

THE American Surveyor

A FOOT IN THE PAST... AN EYE TO THE FUTURE

Vol. 10, Issue 7

BIM-to-Field

California Triangulation

Four historic stations

The Royal Observatory

Mistresses, meridians, and more

Truck Photos

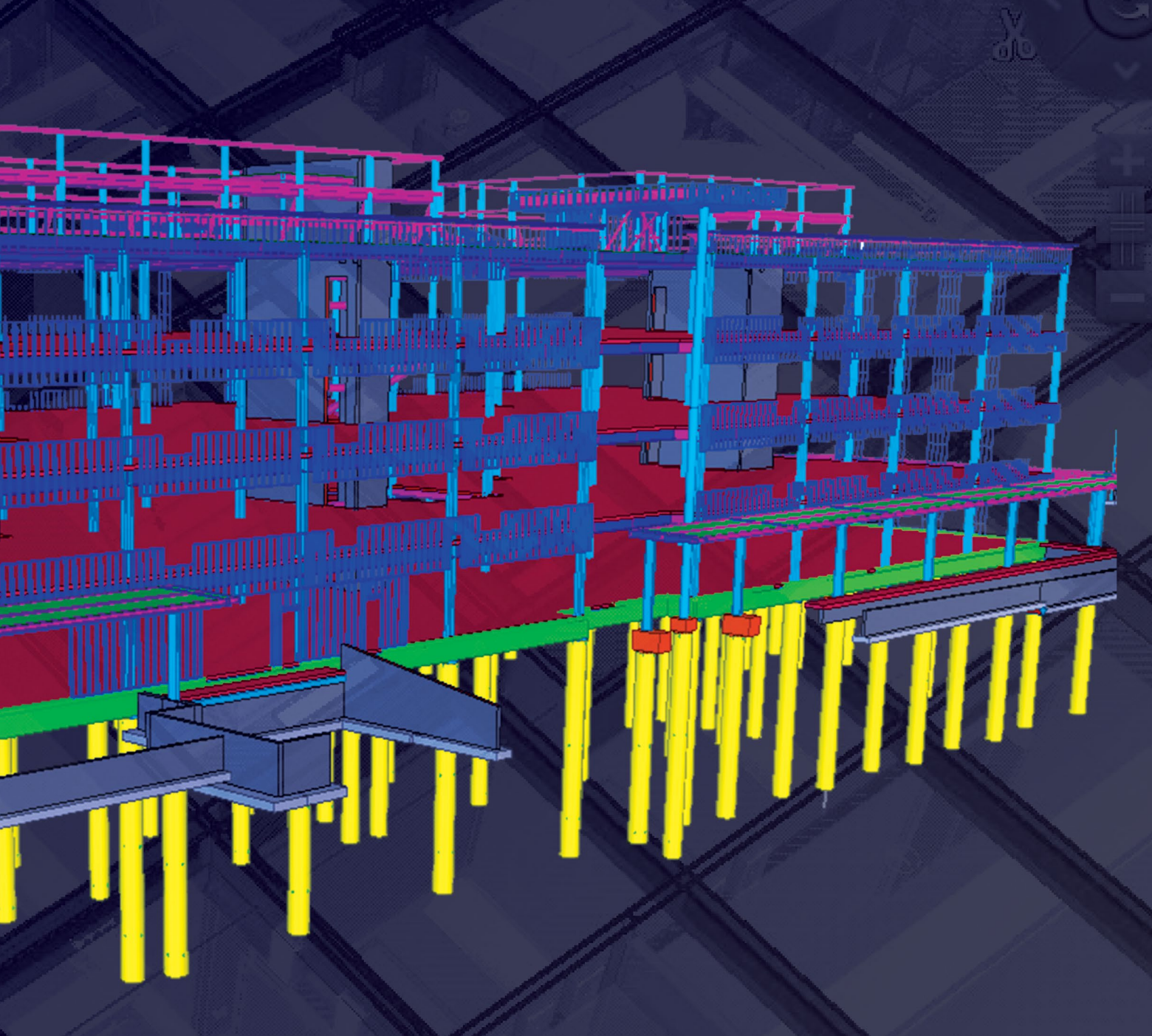
A blast from the past





The Trimble Rockies Campus

>> By Vicki Speed



What happens when a technology innovator known for its range of productivity solutions for building construction contractors joins forces with progressive building professionals to construct the first phase of its own corporate campus?

Technology, technology and more technology. The new four-story, 125,000-sq-ft Trimble Rockies Campus in Westminster, Colo., is a beautiful glassed-in structure set in the shadow of the Rocky Mountains that blends character and functionality.

It's also the demonstration project for a wide range of collaboration technologies used throughout the fast-track 13-month construction schedule—with documented efficiency improvements that began before the first bulldozer arrived on the site in May 2012.

For instance, thanks to design-to-field connections, the team achieved 100% embed placement and zero placement errors during steel frame layout. In fact, the last steel column was erected to within 1/4-inch tolerance. The structural steel erection was completed in 10 weeks with no “fall back” work. The mechanical, electrical and plumbing subcontractors realized 50% or better improve-

ment in field layouts as compared to previous projects.

From robotic total stations to tablets, digital levels to prisms, building information models (BIM) to 3D laser scanners, the Trimble Rockies Campus is an impressive demonstration of how technology can help coordinated project teams drive efficiency, reduce waste and deliver a quality solution quickly and accurately.

Overall, the coordination exercise helped the team flag and fix items in preparation for the issuance of the final design package. Perhaps the greatest advantage of regular coordination meetings was communication and accountability. Each week the BIM coordinator checked through open items and asked each trade to provide percentage complete scenarios for floor models and conflict resolution.

Setting Primary Control

The project team, led by Oz Architecture (architect) and JE Dunn (general contractor) with significant input from Trimble building construction experts, sought to implement integrated project delivery (IPD) techniques and strategies to gain the lifecycle benefits of BIM. Key in the delivery of the building was the development of a digitally and dimensionally accurate model for design and construction coordination, detailing, fabrication, and field level management.

JE Dunn, SCI, MTech, Encore Electric and Frontier Fire Protection utilized Tekla BIMsight for construction model collaboration, conflict checking and site inspections. As the development of the 100% dimensionally accurate federated model of the site and the structure continued, the JE Dunn survey team used model-to-field connection to locate building corners, drilled piers and concrete corners.

With BIM-to-field connections, the project team achieved 100% embed placement and had zero placement errors during steel frame layout.



Surveyors used the Trimble S6 Total Station to complete the closed loop traverse of the new building site.

Initially, surveyors from Accurate EngiSurv LLC used the Trimble® DiNi® Digital Level to gather high-accuracy vertical measurements that were used to transfer elevations from the reference benchmark to the site control points. Surveyors used the Trimble S6 Total Station to complete the closed loop

traverse of the new building site. They were especially happy with the efficiency of the system, stating that they are able to measure points in 2 minutes what used to take 30 minutes, while maintaining exceptional accuracy. This data, adjusted in combination with the level loops completed with the DiNi® Digital Level, form the core of the sites control network.

The S6 traverse and DiNi leveling observations were processed in a single Trimble Business Center project. A simultaneous network adjustment of the observations yielded highly accurate control point values, which will serve all positioning tasks on the site to follow.

JE Dunn's Field BIM Manager initially used the Trimble RTS633 robotic total station with a 360-degree MT1000 active prism to verify control and set curb lines. To begin the process, he uploaded pre-defined points from the civil and structural engineering models to the Trimble Tablet running the Trimble Field Link construction layout software.



Head-to-Head Layout Competition

Primary control points—accurate to 1/8-in. over 1000-ft—were installed on drilled piers and dialed in with Accurate EngiSurv surveying control points. JE Dunn, along with the earthwork and electrical subcontractors used the control points and curb lines to ensure exact grading in required locations, top soil stockpiling out of the way of future construction, and to avoid future construction for temporary utilities.

Once the piers were poured and pier caps set in the formwork, JE Dunn surveyors used Trimble's Robotic Layout Solution—Trimble Field Link for Structures to verify the placement of anchor bolts.

The surveyors also provided significant support to the site activities. For instance, JE Dunn surveyors locate light pole centerlines and 3-foot offsets per the 3D model, which allows Encore to dig the trenches and set the conduit. The exact field positions of the trenches are shot in by Encore electric and are

uploaded to support the owner's as-built conditions model. Knowing the exact locations of the conduit will also help OE, the site contractor, avoid digging in completed areas and provide the owner with critical knowledge about power line locations in the future.

Andre Schlappe with Martin & Martin Consulting Engineers, adds, "Several potential utility collisions were identified early in the design, saving lost time and rework during construction. Also, the color coding and 3D modeling allowed for rapid coordination between disciplines, saving design time on the front end."

Accurate to the Core

To push the boundaries of BIM-to-field opportunities, JE Dunn and Structural Consultants Inc. (SCI), the structural engineer of record for the Westminster project, sought a number of opportunities to further streamline the design, detail, fabrication and construction



In an effort to evaluate the overall productivity and manpower savings gained by using robotic total stations versus traditional (manual) layout, the Trimble project team set up a friendly competition during the construction of the Trimble Rockies Campus building.

Two 2-man teams lined up for a timed competition, pitting technology against paper plans and tape. Each team had roughly 200 points to layout, snap and ID interior wall positions as fast and accurately as possible. The team using robotic layout technology accurately completed the 200 points in 4 hours, while the manual layout team completed 100 in the same 4 hours.

Not only was the robotic technology-enabled team able to complete the task faster, they were able to lay all walls out without error and within exact measurements of the building's digital model.



phases of structural steel, concrete, rebar and exterior metal studs of the project.

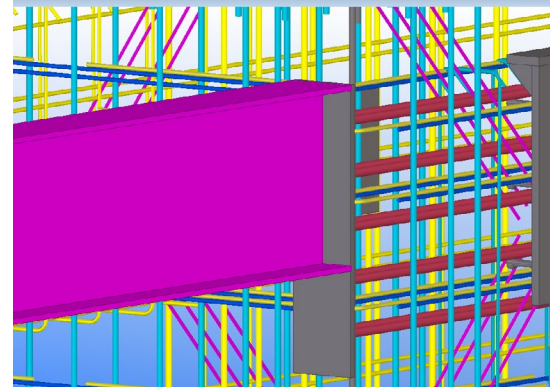
With the intent to reduce duplication of effort, the Trimble Westminster project team looked to use one federated model from design through construction of all steel and rebar elements to expedite steel delivery. The idea is that the same model that is used to permit-approved contract documents is leveraged to detail and fabricate shop drawings for rebar, structural steel, exterior metal studs, and structural components.



For example, on the stair and elevator cores, JE Dunn combined SCI's Tekla Structures steel model, Zimmerman's Tekla and CAD fabrication models (developed from SCI's Tekla Structures model), 2D CAD formwork drawings and elevator shop drawings (pulled from SCI Tekla Structures steel model) into lift drawings, which condensed critical stair and elevator information to one drawing sheet. Then JE Dunn used Tekla Structures in-model review to go over the formwork drawings (2D) and modify the formwork design to miss embeds with formwork ties, flipper pockets, and formwork inserts prior to formwork deliveries to the site or finding issues during installation.

On site, Dunn field crews layout points for stair and elevator core corners. Throughout the construction of the stair and elevator cores, the survey team continued to use the Trimble Robotic Layout Solution to check formwork points as compared to design intent. Crews set the wall formwork and then surveyors again check x,y,z position of formwork. Crews pour concrete and then surveyors check position of embeds, door block outs, flipper pockets and formwork inserts as compared to the lift drawings. The quality checks insured that the final

With the piers poured and caps set in the formwork, field crews used Trimble's Robotic Layout Solution – Trimble Field Link for Structures to verify that the anchor bolt placements are located as specified in the Tekla Structures model.



In-model review tools helped drive discussion during and resolve potential conflicts in advance of fabrication and steel erection.

as-built conditions of the elevator and stair cores fit design intent and minimized the chance of problems with steel framing and concrete decks.

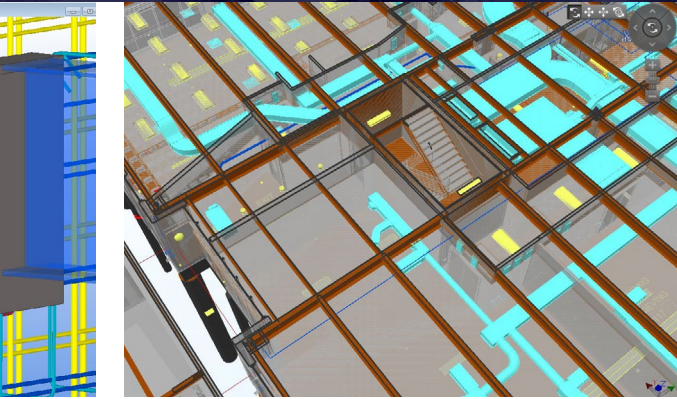
The structural engineer, steel detailer, rebar detailer and JE Dunn as the self-performing (SP) concrete contractor centralized their production work by collaborating within a federated Tekla Structures project model. JE Dunn utilized the structural engineer's design model set up with the appropriate concrete pours to develop lift drawings in Tekla Structures. They also combined the steel detailer's embedment details and the rebar detailer's reinforcement layouts.

Lina Stinnett, BIM Manager for JE Dunn, said, "Using the single Tekla Structures model from design through construction and fabrication allowed us to erect our last steel column within 1/4-inch tolerance."

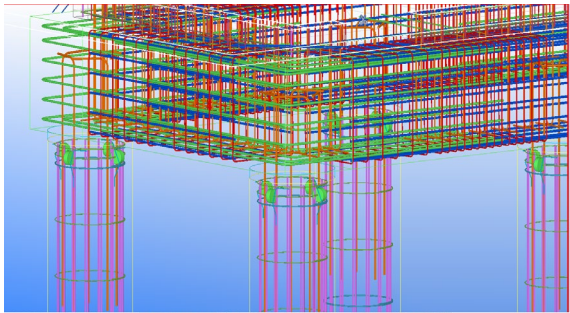
The use of the Tekla Structures structural model by field personnel for direct steel frame layout using robotic Trimble

BIM-to-Field Synchronized Systems

- Trimble Connected Community—dedicated project website to track project progress, store critical and track site activity in real-time
- Tekla BIMsight—project collaboration tool to combine 3D models from IFC-compliant BIM tools, clash detection, markup and design review
- Trimble Field Link for MEP and Structures—transition model data to the field and as-built data from the field to the model
- Trimble Point Creator—create 2D and 3D field points within Revit or CAD and then export to Trimble Field Link for easy stake-out in the field.



MEP coordination using BIM technology in advance of field installation eliminated fit issues.



The structural engineer and concrete contractor used one federated model to detail and fabricate shop drawings for rebar, structural steel, exterior metal studs, and structural components.

total stations and Trimble Tablets resulted in zero placement errors. Each structural steel member could be tracked to its zero position taken from the Tekla Structures model and a Trimble prism on one of the final steel beams confirmed the layout of the entire steel frame.

TIMMS and Beyond

The Rockies Campus project team also took the opportunity to test new technologies.

For instance, a team from Applanix, a Trimble company based in Ontario Canada, brought the Trimble Indoor Mobile Mapping Solution (TIMMS) is an innovative scanning technology for

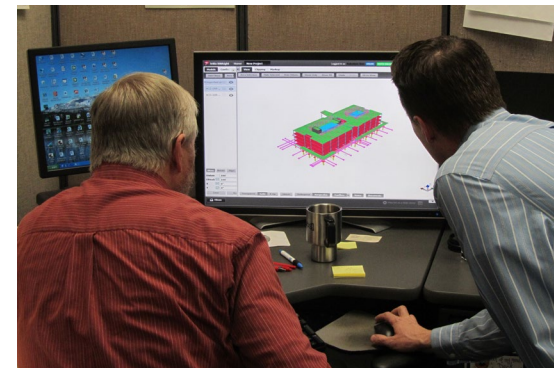
mapping interior spaces (without accessing GPS) to the Rockies Campus project to map the interior of all four floors at the rough-in stage (before the drywall).

TIMMS is a unique combination of LiDAR, cameras, computers and electronics capture a 360 view of an interior space, which can then be used to produce highly detailed and very accurate 2D and 3D geo-located models. Applanix operated the TIMMS pushcart, moving it around and about all

four floors at the Westminster building over the course of about two hours.

JE Dunn was particularly excited about the opportunity to see how it might use the data on this project and

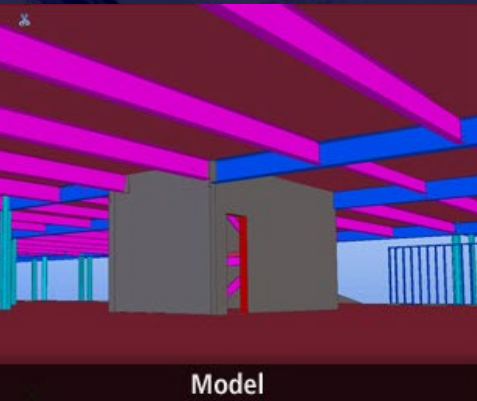
All architectural, structural, mechanical, electrical, plumbing, fire safety and accessibility designs were combined into a single federated model.



- Tekla Structures—create and manage detailed, highly constructable 3D structural models regardless of material or structural complexity
- Trimble PipeDesigner 3D—3D CAD software for piping and plumbing contractors

- Trimble AutoBid Mechanical—generate and manage piping and plumbing bids
- Trimble Accubid Enterprise—estimating software for piping and mechanical contractors

- Prolog Project Management Solution—a flexible and robust project management solution for the management of construction costs, scope and schedules.
- Trimble SketchUp Pro—an easy and intuitive 3D modeling software for contractors that allow rapid creation of models for conceptual design and planning.



Model



3D Laser Scan




As-built

The TIMMS solution mapped the interior of all four floors at the Westminster building at the rough-in stage (before the drywall) and then compared to modeled and as-built conditions.

future projects. One obvious benefit of the data is the opportunity to verify as-constructed systems with the as-designed model. Trimble used TIMMs one more time just prior to move-in to create a 3D model to help the Trimble facility management team optimize space today and in the future.

The Trimble Rockies Campus was completed in May 2013. The benefits of collaborative, technology-driven methods have helped shape a smooth, just-in-time lean delivery process that set a new standard for office construction in Colorado and across the country.

Brad Schenck, vice president of Preconstruction for JE Dunn, concluded, "The Trimble Rockies Campus project provided us a unique opportunity to

demonstrate, evaluate and document the value of collaboration, technology, and innovation to deliver more value to our client while establishing a more predictable, repeatable workflow for the entire project team. Perhaps the greatest value to the industry was that we all took one more giant step forward in improving reliability and reducing waste in materials, processes and labor." 

Vicki Speed is a freelance writer specializing in the building and construction industry. She can be reached at vickispeed1@comcast.net or 303-955-5622



Using the Trimble RTS 773 clamped to structural columns for stabilization, the MEP contractor was able to stake-out hanger locations, "on-deck" prior to the pouring of concrete.



JE Dunn field personnel using the Trimble RTS 773 and Trimble Field Link for Structures layout solution for verifying edge of slab during the buildout of the elevator core.