Putting UAS to the Test for Substation Construction, Monitoring, and Operations

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Overview

- Introductions
- AEP Station Standards pilot project; Why UAS?
- Brief UAS overview
- Logistics
  - Pre-acquisition
  - Acquisition
  - Post-processing
- Limitations of traditional 2D datasets
- Unlocking 3D
  - Change detection, construction monitoring
  - Next steps
- Lessons learned
- Data demonstration
- Q&A
- 5.4M Customers in 11 states
- 40K+ mi electricity transmission network - largest in the nation
- 26K megawatts of generating capacity
• First company in the US to receive FAA exemption for UAS mapping
• Survey history
• Extensive experience with manned aerial platforms and sensors
AEP Station Standards: UAS Case Study

- Station Standards
- Substation construction projects:
  - Span months
  - Complex
  - Expensive
- Traditional monitoring:
  - Reporting
  - Site visits
- Traditional concerns:
  - Alignment
  - Timing
  - Position
- Can UAS help?
**Constraints**
- Construction is very paper intensive task
- Schedules, reports, planning, and progress are all very subjective
- Delay, liability, and overscheduling are often problems
- Project milestones and cash flows are hard to track

**Mitigations**
- Construction progress visualization *(Short Term)*
- Validating accuracy of equipment placement to design and reporting variances automatically *(Long Term)*
- Tracking major construction milestones automatically for updated cash flow *(Short Term)*
- As-build model *(Long Term)*

**Benefits**
- Improve transparency
- Improve efficiency
- Improve scheduling
- Reduce delays, liability, and overscheduling
- Improve updating cash flow
UAS Overview

- Pre-planning / Control
- Acquisition
- Post-processing
- Dataset creation
  - Images
  - Orthoimage
  - Autocorrelated 3D point cloud
  - Surface
  - Image/textured mesh
- "Typical" area of interest
- "Typical" site infrastructure
- But.....
...Electric Substation is NOT your "typical" environment

Energized environment

Complex infrastructure

Close quarters

Small site

Limits of orthoimage

Active construction

100's of Concurrent Projects

6,000+ Stations

Liability / Insurance

Control / PID's

Step back a bit...
Active construction

Control / PIDs

Step back a bit...
Pre-planning

- **Insurance concerns**
  - Draft WO submittal
  - Liability $$ limit
  - Success!!!

- **Landowner notification**
  - Door hangers
  - Specific language

- **Deconfliction policy**

- **Risk / Safety Mitigation**
  - FAA
  - Staff credentials
  - Situational awareness
  - JSA/JHA
  - Device limitations
  - Weather concerns
IMAGE NOT RELEASABLE
IMAGE NOT RELEASEABLE
Acquisition

- Survey control
  - a MUST
- Electrical interference
- Onsite staff notification
- Approach
  - Altitude
  - Pre-programmed vs. manual
- Battery life
- Flight time
- Heat
Data Creation / Monitoring

- Datasets
  - Frames
  - Orthoimage
  - 3D Colorized Point Clouds
  - Image/textured mesh
- Orthoimagery for complex infrastructure
- Obscured control
- Accuracies:
  - x/y is simple
  - z is more complicated
- NOISE - confidence in change detection and monitoring

... need good data to make good decisions
Imagery

- Individual frames
  - Great resolution
  - Challenging to manage
- Single site-wide image
  - Limited by site size/shape
  - Radial displacement
- Orthoimage
  - Artifacts impact analysis
- Horizontal Accuracy: +/- ~0.25 ft

- Utilization
  - Visual inspection
  - Image comparison
  - Measurement
  - Automation is tough in 2D - only imaged based
3D Colorized Point Cloud

- Flight planning provides for substantial image overlap
- Software processing creates 3D autocorrelated datasets
- Datasets:
  - Image/textured mesh
  - 3D point cloud (.las/.laz)
- Horizontal Accuracy: +/- ~0.25 ft
- Initial Vertical Accuracy: +/- ~2.5 ft
- Vertical Accuracy: +/- ~0.25 ft

- Utilization
  - Visual inspection
  - 3D Measurement
  - Comparison to model/design
  - Automate change detection
Change Detection

- Limitations in 2D imagery
  - Frame-based
  - Difficult to compare to other datasets
- Focus on 3D point cloud
  - "Spatial geometry" for comparison
  - Comparison to other point clouds
  - Comparison to 3D models
- ACCURACY DETERMINATION
  - What's noise?
  - What's actual change?
  - Accuracy statement:
    - $x/y$: $\sim 0.25$ ft
    - $z$: $\sim 0.25$ ft
IMAGE NOT RELEASABLE
IMAGE NOT RELEASABLE
IMAGE NOT RELEASABLE
Next Steps

- Refinement of change detection
- Automation of detection
  - Between point clouds
  - Against models
- Object identification
- Comparison to model/parts

Why?

- Compare to 4D schedule
- Check alignment, orientation, clearances, prefab measurements
- Effective way to understand change remotely
- Visual "gut check" - cannot be faked and unlikely to be misunderstood
Lessons Learned

- Risk mitigation is crucial
  - Safety
  - Liability
- Repetitive acquisition can be challenging
  - "noise" on the project site
  - Light conditions
- Creation of imagery is easy
- Creation of ACCURATE imagery is more challenging
- Creation of ACCURATE 3D data is even more challenging
- BUT.. accuracy or an understanding of limitations is needed to ensure successful change detection
- How to best fit UAS data into workflows?
Questions?

Thanks!

- Aaron Lawrence
- Andria Shaman
- Ethan Schreuder