Dean Teska Jr. is a professional land surveyor operating within the state of Wisconsin, boasting accreditation as an FAA-certified small Unmanned Aircraft Systems (UAS) remote pilot. Mr. Teska has over three decades of experience in the construction sector. His educational background includes an Associate’s degree in Civil Engineering Technology from Northeast Wisconsin Technical College.

In 2008, Mr. Teska was enlisted by a contracting entity with a specific mandate: to integrate GPS technology into their equipment and provide guidance on its utilization. Since then, he has remained at the forefront of technological advancements, recognizing the rapid evolution of both hardware and software within the industry, necessitating a continuous effort to remain abreast of their capabilities.
How Survey Technology Helped Transform the I-69 Project
Introduction

Explore different types of technology that can help construction projects and how these technologies were implemented on the I69 project and others across the nation.

1. **GPS Rover with Data Collector** – QC road subgrade, as-built pay quantities, simple station/offsets
2. **Total Station with Data Collector** – control/staking -any layout that requires tight vertical results
3. **Digital Level** – aka “differential leveling” - transferring benchmarks the correct way
4. **Unmanned Aerial Systems** - photo/video site documentation, photogrammetry orthomosaics and surfaces, LiDAR point cloud acquisition, safety monitoring
5. **LiDAR Systems** – Truck mounted, tripod mounted, UAV mounted
6. **3D Construction Models** – Reverse engineering plans, pointing out where they conflict with themselves
Introduction

In Surveying, you need to know how close you need to be.

If you are too close, you won’t be in business long.

If you’re not close enough, you won’t be in business long.
GPS Rover with Data Collector

- Software for collecting data varies by vendor, but mostly does the same thing
- Produces an autonomous location, within 5 to 30 feet, until paired with another base using radio waves or internet correction streams – called RTK (real time kinematic) surveying
- Layout and measurement tools
- Cogo and CAD functionality
- Usually on a prism pole with a bipod that contains a level bubble
  - Raw data can be summoned into a courtroom
- Relies on GPS satellites travelling 7,000 mph
GPS Rover with Data Collector

- Uses CORS network to achieve RTK (real time kinematic), uses base station when CORS is not available
  - Quantity tracking (removals, topographic, square yard items, volumetric)
  - Project construction QC (subgrade elevation verification, staking)
  - Accuracy - plus or minus 0.10' (1 ¼”)
- Be aware of sources of error; know how to check accuracy of the readings
  - Multipath
  - PDOP
  - Residuals
GPS Rover with Data Collector

- Field workflows vary by purpose
- Staking or checking roadway features is easier with smart data!
- Graphical interface based layout, but data is only as good as what was loaded in the data collector
Total Station with Data Collector

- Called “conventional” surveying
- Can be 2 man operation with rod-person/instrument-person combination, or 1 person with robotic total station that tracks the prism pole as you walk
- Basic surveying fundamentals are necessary to successfully operate a total station
- Knowing how to measure and track error is vital to being accurate
Total Station with Data Collector

- Used for staking/checking bridges, storm sewer, sign structures, concrete pavement, transferring benchmarks
- Same data collector software, usually
- Depends on the accuracy of the instrument, but plus or minus 0.02’ under most conditions
- Maintenance requires collimation of instruments at minimum four times per year for the differing weather conditions and sending in for service at least once every two years.
Total Station with Data Collector
Digital Leveling

- The science of transferring elevations from NGS known points to desired locations (also known as differential leveling)
- Reads a bar code level rod to 4 or 5 decimal places
- Many times, the level loops don’t even need adjustment, closing 8 miles loops in under 0.02’ or better
- Having tight vertical control surrounding the project ensures success using the technology
- Must pay attention to where humans can introduce error during the level loops
Unmanned Aerial Systems

- Photo/Video site documentation
  - Monthly progress photos, 150’ AGL, 45-degree oblique images
  - Marketing content
  - Fly through videos of completed projects
- Photogrammetry
- Using Nadir images with 80/70% overlap, combined with ground control
  - Can generate surfaces, but caution must be used in tall vegetation areas
  - Ground sampling (testing the results)
  - Control point frequency, size, and elevation*
Unmanned Aerial Systems Photography

- Knowledge of the exposure triangle
- Golden Hour/Blue Hour
- Light bars
- Camera Sensor
- Shadows/clouds
Unmanned Aerial Systems

- IMU measures the device movement to adjust the trajectory so it matches ground control
- Photos used only for colorizing the pixels
- Data processing these flights and end results may vary
- Terrain follow mode
- Feature extraction
Unmanned Aerial Systems
Unmanned Aerial Systems

- Length of job may prompt the flight to be broken up into pieces, must have overlapping control for each flight at those joint lines.

- LiDAR point cloud acquisition (light and distance ranging).

- kHz of device equals thousands of points per second. (100 kHz is 100,000 points per second in a full 360-degree circle, need to apply field of view to know true #)
LiDAR Systems

- UAV mounted
- Truck-mounted stationary LiDAR system
- Tripod-mounted fast scanners. Lots of options on the market; we use Trimble SX10
- Mobile LiDAR: capable of high speeds, with 360-degree camera system
Unmanned Aerial Systems

- IMU measures the device movement to adjust the trajectory so it matches ground control
- Photos used only for colorizing the pixels
- Data processing these flights and end results may vary
- Terrain follow mode
- Feature extraction
LiDAR Systems
Reverse engineer contract documents, RFI tracker during modeling

- Finds conflicts or ambiguities in the plan before the crews show up
- Allows use of the model to perform the work in the field
- Uses any available metadata that can be used to reduce the efforts to recreate the models
- Layered models for each of the aggregate and surface layers allow for easy quantity verifications or justifications
<table>
<thead>
<tr>
<th>RFI #</th>
<th>Date Submitted</th>
<th>Plan Page</th>
<th>Summary</th>
<th>Description</th>
<th>Attachments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/19/22</td>
<td>sheet 321</td>
<td>Super tables are missing transitions that are shown in the paving grades</td>
<td>Using paving grade sheets, there are pavement slope transitions and it is unclear where they start and stop and where they are zero/reverse crown. Keying in the slope every 25' will not capture the true intent of the lane transitions. Please update the super elevation tables to reflect the slopes that each lane should be</td>
<td>none, can be provided at request</td>
</tr>
<tr>
<td>2</td>
<td>2/1/22</td>
<td>43-49, 55-64</td>
<td>intersection details and curb ramps do not show any elevations</td>
<td>please update plan pages to include the required level of detail on these pages. The contractor’s surveyor is asking for locations on the paving grades that are not clearly at an even station interval.</td>
<td>none, can be provided at request</td>
</tr>
<tr>
<td>3</td>
<td>2/2/22</td>
<td>215-219, 371-380</td>
<td>XY Locations needed on all electrical features. There is no way to layout features if locations aren’t given</td>
<td>Need stations and offsets for all light pole bases, pullboxes, and signal bases. We also need station and offsets for the front center location of the loop detectors</td>
<td>none, can be provided at request</td>
</tr>
<tr>
<td>4</td>
<td>2/2/22</td>
<td>none</td>
<td>no removal plans</td>
<td>There should be a graphic showing where the misc qty table showing removals originated. We will need to justify the over/unders later and need to know what was counted in the bid plan, including but not limited to, pipe culverts, storm sewer, concrete and asphaltic surface, curb and gutter and clear and grub removals.</td>
<td>none, can be provided at request</td>
</tr>
<tr>
<td>5</td>
<td>2/2/22</td>
<td>67</td>
<td>WB Crown taper Sta 481-482+50</td>
<td>the crown lane clearly tapers from 12’ to 15’ leading up to the roundabout, we need the start and stop station of the taper to accurately build this section, even metadata is missing this line.</td>
<td>none, can be provided at request</td>
</tr>
<tr>
<td>6</td>
<td>2/2/22</td>
<td>56, 67</td>
<td>No sidewalk grades given</td>
<td>there aren’t grades on the paving details, the intersection details, and there is not enough frequency of cross sections to obtain these elevations there. Surveyor will just stake horizontal if no vertical is given and liability will be on the construction team to engineer grades unless they are provided.</td>
<td>none, can be provided at request</td>
</tr>
<tr>
<td>7</td>
<td>2/3/22</td>
<td>none</td>
<td>No plan details</td>
<td>plan detail sheets usually give two letter designations to concrete, curb, asphalt and other features so we can tell when the type of roadway or curb type changes and where. The taper callout information is usually shown on plan details rather than intersection details.</td>
<td>none, can be provided at request</td>
</tr>
</tbody>
</table>
Conclusion

Technology can help your project tracking, construction, or assist with proving results and outcomes through good documentation.

1. GPS Rover with Data Collector
2. Total Station with Data Collector
3. Digital Level
4. Unmanned Aerial
5. LiDAR Systems
6. 3D Construction Models
Questions?

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