DASSAULT SYSTEMES

REPLACING PROBLEM-SOLVING
WITH FUTURE TESTING

THE NEW PARADIGM POISED TO DISRUPT THE AEC INDUSTRY

INTRODUCTION

New technology is changing the way Architecture, Engineering and Construction (AEC) companies are solving problems. Reacting quickly to issues and limiting project cost and budget overruns is key to success. But traditional methods of problem-solving will, at best, provide incremental improvement. These legacy methods only limit the growth of current cost, time and waste cushions added to projects.

To change the game, companies need a new approach that lets them drive innovation, increase speed, improve agility, reduce waste, and gain trust with stakeholders. Innovative companies are doing just that, by adopting a new "Future Testing" approach. Future Testing allows all participants in the AEC industry to anticipate issues and opportunities early so they can reduce risk and take advantage of innovative ideas. As a result, they're slashing wasted time and cost currently deemed "standard" in design and construction.

The era of winning by being reactive, stemming significant cost and curbing schedule disruption is ending.

Now is the time to begin the transition away from problem-solving toward Future Testing. Those that don't transform and adopt this intelligent, proactive approach will find themselves losing to a new breed of technology-enabled companies. The waste built into today's bids will put companies at a disadvantage, and the status quo will leave companies behind as others improve.

But this transformation can't happen with digital discontinuity between design and fabrication and insufficient supply chain integration. It's time for a change.

Disrupting the Status Quo: Future Testing

During construction, how many times have you wished, "if we had only been able to anticipate this problem earlier..." All too often, unanticipated issues arise during construction and wreak havoc on schedules and budgets because the options to correct them are limited by work that's already been completed. An issue that could have been addressed quickly in the design phase can be nearly impossible to correct during the build phase.

Instead of firefighting to deal with problems and fixing them with wasted time and money, forward-thinking companies are adopting a Future Testing Cycle. This method allows them to anticipate and avoid issues by experiencing the build process in a digital, virtual environment before physical progress limits the ability to change.

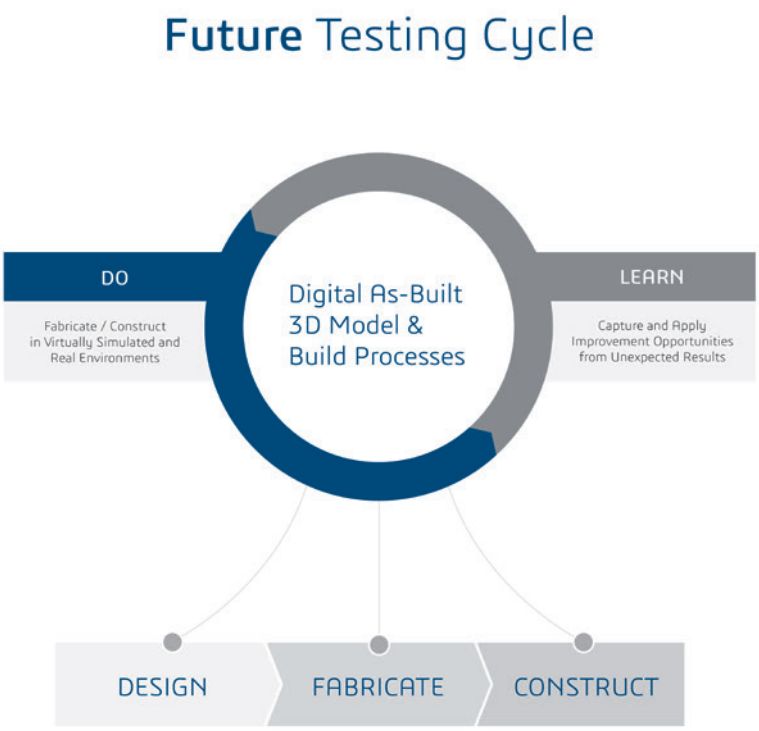
Unlike traditional processes, companies using Future Testing learn from work completed in the virtual environment in addition to learning as they perform physical work. This solution allows them to test many more scenarios – virtually, in addition, to physically – and analyze what works to feed it back into the next cycle. As a result, each step of the process is improved.

Understanding the Future Testing Cycle

Every building and infrastructure design is unique. Whether a project is an artistic work or a more utilitarian design, it has unique requirements for piping, ductwork, structure and other elements that must be designed and coordinated in context. These elements are typically left to later detail design stages of the project. Modernizing craftsmanship with Future Testing allows the 3D digital model from the architect to be extended and enhanced with detailed construction information. It's then used to virtually construct the building and learn from that experience before doing work in the physical world. These innovators are using precise digital models to simulate the construction and the sequence of steps needed to build it, and iterating on this "digital mockup" multiple times to learn and improve. In this way, Future Testing makes the first-time building a unique, "one of a kind" structure as efficient as if the company had made it for the 100th time!

Future Testing also allows AEC companies to incorporate downstream feedback on constructability by collaborating on the virtual model with makers to build in downstream efficiency. Then, as they gain real-world experience executing the project, they continue to update the models with better ways of working and run simulations to prove them out. This way of working shortens the feedback loop so they can apply new methods to the current project, learning as they go and leaning out the process at every phase.

Simulating the build process lets a company visualize the result and the steps needed to get there. This way of working allows for anticipation of what to do differently, determine who to involve earlier, identify avoidable mistakes, and recognize the innovation a company can incorporate. Future Testing helps an engineer cut waste out of the process and identify opportunities for innovation, while creating the "Digital As-Built" on the way.



Future Testing improves the way architects, engineers, fabricators, building product manufacturers and contractors work by using cutting-edge technology to enhance their ability to anticipate and adapt. Dassault Systèmes understands the AEC industry's challenges and the **3D**EXPERIENCE® platform allows forward-thinking companies to adopt the Future Testing solution.

An excellent example of a company employing the Future Testing method is **CadMakers Inc.**, a construction and manufacturing technology company. They work closely with AEC businesses to streamline projects from design to construction, leveraging leading engineering software solutions. Their design approach includes modelling all the building systems — architectural, structural, mechanical, electrical and plumbing, civil and geotechnical — and mapping them virtually in an accurate, virtual 3D model. Then, they get everyone — the project architect, engineers, and various subcontractors — together to view the model and crowdsource solutions to identified problems. This approach combines the hands-on expertise and experience of construction industry veterans with the visualization provided by 3D modelling with a specific end goal of prefabrication for multiple building systems.

The results speak for themselves. CadMakers helped design the Brock Commons - TallWood House at the University of British Columbia (UBC) near Vancouver, an 18 story mass-timber

building. They leveraged Future Testing approaches including virtual design and construction modeling and on-site assembly simulation of manufactured parts. These helped complete the structural components of the project approximately 50% faster and at less cost than traditional concrete buildings of the same size (when factoring in reduction of carrying costs and labor on site due to speed). In fact, the 20-month project was complete three and half months ahead of schedule.

One example of the time savings is the construction of the mechanical room. The time to construct a mechanical room for an 18 story tower such as this with a traditional stick built approach is 800 to 1,000 labor hours. With Future Testing, the job took 160 hours of virtual detailing (3D modeling and kit of parts prefabricated outputs such as spool drawings with cut lengths and bill of materials) and 160 hours of physical assembly. That's a total of only 320 hours, cutting out 2/3 of the required hours. The onsite work was 3 weeks' total with 1 worker, compare to the baseline of 3 workers for 3 months. The results were a significant contributor to the project coming in ahead of schedule and under budget.

The Benefits of Future Testing

Future Testing allows companies to modernize the craft of building by:

- Quickly developing complete, precise models of the building
- Anticipating issues and innovation opportunities by simulating the construction and the build process
- Creating accurate drawings to enable components to be prefabricated, or fabricated directly from the digital models, to exacting tolerance and installed right the first time
- Learning by doing from both the physical and virtual environments, and adapting to improve efficiency as the project progresses
- Reacting to inevitable changes with agility
- Developing confidence and trust with stakeholders

Future Testing for Architects

Future Testing allows architects to see their concepts come to life in full 3D. It helps drive speed and helps unlock creativity during the creative process. Traditionally, architects develop high-level conceptual models to share their artistic intentions and allow others to take the designs to the next stage. But the speed and automation available through advanced technology such as parametric modeling can allow the creative team to go further. They can develop digital models that incorporate company knowledge and represent the building and the build sequence completely and precisely.

The models are complete because designers can use intelligent automation to model the entire building across all trades, allowing all stakeholders to see what it will look like down to the finest details. This way of working allows the architect to get feedback from the beginning. They can build in constructability and knowledge from fabricators and installers into the digital model to anticipate and communicate downstream efficiencies.

Future Testing for Architects – In Action

An example of Future Testing in action for an architecture firm is the development of the Botswana Innovation Hub by **SHoP Architects**. They designed a unique building with a graceful, morphing shape. The plan called for the fabrication of many parts, with multiple variables and tight tolerances. The SHoP team used the Future Testing technique of developing a complete, precise model of the façade system.

Beyond designing a functional, beautiful structure, they focused on constructability. They added information to the model to make fabrication and installation more efficient, for example adding the installation sequence to the design, so it was included on drawings and directly onto the prefabricated parts. The results are impressive. They met the need for a high level of control and the ability to coordinate the fabricator and the construction site that are both thousands of miles away from their design offices in New York, with the materials prefabricated in Cape Town, South Africa.

Future Testing for Engineering Firms

Traditionally, engineering firms review the architect's conceptual designs and independently develop their engineering drawings. This is a wasteful step, which duplicates work and can misinterpret the architect's intent. This disconnect between the designs also makes it incredibly difficult to test new ideas or incorporate changes from the architect.

Future Testing bridges the digital gap. It provides the ability for all stakeholders to collaborate on and visualize a virtual mockup of the project from start to completion in digital form, improving speed and building trust that the desired outcomes will be met. Instead of problem solving and reliance on hindsight, the approach allows engineering firms to anticipate issues or uncover creative opportunities in advance by experiencing the project's as-built behavior in virtual form. It brings all stakeholders together and supports an Integrated Project Delivery (IPD) approach.

Future Testing also allows engineers to analyze designs virtually based on precise 3D models and realistic physics simulations instead of relying on theoretical analysis that leads to costly, unnecessarily overdesigned structures. Today's models can even incorporate a systems perspective, going beyond the physical structure to include everything down to sensors and controllers to simulate overall behavior.

Future Testing also allows you to quickly change plans based on unexpected discoveries or change requests, leveraging techniques like parametric design automation that automate the propagation of changes through the design. In addition to seeing the design in 3D, Future Testing provides them with the ability to experience the changes in advance, so they know they will end up with an optimal outcome. These benefits also apply to Engineering, Procurement and Construction (EPC) firms in much the same way, allowing them to incorporate construction feedback to improve models.

Future Testing for Engineering Firms – In Action

Another great example of an engineering firm leveraging Future Testing approaches is the process utilized by the **Shanghai Municipal Engineering Design Institute (SMEDI)**, when designing the Ganjiang Second Bridge in Jiangxi Province.

The design work for the bridge was led by SMEDI, with engineers from different disciplines collaborating. SMEDI's collaborative design process meant that they clearly defined and divided the work involved, coordinated the roles and tasks, and seamlessly managed the entire project.

In the conceptual design stage, the software allows designers to quickly create complex curves as skeleton lines and even supports using digital sketch tablets. With the skeleton lines created, the component library is crucial to the success of the project. The components (like piers, beams, columns, etc.) are intelligent, rule-based parametric objects and well-categorized in the library. The designers can select desired components from the library and put them on the skeleton lines and then the components adjust their sizes automatically to fit the skeleton lines and generate the BIM model in a well-coordinated manner. If designers change skeleton lines, it drives all components to update along with it, thus greatly saving modification time. Indeed, the **3DEXPERIENCE** platform helped make it much easier for SMEDI to make changes to the design, which can be very frequent and even at the last minute. In the past, making design changes could sometimes take even longer than the original design stage itself.

Future Testing for Fabricators

Suppliers are not immune to the inefficiency of rework, often creating detailed drawings recreating the information in the engineering models. They work independently, digitally disconnected from the architects' and engineers' output. They duplicate information from others' models and drawings to develop digital designs, which is wasteful and can introduce errors.

In their defense, the engineering models typically don't have enough information to cover all the iterations of panels, forms, framing, and other detailed elements they need. With Future Testing, they can leverage design automation to quickly create detailed, precise models using specialist tools to simplify complex design processes like sheet metal bending or pipe routing. Then, they can automatically develop models with exacting tolerances so they can create detailed drawings for the shop or fabricate directly from the design using digitally automated equipment. They can also go further to model and simulate the installation process so items can be prefabricated in a factory setting to slash costs and install correctly on site.

Shifting to a cohesive, complete model helps fabricators easily test new ideas and react quickly to changes. It also allows them to collaborate so they can incorporate feedback from installers to anticipate and mitigate potential issues and rapidly improve processes as real-world experience is gained. The next generation fabricator will use these technologies to take on a bigger role, providing design and engineering services in addition to fabrication. This will let them provide more value and innovation upstream. In addition, it will help them go beyond simply delivering components to becoming a vital, irreplaceable part of the supply chain by offering coordination, communication, and logistics support to the contractor with just in time deliveries to optimize the cost of storage.

Future Testing for Fabricators – In Action

Zahner provides high-quality metal and glass for art and architecture. They employed Future Testing concepts in their work for the innovative Chrysalis project. In this project, they used complete 3D models to give their customers a level of comfort and confidence by quickly and efficiently updating all the stakeholders using digital dashboards. Then, if they needed to clarify some points, the digital model was readily available so an engineer could zoom in, make a quick sketch, annotate it, and save it in their meeting notes.

Future Testing for Contractors

With Future Testing, construction is the realization of the virtual building through the execution of the virtual build process. Leveraging precise 3D models allows for remote fabrication and assembly on site, improving cost and speed. Contractors can build things right the first time to reduce waste of both time and money because issues have been anticipated and designed out of the process. Likewise, pre-validated construction and installation processes allow the trades to act with speed when executing, without interfering with each other.

Perhaps one of the biggest advantages that Future Testing provides to contractors, however, is agility. Inevitably, things change and companies must adapt as circumstances arise. Whether a supplier is late or the owner requests changes, contractors must adjust. Businesses can quickly simulate and evaluate the impact of a change and rapidly validate revised plans by using precise, complete models and world-class design tools. These models allow them to be agile in adapting to dynamic conditions and further developing trust that revised plans can be achieved.

Future Testing for Contractors – In Action

Hardstone Construction's work on the Tivoli Village project is an excellent example of Future Testing in action for a contractor. For this project, they modeled the entire architectural envelope, structure, and mechanical/electrical/plumbing (MEP) systems in-house. They avoided conflicts between subcontractors because they collaborated upfront using an accurate, digital model to work out issues that can cause conflict on site. They could anticipate problems in the design of the building systems using the digital model, for example ensuring there isn't plumbing going through a structural beam, that electrical housings have enough clearance, etc.

Since those systems are typically designed in silos, problems are not found until they are bought together at the construction site. Instead, different disciplines can use Future Testing to jointly view simulations and collaborate on optimal solutions in advance, when compromises are easy and don't create change orders. With this approach, they're able to provide the general contractor with a fully coordinated model and an accurate quantity take-off. By doing this, they optimized the MEP routing to reduce materials by 30% and brought the $300 million project in on time with zero dollars in contractor or subcontractor claims. Hardstone estimates that savings were between $500,000 and $1 million in potential framing cost overruns alone and between $2 million and $3 million overall. This way of working is a clear example of how the Future Testing approach helps save time and money in the AEC industry.

CONCLUSION

The time for AEC companies to become "Future Testing Innovators" is here. Those that don't take advantage of the opportunity will fall behind. On the other hand, those that adopt Future Testing will build confidence and trust with their customers by showing they can anticipate issues and opportunities in advance, yet still adapt to inevitable changes as they occur with speed and precision to realize dreams while eliminating waste.

Tomorrow's leaders are learning to uncover innovation opportunities and avoid issues by experiencing the build process in a digital, virtual environment before the windows of opportunity close due to limitations of what's already been constructed. They're moving beyond the era of firefighting to fix problems with wasted time and money, to anticipating and avoiding them through simulation. In addition, they're employing a Future Testing Cycle to learn from physical and virtual work to improve and simplify construction processes as they go.

The benefits of Future Testing apply not only to the owner, but also to architects, engineers, suppliers, contractors, and the whole team. This leading approach gives every constituent confidence in the process and the outcome because they've experienced it virtually.

The Future Testing approach demands a platform that integrates:

- The right design tools from concept through fabrication
- Intelligent design automation for speed
- Precise simulation of designs and build processes for anticipating issues and opportunities
- Collaboration and visualization to achieve clarity
- The ability to manage knowledge and apply lessons learned from both digital and real environments to improve designs and processes as the project progresses with agility

Future Testing is changing the game for the AEC industry. Dassault Systèmes **3D**EXPERIENCE platform lets companies anticipate through simulated experiences and optimize using visibility into the future as their additional collaborator. With these solutions, the Future Testing approach provides a competitive advantage for those that adopt it, and a significant disadvantage for those that are complacent with current levels of waste and associated budget and schedule overruns. The time to adopt Future Testing is now.

CASE STUDIES

To access the case studies below, click on each image.

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SHOP ARCHITECTS

SMEDI

A. ZAHNER COMPANY

HARDSTONE CONSTRUCTION

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