A Case Study on Drones in Construction

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About the speakers

Andrew Gibson  
*Sr. Integrated Construction Coordinator*

Andrew is currently leading the VDC charge at Allianz Field in St. Paul, MN. He has been with Mortenson for 5 years in the Virtual Design & Construction department. Prior to Mortenson Andrew worked in Architecture for 4 years focusing on multi-family housing & restaurant/retail in the Minneapolis area and surrounding states. Having been on both sides of Architecture & Construction Andrew brings a unique perspective to his current field which helps create a common bridge between the Design Team & Contractor. Andrew’s strong passion for innovation and technology combined with his daily desire to figure out new ways to make AEC processes more efficient & valuable has been essential to his success in the construction industry.

JT McManmon  
*Applications Engineer*

JT is an infrastructure application engineer for CTC Software, an Autodesk Platinum Partner in Minnesota. He has presented at some regional conferences around the upper mid-west as well as Autodesk University in 2016. He worked for a couple of civil engineering firms before moving to CTC. With a practical background as a civil drafter, as well as having worked in land surveying, he has valuable real-world experience and truly understands the application of Autodesk, Inc., software in the infrastructure industry. He is also a drone pilot for CTC and has been involved in discovering ways that drones can help aid the engineering design and capture processes as well as construction site progress.
Getting Started With Drones

A. Hardware & Software
1. Buying a Drone
2. Using Software to Fly the Drone
3. Using the Cloud to Process Data

B. Flying on Site
1. Sitework Planning
2. Calculation of Soil Volumes
3. Tracking of Work Put Into Place
4. Inspections (High Risk Safety Areas)
5. Milestone Work Documentation

C. Cloud Processing
1. Utilizing Point Cloud Data w/ Navisworks or Recap
2. Bringing Mesh Data Into Google Earth
The Right Drone for the Job

• Key factors to consider
  o What do you need the drone to do?
    ▪ Are you going to use different cameras?
    ▪ Do you need a top mountable camera?
  o How important is ease of use?
  o How much flight time is needed?
  o What software will be used?
    ▪ Which drones does that software support?

❖ We primarily used a DJI Matrice 210 and a DJI Phantom 4 Pro
Drone options

Use the right tool for the job

Yuneec 3DR H520-G
DJI Phantom 4 Pro (Incl. V2.0 & Advanced)
DJI Matrice 200 Series (M210 RTK, M210, M200)
DJI Inspire 2
DJI Mavic Pro
DJI Phantom 4 Pro

Supported Versions: Phantom 4 Pro, Phantom 4 Pro V2.0, Phantom 4 Advanced

NOTABLE FEATURES

- 1" 20MP CMOS sensor camera
- Five directions of obstacle avoidance
- 30 minute max flight time

USE CASES

- Entry-level, versatile professional drone
- Perfect for a wide range of projects including mapping, videography, and inspections
DJI Matrice 200 Series

- Dual-battery power system automatically heats batteries when flying in sub-zero temperatures
- Enclosed casing ensures weather and water resistance, allowing you to fly in a wide range of environments
- High-performance motors paired with 17-inch propellers allows for up to 38 minute max flight time
- Perfect for industrial applications including inspections, site surveying, and thermal imaging

M210 RTK
- Dual Downward Gimbals
- Single Upward Gimbal
- Multiple Payload Configurations
- Built-in RTK

M210
- Dual Downward Gimbals
- Single Upward Gimbal
- Multiple Payload Configurations
- Support for thermal + RGB mapping and modelling

M200
- Single Downward Gimbal
- Payload Configuration
Automated Flights

• The drone can fly itself
  o Step One: Tell the drone where to fly
  o Step Two: Tell it how high to fly
  o Step Three: Watch the drone complete the mission
  o Step Four: Retrieve photos from drone
• It really is that simple!
• Some apps that fly drones are:
  o Pix4D
  o Site Scan
  o Drone Deploy
  o DJI Go 4
Picking the Right Flight

- The first selection is flight mode
  - Area Survey
    - Flies over sight in lawn mower pattern
    - Knows how much overlap is needed
    - ✓ Good for a quick site map
  - Crosshatch
    - Same as area survey but does it twice
    - ✓ Good for when camera is at an angle
  - Perimeter Scan
    - Flies around site looking inwards
    - ✓ Good for buildings or structures
Upload Flight Data

• Retrieve the photos once the flight is complete
  o Either from drone wirelessly
  o Or by taking out an SD card
• Upload the photos into the cloud
  o Either from the tablet
  o Or from a computer
• Process the data in the cloud
  o Tag Ground Control Points (GCPs)
Tagging Ground Control Points

Tagging GCPs will greatly improve the accuracy of the location of the data. It will also ensure that each flight is located in exactly the same place throughout the many flights of the site.
Why Drones & Why Now?
Survey Time!
How much do you think it would cost to use drones on your project via a third party?

A. $23,900  
B. $9,700  
C. $36,499  
D. $17,750
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How much do you think it would cost to use drones on your project if you flew in-house?

A. $23,900
B. $9,700
C. $36,499
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How much do you think it would cost to use drones on your project if you flew in-house?

A. $23,900  
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Allianz Field Fun Facts

- 1 of 8 stadiums in the world with the Allianz brand. (only one in the US)
- Seating Capacity is 19,400
- 2,800 tickets for supporters section (standing only seats)
- PTFE Skin wraps the whole stadium (protection from elements & helps acoustics of stadium)
- Allianz Field can fit inside the bowl of TCF Bank Stadium
Hear how orthomosaics were used for better site communication and collaboration
Value Driven Data for Construction

A. Site Logistics & Planning
   1. Project Wide Access to Updated Logistics Plan
   2. Material Drop-Off Routes
   3. Site Utility Coordination

B. Progress Documentation & Comparison
   1. Sitework Planning
   2. Calculation of Soil Volumes
   3. Tracking of Work Put Into Place
   4. Inspections (High Risk Safety Areas)
   5. Milestone Work Documentation

C. BIM Data Integration
   1. Utilizing Point Cloud Data w/ Navisworks or Recap
   2. Bringing Mesh Data Into Google Earth
Site Logistics & Planning

• Safer Project Site
• More Informed Project Team
• Clearly Established Truck Routes

• Laydown Areas Identified & Established
• Ability to Visually Plan Upcoming Work
• Provides Clear & Concise ERP

• Great for Clearly Identifying Parking
Utility Coordination & Layout

Without Drone Data

- Have our layout guy get coordinates for trailers & large objects (1 HR+)
- Ask City power for CAD file tied to city coordinates (1 HR+)
- Use APL to bring in the locations of all the trailers & large items (3-5 min)
- Draw or model those items (5-10 min)
- Check model for conflicts with proposed power box and routing (2 min)

**Time to Informed Decision:** 2 Hours 10 Mins (Perfect World Scenario)

With Drone Data

- Flights take place bi-weekly so the data is already collected & useable
- Overlay City Power PDF in Sitescan via Georeference points (2 min)
- Measure required clearances & check if anything is in the way (3 min)
- **Bonus:** Export overlaid data back to PDF & Markup so it’s easy to read and understand for the whole project team & distribute. (5 min)

**Time to Informed Decision:** 5 Minutes (Total w/ Bonus – 10 min)
Measuring Capabilities

There is a lot of value in just having a constantly updated plan view of the site, but to be able to actually pull accurate dimensions, calculate areas & volumes, as well as keep track & count equipment on site has proven to be incredibly valuable to our superintendents & engineers.
Learn the benefits of photogrammetry for construction monitoring and how easy it is to utilize
Quality Check & Tracking Work (Site Work)
Tracking & Comparing Work Put Into Place

At Mortenson we do a lot of self perform concrete work and having these updated plan views of the project helps our project team track work that has been put into place as well as help make sure we aren’t missing certain items via the PDF overlay tool.
Inspections (High Risk Safety Areas)
Inspections (Rebar & Concrete Deck)
Documentation (Multivista)

Basics:
- Complex structure & enclosure led to project management wanting an efficient way to fully document the exterior of our building throughout key milestones.
- Flew a DJI Inspire up & down steel driver tubes & enclosure taking pictures of details & penetrations we deemed critical.
- Provide Exact-Builts via drone for the in-field utilities & roof progressions that will be integrated with those drawings (Mapping).
- Not done via drone but they are also providing 360 Immersive MEP In-Wall Exact-Builts, 360 Finished Interior Exact-Builts, Finished Exterior Exact-Builts

Deliverable:
- Access to information from both computer and mobile devices.
- Elevations from Architectural set with all images tagged in correct location via their proprietary software.
- Timeliner for images to show progress or comparison
- Built-in Matterport viewer for 360 Exact Builts
- Integration with Procore – Ability to create observations, inspections, & punchlist items from any image or plan within multivista app or website.
- In the words of management, “Cheap insurance for a complex structure”.
See how you can utilize point clouds with your models
Using Point Cloud to Track Work

Point Cloud w/ Models
Marketing & Proposals

A. Customer Impact & Use
   1. Hype Videos for Gameday
   2. Social Media & News Events

B. Mortenson Use
   1. Proposals & Pursuits
   2. Progress Videos
The drone footage was checked by myself and one of the Mortenson Superintendent’s to ensure there were no safety concerns in the footage and then released to the team. The director of production & match day presentation then edited the video into shorter clips to be posted to their website and played on the jumbotron during home games.
"The drone footage that we receive from Mortenson/Multivista has been invaluable throughout the construction of Allianz Field. Having access to a "bird's eye view" of our site coming together from week to week helps keep our fans engaged and excited throughout the entire construction process. Watching the continual progress from these different perspectives gives you the sense of being on-site, which is the ultimate goal as we produce our videos."

Daniel Claxton - Director, Production & Match Day Presentation for MNUFC
News & Media Events
Proposals & Pursuits

• Accurate up to date site information
• Provides great visuals
• Clearly shows our commitment to innovate & improve the construction process
• Could be used for estimating purposes
Learn drone laws and how they apply to flying on an active construction site
FAA Part 107

• Need to be a certified SUAS pilot to fly for commercial purposes
• A SUAS is Small Unmanned Aircraft System and applies to all drones that weigh less than 55 lbs (including payload)
• Key 107 rules
  o Must be able to see drone at all times with no visual aids (no binoculars)
  o Cannot fly directly over people that are under a covered structure
  o Cannot fly over moving vehicles
  o Need special permissions from large airports within 5 miles of flight
  o Max flight height is 400’ above ground or 400’ above structure that is within 400’
• Taking the test
  o Must be taken at a certified testing center
  o Many free study materials are available
Case Study Wrap Up
Challenges

• Getting initial buy-in from project team (while the interface is simple and easy it’s still ‘another’ program the project team has to learn & use)
• Finding a time to fly where we weren’t flying directly over anyone
• Figuring out how the data could be used to help processes & workflows
• Budget

Opportunities

• Flights more frequently than bi-weekly
• Create a drone program within Mortenson, allowing flexibility and frequency of flights for any project
• Inform rest of company about findings & how drones add value
• Potential for AI to automatically track progress of work in the future through image recognition
• Machine learning of items typical to construction sites so they are automatically recognized and color coordinated
Successes

• Constantly updated site logistics plan available to entire project team which created a safer site
• Site coordination of utilities – eliminating need for layout and empowering superintendent to use tool for quick resolution
• Canopy roof logo review with design team for approval
• Tracking of work & productivity (site work, concrete, rebar, steel, roofing, in-field heat)
• Extremely useful in planning upcoming work in weekly work plan meeting
• Provided a new & effective way to inspect & measure rebar as well as have documentation that it was installed correctly
• Brought Quality Control to whole new level
• Enabled & Empowered Project team
• Provided documentation for key milestones & the project as a whole that is easy to access & digest
Upcoming Sitescan Features

A. Vertical Scan Flight Mode (Q4)
B. Ability to use computer vision to automatically identify certain things like cracks in concrete (No Date yet, but in roadmap)
C. Slope Measurement Tool (Q1)
D. Ability to import design surfaces or land surveys via KML’s so you have an accurate base plane for cut fills (Q1)
E. DWG Import for Overlay – providing cleaner lines (Q1)
Where Do We Go From Here?
QUESTIONS?
FINISH SAFE
FINISH STRONG

Progress Videos