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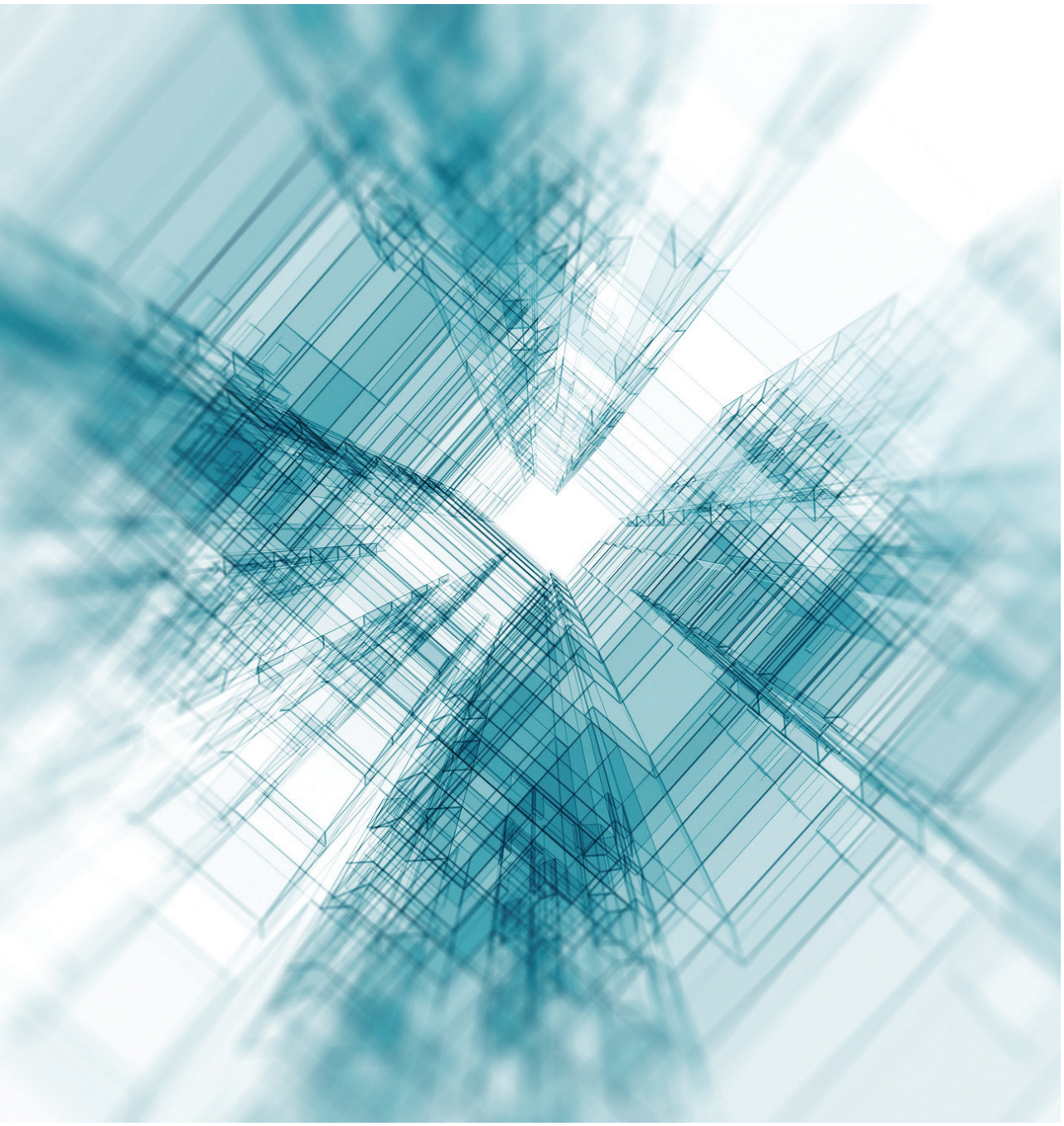
NBIMS-US 2021 Vision Task Force

Building Industry Vision 2021

A View into the Future: A case study of the building industry in 2021



An Authoritative Source of Innovative Solutions for the Built Environment

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Disclaimer: This is a work of fiction. Any resemblance to real buildings or people, alive or dead, is purely coincidental.

Foreword

Building Industry Vision 2021
A View into the Future: A case study of the building industry in 2021

The National Institute of Building Sciences typically does not issue this type of reporting. As a technical organization, the Institute usually delivers research findings on specific issues facing the building industry. However, the *National BIM Standard-United States*® (NBIMS-US) 2021 Vision Task Force (VTF) created this document in a nontraditional format to provide readers with a narrative that captures a view of what the Task Force sees as the future of the building industry.

While this story is a view into the future, it is intended to offer a glimpse into how construction projects may be designed, built, and managed using technology being developed today and perfected as we approach 2021.

The National Institute of Building Sciences and its buildingSMART alliance® (which oversees development of the NBIMS-US™) are thankful to the sponsors of this project; the many volunteers who shared their ideas and thoughts on what they view as the future for the construction industry; and the members of the VTF who worked to create this innovative approach to addressing the future needs of the building industry.

We hope you find this an entertaining and informative preview of what lies ahead.

Henry L. Green, Hon AIA
President, National Institute of Building Sciences

Dana K. "Deke" Smith, FAIA
Executive Director, buildingSMART alliance

Springfield Globe-Times

New Children's Care Center Building Opens Today

Mayor announces town project is ahead of schedule, under budget

By Joe Matlock

May 22, 2021—Springfield, USA

Public tours open today for the new, state-of-the-art Springfield Children's Health and Wellness Center, located on High Hope Road in downtown Springfield.

Mayor Charles Preston, who has worked with the project since its inception, pronounced the building "one of the most beautiful and functionally outstanding structures that I have ever seen." The mayor credits the collaboration of entire building team—Amy Smith, architect; Mike Evans, mechanical engineer, Brad Moore, general contractor; Owen Connolly, building owenrs representative, and Felicia Foster, facilities manager—with the success of the project, which the team brought in under budget and ahead of schedule.

"It's been a pleasure to be involved as a member of the team since this project started. It's amazing to me that the virtual walk-throughs were so realistic, I feel like I have been in this building many times," said Fire Chief William Edgar. "I was especially impressed at being able to use the drone to watch the building as it went up, step-by-step. And being able to 'see' what's happening behind walls could come in very handy for us—and for the police as well."

"It only makes sense, to get the town's police and fire departments involved from the onset of the project design," said architect Amy Smith. "And it was great to get their input in real time as we went along—I think it saved us from making some mistakes that could have proven costly, if—heaven forbid—we do face a disaster in the future. And those drones the chief referred to could also come in handy for the city if a severe weather event does take place."

"And I am happy to know that the fine City of Springfield has worked with your team on a contingency plan to build temporary shelters if we need to." said the mayor. And I do hope, that come election time, the good people of Springfield will remember how we encouraged them to chime in on decisions about the building during the planning process

(Story continues on page 2.)

A Word from the 2021 Vision Task Force Chair

This is a story about a real project in 2021. Okay, so it's not real. But it is realistic. The processes, collaboration, and technologies discussed in the story are not far from being an everyday reality.

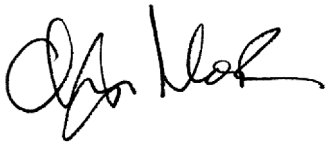
In early 2013, the buildingSMART alliance® formed the *National BIM Standard–United States®* (NBIMS-US) 2021 Vision Task Force (VTF) to focus on defining, predicting, forecasting, and in some cases guessing at what the future of the building industry might hold, and therefore what NBIMS-US™ needs to look like to support that future. This is a highly strategic effort that will form the basis of a larger effort aimed at developing a comprehensive roadmap for the entire capital facility industry. The importance of these efforts cannot be understated in any context.

The initial effort of the VTF was to request subject matter experts from every corner of our industry to provide short essays about the nature of their role, profession, or industry as it will be in 8-10 years.

We collected close to 40 of these essays, and also spent considerable time researching other references to the future of our industry (conferences, seminars, writings, etc.). We then wove all this knowledge together to create a single, compelling, and tangible vision of how a construction project may be built in the future, including the technologies and processes that would be in common use.

We deliberately chose the relatively short timeframe of 8-10 years, as we believe it can be reasonably predicted. By studying the innovators, the leaders of our industry—the "2 Percenters"—and by understanding what they are doing, how they are doing it, and what benefits they gain; it is not far-fetched to predict that the rest of the industry will soon be following suit.

And so I contend that while of course the story actually is fiction, project case studies that resemble this are coming in the not-too-distant future.



Chris Moor
Chair NBIMS-US 2021 Vision Task Group, Chair NBIMS-US Project Committee, Version 3, and Director of Industry Initiatives at American Institute of Steel Construction

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WALLS AND CEILINGS

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The project in this text is a six-story children's medical care facility. It had to be designed and built in eight months' time to guarantee continuous provision of care. It opened on May 22, 2021.

The old maxim of "time-cost-quality: pick any two" was not acceptable to this owner, and the project team excelled to produce a high quality project ahead of schedule and without any cost overruns. How? The following story will explain.

http://www.nationalbimstandard.org/vision2021

Technology + Process = Success for New Springfield Children's Care Center

by Joe Matlock
Dateline: Springfield, USA
May 22, 2021

Springfield Times-Globe veteran reporter Joe Matlock interviewed members of the project team that built Springfield's new Children's Care Center in order to understand how they planned and built this complex project under budget and ahead of schedule. Their story shows that this talented team of people, who stake their professional reputations on trust and collaboration, have come a long way from how the construction industry used to work.

Be a fly on the wall as Joe shares his conversation with the team.

– 1 –
THE MEETING OF THE MINDS

I initially met the Springfield Children's Care Center project team at the headquarters of the Institute of Designers and Builders (IDB). The IDB is a relatively new organization that resulted from the merger of the American Institute of Architects and the Associated General Contractors in 2017. Brad Moore, general contractor; Felicia Foster, facilities manager; and Amy Smith, architect; were waiting outside for me.

The four of us walked into the building together and up to the conference room. Owen Connolly, the owner's representative and an extremely well respected businessman, was already there waiting for us. Rumor around Springfield had it that Owen was one of the main drivers behind the collaboration and the technology used on the project.

Mike Evans, the mechanical engineer, and Fabrio Jones, the structural steel fabricator, showed up a few minutes later. Fabrio, a native of Italy, was due to receive a Lean Construction Award from IDB later that evening.

These six professionals represented the key players in the success of the project, and it was clear to this reporter that they were happy to see each other again.

Owen Connolly took the initiative and gave his owner's view of just how far building construction has come in the last few years: "From an owner's perspective, I marvel at the changes that have taken place in the past eight years," he said. "Just like all the other players in the industry, as owners we finally had to step up to the plate and assume responsibility for the buildings we are creating. We had to start taking part in the process,

from design through commissioning, and well—we just did it. And I know I don't have to tell this to anyone in this room, but Building Information Modeling, or 'BIM,' made it possible for us to do just that.

"I guess in the beginning, owners might have wondered, 'Why should I pay extra for BIM when it is supposed to be saving the rest of you guys in the building industry money?'' I can tell you, we have benefitted by ensuring we don't pay more at the end of the project. Those coordination disasters used to be written as owner-directed changes because of the general contractor's ownership of the pen. That's just not acceptable anymore.

"One of the main drivers of change in the building industry—and one of the biggest changes itself has been procurement. Today, it's mostly design-build or design-build-operate," Owen continued. "For a while there, we thought Integrated Project Delivery, what we call 'IPD,' would become 'it' as a delivery method. That didn't happen for every project in the country, but it did demonstrate that the old traditional building methods were holding back the industry."

"I'm also happy to say that facility data created during design is being further used to support other facets of the owner's business mission," he noted. "This has brought opportunities to design firms and members of the practice network to provide new services. Take this new children's hospital project, for instance. Mike Evans, the project's mechanical engineer and his firm already have a contract to analyze the monthly energy use for the new hospital and suggest tweaks to keep usage and operating costs down."

Brad chimed in: "There's no doubt that procurement methods have really changed. But I maintain that if there is one overarching factor that has made this quantum leap in practice possible, it's the fact that we can actually share data effectively—interoperability now works and, as a result, so does collaboration."

Felicia nodded. "Agreed. Our world is no longer drawing-centric, it's now data-centric; that means data sharing, not data duplication. I see that as the sea change for the way we started operating in 2017."

My presence in the room as the reporter seemed to have been forgotten as the team continued to chat, much to my fascination.

"Was it that long ago?" Brad said. "That was the year the economy boomed and people like Mike, Amy, and I returned to the industry. That also was the year that the National Institute of Building Sciences hired the National Institute of Standards and Technology to update its 2004 study on the cost of inadequate interoperability in the US capital facilities industries. Remember that one? The original study put the cost at $15.8 billion/year; the 2017 study put the costs at nearly double that."

“That study concluded that to ignore the costs of interoperability is not sustainable, and called for immediate action by the industry’s public and private sectors,” Amy added. “One of the first things the President did when she took office in 2017 was to issue a federal executive order for the formation of a public-private Capital Facilities Interoperability Commission. Of course, protocols and standards make this all possible, and the industry standard is NBIMS-US™. I’m on the NBIMS-US Project Committee working on another update, and we’re projecting that the 2024 study will prove that the number has dropped by $18 billion/year.”

Mike said, “Yeah, and that was about the time that just about everything went to the cloud, too. It sure makes sharing information easier.”

“Interoperability is important, but even more important is the collaborative way that practice networks now work,” Amy asserted. “I’m just happy that we work in practice networks now. Besides, it gives us a better Big Picture about the project. And frankly, just talking to other architects day in, day out—got old. I can learn a lot more from keeping it interdisciplinary.”

I interrupted the conversation to ask Fabrio about his award for lean construction. That award honors those who advance lean processes for the industry—making for a more collaborative, efficient and cost-effective building industry—throughout the project life-cycle. Fabrio was CEO of Jones Steel, which had won the award this year for their innovative fabrication facilities and processes.

Fabrio was humble about the award. ”It’s an incredible honor and I am truly grateful,” he said. “The award really goes to the lean design process that has enabled us to make great advances in steel fabrication. By collaborating with designers and contractors much earlier in the process, we are able to provide the project team with extremely accurate schedules and pricing and can even forecast problems before they happen.”

I asked how that was possible.

“We have a model of our shop that enables us to digitally fabricate the project before we have even purchased any steel. This means we can simulate the work load on our robotic and CNC equipment as well as our assembly and welding areas,” Fabrio explained. “Any bottlenecks show up immediately, as well as any errors or problems with the design or detailing. Everything is passed to us via a model, and we can run that model through the shop to estimate times, schedules, and so on—and of course to see how the mix of work fits with the other jobs we have going on. We actually share this shop model with the general contractor such that we can adjust schedules and ensure the minimum of disruption when something does change or is wrong. It’s a long way from just 10 years ago.”

“But the technology and the equipment you use seems to have been around for a while,” I noted.

“Yes, that’s true. The difference is that now we have a standard format for sharing data – sharing the model. It’s all based on buildingSMART’s IFC open standard and a lot of work that the American Institute of Steel Construction did a few years ago to improve workflow and data sharing. Rather than dealing with the hundreds of files and proprietary systems we used to deal with, we now just get a single file that gives us all the information we need.

I vowed to visit Fabrio’s fabrication shop in the near future.

Switching gears, I turned to Amy and Felicia and asked them about how they structured and fostered their collaboration as a team.

“Well, of course we all work remotely, but as a team we designated the first and third Monday of every month as something we call ‘Faceday,’” said Felicia. It’s something none of us ever like to miss, and at the very minimum we will conference in if we can’t make it.”

– 2 –
THE CONSTRUCTION SITE

I asked Amy and Felicia to walk me through a typical Faceday.

“So, let’s just take the example of a typical Faceday at the jobsite,” said Felicia. “We’d meet at the site early morning and first of all just walk the site. It was always great to walk the site because while it was buzzing with activity, it also was kind of calm and orderly. We operated in a very open, organized manner, with materials and components arriving just in time. As much as was feasible, components were prefabricated offsite and even tested offsite to minimize any delays due to errors, etc. We didn’t even allow any items to ship until they were needed—and we used a ‘pull’ system from the site to signal the suppliers and subcontractors when to deliver. Simple things like this helped us eliminate all those kinds of delays.

“Honestly, even a newcomer to the project could grasp immediately whether things were going well at any moment, because we used a very visual–and low tech I might add–system of signals coupled with a process that tracked the building model one step ahead of actual construction.”

Amy continued: “All the construction team workers carried individual, location-aware tablets with instructions on them. We knew where everyone was at any time. And everyone knew what to do and when. As they checked in, the first place they went was to what we call the project portal. It’s kind of a holographic/3D model, and as the workers showed their badges, they got their assignments for the day, along with tutorials downloaded to their tablets. The tablets tracked the work progress and allowed us to get a live look at progress and schedule. All the as-built data was collected as they go, followed up by inspectors—both human and drone.”

“Drones?” I asked. “I guess they are pretty common these days, but how did you employ them specifically?”

“Yes, we used drones for a number of things,” Amy explained. “Material delivery, moving tools and equipment to the right location at the right time, and for inspection and surveying. Also, everything is embedded with an RFID tag, which ensured that we knew where everything was—and more importantly—that it’s in the right place. Even the equipment and tool locations were scheduled into the system. And what we call ‘smart tools’ even sent alerts about their location and locked themselves until any issues were resolved.

“All the information anyone needs was available and easily accessible anywhere on the site. Knowledge is about getting information when you need it, not when it’s available. We have used that maxim throughout this project. Everyone has a tablet, a phone, or a phablet that gives them the information they need to get the job done.”

Brad commented about how proud he is of the operation: “There’s no waste. It’s completely integrated throughout the process up and down the supply chain and with all the people involved. To my mind, that’s what makes this such a quick, safe, and cost-effective project. It’s the way every project ought to be run.”

“It is so orderly,” Owen added “All machines, equipment, materials, people, and tools are orchestrated from a central project portal–everyone knows where everyone and everything is. Even an old codger like me can follow what’s going on.”

I asked the team about using augmented reality or virtual reality, as I had read about its use on other projects. But rather than talk about it, they decided to show me. They handed me a hard hat with a series of buttons and lights on the side and a heads-up display (HUD) resembling the old Google Glass.

The hat beeped a couple of times, and then I was in a new world. Brad informed me we were now on the northeast corner of the building, at the junction of High Hope Street and Skillset Lane. It was an incredible feeling, knowing I was sitting in a conference room, but with my eyes telling me I was at the project site from a few months ago.

The technology is truly amazing. The team walked me up to the roof to show me one of the centerpieces of the new facility—a healing garden. I hadn’t yet seen this in real life, but the HUD gave me a really good feeling for it, even though it was only the final design and not the finished article.

“This healing garden,” Amy explained, “is a meditative place that the kids—and the staff—can use, and it’s a green roof, too. I’ll show you how it looks and feels at different times of day.”

She scrolled through various times of day and cloud cover and finished on a wonderful sunset. It felt like a great place to get better!

We took the hats off and I switched conversational gears again. What about shop drawings or construction drawings? I asked. I hadn’t seen any yet, but I also knew the paperless office was still a pipe dream.

“No, we’re not paperless. I wish we were,” said Mike. “But we do a lot more now with electronic versions of shop drawings and of course models.”

Fabrio took over. “Shop drawings for complex assemblies still exist, but we try to use the model as much as possible, as it provides so much more context—especially during fabrication. Part of the problem is training the workers to be able to manipulate the model; it’s not always easy to use. We still have a way to go on that.

“But truly, we don’t need shop drawings anymore. As I said before, we can fabricate directly from the model, and our equipment also reads the model data and can pre-process pieces and even assemble and weld the pieces together in some cases. It makes for a much more seamless flow and again, enables feedback and live status reporting to be completely visible to those who need it. Mike has much of the same capability with MEP (Mechanical, Electrical, Plumbing)—he can prefabricate piping, HVAC (Heating, Ventilation, and Air Conditioning) systems and electrical components using the same just-in-time philosophy. Other trades too have similar processes. This is not your father’s shop floor.”

“What about site safety?” I asked, recognizing at the same time this particular project had zero accidents and by the looks of it a very happy workforce.

“Site safety is still Job 1,” said Brad. “Again, the model is the key. It can scan for hazards ahead of time and flag them for attention as they arise. As we said, the location of workers, as well as of their tools and equipment, are completely known at any given time and these on-site checks make recordable injuries basically a thing of the past; I can’t remember the last year when the industry lost someone on a site.

“Even the drones’ flight paths are preprogrammed within the schedule and continually monitored to eliminate potential accidents. The drones have a 360-degree alert system that prevents them from colliding with anything.”

– 3 –
THE INTEGRATED STUDIO

We moved the interview to the architecture firm where Amy worked—only a few miles from the job site. The firm owned a serene-looking, five-story brick building, and the team headed to its top floor. Mike was already there.

On the top floor, we all met in a conference room that was really a 'hoteling' space that had been adopted by the project team whenever they needed it Of course it was equipped with all the latest technology, including a Keurig28 coffee maker that only required a swipe of our watches to know what to serve each of us.

Amy brought up a map of the project site on the smart board and overlaid it with the surrounding underlying and overlying GIS (Geospatial Information Systems) data, permitting information and infrastructure. "The third generation LiDar, coupled with the amount of publicly available site information, really helped us right from the start of the project," she said. "We knew exactly the context of the site without leaving the office. In fact, we even obtained the building permits online—within about two days. The permit and all the documentation, specification, and past concepts of the project are all part of the finished model—a full history is embedded. We can walk through a time lapse of the project from bare ground to finished building."

The new low-vision requirements in the building code are a great example of this. The team was able to simulate the new requirements and evaluate and test the solutions, including up to date costs of the various iterations.

"With the simulations available to us, coupled with the automatic code checking, getting the low vision lighting was actually quite straightforward," Amy explained. She pulled up a video of a virtual walk-through of the hospital lobby with various simulations showing how it would truly look in real life. The contrast between the original option and the chosen, LED solution was remarkable, even in a world of virtual reality. The calculations that were automatically run illustrate that despite its rather steep initial cost, over three years' time, the LED solution's energy savings will more than pay back the additional outlay. What's more, this project requires the actual performance to meet the design parameters, with designers on the hook for up to five years after commissioning, so the projections I saw are probably conservative and do not cover the savings due to reduced operations and maintenance costs.

I then asked how the concept of practice groups works.

"Basically, we have an online design room," Amy explained. "Everyone is allowed access. We now work within practice networks, not the megafirms of the past. It's all about following a lean design process. We find people based on their experience and knowledge and bring them together in a shared space. The transparency of people's experience, in-

cluding the various rating systems for BIM and virtual construction, is really valuable and removes much of the headache we used to have. We can find out who has been on what course, how they fared, what projects they have worked on, whether they are NBIMS-US™ qualified, etc., etc. At least for our projects, all the subcontractors are brought on based on qualifications, not price. That's a big shift, one that many people in our industry are still struggling with. But it works. And they are involved from the very start. The value of getting input from everyone involved in the project—from the owners to the subcontractors to the people who will occupy the building—may be hard to quantify, but it's difficult to be successful without it. So we use a virtual online space, we host 'Facedays,' we use social media and video conferencing and every tool you can think of just to keep everyone connected. It's an effort but it's worth it."

"Our process is completely collaborative. Sort of like IPD from the past but better, and involving more people," Brad added. "The architect is back to functioning more like the master builder, while the general contractor is a master scheduler and planner. It's less about roles and more about the process—being lean and eliminating waste of time, money, and effort."

"And it all centers on the model, the BIM?" I asked him.

"Yes, it does. Everything is about the model. We can virtually build anything before we have a person on site or any material ordered. We add schedule for everything, including things you wouldn't think of typically, like the location of people and equipment. We have a continuous database of cost so we know the effect of changes, delays, or errors, immediately. Even our specifications are part of the model. It took us a long time to move it all to this virtual world, but it's absolutely worth it.

The team estimates that the model saves the project owner about 20 percent of total costs, when compared to the methods used 8-10 years ago. These estimates are hard to come by, because so many things have changed and since no two buildings are alike. However, the general trend in the industry toward at least on-time, on-budget project delivery is a far cry from yesteryear, when cost over-runs and delays of months or even years were accepted, even expected.

"Do you all use the same hardware and software?" I asked.

"It doesn't matter," Felicia said. "A big part of what makes the lean process and data-sharing work is interoperability—everything can work together because the interface is so good these days. "

"We don't need to export huge models so that the next guy has to import them. Our data is in a cloud. The drawings, specs, and models are seamlessly linked," Amy added.

The maturing world of open standards within the construction industry have enabled this apparently seamless interoperability to occur. And it's a crucial element of success enabling individuals and teams to use the best tool, be it software or hardware, for the job without concern over being able to send or receive the required data.

"buildingSMART International, buildingSMART alliance, and the hundreds of volunteers who made this happen should be applauded for their efforts. They kept persevering even when nobody believed them," Owen stated.

Estimating and cost control are a central part of this process. Live and seamless connections to product and material metadata, as well as live updates of the effects of changes, mean project teams can work with owners who have their eyes wide open, knowing the actual effects of the decisions they make in real time. Not only that, the model supports this type of control throughout the lifecycle of the building: through occupation, operations and maintenance, and even through to reuse or demolition.

The idea of demolition brought to mind the question of sustainability and how "earth friendly" the project is, but the team dismissed my line of questioning with a simple "for us, sustainability just 'is.'"

The building, designed to Green Codes, will provide a net energy gain and be restorative to the environment. Obviously it has the green roof, but it also houses a photovoltaics array and low-energy heating and lighting throughout. This of course will be monitored through occupation as part of the new regulations that require monthly reporting to the public and to the city.

My final question was about intellectual property—the age-old concern for ownership of ideas and knowledge. But again, the team batted it back as a non-issue.

"The paradigm for intellectual property for us is that anything we create is attributed to us and is going to be a mouse-click away for others. We also have the information-creator control who has access to the information," Felicia explained. "Our value is in the knowledge and processes we use to create new connections, ideas, spaces, communities, and value. But we can always check with our lawyer, if we have concerns."

"Yes, the lawyers are involved as early as everyone else, just to avoid issues right from the start. This reduces our insurance costs and eliminates the he-said, she-said fights that used to cost our industry millions," Mike added. "The model tracks who created what, and if someone put in faulty information, then that person would be identified, and the whole team would not be punished for one person's errors. The at-fault individual would simply pay more for their insurance premium."

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THE WALKTHROUGH

A few weeks after my initial interview at the opening of the care center, I was fortunate enough to accompany Amy, Owen, and Brad as they escorted the mayor of Springfield, the chief of police, and the fire chief on a walk-through of the finished building.

The mayor and the fire chief made a point to tell me just how involved they and their staffs had been throughout the project. “It’s amazing to me that the virtual walk-throughs were so realistic, I feel like I have been in this building many times,” said Fire Chief William Edgar. “I was especially impressed at being able to use the drone to watch the building as it went up, step-by-step. And being able to ‘see’ what’s happening behind walls could come in very handy for us—and for the police as well.”

In fact, the team has gone further than merely involve the city in the building of the project. The team also worked with city agencies on contingency plans for natural disasters, temporary shelters, and various other sets of emergency data immediately accessible should anything happen.

I followed a group of people on one of the tours that Felicia was giving, and noted the new staff swiping name badges at the various entrances and receiving individualized greetings upon doing so. Apparently the same technology would be used during operations to advise the staff of specific work issues awaiting their attention. This truly is a high-tech facility, even by today’s standards.

The building has sensors throughout that automatically and continuously collect data about how the facility is performing. This data allows the operations manager to not only monitor and adjust environmental factors like temperature and lighting, but also to understand the building’s use, occupancy, and human traffic patterns—and adjust internal climates and plan maintenance accordingly. Even the patients are RFID’d, just one final example of the user-environment-technology interface that the project team has captured so well.

Writer’s note: This reporter has been covering the building industry for the Globe-Times since the first energy crisis in the 1970s. Of the hundreds of projects that have been reviewed over decades, the Springfield Children’s Care Center captures the highest marks in terms of both product and process. It delights all the senses, and, as readers will recall, came in under budget and ahead of schedule.

Time will tell if its actual performance meets projections. This reporter will be back on the project scene and meet with the team six months from now to bring readers his first-hand observations of the building’s operations and commissioning process.

Summary and Conclusion

by Chris Moor, Chair, 2021 Vision Task Force

The story of the Springfield Children's Care Center Project offers a realistic view of how projects can and will be built in the future. If we look hard enough, most of the technology, processes, and collaboration mentioned can be found in operation today, albeit in their infancy and, of course, in silos.

The story imagines a world without limits, a world in which the industry at large understands how to move forward for the benefit of all. After all, the benefits are obvious, and real, with many projections illustrating a:

- 20% reduction in costs of building with an even bigger saving during operations
- 20% reduction in energy use.

Analysis of the various essays and research used to develop the story shows their findings essentially can be placed under six broad headlines:

1. Sustainability

Many of the references to sustainability within the essays are largely implicit, because it is so core to the general working practice envisioned. The concept of sustainability and "green building" as we know them today will not exist in 2021. It will be normal practice to consider not only the energy usage and performance of a building during its occupancy, but also through the overall lifecycle of that building, even after its useful life—with, for example, recycling planned into the initial construction of the project. As with many other things, what is innovative in 2014 will be common in 2021. One intriguing concept presented is that of the design team remaining responsible for the actual performance of the building for several years after occupancy. The idea of developing contracts that tie design to performance is one worth exploring.

2. Facility Management and Operations

Facility owners, managers, and operations management often are touted as the big winners in any publication on how to improve the capital facilities industry and construction industry. While this is true, the bulk of the necessary effort to make it true happens much earlier in the project's lifecycle, specifically in design and construction. By having a building designed with facility management and operation in mind, the owner can indeed reap the benefits through maintenance savings, energy savings, and occupancy savings. But the owners first must take responsibility for ensuring the environment is in place to be able to take those benefits.

3. Data, Interoperability, and Integration

The digital world brings with it an immense amount of data—aptly termed "big data"—but it is the accessibility and usability of that data that really makes the difference in this vision. With the advent of accepted open standards, the change in psychology about sharing data, and the philosophical shifts in how data should be shared, the "I" in BIM (Building Information Modeling) clearly plays a strong role in the future of the industry.

Similar to sustainability, interoperability and data-sharing across platforms and across disciplines in the story were largely implicit: they just worked. Open Standards, such as buildingSMART's Industry Foundation Classes (IFC), played a huge role in that. In fact, by 2021, IFC had almost become equivalent to what html is for the Internet—perhaps leading to the "Internet of Buildings." Yet one of the key takeaways from our research is the value of using data from across the spectrum. A small example is the compatibility of GIS (Geographic Information System) data with BIM data, but another is the ability to integrate outside data sources as well. An example of this would be integrating historical weather patterns with demographic and psychographic information.

The accessibility of the data and of open standards appears to lead toward new and innovative software solutions that focus on small niches yet still fit in seamlessly with all of the other software being used. The bottom line is there is a major expectation that the information and data we generate can be used effectively to help every aspect of a building project and a building's occupancy. There is a subtle but crucial paradigm change too, in that people retrieve the information and knowledge they need when they need to consume it, not just when it happens to be available. In other words, learning shifts from "just in case I need to know" to "just in time—I need to know now."

4. Building Codes, Specifications, and Standards

Building codes, specifications, and standards were rarely referred to in the essays. In fact, the issues surrounding them were deemed to be just as complex in the future as they are today, even if access to the information were somehow easier. There were two progressive concepts surrounding these issues: The idea that update cycles were drastically reduced due to the emergence of social media; and that code checking, permitting, and standards compliance all were part of an automatic (or at least semi-automatic) process.

5. Technology

While the issue of technology, ranging from drones to robots and from the cloud to Google Glass™, was very prominent in virtually all the essays and research, it must be remembered that technology only enables everything else to happen. Focusing on the use of UCUVs (unmanned construction utility vehicles) that deliver materials

around the site when they are needed, or the use of SMART tools that know where they should be and when, ignores the reason why they are important. Any feature without a benefit is unnecessary. However, almost without exception, any introduction of the many technologies was always done in relation to the function it fulfilled and the benefit it provided. UCUVs, SMART tools, sensors, and tags (such as RFID) were all brought into play with regard to safety issues. Augmented reality and heads-up displays such as Google Glass™ played a huge part in planning and operations (and maintenance) as well as in assembly and construction. Laser scanning played a role not only in surveying, but also in quality control and assurance. One could posit that the technology references indicate where the industry suffers the most pain, as well as how it envisions those issues being resolved.

6. **Process, Efficiencies and Collaboration**

   Social and cultural aspects play a huge role in the success of any delivered project, and references to process planning, efficiency planning, and various collaborative methods were abundant to the point of being assumed. The idea of IDCO (Integrated Design Construction Operations) organizations; enterprise delivery; virtual design, fabrication, construction, and facility management; just-in-time techniques; business process mapping; early involvement; collaborative contractual arrangements; or reducing waste was at the center of just about every essay. There were few direct references to “lean” specifically, but the process references all pointed in that direction. Interestingly, the issues and fear currently surrounding issues related to data and model sharing—such as Intellectual Property; trust, liability, and risk; and an increase in disputes due to changing roles and responsibilities—were unfounded, overcome, or in fact non-existent. Unfortunately, we still have a need for lawyers though…

So how do we get there?

The mandate of the Vision Task Force was not to discover the magic bullet: There isn’t one. It was to spark some debate and awareness about how we can all play a part in making our industry more efficient.

The essays and the research pointed us subtly in various directions, none of which are particularly challenging when taken alone. The top four needs for the industry as I see them are:

1. We need a crisis or a **Mandate** to initiate change. Many would argue we already have the crisis, we just need others to recognize how inefficient out industry actually is and mandate some change—from the top. A government mandate may be enough, but mandates can come in many different forms. Also, owners need to start taking some responsibility for spiraling construction costs

2. We need **Investment** for technological support of open standards and open platforms—IFC and other formats

3. We need to change our **Culture**, starting with contractual arrangements and the way project teams are organized, including, perhaps, a 2-3 year operating component to ensure that buildings perform as they should

4. We need funding for huge amounts of **Education**, i.e., a brand new educational platform to:
   - Initiate cultural change
   - Support new technologies and ways of working
   - Enable leaders and innovators to share their experiences
   - Support lean education – principles, methodologies, and action plans.

We did not intend for this publication to be precise or to accurately predict exactly what a construction project will look like in 8-10 years. We wrote it to provoke some thought about solutions to our clearly floundering industry. We are in the midst of a massive paradigm shift, and it's an exciting time. Everything we learned through this exercise points to how all facets of the building industry are looking for solutions they can embrace; we need to step forward and embrace the challenge of finding those solutions.

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