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**Collaboration  
Makes  
Construction  
Lean**

 **AME** Association for  
Manufacturing Excellence  
*Enterprise excellence through shared learning*



# Message from the Editor-in-Chief

## The Skinny on the Real Lean

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Many small change movements are struggling for stage time right now. That can be seen in the variety of *Target* articles that extend lean thinking: Lean and Green; supply chain; lean in industries from health care to construction; lean product development; lean performance measurement; lean corporate governance; even lean government agencies.

My sense is that within a few years many of these movements will coalesce into something much bigger. In the meantime, it is obvious that "lean" pursued as most North American enterprises do today is no miracle cure for financial woes. As evidence, Exhibit #1 is the American auto industry. Some glue to stick all this together is missing.

Magic bullet purveyors remain confident that if only companies properly installed their technology, technique, or system, surely wealth will follow. Question: Will firing a thousand magic bullets hit anything important? Not unless we're aiming at it.

Suppose the target is us and our business thinking. In that case, shooting ourselves with a bullet, magic or otherwise, is more like suicide than sustainability. But because so many fragmented lean initiatives have trouble sticking to their regimen, it is hard to escape concluding that our vision of what we're trying to do and why remains fragmented.

By survey, AME members' top concerns are leadership and sustaining lean gains. Peel a few layers off this onion, and one begins to smell conflicting objectives. Learning the lean way is incompatible with how most of us run private companies, or

for that matter, most other work organizations. New technologies or techniques are stressful to adopt, as can be seen with major software changes, but still much easier than changing how we fundamentally think. Here's another go at the essence of "lean think:"

1. The objective is to sustain daily, autonomous, but collaborative problem-solving at the working level. That's possible only if a common mission is held by all.
2. Methods for seeing and solving problems are important. Sentiment is not enough. To stay sharp, a full set of complementary tools must be practiced all day, every day.
3. This system of disciplined thinking and learning has to displace our instinct to control a working organization as if it were merely another asset of ownership.

Have trouble staying awake so far? Don't see what's different? You're normal, and besides, no words are adequate. The real lean is a deep change in habitual thinking about nearly everything we do. Like The Toyota Way, it is grasped slowly by doing, and impossible to comprehend by mere reading. You don't implement it. You create the human environment for it. So start being creative.

Robert. W. Hall, Editor-in-Chief



# Collaboration Makes Construction Lean

*From General Motors plants to healthcare facilities, collaborative lean construction is making headway.*

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Karen Wilhelm

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**G**eneral Motors is a driving force in bringing lean to construction, through what it calls 3D/Lean Design and Delivery. For GM, the application of 3D modeling to construction emerged naturally from its use in product and process design. Vehicles have been designed using 3D solid modeling for years. Manufacturing engineering extended the technique to process, equipment, and systems design in what has been known as the virtual factory. Extending the same 3D digital representation to wrapping a building around the manufacturing system design seems a logical evolutionary step.

Beginning in 2003, GM cut its 3D/Lean construction teeth on an assembly plant near Lansing, MI in Delta Township. With

partners Ghafari Associates LLC and Alberici Constructors, it built the 2.4 million sq. ft. plant to meet high environmental standards, becoming the first (and only) automotive plant in the world to achieve LEED Gold certification<sup>1</sup> for the body shop, general assembly area, and the administrative and visitor center. The plant also won a 2007 Construction and Design Award from the Engineering Society of Detroit (ESD).

The challenge given the design team was to complete the building of the plant in 18 months, 25 percent sooner than would be expected if they used traditional design-bid-build methods. 3D modeling and lean seemed to them like the only way to respond. They completed the job in 19 months, just short of the goal.

Collisions and interferences are discovered on the job site in traditional construction. If the plumbing system design results in a water pipe going through structural steel, work has to stop for the plumbing system to be redesigned and reworked on the fly. Costs increase and the performance of the intended water system will likely be compromised. Because thousands of design decisions are being made by architectural and engineering groups that don't communicate with each other, such mistakes have been seen as a fact of life. On the

## In Brief

Lean in the construction industry offers some lessons for lean manufacturers. Collaboration among companies in the value chain is facilitated by 3D and 4D modeling of the product and process. This focuses the players on constructability, avoiding costly mistakes and assuring just-in-time availability of materials and workers. In some instances, collaboration and lean are being built into standard multi-party contract templates.

Lansing Delta Township project, 11,000 interferences were detected in the modeling phase and avoided in actual construction.

The project was not without obstacles. Software compatibility was particularly knotty. GM's manufacturing engineering team used AutoCAD and UGS FactoryCAD. Ghafari used MicroStation design software from Bentley Systems, and created the 3D model with JetStream from Navis Works Ltd. Alberici used Tekla Structures for steel fabrication, and other contractors used different 3D tools. Some subcontractors even demanded 2D drawings, which MicroStation had difficulty producing. Eventually those subcontractors found the 3D model was more useful, and the thousands of drawings constituted waste. GM has since made NavisWorks<sup>2</sup> and 3D their compatibility standards. No 2D allowed.

The use of direct digital exchange from design to construction suppliers' manufacturing equipment controls means that all structural steel, for example, can be cut and fabricated offsite with certainty that it will fit up when installed. This means no more shop drawings. Mill orders can be delivered in ten days, rather than weeks. HVAC systems, piping, electrical, and other components can be delivered just-in-time.

GM is upping the ante and expanding its Toledo, OH, transmission plant in 4D, with time and sequencing as part of the model, not planned separately. Simulations show the structure, skin, and equipment growing together, a giant step from a typical architectural fly-through.

The future, as GM Global Director of Capital Projects Jack Hallman told Robert Mitchell of *Computerworld*, is 5D — the addition of costs to the model. Hallman told Sue McCraven of ESD's *Technology Century* magazine that he wanted to see the models used throughout the life cycle of a building. Instead of throwing away the costly model at the end of the construction project, it would be used as reference for spare parts numbers and equipment attributes. He wants to see it integrated with MAXIMO, GM's preventive and predictive maintenance scheduling system.

Beyond the wizardry of 3D, 4D, and 5D building information modeling (BIM), what's the connection with lean? Obviously, the waste of drawings and separate design data creation is reduced or eliminated. According to many, however, it is the collaboration and teamwork driven by the integrated modeling process that reduces the waste of time, motion, material, and human effort during both the design and construction phases of the project. GM's design-build teams meet weekly to consolidate the model and resolve collisions and interferences detected by the software.

### ***An Ideal Contractor***

Ideal Contracting LLC has been a key partner of the GM and Ghafari team for four major projects. One is a 435,000 sq. ft. renovation of a GM V6 engine plant in Flint, MI, which won a 2006 Design/Delivery Process Innovation Using BIM award from the American Institute of Architects. The other three are a 287,000 sq. ft. addition to an assembly center in Ft. Wayne, IN, a 40,000 sq. ft. expansion of an assembly center in Pontiac, MI, and a 750,000 sq. ft. expansion of the Toledo transmission plant.

Greg Sorrentino, vice president and general manager of Ideal Contracting, has done just about everything you can do in construction over a 30-some year career, from sweeping the floors to growing a little contracting firm to the eighth largest in Michigan. Sorrentino first encountered lean in a structural steel fabricating firm when companies such as General Motors sent experts to teach lean processes to its construction suppliers.

Manufacturing was one thing, but in the design/build phases of construction, applying lean was a different story. "I never could see how the way they instituted lean in manufacturing would work in the construction business," says Sorrentino. "Most of the things I had ever heard about lean construction was to make sure that you stack things close to the job site, and most of that was just common sense. It wasn't until we started getting involved with 3D

***"...we end up verifying constructability on the job before we actually start building. We've already built it once."  
Greg Sorrentino, vice president and general manager of Ideal Contracting***

modeling that I saw a real lean process. That's where I really saw how it could all come together. It's a collaborative approach. In the design process, we're collaborating with the owner and all of his people, so we're able to have everything they need in the model. We're able to do collision detection before we actually build. So we end up verifying constructability on the job before we actually start building. We've already built it once."

Construction costs are better controlled with collaborative 3D modeling for reasons besides avoiding design blunders. Contractors can more accurately estimate raw material requirements, for one thing. Some have told Sorrentino they've experienced as much as 20 percent reduction in materials costs. Overtime vanishes. Change orders, typically accounting for 10-15 percent of a project's final cost, are reduced. Sorrentino says that in the projects he's completed so far, there has not been a single change order.

As long as they build to the model, contractors can fabricate offsite, bring in three to four days' worth of material right to where they need it and put it up exactly when the schedule calls for it. There's no waiting for another trade group running behind schedule because of rework, late deliveries of material, or other causes. With smaller amounts of material on site, workers spend less time walking around. "We've been able to cut 21 percent out of the overall cost and about 30 percent of the time out of a project," says Sorrentino.

Managers and superintendents prefer the new approach. "They love it," says Sorrentino, "because it seems to take out a lot of anxiety. They take a lot of pride in what they do and they want to do it right. They work with the model and they know what's coming and what to expect. What trade and craft workers like about building to the model is that they don't have to take down something they already put up. Morale on the job sites is tremendous. Our trades guys know that when a load of material comes out that that's the amount of work that has to go in that week. They

know if they just follow the model, they're not going to have to go back and explain why this or that happened or have arguments over who got to what space first, none of that stuff."

Collaboration begins in the 3D modeling process. "From the time we all sit down and say OK, we're going to build this project, it's a team," Sorrentino says. "There is no owner or contractor. We lock arms, and we are now one group. Great ideas come up all the time about what you can do better. That's probably the most exciting part about it. This really does open up the lines of communication between subcontractors, owners, the architect, and the general contractor. All that other stuff that everybody tells you, if people don't view themselves as a team, they're not going to be very successful."

Other lean principles applied by Ideal Contracting are workplace organization, training, continuous improvement, and standard work. On-site process changes are not permitted. The model is the standard work. Continuous improvement is about taking their learning and applying it to the next job. The company does a "lessons learned" on almost every major project, sometimes including the subcontractors. "We do that on a formal basis," says Sorrentino, "but you have to be constantly looking at your process, making sure that you're on top of it, that you're improving on a continual basis. This is a highly competitive business and we cannot just lay back and say, 'Well, we've got it all figured out.' That's not realistic. So we are always looking to improve."

### ***Understanding What the Manufacturing Client Needs***

Sorrentino is justifiably proud of the quick turnaround Ideal Contracting can promise. "We did 435,000 sq. ft. without anything on paper and we walked off the site eight months later, with all the utility loops in and everything else. That's how quick it works. These projects don't last a year anymore. We're doing an 800,000-sq. ft. job right now and we've only been there

a year, and we'll be done next month. These projects used to be two-year programs. When we show people how much time they actually save, it's phenomenal. On a basic 300,000-sq. ft. building, the old design-bid-build process would take 80 weeks. We cut it all the way down to 48."

The shorter leadtime means the manufacturer's product and production engineers gain the time to refine the product design and how best to use the manufacturing space, and still hit their product launch target. If production requires a piece of machinery in a specific place, the building design will take that into account instead of the other way around. The building's no longer on the critical path. The process is. If the job is in an existing facility, less time spent on construction means less disruption of ongoing operations.

How often do you hear of a supplier voluntarily reducing his price? As a supplier of contracting services to his clients, Sorrentino says that the collaborative process has allowed Ideal Contracting to do just that. "On the five projects we've done using this process," he says, "the owner has experienced a 21 percent reduction in price from the start of the project to the end. I can show you all the documentation. It's amazing. You would never think that that would hold up after a while but it does."

Ideal Contracting has been named a GM Supplier of the Year for five years running. The company's readiness to adopt lean methods and focus its work on the manufacturer's purpose of a high-quality product efficiently makes it poised for further success. Even in the depressed manufacturing climate of the region surrounding Detroit, Sorrentino says Ideal has as much work as it can handle.

### ***Growing a Company by Growing People***

Adopting 3D modeling and the lean approach is just the latest of the actions Greg Sorrentino has taken since he joined Ideal Contracting six years ago. He came to the company with a business model in mind, to build quick-response projects for

manufacturing companies. He soon bid on such a project for GM and Ideal was awarded the contract. Good performance led to further work, giving the company the sustainable business that allowed Sorrentino to build the company.

"Pay all your bills when they're due," is Sorrentino's first rule of supply-chain harmony. Ideal Contracting has even been known to help out subcontractors who hit financial crunches by paying them before being paid themselves. "I need them just as much as they need me," he says. "But I need them probably more, because I need them to get a job. I can't do electrical work, so I need electricians, I need mechanical work, I need all of that. So I depend on them very heavily. We have good relationships with all the major subcontractors in town."

Now able to focus on the market for industrial construction, Sorrentino went out and recruited people that he knew were good at it, adding, "You're only as good as those people. I found really strong individuals. We work well as a team. It's a good atmosphere."

Sorrentino says the company pays close attention to safety. "That's a huge thing around here," he emphasizes. "We have a program called Safety Observation Process. We try to make safety a positive thing. We try to involve the tradespeople. It's not punitive. On one repeat contract we've had for a number of years, we've done almost two million man-hours of work without an incident."

Insurance rates go down, but more importantly, people aren't hurt or disabled by something bad happening on the jobsite. The company's safety slogan is, "Safety Comes in Cans: I can, you can, we can." Almost every day, safety training or discussion takes place on every jobsite. It's a big part of the culture.

Especially in Michigan, there are those who blame high costs on unions. Ideal, on the other hand, has increased its employment of union workers. "From having no agreements with any unions, we are signatory with the carpenters, laborers, ironworkers, and operators unions. We have a





***When the team truly collaborates and applies lean thinking for the achievement of the whole, not the interests of its member companies, the benefits will be reaped.***

great relationship with them, and they've been very supportive of us," says Sorrentino.

Sorrentino continues, "I've got some of the smartest young talent right now in the industry. Ideal has internship programs with Eastern Michigan University and Michigan State University. We're hearing that interns coming back to school from here are much more advanced than those coming back from other companies. We expose them to every facet of the industry from looking for a job, bidding the job, building the job, running the job, closing out the job, everything you could possibly imagine that happens on the construction site. And we do that in 13 weeks. We do it for two reasons. One, we want to see how much work they can handle and if they're a candidate for us for future employment. And two, when they go back to school they are geeked up about working in this industry."

Ideal Contracting is located in a largely Hispanic part of Detroit. Frank Venegas, who owns the company, is committed helping the community, as is Sorrentino. "After

you've made the money," says Sorrentino, "the best part of it is watching other people make it. It's kind of fun. We help kids with their education and apprenticeships, and that helps them see a future."

One young woman from the community is now the company's payroll clerk. Ideal is helping her get her degree in accounting from the University of Michigan, where she is a junior. Sorrentino says, "She's the oldest of six kids and she helps her parents pay the bills. We saw a talent in her. Hard-working smart young lady. Someday she'll be a CFO."

### ***It's Not the Tools, It's the Thinking***

Much of the writing about the development of modeling and simulation in construction focuses on the technology and systems that produce the visible result. Multicolored animated build sequences, zooms, and rotations are fascinating. People are likely to think that the tools create the magic, and not get the message that the tool is only as good as the team that uses it. When the team truly collaborates and applies lean thinking for the achievement of the whole, not the interests of its member companies, the benefits will be reaped. Otherwise, there will be gains, but the full potential won't be reached.

### ***Formalizing Lean Construction Collaboration***

The same as in manufacturing, lean construction aims for a smooth flow of design and construction activities by improving trust, communication, clear understanding of scope, and the reliability of the team's work plan. Creating value for the customer is paramount, as the customer defines value in collaboration with the contractor.

Lean construction is not just the Toyota Production System applied to installing mechanical systems or hanging drywall. Construction as a whole — the system composed of the building owner, the architects, engineers, contractors, subcon-

tractors, project managers, superintendents, and workers — involves a different lean approach. Construction is a project, not repetitive manufacturing.

Those with a high-level understanding of lean will already see in manufacturing the big picture the lean construction people are painting. A new product, for example, starts with an idea, becomes a concept defined according to the value the customer is ready to pay for, is transformed through collaborative product and process design and validation, goes through a pre-production phase where the production system is laid out, and only then do all the plans culminate in what people usually think about when they encounter lean manufacturing. Construction is simply another type of project.

A key organization developing lean construction as a discipline is the Lean Construction Institute (LCI), founded by Greg Howell and Glenn Ballard in 1997. It draws upon research conducted in places such as the University of California, Berkeley, Stanford University, and the University of Cincinnati. Not just an academic endeavor, LCI also includes facility owners, architecture and engineering firms, and design and build firms that have been applying the research in the field and innovating methods to spark further research.

As part of its work, LCI has developed detailed planning and management tools, the Lean Project Delivery System®, and the Last Planner System® of production control. As LCI explains, the traditional project-planning model uses a highly-developed cascade of projects and sub-projects with work broken down into whatever units the manager deems proper, the duration of the work and dependencies analyzed, critical paths determined, and resources assigned. Project leaders create planning charts in living color and great detail. Somehow, things rarely work out like they should. Activities that should be 100 percent complete when the next set of tasks is scheduled to start, aren't. Interdependencies are missed. Resources aren't always allocated realistically. The "should" is there. The

	Five years ago (approximately)	Now
Revenue	\$30 million	\$132 million
P/L	\$ 600 thousand loss	N/A
Management employees	2	40
Tradespeople	0	70
Self-performed work	All performed by outside contractors	Carpentry Millwork installation Acoustical ceilings Drywall Excavation Concrete Steel Demolition

**Figure 1.** Ideal Contracting has grown by focusing on the needs of the industrial market, implementing 3D collaborative processes and developing people and capabilities.

"can" and "will" are not.

This traditional approach to construction project management can lead to near-chaotic situations, finger-pointing, replanning, negotiating for more time and money, and sometimes, financial liability pushed as far down the supply chain as possible.

LCI's methods use team planning and pull techniques to develop the phase schedules that integrate the work of multiple sub-contractors who will conduct structural, mechanical, electrical, and other work. Integrated plans configure supply systems (flows of materials and information) with project execution (work flow and resource flow).

### **The Team Builds the Schedule**

In LCI's team project planning process, which starts these days with a detailed 3D model, the team, made up of representatives of the organizations involved in the project, develops a pull schedule from a target completion date, defining and sequencing tasks that must be completed to release work. On sheets of paper or sticky notes, team members write brief statements of work they must perform in order to release work to others, or that must be completed by others to release work to them.

As the notes are put on a wall in their



***Collaborative  
planning has  
evolved even  
further ...***

expected sequence, people see the how their activities affect others. They can improve the overall process by moving and adjusting the sheets, helping each other come up with better methods, batch sizes, and handoffs. They look at the average time each unit of work will take, without padding them or adding contingency time. This is the ideal schedule. It should leave time available between the start date in the original plan and the possible start date revealed by this detailed planning. They could decide to use the available time by:

- 1) Assigning it to tasks prone to high variability
- 2) Investing more time in prior work, or allowing more information to emerge, or
- 3) Move up the phase completion date.

The team deliberately and publicly generates, quantifies, and allocates schedule contingency. Contingency in construction represents the safety margin in the deadlines of the plan. It is traditionally included in the bid, increasing costs to the owner.

Once the master schedule is agreed upon, teams turn to designing a production system for accomplishing the work. The deployment cascade moves from project (a commercial office building, for example), to phase (substructure), to operation within the phase (place drilled caissons), to process within the operation (fabricate cage), to step in the process (weld coiled bar helically around cylinder, fit and tack lifting bands, weld out lifting bands), and finally to the assignment for the day (perform welding steps in operation "fabricate cage"). Some or all of this detail will be incorporated into the model. With process sequence and time represented, the model becomes 4D.

The Last Planner System formalizes the way project delivery will be conducted. Regular meetings, weekly or monthly, take a realistic look at a six-week horizon. At this point, it's possible for the team to see for sure what work will be ready for release to the next trades contractor, who can reliably promise exactly when that team will arrive on site. Suppliers can reliably promise when materials will arrive. Planners can

reliably say whether the planned area for delivery of materials will be available. Shared resources such as cranes can be reliably promised to be ready for use. Problems can be identified and assigned to specific people for investigation. The Last Planner in the whole system is the foreman who assigns specific work to work teams the day or week before it is to be performed, with the assurance that everything will be ready when they get there.

### ***The Collaborative Contract***

Collaborative planning has evolved even further, as LCI leads a drive to develop new forms of agreement to facilitate the working of multi-firm teams and embed lean processes into an explicit understanding of how work will be done. A proposed standard contract is called the "Integrated Agreement for Lean Project Delivery between Owner, Architect & Construction Manager/General Contractor." This is a single contract that lays out the agreement among all the key parties for how the building will be designed, built, and paid for, as well as how risk and reward will be apportioned. In addition to starting off with shared knowledge and understanding among the players, the contract itself is meant to support the lean construction philosophy. (Various architecture and contracting associations are developing integrated contracts too, but not based on lean.)

In defining relationships and responsibilities:

- The contract designates an empowered core group — a team — that makes all the necessary decisions throughout the project. An executive group oversees the core group, but does not get in and run the project.
- The agreement delineates the participants' roles in weekly planning meetings, how communication will be conducted, and how trade subcontractors and suppliers will be selected and added to the project.
- The budgeting phase includes the target value design and a cost model. The idea is to design to a detailed estimate — starting with what the owner can afford

and really needs, instead of architects blue-skying a bunch of nifty technical features.

- A whole section of the contract sets out a shared understanding of what collaboration means, and how it will be used to integrate preconstruction services.
- The engineering phase includes provisions for value analysis, value engineering, and constructability.
- The construction phase includes requirements for 5S plans, safety plans, a definition of excusable and inexcusable delays, how change orders will be handled, how quality will be assured, and so on.

The conversation that leads to the document tends to identify where pockets of contingency — margins of safety — have been included. If added together, they are likely to exceed any reasonable estimates for the system as a whole. The whole contingency is then apportioned by agreement among the key parties, with the owner retaining some significant part of the risk. Agreements are reached on the amount and type of insurance the parties will purchase to cover adverse events. This is completely unlike the typical contract, where the owner's goal is to push all the risk on the contracting partners, which may result in lengthy litigation after the project is over. Surfacing the underlying concerns that caused parties to include unrevealed contingencies in their bids requires and helps develop trust, the basis for a successful project.

Among the leaders in lean construction who have been testing the relational contract is Sutter Health, which is rapidly expanding medical services in California and investing in new hospitals and medical centers. DPR Construction Inc. and Turner Healthcare are construction firms that have executed a number of the projects, with Skanska coming in to handle some others.

Experience piloting the agreement has resulted in some recommendations:

- Determine the authors of architectural and structural models at the start of the project, with the whole team.

- Clarify who owns the models.
- Pre-qualify team members for the capability to produce 3D models and work in 3D.
- Determine specific collaboration and modeling responsibilities.
- Agree on a protocol for sharing models.
- Agree on coordination and conflict resolution.

### ***Collaboration Continues after the Project is Done***

The companies pioneering the LCI system, along with many subcontractors and suppliers, have learned how to trust each other and genuinely collaborate. Little wonder that those firms want to work together on later engagements. This is leading to self-assembled teams that collectively bid on a major project in the offing. Experience with the relational contract is another piece of knowledge that enhances the competitiveness of their teams. It poses the power of value stream integration versus selecting new partners on every new project.

As GM has learned, moving the knowledge gained in lean product and process design to the construction of manufacturing facilities has lagged. Indeed, applying a deep knowledge of lean — particularly an awareness of *muri*, the waste of "overburdening" resources, and *mura*, the waste of variability in project execution — to product design and development projects is only beginning. The lean construction and lean manufacturing communities could teach each other a lot if they collaborated across industry lines.

#### **Resources:**

Lean Construction Institute, [www.leanconstruction.org/](http://www.leanconstruction.org/)

International Group for Lean Construction, [www.iglc.net](http://www.iglc.net)

Michigan State University, Construction Management Program, School of Planning, Design and Construction, [www.spdc.msu.edu/cm](http://www.spdc.msu.edu/cm)

*Author's note: Projects are different from repetitive manufacturing processes. Many have attempted to apply the same rules of flow and standardization, but this can be the wrong move. The variables are different, and it's difficult to predict exactly when each stage will commence, how long it will take, and who will be available. The culture of heroes — overloaded people working through the night when deadlines loom — works against the smooth flow of work. Toyota's product development process, with teams working steadily in the "big room" or oobeya, has provided a better model. It's described by Takashi Tanaka in "Quickening the Pace of New Product Development;" see the QV System, Inc. website <http://www.qv-system.com>.*

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*Karen Wilhelm is a freelance writer and publisher of the blog, [Lean Reflections](#).*

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#### Footnotes

1. LEED (Leadership in Energy and Environmental Design) Gold Certification is awarded by the U.S. Green Building Council. For more information go to <http://www.usgbc.org>.
2. NavisWorks was acquired by AutoDesk, the developer of AutoCAD, in May, 2007.

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