PASSING THE BATON

White paper

Executive Summary

The handoff between project engineers and fabricators is a key juncture in project delivery. Any mistakes at this stage can mean costly rework and project delays, and an inefficient handoff of design data can bloat budgets and unnecessarily extend project schedules – leading to cost overruns, litigation and unnecessary headaches for owners.

Historically, design teams have delivered two-dimensional project drawings to fabrication teams. This process has changed little over time, even as the architecture, engineering, and construction (AEC) fields have embraced the three-dimensional workflows of building information modeling (BIM). On a typical project, engineers and fabricators build out their own separate 3D models, a process that results in wasted labor, lengthier project timelines, and an increased likelihood of mistakes.

The emergence of cloud collaboration and other technologies makes it more practical than ever for different project teams – including teams separated by geography – to work together effectively. Meanwhile, factors such as growing infrastructure needs, shrinking project schedules, and industry-wide staff shortages are combining to create a demand for better efficiency from AEC teams. With all this change happening however, the industry continues to use traditional processes methods and cultural mindsets that restrict the potential to adopt technologies to their fullest potential.

Here, members of Autodesk's sponsored Engineering Executive Council (EXC) lay out the status quo, explain how improvements to the current situation will benefit project owners, and offer some initial solutions based in people, processes, and technology.

Where Things Stand: The Challenges of Handing Off Digital Deliverables

The introduction and widespread adoption of building information modeling (BIM) across the AEC industry has resulted in a number of benefits, including a reduction in the number of coordination construction errors (Dodge Data & Analytics, 2017). However, to date, BIM hasn't reached its full potential. The automation and repeatability of BIM workflows ought to have resulted in shrinking project schedules, fewer change orders, and cost reductions across the industry. So far, that hasn't happened.

This is largely because BIM processes are still typically siloed, with engineering and fabrication teams working separately from one another, and in many cases never interacting in a common digital model. Here's a common scenario: Working in BIM software, engineers will take a design further along than they need to, often working to a level of detail (LOD) that could be used in fabrication. However, after the engineering team hands off the project, the fabrication team will typically ignore the engineers' 3D model entirely, instead basing their work on two-dimensional contract drawings. At this stage, fabricators may use BIM tools to create their own 3D models, resulting in significant overlap between the two teams' workflows.

This status quo is prone to errors. For one, when multiple teams are duplicating the same work, there are more chances to introduce mistakes. But also, misinterpretations of two-dimensional drawings can lead to additional errors. These can be avoided through requests for clarification, but those come with their own problems, bogging engineering teams down with additional work and sometimes leading to tension and miscommunications between engineers and fabricators. As project schedules accelerate and projects become more complex, design changes happen more regularly. This creates an even greater potential for error especially with last minute changes.

Project teams aren't deliberately making the design-to-fabrication handoff more complex and inefficient than it needs to be, of course. Rather, they are simply following industry-standard practices that have developed largely as a result of existing contract structures. In their current form, these contracts serve the goal of minimizing the risk of liability and cost overruns for each individual team, rather than aiming to optimize and streamline the entire design and construction process.

When fabricators receive a 3D model from engineers, they often don't even have the legal, contractual right to rely on that model. Instead, the contract points them to two-dimensional drawings, and so that's where they go. Similarly, because engineers know that their 3D models are unlikely to be used by contractors, they sometimes make their models less than 100 percent precise. While a difference of half an inch won't affect the reliability of a structural model to do structural analysis, fabricators simply can't use a model unless they know its purpose or intent.

At this point, there are very few incentives, structures, and processes in place to encourage the sort of close collaboration between teams that would help to streamline the design-to-fabrication handoff. Occasionally, some forward-thinking firms will take matters into their own hands – working across teams in a common BIM environment, for example, or even physically placing members from design and fabrication teams together at one site to improve collaboration and communication. But for now, these scenarios are the exception, not the norm. To create industry-wide change, project owners will need to insist on a delivery process that mandates collaboration between teams to achieve project goals.

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Why This Matters: How a New Handoff Process Will Benefit Owners

The handoff between engineers and fabricators is, essentially, the point at which a project begins to transition from being mere information (i.e., design drawings and 3D models) to becoming the physical, fabricated components of what will eventually become the final building. This stage is crucial in determining whether the original design intent will ultimately come through in the finished product.

This is becoming ever important for building owners who want to know that their building is going to be built, commissioned and operated where the costs are predictable. The more insight that is provided about constructability and building performance upfront, the better insight the owner will have into predictability of cost. Also, owners are becoming more concerned with their investments impact on occupancy wellness, building resilience and sustainability. Designs that minimize greenhouse gases and carbon footprint while maximizing energy performance must cascade through the design to fabrication handover. If they don't, the building owner will not end up with what they paid for. Today, most owners live with an end product that is different than what they envisioned with the design team. In the future, this will not be the case as they raise their expectations for how their building performs throughout the building lifecycle.

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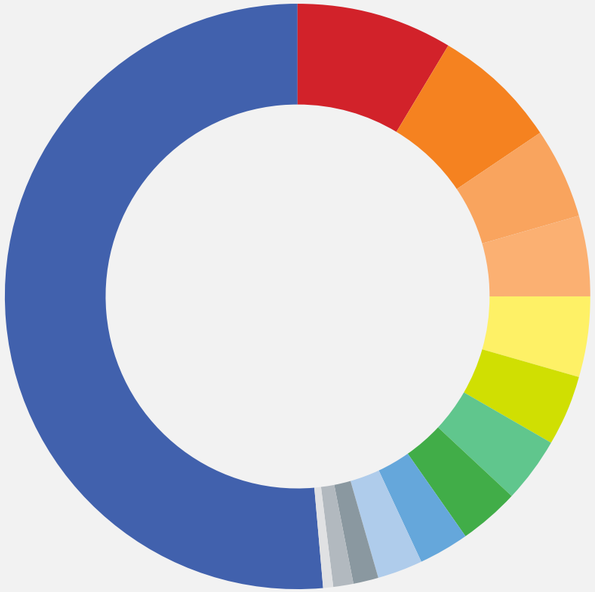
Government department framework analysis

Overview of various costs associated with a typical project



51.3%	Product
8.4%	Client risk
7.0%	Supply chain overhead
4.8%	Site overhead (supply chain)
4.4%	Site overhead (plant)
4.4%	Client fees
4.1%	Constructor design fees
3.5%	Site overheads (management)
3.2%	Supply chain profit
2.7%	Constructor overheads
2.6%	Escort costs
1.4%	Constructor profit
1.1%	Design development contingency
0.4%	Constructor risk

Of every £ spent, just over 51% results in residual asset value for the client.
By focussing on scheme optimisation, both the material cost (i.e. the cost of the asset) and the associated sources of waste can be significantly reduced.

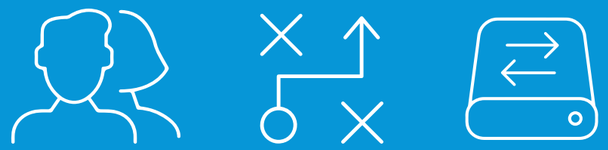
Source: 'Delivery Platforms for Government Assets: Creating a Marketplace for Manufactured Spaces'
http://www.brydenwood.co.uk/filedownload.php?a=18-59db7e15aa5f8

'Platforms: Bridging the gap between construction + manufacturing'
https://www.brydenwood.co.uk/filedownload.php?a=360-5aaf9367d5105

Moreover, improvements in the handoff between engineers and fabricators will allow project owners to enjoy the full benefits of BIM workflows. The rework and errors that stem from existing processes can lead to cost overruns and project delays – two things that project owners desperately seek to avoid. By encouraging changes that lead to project teams working together more closely, owners will ultimately cut their costs and timelines while improving project outcomes.

Owners will also achieve better designs that reduce carbon footprint during construction but also across the building operations. Reduction of greenhouse emissions and material waste through energy optimization and efficient use of manufacturing products will help building owners reduce costs in the long run and the impact on society as whole.

People, Processes & Technology



Members of the EXC have identified a number of different changes around people (culture), processes, and technology that they think can improve the design-to-fabrication handoff and yield better outcomes for project owners. They've listed out 3 concepts organized by culture, technology and process to frame out a potential solution for the industry.

People

Perhaps the greatest roadblock standing in the way of improvements to the design-to-fabrication handoff is a lack of trust, caused by factors including a lack of data fidelity, misaligned goals between teams, a low-bid mentality among clients, and a lack of understanding of the all-inclusive design lifecycle. The EXC has identified near-term, mid-term, and long-term initiatives that have the potential to build a strong foundation of trust between teams.

Near-Term

- **Establish Data Standards:** Minimum standards for data accuracy and access must be established to enable the effective transfer of critical, reliable information across platforms – regardless of the technology used. When teams can trust each other's data, they'll also trust each other more.
- **Shift Away from Low-Bid Contracts**: A reliance on low-bid contracts prioritizes cost without any regard for actual value. Removing cost as the primary driver for success, and instead moving to a model that rewards the value of collaborative partnership, will ultimately result in more creative, cost-effective design-to-fabrication interactions and solutions.
- **Aligned Business Goals:** Project owners should engage design and fabrication teams in a frank discussion about each project's business and financial goals, with a resulting set of documented objectives that will create a more equitable risk-to-value ratio and foster trust between stakeholders.

Mid-Term

- **Contract Evolution:** Existing contract structures should be modified, with a focus on equally valuing risk and reward – similar to the integrated project delivery (IPD) model. The equity created by this arrangement encourages and even demands collaboration and sharing of concepts, data, and expertise.

Long-Term

- **Shared Business Knowledge/Understanding Framework:** Ultimately, all stakeholders should reach a point where they can work together to provide the entire project team with a fundamental understanding of each team's workflows, tools, and capabilities – thus enhancing the ability of project teams to work together to develop innovative, cost-effective, and timely solutions.
- **Multi-Discipline Educational Programs Framework:** Once the AEC industry has improved project delivery, it should also work with educational programs to develop and provide consistent coursework and internship experiences that educate students about multi-disciplinary workflows, tools and processes. This will prepare new entrants to the AEC industry to contribute to project success in a holistic manner.

Processes

The AEC industry needs to adopt a framework for project delivery that

- Is flexible for all delivery types
- Defines desired outcomes by provided level of information (fabrication etc)
- Defines desired outcomes by building lifecycle phase
- Aligns above outcomes with who is responsible

By taking this step, industry stakeholders will be able to design a process around desired project outcomes that aligns responsibilities along the project design lifecycle with the needed information, and provides the right information to the right people at the right time. This approach will reduce wasteful and redundant workflows, enable cultural change, enhance project team morale, and improve project outcomes – leading to higher value to the project owner (and, ultimately, to the AEC industry at large).

Technology

By optimizing the value of information as it is passes between engineers and fabricators, stakeholders can reduce wasted time and do more with less – helping their firms and the larger industry to meet the growing demand on resources. However, there are significant challenges to streamlining the flow of data between teams, including the variation in model content, differing construction means and methods, and the inability to quickly validate content.

Members of the EXC propose the following solutions to address these impediments:

- **Data validation:** If model data could be presented in a manner that was easily validated, project schedules would shrink. Currently, there is no reliable way to validate that another team's information is correct; and so, instead of taking and building upon an existing model, these models are often recreated from scratch.
- **Data change management:** Technology that enables teams to build a functioning analytical model to capture design intent would allow fabricators to review the impact of proposed changes before engaging the engineering team. With existing technologies, contractors typically need to involve engineers when they modify a design.
- **Manufacturing content for MEP:** Creating an industry standard for parts and equipment would dramatically streamline the design and fabrication processes. In structural engineering, there are standard shapes and member sizes that can be easily modeled by a design team and then handed off to steel fabricators, who add connection details and prepare fabrication drawings. However, this is not the case in the MEP disciplines, where parts and equipment come in various shapes and sizes – often forcing teams to re-model during fabrication.
- **Cost insight:** Software that could assign costs to different project elements as a design is being created would help project teams to meet cost targets on their first pass. As it stands, it is very difficult for project teams to understand the cost implications of their design choices until after the design is substantially complete. This often results in rework being required to meet cost targets.
- **Supply chain insight:** Similarly, engineers currently create their designs without knowledge of available inventory. This slows the construction process when fabricators have to source (and then get engineering approval for) an alternate part. Software that could connect to product inventory could significantly limit rework.

If engineers had cost, inventory, and standard part information at the beginning of design – and if contractors were able to trust and adjust the model with real-time feedback – these changes would provide the owner with significant value in terms of schedule and cost certainty.

Conclusion: Why Now, and Why Owners

Current conditions in the AEC industry present unprecedented opportunity for the emergence of a new project delivery model, while also putting renewed pressure on firms to find ways to work more efficiently. The pace of project schedules and complexity is accelerating, and the demand for rapid design and construction will only increase as global urban population growth puts pressure on the industry to build more projects, more quickly.

More than any other group of stakeholders, project owners stand to benefit from improvements in the project handoff between designers and fabricators. By eliminating inefficiencies and competing interests, owners can create an environment where all stakeholders collaborate to improve project quality, reduce costs, and speed up timelines. Also, more than any other group, owners have the ability to exert influence and create real change in the way teams work. While individual firms can improve their own practices, systemic change will not come about until an industry-wide set of processes, technologies, and cultural norms is adopted. By insisting on change, project owners can make it happen.

As next steps, the authors plan to do three things:

- Explore more deeply existing BIM standards and contractual models that improve the interface between design to fabrication on projects. This includes reviewing recent release of ISO's new 19650 BIM standard and possible applications for the US and Canadian markets.
- Use those best practices to frame out more details into the culture, process and technology concepts they outlined above.
- Validate that their concepts work, by implementing the processes and technologies on a pilot project in 2020. This will help prove out the benefits of using more integrated delivery models

Doing the above will solicit debate in the industry for why and how the industry should transform itself in how it delivers building projects. The time is now for building owners to respond to the systematic process and cultural challenges facing the AEC industry.

The engineering and fabrication industries can help owners implement a new vision and are willing and ready to rise to the challenge. The net positive impact on increasing cost predictability and other project outcomes like occupancy wellness and reduced energy and material waste will transform our industry.

Who is the Engineering Executive Council?

The Engineering Executive Council, formed in 2017, is composed of a select group of high-level executives from a variety of engineering and fabrication firms throughout the U.S. and Canada. With a focus on the MEP and structural disciplines, the group regularly convenes to network, explore issues affecting the field, and share best practices among peers.

The purpose of the Council is to identify and discuss industry-agnostic transformative technology trends and key business challenges and opportunities, and to better understand and react to the impact of these forces on their business.

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