Figure 1: A 3D model illustrates the proposed overall I-95 New Haven Harbor Crossing Corridor Improvement Program.
Image courtesy of Parsons Brinckerhoff & Connecticut Dept. of Transportation.

3D ENGINEERED MODELS

From Projects to Companies, and Companies to Industry

Talk to any contractor about what is the most important aspect of project delivery beyond safety and it's delivering a project on time and on budget. Yet we have seen numerous studies that show upwards of 25% of projects costs are tied to change orders, RFI's, rework and design clashes that are not found until construction begins due to a silo type project delivery approach. In an era where tax and private dollars are scarce and intolerance for waste is at an all-time high, to be successful we have to look at doing things differently, more modern and more accurately.

In a report, "Strategic Transport Infrastructure Needs to 2030," released by the Organization for Economic Cooperation and Development (OECD), it noted we need to invest $53 trillion in infrastructure over the next 20 years worldwide—the equivalent of three times the European Union's $18 trillion GDP. While impressive numbers, the most striking aspect of the report was the following statement:

> Alex Wittenberg, head of the Oliver Wyman Global Risk Center, comments: *"Better risk management of large investment projects could free-up $5 trillion, or about 10% of total required infrastructure investments, for other purposes* ***by minimizing cost overruns and delays.***"

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Fortunately, by combining the strengths of the building information modeling (BIM) process in both design and construction phases, and coupling that with better project delivery options, engineers and contractors can automate much of the design to construction workflow, dramatically improving productivity and accuracy, and completing heavy construction projects faster and more profitably.

Streamlining 3D Design to Construction

As infrastructure modernization speeds up globally, construction firms are having difficulty keeping up with the contracted schedules and budgets while the complexity of the infrastructure projects increases. This is combined with finding enough skilled estimators, project managers, surveyors, and equipment operators to keep these complex projects on schedule using workflows designed for projects with far less complexity. As a result, many developing countries face a labor shortage—a situation that is exacerbated by the large number of seasoned operators at or near retirement age, and the lack of enough skilled younger workers to replace them.

BIM is an integrated process that enables professionals to explore a project's key physical and functional characteristics digitally—virtually before it is built. It uses coordinated, consistent information to design, visualize, simulate, analyze, and then document and deliver a project **(Figure 1).** By looking at ways to streamline the design-to-construction workflow using model-based design and a BIM process, infrastructure projects can be completed with the next-generation workers where it previously was performed only by a few seasoned professionals thereby limiting construction throughput.

Figure 2: A 3D rendering shows the complex bridge-erection sequence on the I-95 New Haven Harbor Crossing Corridor Improvement Program.
Image courtesy of Parsons Brinckerhoff & CTDOT.

Better Construction Planning in the Office

Traditionally, design data created by the civil engineers has been somewhat isolated and fragmented from the rest of the project team. What they created very often would not move across to the contractors nor was it intended to do so. Contractors were expected to create their own set of information separate from the engineer, and there was no easy way to close this gap—one that could enable the rich design information to cross over to the construction phase, let alone address the legal framework by which it could happen. In addition, the ability for the contractors to impart their years, if not decades, of construction knowledge into the design process was not previously possible since many designers never knew which contractor would be selected to do the construction. And even if they did, there was really no interface in the design process where contractors could plug in.

BIM changes this. The process and its collaborative visual/analytical nature de-risks projects by making outcomes far more predictable and with a reduction in errors, increasing margins. BIM produces component-based construction models that enable the virtual construction, leveraging LiDAR and laser scanning point clouds into model sequencing, and operation of infrastructure as part of the planning and design phase. The benefits of a BIM process for heavy contractors working collaboratively with designers include:

Communicate design intent during planning, zoning, and public involvement meetings.

- Aid project stakeholders in understanding the scope and intent of the project regardless of background or profession.

Visually explore the engineer's designs with them clearly and accurately before construction:

- Integrate 3D models (BIM & Point Clouds) of all trades for

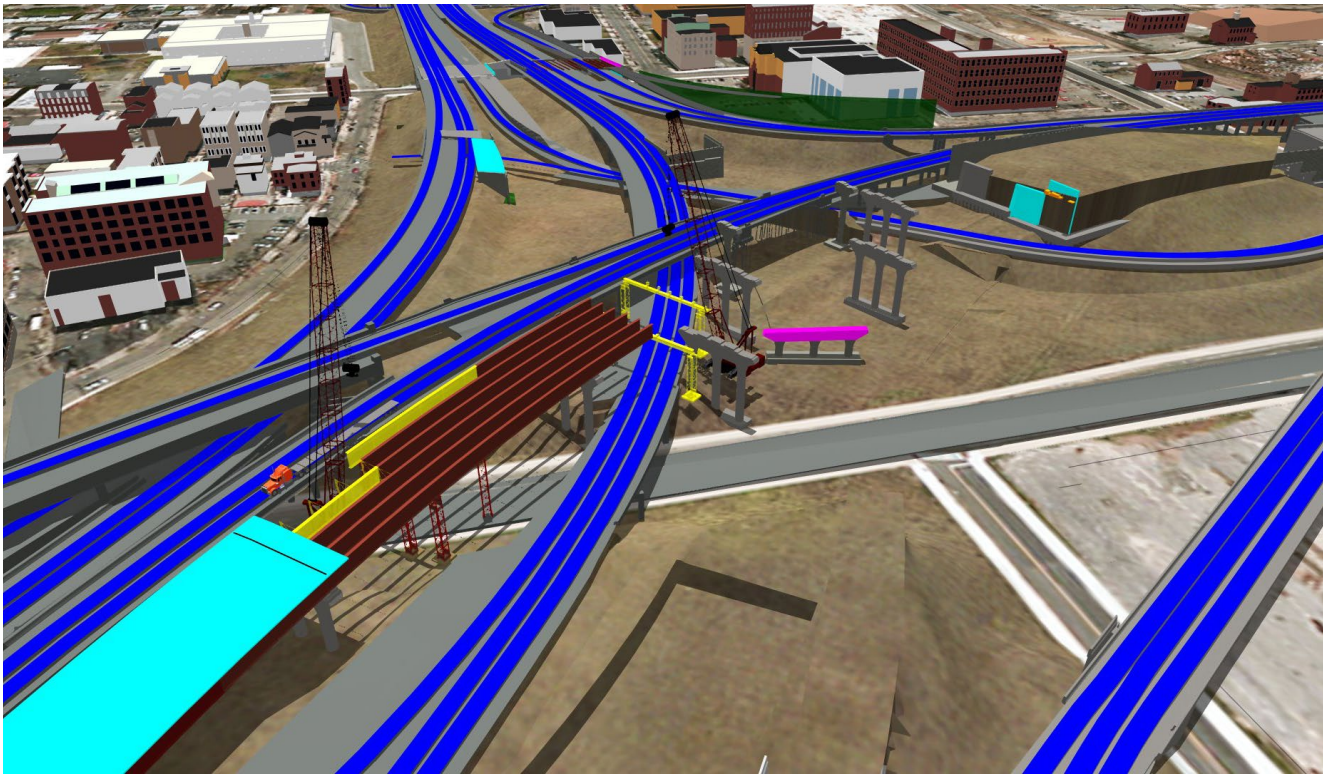

Figure 3: Components highlighted in color in this 4D schedule-linked model represent active construction activities of the I-95 New Haven Harbor Crossing Corridor Improvement Program.
Image courtesy of Parsons Brinckerhoff & CTDOT.

clash detection/avoidance and constructability issues before they materialize in the field **(Figure 2)**.
- Detect errors where they are less costly to fix using constructability analysis
- Collaborate with extended project team stakeholders including:
  - Subcontractors
  - Local utilities
  - Owners
  - Municipalities
- Ensure "currency" of models
- Reduce RFI/change orders

Accelerate the decision-making process by visualizing/analyzing project parameters to support:

- Estimating takeoff—balancing cut/fill volumes
- Project environmental impact
- Infrastructure lifecycle cost analysis
- Heavy construction time/scheduling
- Carbon impact
- Maintenance requirements (roads, water, sewer, drainage)
- Shop drawing production and prefabrication of infrastructure components

Visualize construction logistics to review and optimize construction sequencing and schedule **(Figure 3)**:

- Lane closures
- Utility outages
- Trade sequencing (bridges, drainage, sewers)
- Equipment and material schedule optimization
- 4D (time); 5D (cost) planning

The BIM process and its design models become the single truth of design for planners, engineers, contractors, fabricators, and commercial and operational managers.

Better Construction Project Execution in the Field

One of the ways in which model-based design and a BIM process in the office is having a big impact in the field and construction execution is GPS machine

control. It has begun to revolutionize the heavy construction industry in many regions of the world and will continue to do so in other countries by making it possible for contractors to complete projects faster, within budget, and to a much higher degree of accuracy. In fact, using GPS machine control technology with laser leveling and a model, contractors can deliver:

- **Time savings:** Construction crews can operate 24/7 without having to wait for staking, cut sheets, and crews.
- **Safety:** No one is in harm's way while the machines are operating, as no one is required to set grade stakes.
- **Cost savings**: Engineers save time during the modeling process, and contractors save time in the office and in the field.
- **Green design:** More efficient operation results in reduced material use and waste, lower fuel costs, and more accurate outcomes.

Other benefits for contractors in the field being realized using a BIM process includes:

- **Accuracy**: From design model to field, teams can greatly reduce interpretation/interpolation errors and costly rework.
- **Better jobsite management:** The single, real-time model and user-specific views enable much better interrogation of design and accurate, real-time documentation of everything your crew does.
- **Construction sequencing:** Users are able to sequence construction, equipment, and materials and track progress against logistics and timelines established in the office by use of laser scanning for up-to-date as-builts.

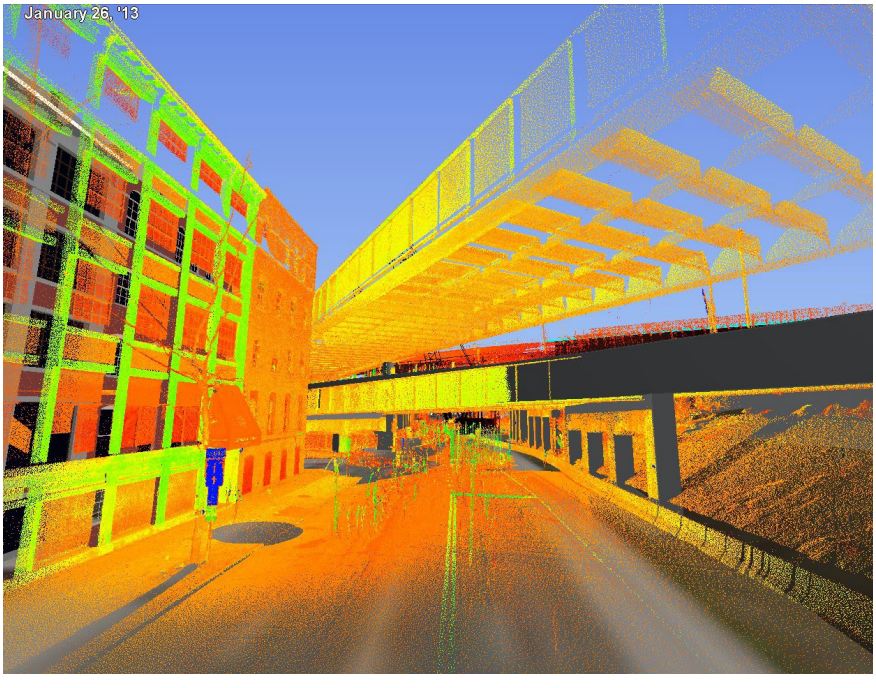

Figure 4: A 3D LiDAR point cloud is viewed inside the project 3D/4D model of I-95 New Haven Harbor Crossing Corridor Improvement Program.
Image courtesy of Parsons Brinckerhoff & CTDOT.

From Coordination to Collaboration and Constructability

BIM provides great value to contractors, helping them achieve success by modeling for constructability in the office and using that information in the field to drive the physical construction process **(Figure 4)**. But the value does not stop there, and can be extended even further if desired. Automating phases within the workflow of design to construction is one step, but if designers do not or will not share the models with contractors due to liability or legal reasons, the process will often come to a halt.

Industry experts have worked together to develop several new project delivery methods that address risk and liability, licensing, and usage rights for the distribution of digital data, such as models from BIM. Most prominent among these approaches is integrated project delivery (IPD). IPD is *"a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction."*

IPD stems from current challenges facing the design and construction industry, the need for a more holistic view, and understanding of the project from three key perspectives: the designer, the contractor, and more importantly, the owner. This is partly driven by industry

history and past experiences but also by no one discipline truly "knowing" all the intricacies of a project and having a holistic view of the project. In fact, many seated at the table do not have the perspective of what is required for successful project execution across all disciplines or how their decisions may impact others. They only understand it from their unique perspective.

lower project risk and better predictability of project outcomes as a top benefit.

But contractors are more than 'just a bunch of projects,' and it's the notion of what BIM might do to enable better corporate performance that's spurring early-adopters onwards to the next level. Arguably for the first time in history contractors are now collecting via intelligent 3D models large volumes of high-integrity, highly structured project information.

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Using models and a BIM workflow to facilitate discussion on the design are an ideal complement to this delivery approach. BIM is a technology process, whereas IPD and Project Alliancing (PA) are behavioral processes that enable teams the legal umbrella and framework to foster better collaboration and set the stage for more efficient design and construction process overall.

From Projects to Companies, and Companies to Industry

The case for BIM adoption on infrastructure projects, whether social or economic, are today too compelling to ignore—better productivity, better predictability of outcome, and ultimately better project profitability are all up for grabs. In its 2012 Business Value of BIM for Infrastructure SmartMarket report, of those companies surveyed, McGraw Hill reported that within two years over 50% of firms were expecting to use BIM on 50% of projects. 60% perceived achieving

How might this be put to work, or indeed monetized beyond the individual project? Examples might include:

- Development of standardized designs for infrastructure elements, optimized for constructability, whole-life cost performance, embedded carbon or even by cash-flow needs.
- Applying 'data mining' techniques to predict future outcomes, commonly referred to as Predictive Analytics, in a similar manner to the retail and finance sectors. Perhaps identifying risks to critical path, skills shortages, or historic over-estimation of manhours and more.
- Aggregating material data to reduce unit cost through multi-project acquisition and reduce risk through data-driven material hedging.
- Combining sensor data and point clouds with BIM models to build risk-models to determine how much value is left in an asset when a contractor is taking on an existing infrastructure asset.

Conclusion

Taking things to a logical conclusion, BIM may perhaps inadvertently change the industry in another sense. Infrastructure has long been a favored asset-class for investors seeking low-risk steady returns over long periods of time. But funding the construction phase of projects has been less attractive, not least because of the history of cost and schedule overruns. Now imagine an industry where BIM based delivery is the norm. That's an industry where cost and schedule overruns should be on average lower than today. That should translate to reduced risk for project investors and help oil the wheels of finance—a particularly welcome development in this era of constrained public finances and a scaling back by the banks in issuing long tenor infrastructure development loans.

Early adoption of these exciting new technologies and processes can also help ensure that your company will not only remain attractive to young talent that can help your firm prosper far into the future, but it can also help to expand your ability to deliver more complex projects on time and on budget with better predictability.

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