, Kaiser Permanente, Sutter Health Care, a German OEM and a Russian Manufacturer to adopt versions of 3D/Lean Enabled Delivery.

The design construction industry has been slow to adopt the lean thinking, Direct Digital Exchange and technological tools embraced by more progressive industries. This project series proves that the combination of a collaborative design/construction team using a 3D-Enabled Lean approach can consistently produce breakthrough results.

Exhibits

3D Enabled – Automotive Design / Build Project Series


2004 LANSING DELTA ASSEMBLY COMPLEX

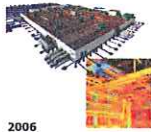
- 1.7 million sqft
- LEED Gold certified
- Steel fabrication to design
- Enhanced MEP coordination
- Piloted HVAC fabrication from 3D models
- Learned cannot use new technologies to solve old practices


2004 FLINT V6 ENGINE PLANT (V6)

- 455,000 sqft
- Steel design to fabrication interfaces
- Fully coordinated MEP systems prior to construction
- Off site fabrication and just in time delivery
- Zero changes from collisions
- 26% schedule acceleration


2005 FORT WAYNE, PONTIAC

- 300,000 sqft & 130,000 sqft
- Fully developed steel – design to fabrication and back – no 2D drawings
- Eliminated 2D steel shop drawings reviews and implemented a 3D-based steel review process
- Full deployment of Projectwise


2006 TOLEDO TRANSMISSION PLANT

- 800,000 sqft
- 3D-based estimating (pilot)
- 3D laser scanning and modeling
- Centralized location for all active project documents (document management)
- 4D schedule (pilot)
- 3D process integration

Exhibit A1

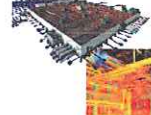
3D Enabled – Automotive Design / Build Project Series


2006 ASSEMBLY COMPLEX

- ~1.3 million sqft
- Introducing 3D-based estimating
- Centralized location for all active project documents (document management)
- Distributed team center
- Webex based collision review


2007 TOLEDO TRANSMISSION PLANT – PHASE 2

- 230,000 sqft
- 3D laser scanning and modeling
- 4D schedule


2007 TOLEDO TRANSMISSION PLANT – PHASE 3

- 600,000 sqft
- 3D laser scanning & modeling
- 4D schedule

Exhibit A2

3D / Lean Across the Supply Chain / Value Stream

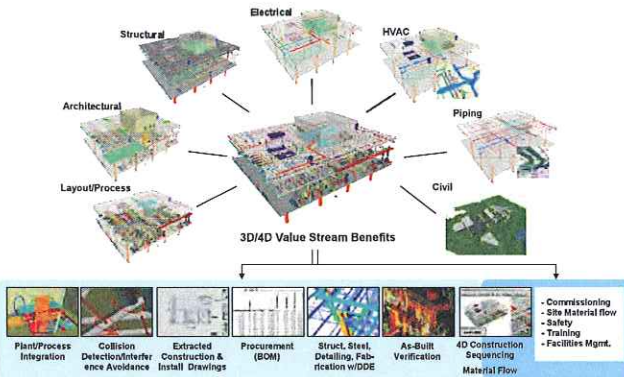


Exhibit B

Automated Collision Detection Collaborative PM Approach

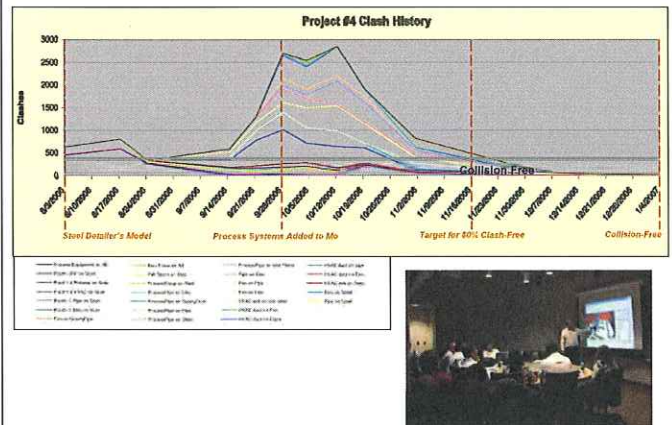


Exhibit C

Results After Five Consecutive Projects

Faster & Better

- Up to 23+% faster delivery
- 3D "As-Built" before construction
- No field rework / material mistakes & No delays for interferences
- Steel mill order time reduced 50%
- 3D elements created once and shared. Most drawings extracted from model
- RFI's only to owner
- Install once: Improved trades morale
- Space protection for maintenance / codes / process

**Lower Cost**

- Up to 21% cost reduction from initial cost model
- Value engineering decisions earlier using full-discipline 3D schematic model
- Virtually no field overtime
- Bi-directional data exchange
- Time to market accelerated – Building is no longer part of critical path
- No \$\$ change orders from design / building interferences
- Reduce number of dumpsters – No scrap

**Safer**

- Increases off-site fabrication
- Reduce scrap material (20%)
- Less job site clutter / JIT material
- Better trades coordination & (less trades overlap)
- Fewer (JLG) lifts in building at same time
- Reduce trailer city footprint for contractors (less site traffic)
- Reduced schedule / lowers emissions & fuel use



Exhibit D