Mortenson®

JULY 2014
Project Analysis Report

THE IMPORTANCE OF VIRTUAL DESIGN & CONSTRUCTION

VDC-DRIVEN OUTCOMES

THE IMPORTANCE OF VIRTUAL DESIGN & CONSTRUCTION

Over the past decade, Mortenson Construction has increasingly leveraged virtual design and construction (VDC) to design, plan and build higher quality facilities faster while reducing costs, increasing job site safety and enhancing our customer experience.

The following report analyzes 18 projects completed by Mortenson between 2004 and 2013. It details activities beneficial to the projects, highlights those benefits and demonstrates why VDC activities are important.

In more than these 18 projects, an average cost reduction of 2.95% was returned to customers as a direct result of VDC activities. Additionally, significant cost reductions were realized, but un-quantified.

The project analysis will demonstrate three key VDC attributes:

CONTROLLING RISK BY ENHANCING AGILITY

IMPROVING QUALITY WITH DIGITAL PROTOTYPING

ENHANCED DECISION-MAKING

VIRTUAL DESIGN & CONSTRUCTION RESEARCH RESULTS

PRE-PLANNING --► DESIGN --► CONSTRUCTION

DIRECT VDC RESULTS ON **18 PROJECT CASE STUDIES:**

600 TOTAL DAYS
DIRECT **SCHEDULE** REDUCTIONS

32 DAYS AVERAGE SCHEDULE REDUCTION DUE TO **VDC PROCESS**

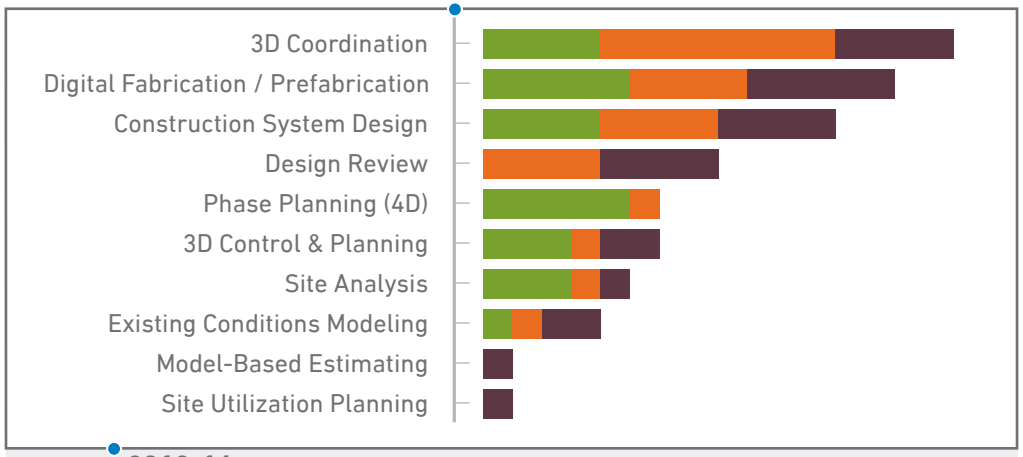
25% AND GREATER
PRODUCTIVITY INCREASES

2.95% AVERAGE
DIRECT **COST** REDUCTIONS

IMPROVING CONSTRUCTION QUALITY

DELIVERING AN EXCEPTIONAL EXPERIENCE

PROCESSES* WITH **SIGNIFICANT OVERALL IMPACT**



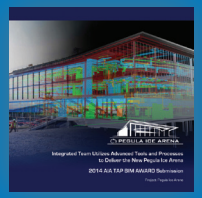
2012-14

416 TOTAL **VDC PROJECTS**

52 **DEDICATED VDC** TEAM MEMBERS

+600 **VDC ENABLED** TEAM MEMBERS

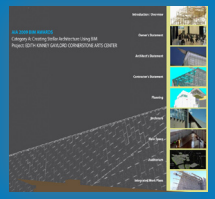
* To learn more about the industry defined VDC Processes adopted by Mortenson Construction, please visit the Penn State BIM Execution Planning Website.

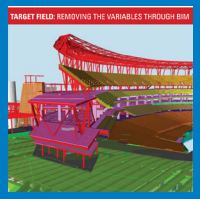






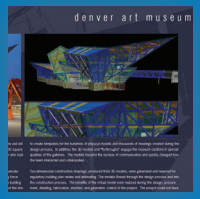










Click on the image thumbnails above to launch each project case study.

VDC PROJECTS

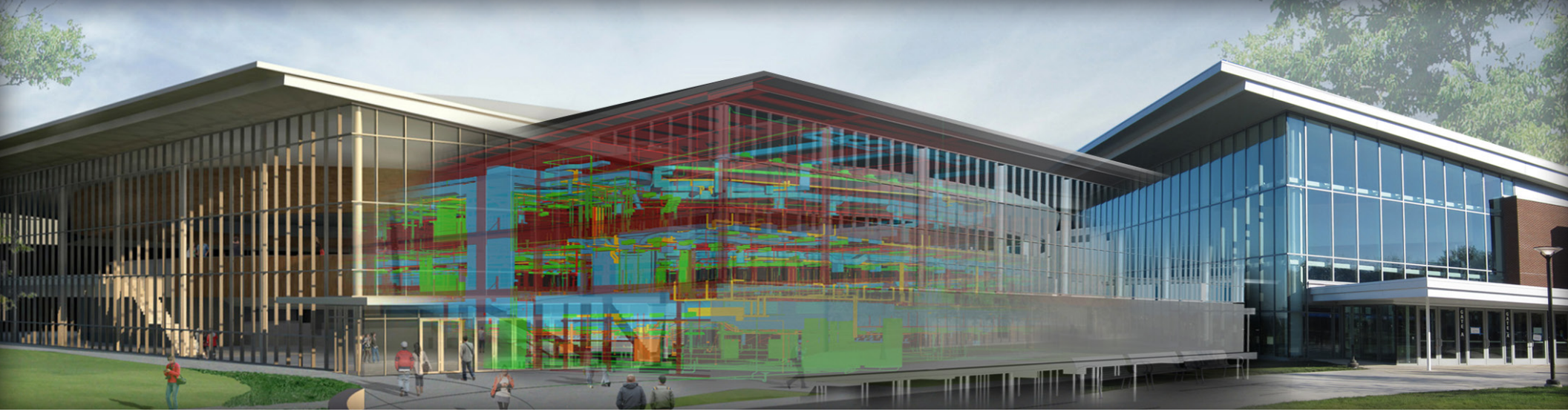
The 18 case studies analyzed for this report utilize the virtual design and construction process, which is designed to be repeatable, continuously improved and innovative. This approach has been shown to be very consistent in driving project cost and schedule down, mitigating unforeseen circumstances and increasing customer satisfaction.

Mortenson has found that certain activities and project characteristics are key performance indicators of a robust VDC investment. The presence of these indicators on a project has proved to be a reliable way to predict a positive return on the investment made in the VDC process.

Typically, this return is realized in the form of value added to the project by reducing schedule and cost, improving construction quality and ensuring customers get the results they expect.

PROJECTS ANALYZED WITH VIRTUAL DESIGN & CONSTRUCTION

Project Name	Completed	Page
Pegula Ice Arena	2013	**8**, 9, **15**, 18
Northwestern Mutual	2013	**7**, 9, 13, 18
Ralph L. Carr Colorado Justice Center	2013	9, **11**, 13, 18, **21**
The Lurie Children's Hospital	2012	18, **21**
Warriors in Transition Barracks	2011	9, 13
Central Washington Hospital	2011	9, **12**, 13, 18
The Replacement Hospital	2011	9, 13, 18
Wisconsin Institutes for Discovery - Madison	2010	13
The Medical Center	2010	13, 18
Showare Arena	2008	9, **17**, 18
Daikin-McQuay Applied Development Center	2009	9, 18
Target Field	2009	**8**, 13
Tulalip Resort Hotel	2008	9, 13, 18, **20**
University of Colorado Denver Health Science Center Research Complex II	2008	9, 13
Edith Kinney Gaylord Cornerstone Arts Center	2008	9, 18
Harley-Davidson Museum	2008	13
Benjamin D. Hall Interdisciplinary Research Building	2006	9, 13,**16**
Denver Art Museum	2006	9, **12**,13, 18



INTEGRATED APPROACH & CONSISTENT PROCESS

Gaining the full benefits of VDC requires committing to the process at the beginning of the project and making sure the process is well leveraged throughout the project's duration.

PRE-PLANNING

Develop a project execution plan to set performance expectations and formalize the process and the people.

- Define customer success factors; engage owner
- Define VDC scope to focus on mitigating project risk
- Ensure project team sets performance measures to gauge success
- Utilize an integrated collaborative delivery approach
- Adoption of BIM is driven by leadership
- Project team defines how BIM will be used to improve communication

DESIGN / PLAN

Improve communication and collaboration through a 3D virtual model to drive early design decisions that could impact downstream construction processes.

- Build trust through a collaborative approach to project challenges
- Utilize model throughout the project to enhance communication
- Engage the customer to improve decision-making processes
- Implement virtual prototyping on high-risk areas of project
- Employ immersive virtual environments to drive properly timed design decisions
- Integrate the right technology platform to support people and processes

CONSTRUCTION

Drive the use of the model into the field by using technology in innovative ways.

- Integrate BIM / VDC into field operations to add value
- Train workforce on technology to support enhanced communication
- Deploy Mobile technology to facilitate project data access and collaboration in the field
- Leverage 4D to drive agility and flexibility into project planning and execution
- Increase certainty through construction system design for self-perform scopes of the work
- Apply digital fabrication and prefabrication strategies
- Leadership support is critical to encourage and drive innovation in the field.

CONTROLLING RISK BY ENHANCING AGILITY

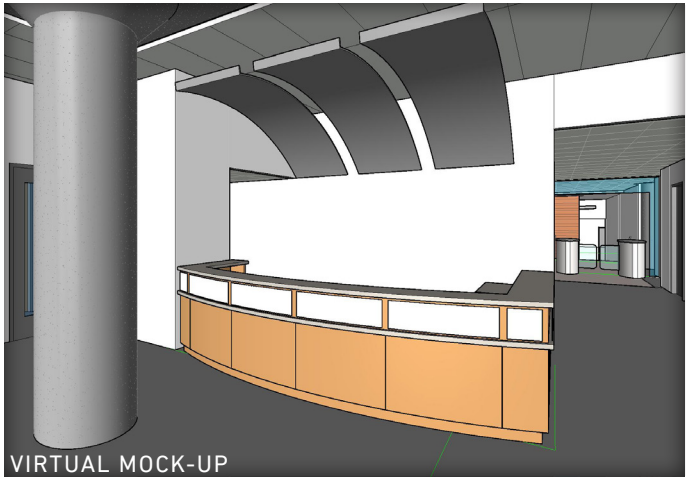
Virtually all construction projects encounter unforeseen circumstances with the potential to delay the project schedule and rapidly increase project cost. Certain VDC activities can enhance flexibility and prepare project teams to quickly address these inevitable problems. Flexible, agile project teams are able to shuffle phasing, schedule and resources to mitigate delays and maintain high productivity levels, ultimately delivering projects on time, if not ahead of schedule.

Traditionally, construction projects have dealt with uncertainty in a reactive way. VDC allows Mortenson to act in a proactive manner, which has been shown to consistently reduce project schedule and cost while improving quality and delivering on our promise to our customers.

NORTHWESTERN MUTUAL

TARGET FIELD

PEGULA ICE ARENA



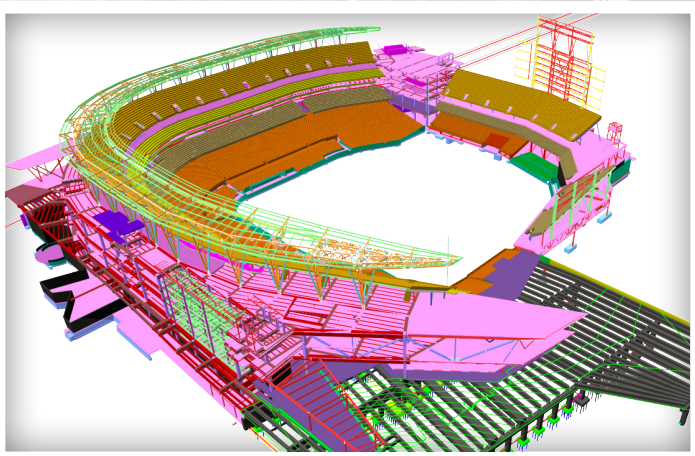
VIRTUAL MOCK-UP

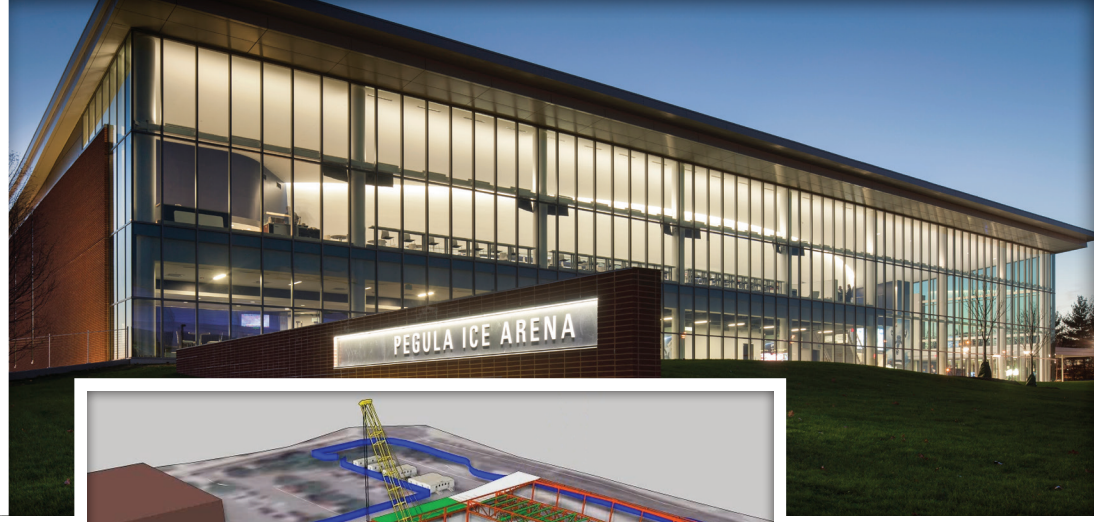
FINAL PHOTOGRAPH

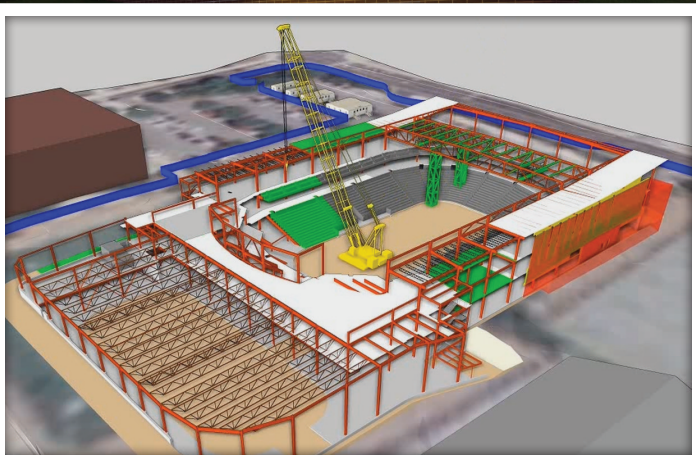
NORTHWESTERN MUTUAL

Before Northwestern Mutual offices were retrofitting into an existing building, Mortenson developed a point cloud model by laser scanning the existing building. Analysis of that model showed the structure was significantly out of square. This process averted large amounts of rework, additional cost and schedule delays. Ultimately the project was delivered more than **$1 million under budget and a month ahead of schedule**.

> **"BIM was a fantastic tool; it allowed us to visually see our new office space prior to construction starting. The original 1920's concrete construction was renovated many times over the years, and few areas were square and plumb. Without laser scans and BIM models, our risk of cost changes would have dramatically increased. The virtual mock-ups proved valuable as we were making final design decisions and ensured the end result would meet our expectations as a 21st Century workplace and be easily maintained. Posting virtual fly-throughs to the internet proved to be a great way to get 6,000+ employees engaged in the construction process. BIM truly impacted our project's success."**
>
> [CUSTOMER STATEMENT]







TARGET FIELD

Phased design with heavy overlap of construction activities typically leads to strained relationships and substantial rework. This is especially true on a job where nearly **one million dollars of work was being put in place per day** by up to 900 workers. Target Field, however, served as a shining example of how total team collaboration can be achieved through use of building information modeling. The best evidence for this was the unprecedented early issuance of a certificate of occupancy, **over three months prior to the contractual substantial completion date**. All parties agree that modeling provided a forum for communication where complex issues could be resolved without impacting critical path activities.

> **"I've never seen a sports facility of this complexity completed this far ahead of time."**
>
> [CUSTOMER STATEMENT]

PEGULA ICE ARENA

While building the Pegula Ice Arena, modeling the complex geological formation below grade resulted in the realization that redesigning both the foundation and the work sequence was necessary. A 4D model was utilized to analyze possible options and to communicate their schedule impacts to the customer. Optimizing the solution for this problem **saved the customer $260,000 and took 30 days off the schedule**.

> **"Given our experience with various BIM techniques and technologies over the past six years, selecting an innovative Pegula Ice Arena project team at the forefront of BIM technology was vital to the project delivery."**
>
> [CUSTOMER STATEMENT]

600 DAYS

DIRECT SCHEDULE REDUCTIONS*

32 DAYS AVERAGE SCHEDULE REDUCTION

MOST SIGNIFICANT PROCESSES:

- **Phase Planning (Macro 4D)**
- **Digital Fabrication / Prefabrication**
- **3D Coordination**
- **Construction System Design**

PHASE PLANNING (MACRO 4D)

University of Colorado Denver Health Science Research Complex II	4D was used to avoid field conflicts between subcontractors scheduled to work
Benjamin D. Hall Interdisciplinary Research Building	Decisions made from 4D simulations helped the project be completed 40% faster
Showare Arena	30-day schedule delay mitigated by 4D simulation re-sequencing construction activities
Ralph L. Carr Colorado Justice Center	Two months saved on project schedule by utilizing highly-detailed micro-level 4D simulations for critical project components
The Replacement Hospital	Significant schedule loss avoided due to 4D simulation identifying steel erection sequence error
Pegula Ice Arena	Saved 30 days in project schedule

EXISTING CONDITIONS MODELING

Northwestern Mutual

3D COORDINATION

Edith Kinney Gaylord Cornerstone Arts Center	16 week delay averted for both contractor and subs
Denver Art Museum	Steel erection completed three months early
Showare Arena	Time saved by identifying issues: 18 days (steel), 11 days (column wrap), 7.5 days (catwalk/duct work clashes)
Daikin-Mcquay Applied Development Center	Four weeks saved by resolving 2,600 clashes, six weeks saved with general collaborative sessions

CONSTRUCTION SYSTEM DESIGN

Tulalip Resort Hotel	Structural schedule completed six weeks early
Showare Arena	13 days saved by identifying issue with ice slab header trench
Ralph L. Carr Colorado Justice Center	17% reduction in elevator core schedule, facilitated by lift drawings
The Replacement Hospital	Concrete lift drawings reduced concrete schedule by 79%

SITE ANALYSIS

Pegula Ice Arena

University of Colorado Denver Health Science Research Complex II

Benjamin D. Hall Interdisciplinary Research Building

3D CONTROL & PLANNING

Denver Art Museum

Ralph L. Carr Colorado Justice Center

Central Washington Hospital

DIGITAL FABRICATION / PREFABRICATION

University of Colorado Denver Health Science Research Complex II	50% reduction in schedule for mechanical subcontractor
Daikin-McQuay Applied Development Center	Prefab prevented a five-week delay
Northwestern Mutual	10% overall schedule savings from prefabrication; 2,500 hours (20%) saved by prefabricating plumbing and piping
Pegula Ice Arena	Five weeks saved by simplifying submittal process and obtaining right-to-rely on BIM
Central Washington Hospital	Prefabricating headwalls saved 18% in man hours, four weeks on interior rough-in and three weeks on casework; prefabricating exterior framing, sheathing and moisture barriers saved six weeks on the exterior enclosure schedule
Warriors in Transition Barracks	Pre-Assembled Roof Truss and Deck sections strategy reduced overall project schedule that led to a 14% faster project delivery

*Quantified days saved. Time savings that were un-quantified are not included, though they were significant.

IMPROVING QUALITY WITH DIGITAL PROTOTYPING

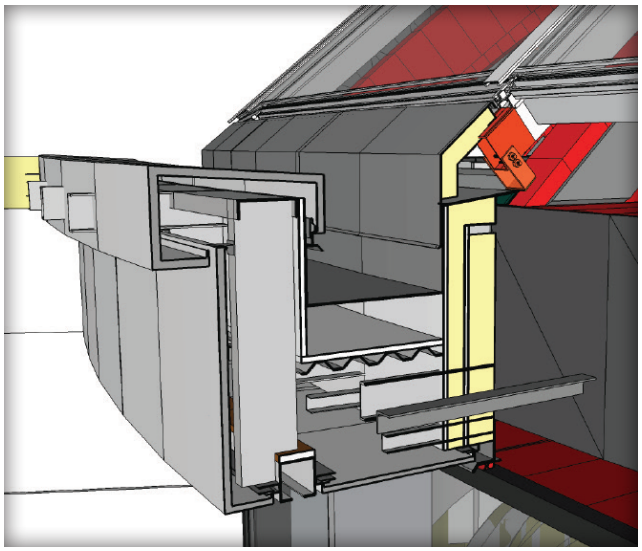
Because each construction project is unique, problems with constructability and detailing are common. Traditionally, this uncertainty has been addressed in the field with limited information, or else by physical mock-ups, where especially complex or critical conditions are worked out before being implemented on the actual project. Both of these approaches are problematic; the first makes it difficult to understand how seemingly small decisions may have a significant impact on the project. The second approach is effective, but time intensive and costly, usually being deployed only a handful of times on each project.

Mortenson has integrated lessons learned by the automotive, aerospace and manufacturing industries and has concluded that developing complete, detailed virtual prototypes is an effective way to test assembly strategies. Since implementing this strategy, Mortenson has repeatedly improved the certainty of outcomes and consistently reduced the inherent risk of construction activities with the help of virtual prototyping.

RALPH L. CARR COLORADO JUSTICE CENTER

DENVER ART MUSEUM

CENTRAL WASHINGTON HOSPITAL

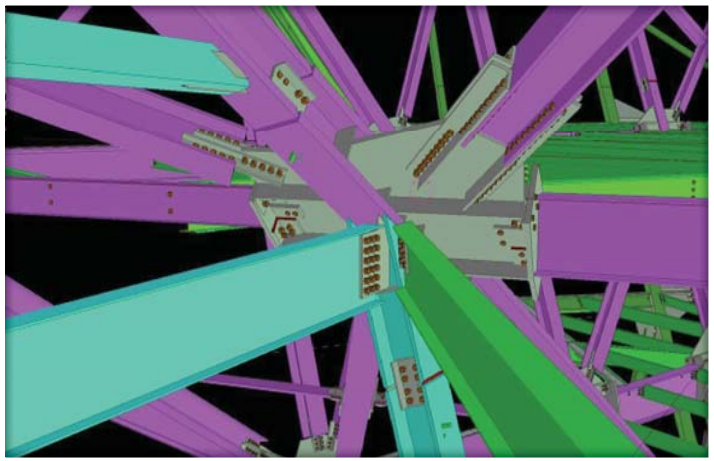


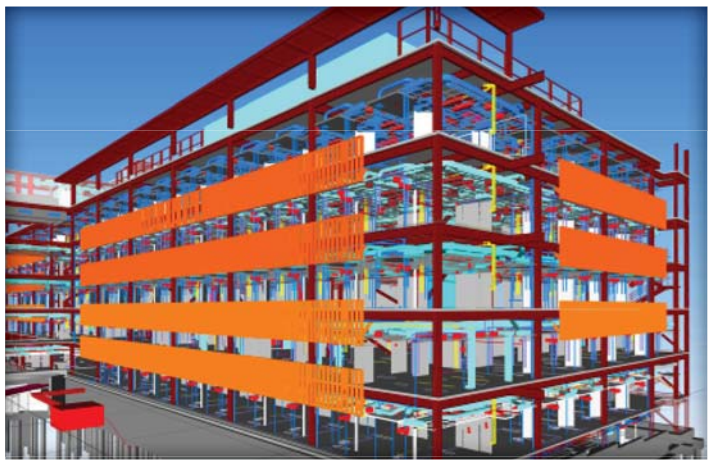
RALPH L. CARR COLORADO JUSTICE CENTER

The team delivered design intent through highly detailed 3D virtual mock-ups and holistic building enclosure coordination, which reduced project risk and cost of delivery by averting the potential for late and costly design clarifications. By virtually expediting and communicating key detail finalization, rework on the exterior skin was virtually eliminated, and additional costs typically associated with detail modifications during fabrication or installation were avoided. This played a crucial role in **averting an estimated $2,440,000 in rework costs**.

"Of particular note is the advances in technology and integration of BIM with a majority of the subcontractors. Coordination was significantly enhanced and field issues minimized as a result. The high standards for quality and conscientiousness has been unparalleled in my 30 years of experience. It has been a sincere pleasure and honor to be on this team."

[ARCHITECT STATEMENT]





DENVER ART MUSEUM

Mortenson **saved the Denver Art Museum $400,000** by resolving over 1,200 clashes before the steel arrived and **erecting the steel three months early**.

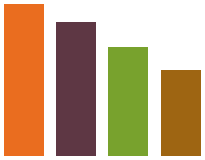
> **"Faced with the challenge of this buildings' complex geometry, we clearly had no choice but to exploit the computer's ability to calculate, graphically portray, and communicate the critical geometries of this building. What we did not realize, however, was how valuable the three-dimensional model would become as a tool for effective multi-disciplinary collaboration, not only among the design team, but ultimately also with the constructors."**
>
> [ARCHITECT STATEMENT]

CENTRAL WASHINGTON HOSPITAL

Virtual mock-up showing all layers of building enclosure including exterior framing, insulation, vapor barriers, brick and curtain wall window system used to coordinate entire enclosure with the end goal of eliminating conflicts and RFI's. This model was then used with the trades for greater understanding of installation and aided in schedule certainty.

By including the building envelope and all MEP systems in the model, it was possible to prefabricate the enclosure of the building. **Overall, prefabricating exterior framing saved six weeks on the exterior framing schedule**.

25% AND GREATER
PRODUCTIVITY INCREASES*



MOST SIGNIFICANT PROCESSES:

- **3D Coordination**
- **Construction System Design**
- **Design Review**
- **Digital Fabrication / Prefabrication**

EXISTING CONDITIONS MODELING

Northwestern Mutual	
Target Field	

DESIGN REVIEW

Research Complex II	VDC review of design resulted in the reduction of construction RFI's by 74% during the foundation phase and by 47% during the steel erection phase
Northwestern Mutual	Customer Design Finalization through Virtual mock-up led to early system coordination, higher efficiency during installation and zero rework
Benjamin D. Hall Interdisciplinary Research Building	The reduction in rework contributed toward over 162,000 hours without a single lost time incident

3D COORDINATION

Wisconsin Institutes for Discovery	30% of construction waste avoided
Warriors in Transition Barracks	35% Reduction in Landfill waste through effective coordination
Target Field	BIM used for coordination and review of over 3,000 tons of steel, reducing need for traditional 2D shop drawings
Harley-Davidson Museum	3D model provided cost and time savings through eliminating rework in the field. BIM use benefited prefabrication and early coordination thus maximizing construction efficiency.
Central Washington Hospital	BIM coordination facilitated 50% reduction in RFI's compared to past projects

CONSTRUCTION SYSTEM DESIGN

Tulalip Resort Hotel	Increased production rate of shear walls by 26%; iron workers decreased installation time of stud rails by 20%; concrete structure man hours reduced by 22%
Ralph L. Carr Colorado Justice Center	Lift drawings increased elevator core productivity by 235% (forming) and 250% (embed)
The Replacement Hospital	Concrete lift drawings produced for parking structure increased production by 79%
The Medical Center	Concrete lift drawings drastically improved productivity during concrete installation while minimizing rework that led to a incredible 23 month project completion

MODEL-BASED ESTIMATING

Pegula Ice Arena	

SITE ANALYSIS

Target Field	

DIGITAL FABRICATION / PREFABRICATION

Ralph L. Carr Colorado Justice Center	25% of mechanical work shifted to prefab facility
Warriors in Transition Barracks	Prefabrication strategies led to a reduction in punch-list process by 50%
Benjamin D. Hall Interdisciplinary Research Building	Prefabrication enabled a reduction of field labor and construction time with high-quality results

3D CONTROL & PLANNING

Denver Art Museum	
Target Field	

*Quantified productivity improvements. Productivity improvements that were un-quantified are not included, though they were significant.

ENHANCED DECISION-MAKING

Customers must make many decisions during the design and construction phase of their project, and effective communication is necessary for success. Reliably presenting customers with accurate, digestible information is critical to ensure those decisions are well informed and timely. By using virtual models for visualization rather than the tradition process of having customers make decisions based on arcane and abstract 2D drawings, Mortenson dramatically improves results.

Through extensive use of virtual models as a communication tool, Mortenson customers are more confident in their decisions – which also leads to time and money savings in the overall design and construction process. Mortenson continues to innovate in this arena, investing in emerging technologies such as immersive virtual reality. This allows customers to intuitively experience and respond to their projects before they are built.

PEGULA ICE ARENA

BDH INTERDISCIPLINARY RESEARCH BUILDING

SHOWARE CENTER

PEGULA ICE ARENA

Mortenson used immersive virtual walkthroughs extensively to evaluate sight lines, office configurations, lighting locations, site signage and many other design elements prior to construction of the Pegula Ice Arena. Changes made as a result of this **directly saved the project $475,000**.

During a fully immersive virtual walkthrough, the project team were able to focus on specific areas with the coaches and athletes, such as the locker rooms, offices, and suites which ensured scope and layout of these spaces met and exceeded expectations well in advance of construction.

> **"Team members were able to use BIM in design presentations, allowing real-time input and visualization by the client; as well as being used to create accurate representations of the final construction, in a variety of mediums including virtual environments, that enabled the Client to make informed decisions."**
>
> [ARCHITECT STATEMENT]

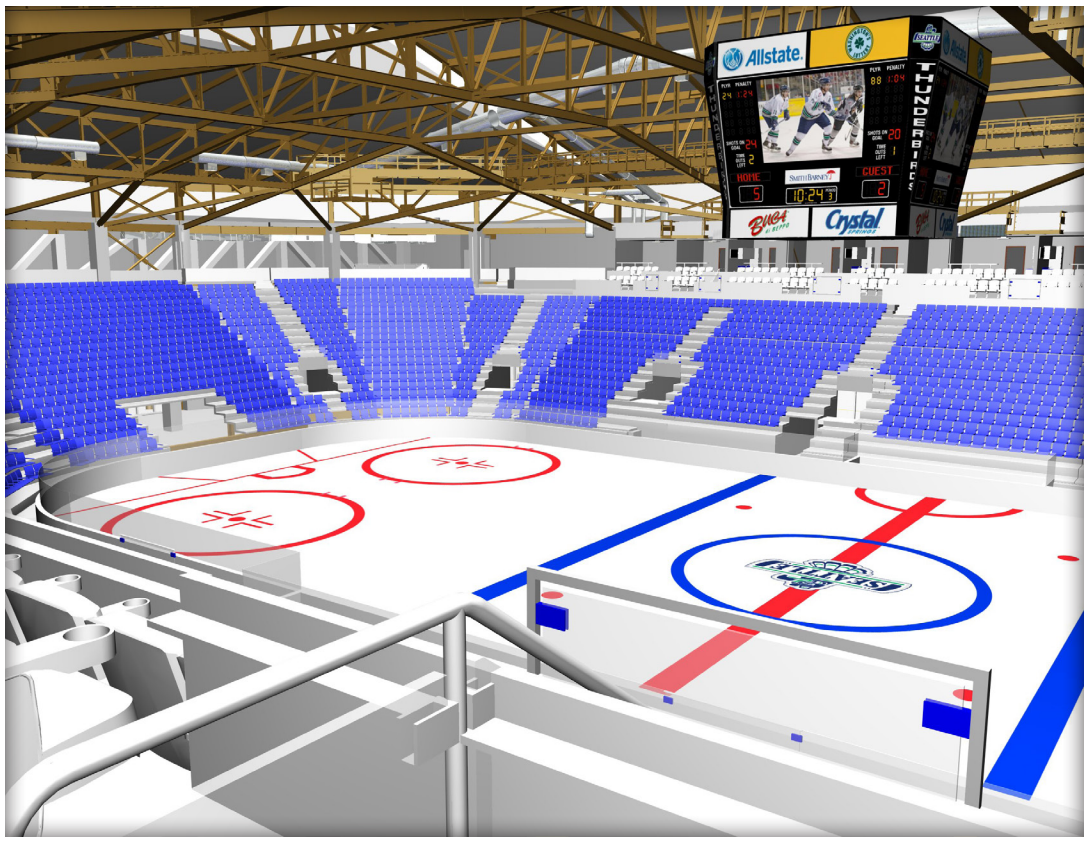
> **"Drawings are two-dimensional, so it gave us kind of a first step feel of how the arena was going to look. The CAVE experience gets you more excited, and it gets you thinking differently on the usage of the facility."**
>
> [CUSTOMER STATEMENT]

BDH INTERDISCIPLINARY RESEARCH BUILDING

During the conceptual design phase, the DBOM* team proposed a project with a tight floor-to-floor height and an extra floor in the building, providing **14% more leasable floor area** than was requested. They analyzed and established this concept with the 3D model, which addressed the owner's concerns with the team's approach and gave them the confidence to select the proposal.

> **"The DBOM approach challenged traditional design and construction methods, and fostered innovation with new technologies. Nothing illustrates this more dramatically than the project team's dedication to BIM, and its exhaustive application towards every aspect of design and construction."**
>
> [CUSTOMER STATEMENT]

*Design Build Operate Maintain



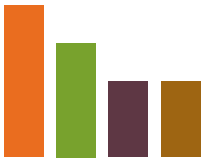
SHOWARE CENTER

With some photorealistic enhancements to design/construction BIM, the "marketing model" was used to virtually "fly" potential suite patrons, advertisers and season ticket holders through the virtual building and show realistic views from any suite, seat and advertising location in the arena.

By using the model to give potential suite and season ticket owners a realistic view, **25% of suites and seats were sold before they were even built** at the ShoWare Center.

> **"The model provided our sales team with something tangible to show perspective suite owners and advertisers. We were also able to show a video created from the model of the ShoWare Center during hockey games in our former arena. Invaluable."**
>
> [CUSTOMER STATEMENT]

2.95% AVERAGE
DIRECT COST REDUCTIONS*



MOST SIGNIFICANT PROCESSES:

- **3D Coordination**
- **Design Review**
- **Construction System Design**
- **Digital Fabrication / Prefabrication**

EXISTING CONDITIONS MODELING

Northwestern Mutual

PHASE PLANNING (MACRO 4D)

The Replacement Hospital

DESIGN REVIEW

Ralph L. Carr Colorado Justice Center	$755,000 averted by reviewing design details
Pegula Ice Arena	$475,000 averted by using a CAVE environment to review design elements
Showare Arena	Model assisted marketing team in selling 25% of season tickets before construction
Central Washington Hospital	$120,000 in enclosure and structural costs was averted by modeling a "standard worst case scenario" on the upper patient floor
The Replacement Hospital	Virtual mock-ups reduced need for multiple physical models to one; virtual interior mock-ups accelerated approvals for spaces

CONSTRUCTION SYSTEM DESIGN

Denver Art Museum	Concrete lift drawings prevented coordination issues and costly job site conditions
Showare Arena	$32,000 saved by identifying issue with ice slab header trench
Ralph L. Carr Colorado Justice Center	$120,000 saved by using lift drawings to get 100% of all 2,242 steel embeds in the CIP elevator cores on the first attempt
The Medical Center	Concrete lift drawings reduced cost of concrete work by $200,000-$225,000

SITE ANALYSIS

Pegula Ice Arena

3D COORDINATION

Tulalip Resort Hotel	234 dimensional conflicts, three major structural issues and over 2,500 MEP clashes were resolved
Edith Kinney Gaylord Cornerstone Arts Center	$90,000 saved through pre-construction 3D coordination
Denver Art Museum	$400,000 saved in Steel Scope by 3D coordination
Showare Arena	Cost savings by identifying issues: $153,540 (steel), $27,500 (column wrap), $31,400 (catwalk/duct work clashes)
Ralph L. Carr Colorado Justice Center	$2,440,000 averted by clarifying 60% of envelope design early
Pegula Ice Arena	$161,000 saved by improving coordination
Central Washington Hospital	Project completed $7 million under budget, significantly due to BIM coordination

SITE UTILIZATION PLANNING

Pegula Ice Arena	Utilization planning led to $200,000 savings

DIGITAL FABRICATION / PREFABRICATION

Daikin-Mcquay Applied Development Center	$370,000 in prefab savings
The Lurie's Children's Hospital	Med gas used prefab to beat estimate by 35%; hydronic copper prefab pipe beat estimate by 15% (floors 3-9) and 51% (floors 15-16)
Pegula Ice Arena	$100,000 averted by simplifying submittal process and obtaining right-to-rely on BIM
Northwestern Mutual	$20,000 in prefab savings

3D CONTROL & PLANNING

The Medical Center

*Quantified money saved. Nine of eighteen projects had quantified results.
Cost savings that were un-quantified are not included, though they were significant (e.g. Central Western Hospital).

THE LAST 100 FEET®

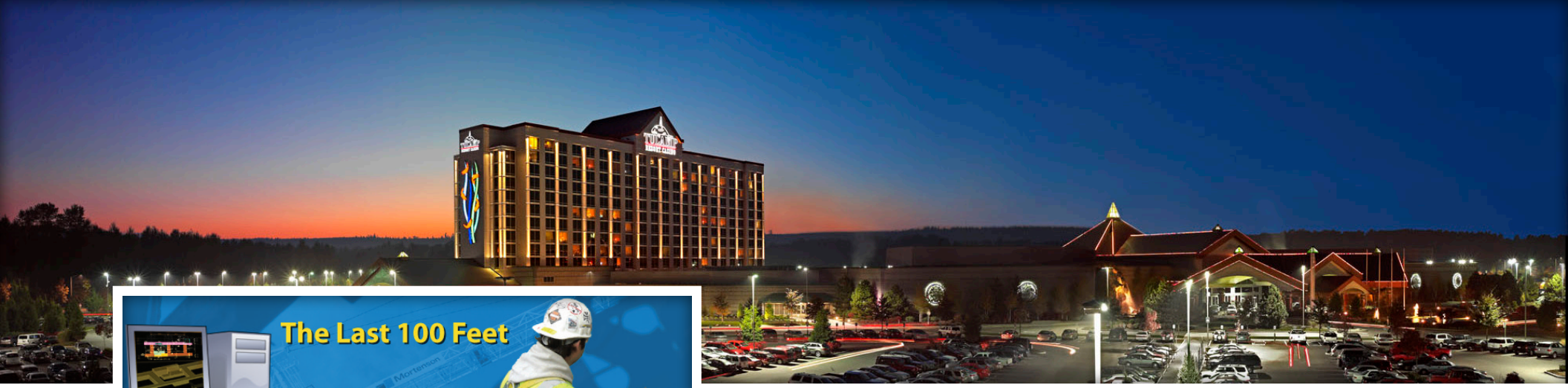
All the effort invested into communication, virtual prototyping and proactive planning can be wasted if the decisions made from those processes are not effectively integrated at the job site. Mortenson is committed to continuously improving the flow of information to and from all project team members.

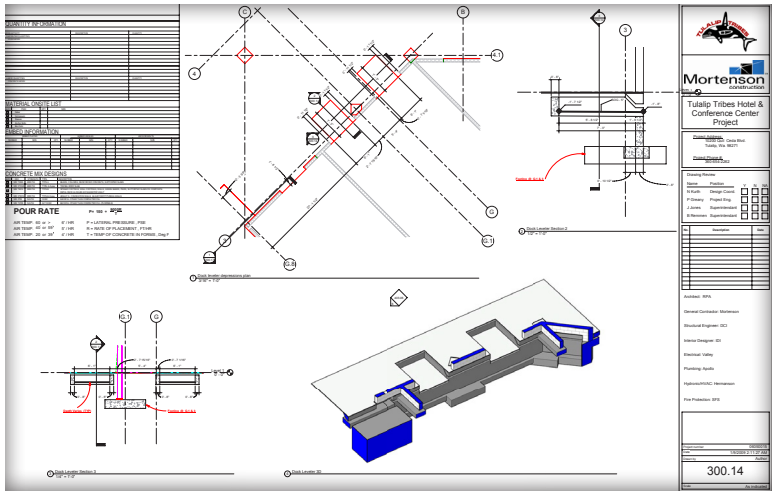
Taking VDC the last 100 feet has proven many times to save considerably on the time and cost of projects. In our experience, it dramatically reduces mistakes, rework and time wasted in numerous trips back to the trailer to search each drawing for the information needed.

TULALIP RESORT HOTEL

RALPH L. CARR COLORADO JUSTICE CENTER

THE CHILDREN'S HOSPITAL



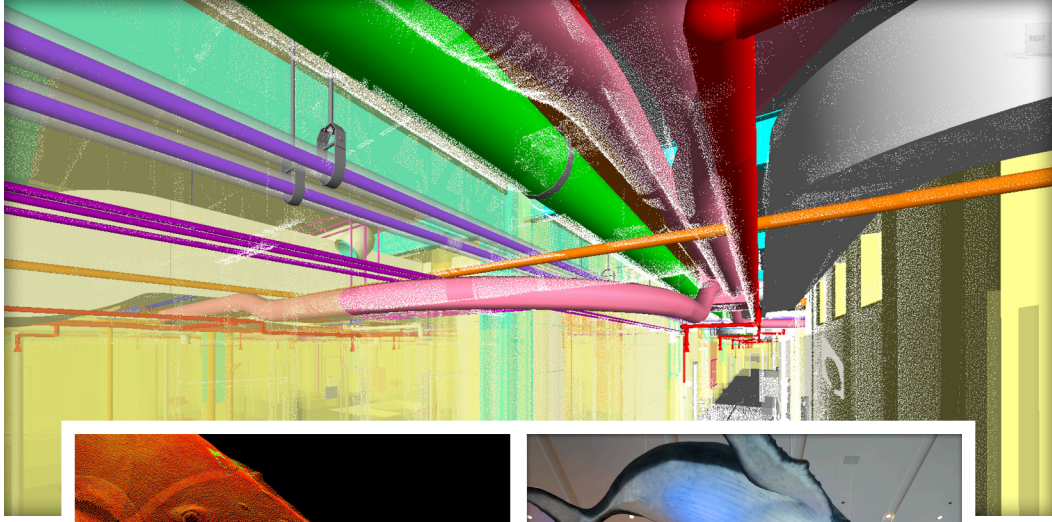


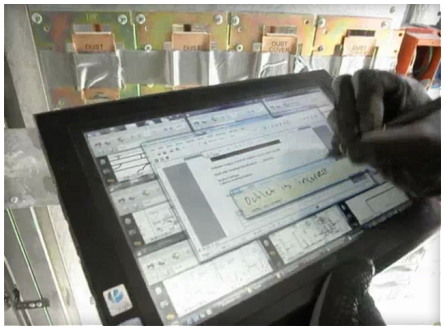
TULALIP RESORT HOTEL

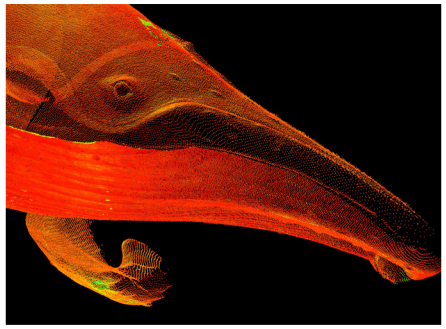
An integrated work plan clearly defined the scope of work and provided all necessary information to complete it. It combined 2D drawings, which are useful for layout, with an axonometric view of the scope, helping the workers understand what the finished product should look like and what the most efficient sequence of steps would be. This focus on communication resulted in just one RFI per $127,400 of work in place, compared to an average of one RFI per $37,135 of work in non-BIM projects.

> **"Our hotel was completed on time and on budget. Working with Mortenson, who has a firm understanding of the practical application of technology available, made this a successful project. There is no doubt in my mind that we would not be where we are today if the team had not effectively and expertly implemented BIM."**

[CUSTOMER STATEMENT]







RALPH L. CARR COLORADO JUSTICE CENTER

Efficiently connecting field personnel with the right information at the right time is a major challenge, especially with the enhanced reliance upon BIM for this project. Remote access to the model became the solution. Touch screen plan room computer interfaces and tablets all but replaced paper drawings in the project site office, **reducing printing costs by over 50%**. All models and plans were uploaded and all details were linked electronically to speed access.

> **"BIM coordination between design team and construction groups has been exceptional. We expect the modeling information will be equally valuable for ongoing facilities management use."**

[CUSTOMER STATEMENT]

LURIE CHILDREN'S HOSPITAL

At the Children's Hospital, our industry leading approach with the use of VDC in the field enabled us to be more efficient; ensured that everything was installed where and how it was supposed to be; eliminated rework; and provided world-class results. Using BIM in the field was a driver for the success of the Children's Hospital construction and kept workers updated with the latest information. Laser scans of the MEP systems allowed Mortenson to measure the delta between the digital prototype and the installed work.

> **"The project involved more than 800 individuals and its success was due, in large part, to Building Information Modeling."**

[CUSTOMER STATEMENT]

PARTNER ACKNOWLEDGEMENT

The 18 projects were successful through an effective collaborative team approach. The design and construction partners listed below contributed to the BIM/VDC processes for the case study projects.

ARCHITECTURE

Albert Khan Associates, Inc.
Anderson Mason Dale Architects
Anderson Mikos Architects,Ltd.
Antoine Predock Architects
Ballinger
Bohlin Cywinski Jackson
CollinsWoerman
Crawford Architects
Davis Partnership Architects
DLR Group
Eppstein Uhen Architects
Fentress Architects
HDR Architecture
HGA Architects & Engineers
Kahler Slater Architects
Kling Stubbins
LMN Architects
PBK Architects
Pentagram Architecture
Populous
Ruhl-Parr/Moran Architects
Solomon Cordwell Buenz
Studio Daniel Libeskind
StudioINSITE
TranSystems Corp.
URS
Uihlein Wilson Architects
ZGF Architects

ENGINEERING

Affiliated Engineers, Inc.
AHBL
BCER Engineering
Cator, Ruma & Assoc.
CDiEngineers
DCI Engineers
GRAEF Graef, Anhalt, Schoemer
KJWW Engineering Consultants
Magnusson Klemencic Assoc.
Martin Schrieber and Assoc., Inc.
Martin/Martin Consulting Engineers
Martino & Luth, Inc.
MBJ Consulting Structural Engineers
MEE Eningeers
MKK Consulting Engineers, Inc.
Pierce Engineers, Inc.
Ring & DuChateau, Inc.
RMH Group
S A Miro, Inc.
Seneca Group
Sparling
The Ballard Group
Theakston Environmental
Thomas Tormasetti
Walter P Moore
Wood Harbinger Inc.

CONSTRUCTION

AAA Waterproofing
Ahern Fire Protection
Allied Steel
Apollo Sheet Metal
Belonger Corp.
Bob Biter Electric
Cives Steel Co.
ColonialWebb Contractors
CSE Construction Supply & Erection
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East Coast Fire Protection
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Hanson Structural Precast
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Hunt Electric
Ice Builders
Illingworth-Kilgust Mechanical
J&B Electric
Leffler Group
LPR Construction Co.
McKinstry Company
Merrill Iron & Steel, Inc.
Metropolitan Mechanical
MG McGrath Inc.
Mortenson Construction
Newmech
New World Millworks
Newcrete Products
Parsons
Pieper Electric
RK Mechanical
S.A. Comunale
Sasco
Staff Electric
Sturgeon Electric
Swisslog
The Farfield Co.
The Gallegos Corporation
Trainor Glass Company
Tweet Garot
US Engineering Co.
Valley Electric
Viking Automatic Sprinkler Co.
Waukegan Steel
Western States Fire Protection
Westphal Electric
Zalk Josephs
Zimmerman Metals Inc

BIM/VDC

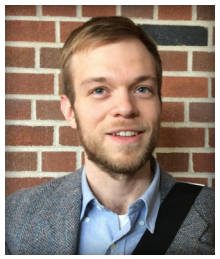
Listed below are the contributing Technology platforms used to in supporting our projects, process and people.

TECHNOLOGY PLATFORMS

AGTECH Earthwork 4D
ANSYS Fluent
Autodesk 3DMax
Autodesk AutoCAD Products
Autodesk BIM 360 Field
Autodesk BIM 360 Glue
Autodesk CADmep
Autodesk CAMDuct
Autodesk Civil 3D
Autodesk Navisworks Products
Autodesk Point Layout
Autodesk Revit Products
AutoSprink
Beck Dprofiler
Bentley MicroStation
Bluebeam Revu
EastCoast CADCAM Solutions
Faro Scan Scene
FormZ
Google Earth Pro
Graphisoft ArchiCAD
Innovaya
Lumion3D
ProjectConnect®
Rhino3D
SightSpace 3D
Synchro 4D
Trimbe Tekla BIMSight
Trimbe Tekla Structures
Trimble QuickPen 3D
Trimble SketchUp Pro
Unity Game Engine

RESEARCH PARTNERS

This study was completed as part of a research consortium between the University of Minnesota and Mortenson Construction, the Master of Science in Architecture Research Practices (MS-RP) program. For further information regarding this study or the MS-RP program, please contact the following individuals:



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SCHOOL OF ARCHITECTURE
UNIVERSITY OF MINNESOTA

VDC REGIONAL PROFESSIONALS

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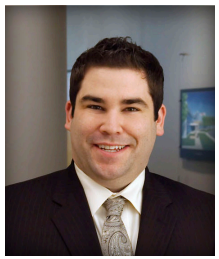

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