

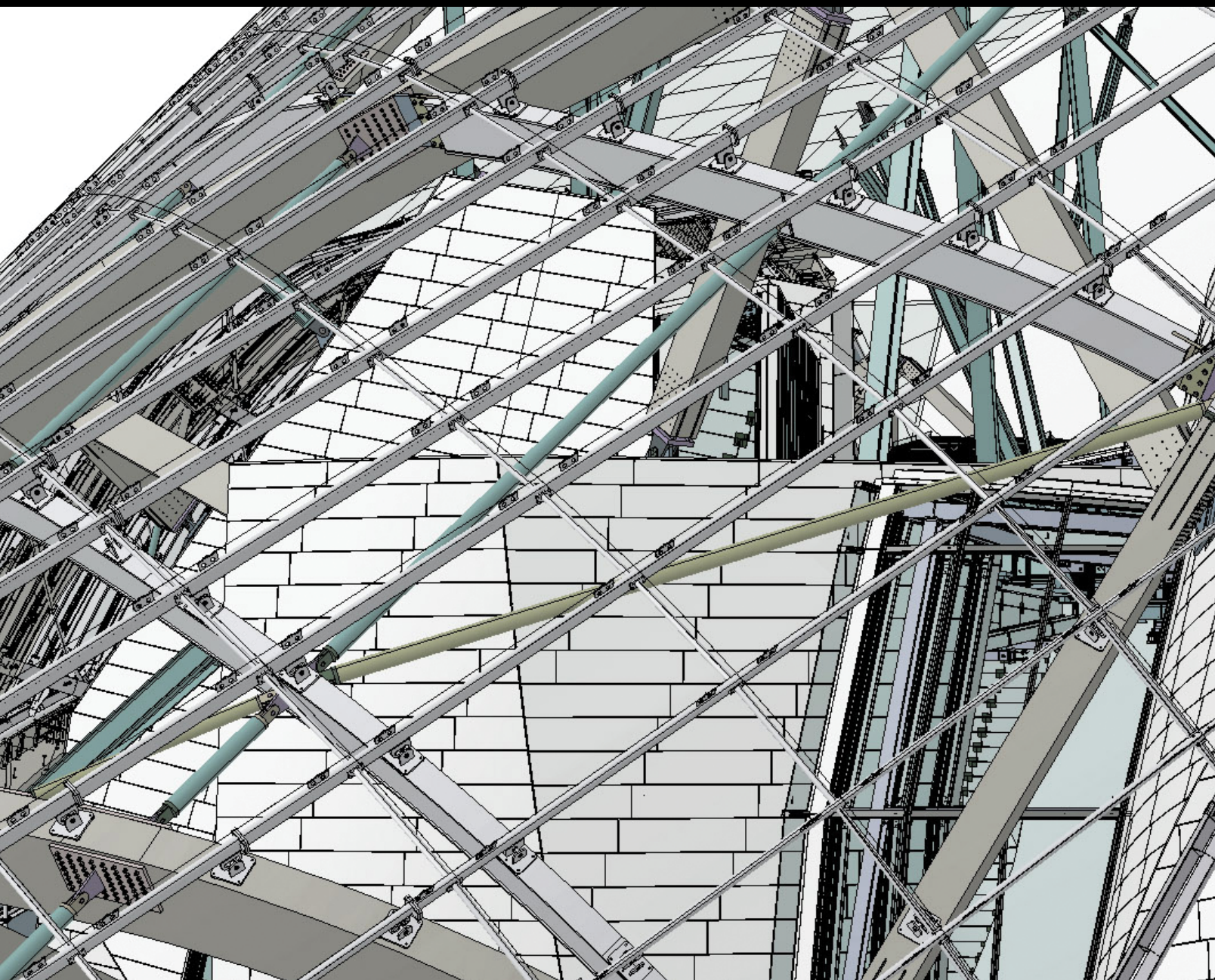
# JBIM

## Journal of Building Information Modeling

An official publication of the National Institute of Building Sciences  
buildingSMART alliance™

*National Institute of Building Sciences: An Authoritative Source of Innovative Solutions for the Built Environment*

Fall 2012



# **BIM Really Can Be a Team Sport**



# JBIM

## Published For:

The National Institute of Building Sciences  
buildingSMART alliance™  
1090 Vermont Avenue, NW, Suite 700  
Washington, D.C. 20005-4905  
Phone: (202) 289-7800  
Fax: (202) 289-1092  
nibs@nibs.org  
www.nibs.org

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### MATRIX GROUP PUBLISHING INC.

Please return all undeliverable addresses to:  
5190 Neil Road, Suite 430  
Reno, NV 89502  
Phone: (866) 999-1299  
Fax: (866) 244-2544

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Jessica Potter  
jpotter@matrixgroupinc.net

## PUBLISHER

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## EDITOR-IN-CHIEF

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ssavory@matrixgroupinc.net

## EDITOR

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## FINANCE/ACCOUNTING & ADMINISTRATION

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## LAYOUT & DESIGN

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**On the cover:** The Fondation Louis Vuitton, a new art museum in Paris, is pushing the limits of BIM technology and demonstrates how BIM, enabled by a cloud-based file management and project collaboration platform, can help large distributed teams work together. The 3D cover image, produced by Digital Project™, shows the façade of the Fondation Louis Vuitton.

# Augmented Reality: Bringing BIM To Life

By David Wilcox, Marvin Johnson and Peter Carrato

## REALITY

Since the term was first coined in 1990 at Boeing<sup>1</sup>, augmented reality (AR) had remained a research or mostly military application. Over the last 10 years, though, the automotive industry has become a leader in the development of AR for factory planning exercises<sup>2</sup>, with more powerful laptops that allow users to view changes live in the context of their immediate surroundings. It is only in the last few years, however, with the explosion of the use of mobile devices and a similar growth in information-rich building information modeling (BIM), that AR has reached the construction site. AR permits viewing the design, construction or operational information where it's needed: on location.

AR differs from virtual reality in that it enhances rather than replaces the real world. What is augmented on a construction project? Mostly the visual environment—seeing the future (what is not yet built), seeing what's hidden (buried) and seeing what cannot be seen

(alignments, kinematic envelopes). Also, additional data associated with the assets can be accessed where it is linked to the graphic elements.

The Bechtel team on the Reading Station Area Redevelopment Project (RSAR), a part of the Crossrail project (Europe's biggest engineering project), is deploying AR to give live access to the BIM information in the field (**FIGURE 1**). One of the key drivers is to improve the efficiency and safety of field personnel. Having BIM data accessible for decision making at the site maximizes their field presence, which is the most effective way to create a safer site. The ability of AR to “see” what is hidden, such as buried services, will play a vital role in avoiding cable strikes and similar incidents.

## AUGMENTING BIM

AR is a computer vision technique that aligns data, relative to a current video frame, at the correct perspective relative to the users' viewpoint, utilizing the mobile

device's built-in camera, compass, GPS and accelerometer, thereby allowing additional data to be accurately laid over the view through the device.

The process starts with extracting the information and geometry data from the existing project's BIM and combining this to create AR content in the format required for the display media. Once on site, the AR model is registered to its real-world position using one of three available methods:

1. GPS positioning is limited by the mobile device's capability and cannot yet be used for centimeter accuracy. It is, therefore, limited to more generalized location-based uses, until the mobile devices are equipped to access more accurate positioning data from survey rovers.
2. Marker positioning systems, typically used in the automotive industry and referred to as fiducial markers, offer a more accurate method. These specially encrypted and unique markers, when combined with a camera calibration process, employ computer vision techniques to understand the focal position, orientation and current video frame perspective to accurately display the content.
3. Gravity-based alignments utilize feature-rich imagery, such as buildings and a device's accelerometer, to recognise the direction of gravity and provide better calibrated models.

Using BIM exchange formats (Industry Foundation Classes, ifcXML, CityGML and gbXML), workflows include assigning meta-data to AR graphics, which, in turn, call up database links into asset information. An important consideration in adopting AR technology on RSAR was to go beyond simple model graphic



Figure 1. An AR device view of a proposed platform canopy.

displays relative to a known position so that the technology would supplement the information the users have for their task. It was also decided that AR should extend the BIM process, in that data should not only be retrieved from the model but also allow for two-way transfer to record site data.

The new Augmented Reality Experience Language (AREL)-formatted AR systems are able to combine IFC standard (ISO16730) compliant building models into the process so that each asset is recognised within the AR media display device. When data is accessed from project cloud servers, site teams can retrieve and visualize potentially unlimited project data based on position.

## AUGMENTED REALITY

One of the RSAR requirements is to provide site teams with 4D simulations of construction sequences at stage gate reviews. This has been a desktop exercise but now AR has achieved viewing of the 4D sequence in the field.

At Reading Station, a new 98 ft. x 164 ft. transfer deck is being constructed spanning four new rail platforms and 10 existing operational platforms (**FIGURE 2**). The proposed launch sequence for the transfer deck has 10 stages, with the main section being moved 36.7 ft. into position using hydraulic pistons in the first stage alone and over 160 ft. in total during subsequent moves. The 4D simulation was converted to AR format while practical and safe locations from which to view it were identified at the site. Given the scale of the transfer deck a totally immersive AR environment was not possible, but three vantage points were selected relative to magnetic markers that would correctly align the BIM model to the existing construction, balancing the requirements for deploying AR in terms of viewing from a position of safety while providing maximum effect and usability. The live results were captured on video as an aid for contractors to review to understand the launch sequence.

In the rail industry, access for maintenance staff to site data, such as line speed and safe access routes, is a prime concern for network management companies, particularly for safety-critical data that changes regularly. Visualizing

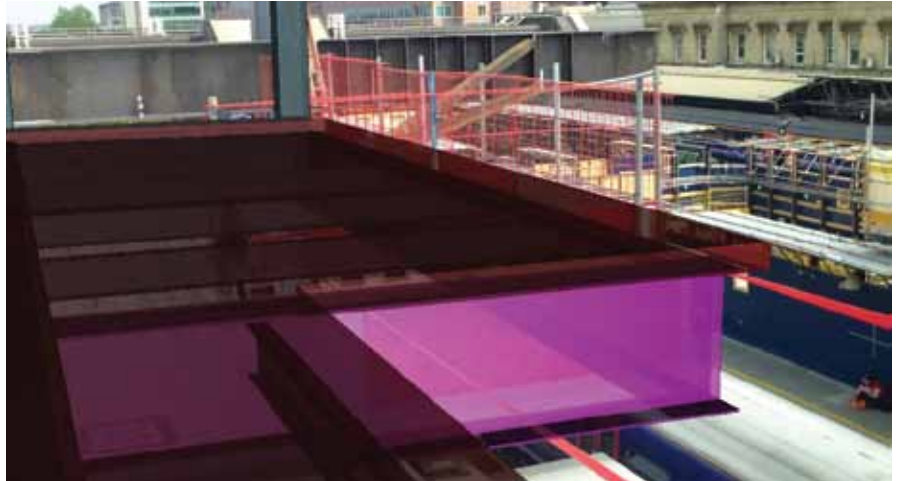


Figure 2. An AR device view of the Reading Station transfer deck.

this data in relation to their position would reduce the amount of paperwork carried by staff, assist with their maintenance regimes and provide assurance that the information is current. As part of this initiative, AR applications have been tested for iPhones that display local hazard directory information over three miles. This data is presented as local points of interest “bubbles” in the camera view, with accuracy of 16 to 32 ft., relative to the users GPS position.

## AUGMENTING THE FUTURE

AR offers great possibilities to visualise 3D data but combining it with BIM data and using it throughout the project life cycle maximizes the impact and benefit to engineering, construction and maintenance. It allows them to view feasibility design in-situ using increasingly accurate positioning methods, assists construction with 4D simulations and clash detections, and can be used as a tool for visual asset management data and recording in the field. Bechtel is actively

introducing innovative deployments of AR as part of its BIM and mobile applications strategy. ■

*David Wilcox is Building Information Modeling Lead for Bechtel Civil. Marvin Johnson is Engineering Data Specialist for Bechtel Civil. Peter Carrato is Manager of Building Information Modeling, Bechtel Corporation.*

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# BIM for Construction Safety: A Case Study

By Alex Behringer and Salman Azhar

A CRUCIAL FACTOR IN CONSTRUCTION SAFETY PLANNING is to properly identify all possible hazards before they occur. A building information model (BIM) allows construction stakeholders to visually assess jobsite conditions and recognize hazards, and it provides them sufficient time to develop adequate hazard mitigation plans.

The utilization of BIM technology can result in improved occupational safety by connecting the safety issues more closely to construction planning. This provides a more illustrative site layout, while providing methods for managing and visualizing up-to-date plans and site status information. The use of BIM also encourages other project partners, such as designers, sub-contractors and safety specialists, to become actively involved in both risk assessment and planning.

This article reports an in-progress research project where BIM technology is utilized to perform safety planning and management for an ongoing construction project located at the campus of the Auburn University, in Auburn, Alabama. The project is a Recreation & Wellness Center. BIM models and 4D simulations are used to communicate the following safety plans: 1) crane management; 2) fall protection; and 3) emergency response plans. 4D phasing simulations, 3D walk-throughs and 3D renderings are utilized to identify various hazards and to communicate safety management plans to the workers.



Figure 1. A 3D rendering of the project

## PROJECT DETAILS

**Owner:** Auburn University Facilities Division

**Project Manager (Construction Team):** Robins & Morton

**Architect:** 360 Architecture

**Cost:** \$50,000,000

**Size:** 240,000 sq. ft.

**Delivery System:** CM Agency

**Start Date:** October 2011

**Projected Substantial Completion Date:** May 2013

The architecture firm, 360 Architecture, based in Kansas City, Missouri, developed the base BIM model of this project for communication and visualization purposes. The research team acquired this model and enhanced it by adding missing design details and temporary safety features. **FIGURE 1** is a project rendering used for marketing purposes.

The following sections describe the BIM-based safety plans generated from the base BIM model.

## CRANE MANAGEMENT PLAN

The purpose of a crane management plan is to: 1) identify the swing radius of the crane to ensure its safe distance from power lines and nearby structures; and 2) identify what trade/crew will be utilizing the crane at a particular time. On this project, two lattice-boom crawling cranes are being utilized to pick and place the structural members. The crane on the North side of the project is a 110-ton Link-Belt 218 HYLAB unit and the crane on the South side is a 250-ton Manitowoc Model 999 unit. **FIGURE 2** illustrates the steel truss placement in the crane management plan.

As depicted in this image, the colored masses (yellow, orange and blue) are used to demonstrate the crane's swing radius and zone of influence. The yellow mass communicates the possible extent of the crane's swinging boom at any moment during a particular day. Collision detections can be utilized to generate weekly reports of any non-steel installation activities scheduled to take place within the crane's planned swing radius, according to the placement dictated by the overall project schedule. The resulting

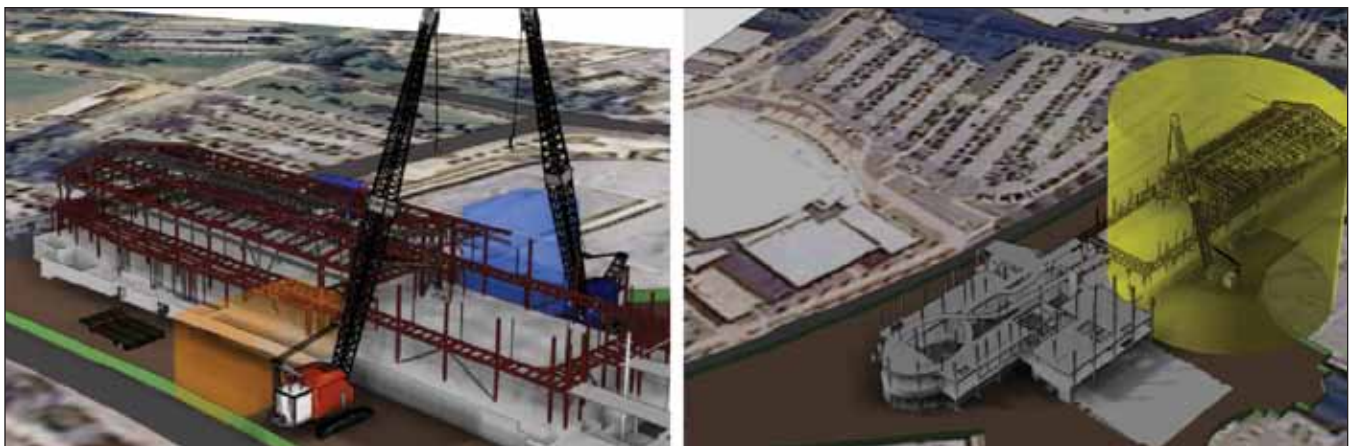


Figure 2. The crane work zone and steel truss placement in the crane management plan.

report can be used during a segment of the project's periodic safety meetings to mitigate unplanned risks due to the crane's interaction with construction personnel. Alternately, 4D simulations can be utilized for safely planning construction activities.

### FALL PROTECTION PLAN

The fall protection plan for leading edges is prepared according to OSHA *Subpart M: Fall protection standards*. Two types of fall protection railings are modeled: 2x4 wooden railings on the second level (concrete structure) that are bolted to the concrete slab and 3/8" steel aircraft cable railings on the third and higher levels of the project (steel structure). Holes in the elevated slabs are covered by plywood coverings and roped in caution tape, as required by OSHA.

After modeling the fall protection railing components, the railings are placed on the structural BIM model. While performing this process, the researchers were able to identify multiple falling risks through the 3D view that were not easily found within the 2D plan view. These conditions included stairwells and skylights that were not yet constructed, so fall protection railing was placed at these locations. The modeled railings are then segregated by zones and levels and the resulting railing sections were exported to Synchro® for developing 4D simulations. The 4D simulation provides complete details to the contractor as to the location and date that the railings are to be installed or removed. **FIGURE 3** depicts a typical railing family and its placement in the BIM model.

### EMERGENCY RESPONSE PLAN

The BIM-based emergency response plan consisted of five sub-plans, namely construction crew entrance/exit; construction equipment and deliveries route; temporary facilities and job trailer locations; emergency vehicle(s) route; and severe weather precautions to orient workers with the construction site. The 3D walk-through animations and renderings were generated from the BIM models to communicate emergency response plan to the workers. **FIGURE 4** illustrates parts of the emergency response plan.

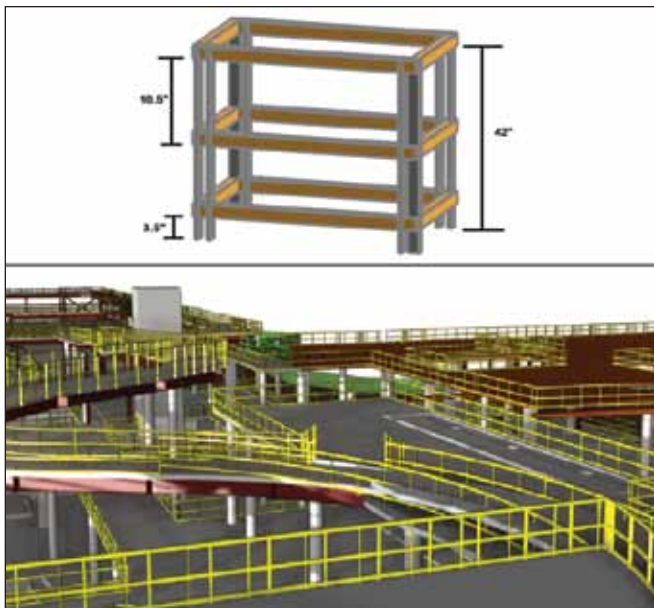


Figure 3. A model of the railing system for fall protection.

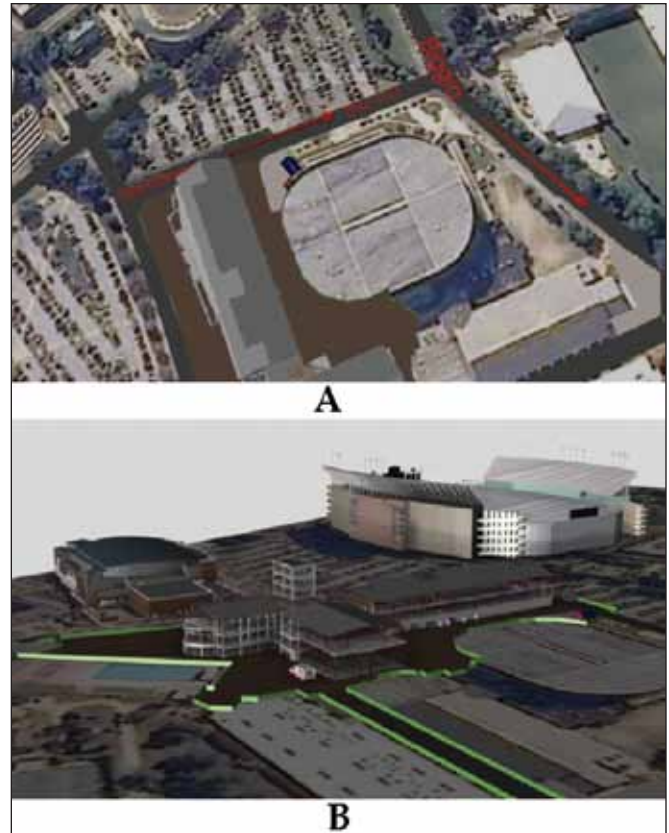


Figure 4. Screenshots of the emergency action plan. A) Traffic flow directions. B) Ambulance arrival path.

### CONCLUSION

Both internal and external validations were planned and implemented to verify the usefulness of this study. The project team recently completed the first cycle of the validation process, during which the BIM model with integrated safety elements and 4D simulations were shown to a focus group of BIM professionals. The consulted members described the three main perceived benefits: 1) improved communication of the safety plan among the construction personnel; 2) improved communication of the project's safety plan between OSHA and the owner; and 3) logistical details of construction safety tasks being fully addressed in the preconstruction phase.

In the following months, the project team will demonstrate the BIM models and simulations in regular safety meetings and will thoroughly evaluate their effectiveness. ■

*The authors would like to express their gratitude to Paul Horne, Project Engineer, Robins & Morton Group, for providing the base BIM models and safety plans. Appreciation is also due to Paul Hedgepath, Director of Virtual Construction at M.J. Harris Construction, Birmingham, Alabama, for providing continuous feedback throughout the project. This study is supported by funds provided by the College of Architecture, Design and Construction Seed Grant and Building Science Construction Industry Fund.*

*Alex Behringer and Salman Azhar are with the McWhorter School of Building Science, Auburn University, Auburn, Alabama.*