



UNMANNED AERIAL VEHICLE (UAV) SURVEY FOR YEAR-END MINING RECLAMATION ESTIMATION

Prepared For

**2017 JOINT CONFERENCE -
WV TASK FORCE, ASMR, ARRI**

Presented By

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OUTLINE OF PRESENTATION

- ▶ **Overview of UAS/UAV technology**
- ▶ **Project Background**
- ▶ **Methodology**
 - ▶ **Pre-flight planning**
 - ▶ **Flight operations**
 - ▶ **Data Processing**
- ▶ **Results**
- ▶ **Challenges and Summary**



OVERVIEW OF UAV/UAS TECHNOLOGY

- ▶ **Unmanned Aerial Vehicles (UAV) / Unmanned Aerial Systems (UAS) finding wide use for environmental survey and analysis**
- ▶ **Aerial photography and topographic deliverables – alternative to traditional ground-based and aircraft-based approaches**
 - ▶ **Time savings – mobilization, data capture, processing**
 - ▶ **Safety benefits**
 - ▶ **Flight limitations reduced**



While the technology offers several advantages, not a total substitute for traditional methods...

- ▶ **Accuracy considerations**
- ▶ **Ground control need**
- ▶ **Coverage area & survey efficiency**



OVERVIEW OF UAV/UAS TECHNOLOGY

- ▶ Fixed wing or quad-copter
- ▶ eBee by senseFly
- ▶ GNSS/RTK receiver
- ▶ True-color or Near Infrared (NIR)
- ▶ Automatic 3D flight planning
- ▶ Max. Flight Time 45 Minutes



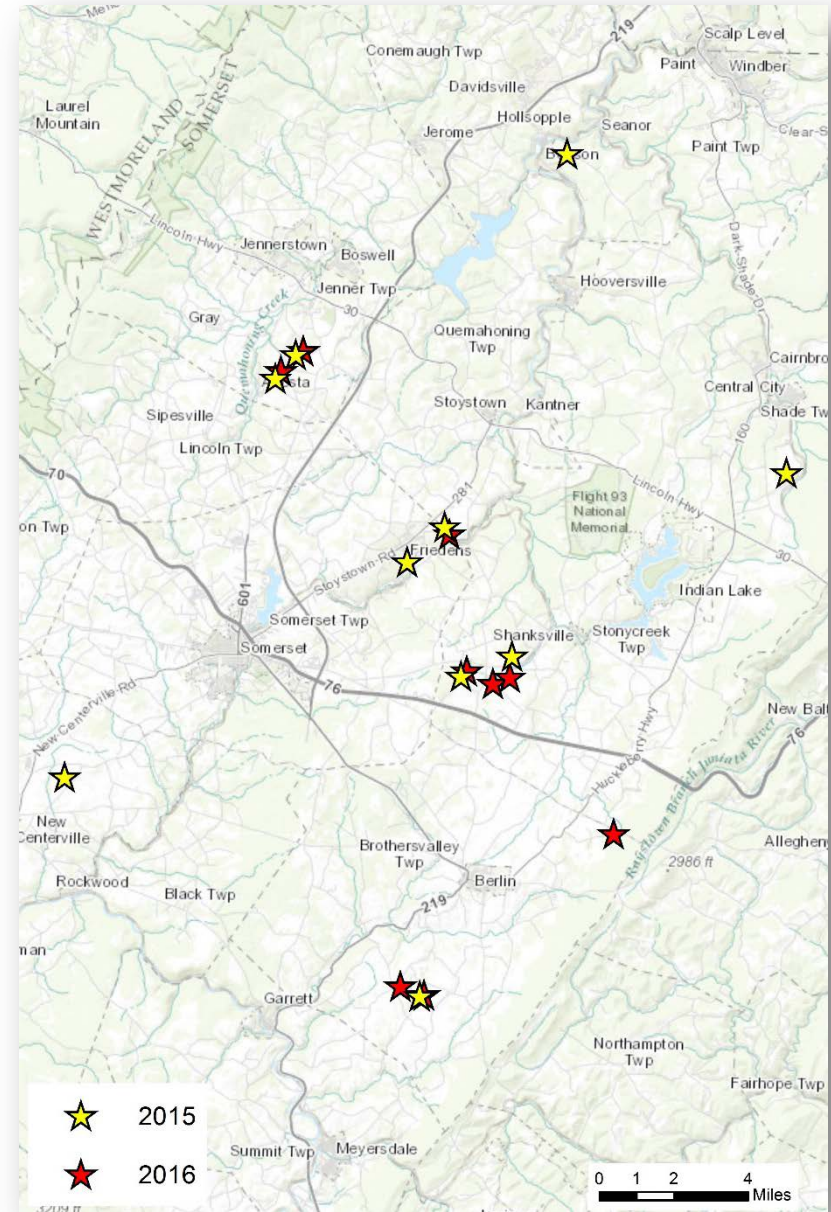
PROJECT BACKGROUND

- ▶ **Mine operators evaluate mining assets at the end of the year for financial reporting and reserve estimation**
- ▶ **Data must be compiled as close to year-end as possible to ensure accurate reporting and forecasting for budget models**
 - **Asset Retirement Obligations (ARO) reporting – project future financial impact of mine reclamation**
 - **Stockpile Reserves – calculate end-of-year material quantities at active plant sites**



PROJECT BACKGROUND

- ▶ **Corsa Coal operates several deep mines, surface mines, coal refuse disposal areas, and prep plants in Somerset County, PA**
- ▶ **Required year-end aerial and topography survey of selected sites**
- ▶ **Explored UAS approach –**
 - **Flexible timing for scheduling and deployment**
 - **Tap into existing VRS system – real time data corrections**
 - **Quick processing & turn-around time for volume calculations**



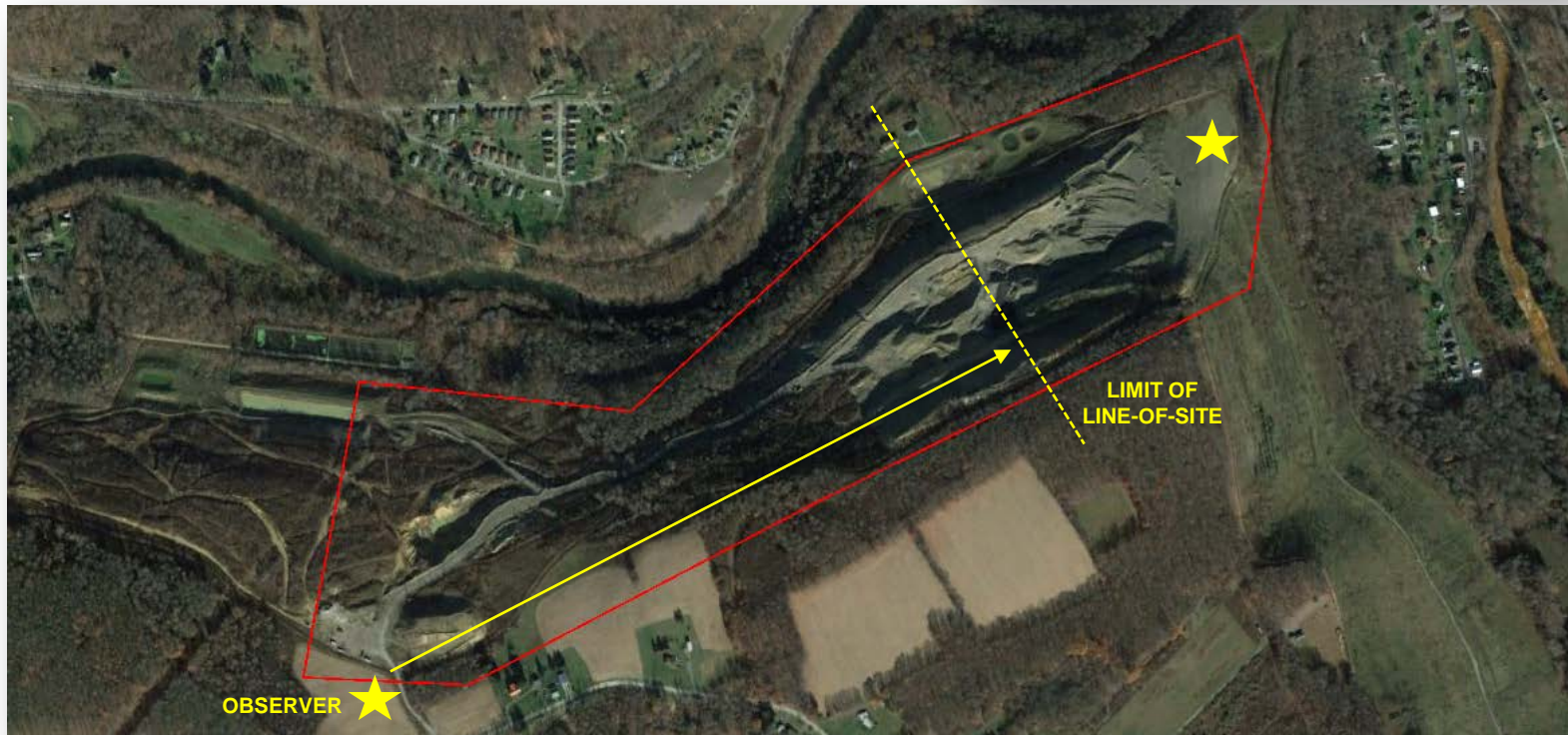
PRE-FLIGHT PLANNING

- ▶ Federal Aviation Administration (FAA) Section 333 Exemption, Pilot In Charge (PIC)
- ▶ Airspace analysis - 5 nautical miles of an airport reference point (ARP), requires airport notification and coordination
- ▶ Visited local county airport, monitoring of air traffic via radio during operations



PRE-FLIGHT PLANNING

- ▶ Mobilization
- ▶ Take-off / landing selection
- ▶ Safety precautions
- ▶ Property access considerations



PRE-FLIGHT PLANNING

- ▶ Use UAV flight planning software (senseFly eMotion) to build projects
- ▶ Import site boundary from GIS / CAD and develop flight paths
- ▶ Set take-off and landing targets, survey control as necessary

The screenshot displays the senseFly eMotion flight planning interface. The main view is a 3D aerial map of a site with a red boundary and yellow flight paths. A status window on the left shows: 0 ft/ATO, 810 ft/AMSL, 0:00, GNSS status: Standalone 3D, Idle, Ready to take off. A data panel on the right shows: Autonomy (Battery voltage: 98% (12.4 V), Time in flight: 00:00, Home distance: 0 ft, Estimated wind: A, Link quality: 93 %, 0.0 kts), Flight data (Ground speed: 0.0 kts, Altitude: 810.4 ft/AMSL, 974.4 ft/WGS84, Ground sensor height: 0.0 ft, Position: N 40.0648154°, W 82.1097711°), Instruments (AIRSPD: 0.0 kts, ALTITUDE: 0.0 ft/ATO), Identification (Name: Simulator (ER-01-008), Drone Flight Log: -), and Camera information.

0 ft/ATO
810 ft/AMSL
0:00
GNSS status: Standalone 3D
Idle
Ready to take off

Autonomy
Battery voltage: 98% (12.4 V) | Time in flight: 00:00
Home distance: 0 ft (---) | Estimated wind: A
Link quality: 93 % | 0.0 kts

Flight data
Ground speed: 0.0 kts
Altitude: 810.4 ft/AMSL, 974.4 ft/WGS84
Ground sensor height: 0.0 ft
Position: N 40.0648154°, W 82.1097711°

Instruments
AIRSPD: 0.0 kts | ALTITUDE: 0.0 ft/ATO

Identification
Name: Simulator (ER-01-008)
Drone Flight Log: -

Camera information
Camera type: WXP-DCP

SURVEY CONTROL

- ▶ **eBee UAV has Real Time Kinematic (RTK) satellite navigation that can be synced with a ground-located base station or virtual reference station (VRS)**
- ▶ **“Real time” GPS corrections via VRS require wireless hot spot, so cell phone reception necessary**
- ▶ **“VRS-only” survey yielded excellent results**
- ▶ **Added ground survey control tie-ins for selected sites**
- ▶ **Key to recognize past survey control protocol, datum, etc. in comparing volume calcs for present data survey – choose control method accordingly**



FLIGHT OPERATIONS



- ▶ Most sites required 2 “set-ups” and 2-6 flights to cover area with sufficient overlap
- ▶ PIC and observer – monitor environmental conditions, air traffic, and other hazards/contingencies



DATA PROCESSING

- ▶ Software processes imagery, generates ortho-mosaic, and topographic model for use in GIS / CADD software



AUTOCAD
MAP 3D



- ▶ High resolution elevation model used for volume calculations and to generate smoothed 2' contours



Volumes by Triangulation (Prisms)

Tue Jan 19 09:25:34 2016

Cut volume: 30,476,022.5 C.F., 1,128,741.58 C.Y.
Fill volume: 38,890,633.3 C.F., 1,440,393.83 C.Y.

Area in Cut : 2,169,620.2 S.F., 49.81 Acres
Area in Fill: 3,847,256.0 S.F., 88.32 Acres
Area exactly in daylight: 119,479.8 S.F., 2.74 Acres
Total inclusion area: 6,136,356.0 S.F., 140.87 Acres
Total exclusion area: 558,697.4 S.F., 12.83 Acres

Average Cut Depth: 14.05 feet
Average Fill Depth: 10.11 feet
Cut to Fill ratio: 0.78
Import Volume: 311,652.3 C.Y.
Elevation Change To Reach Balance: -1.371
Volume Change Per .1 ft: 22,727.2 C.Y.

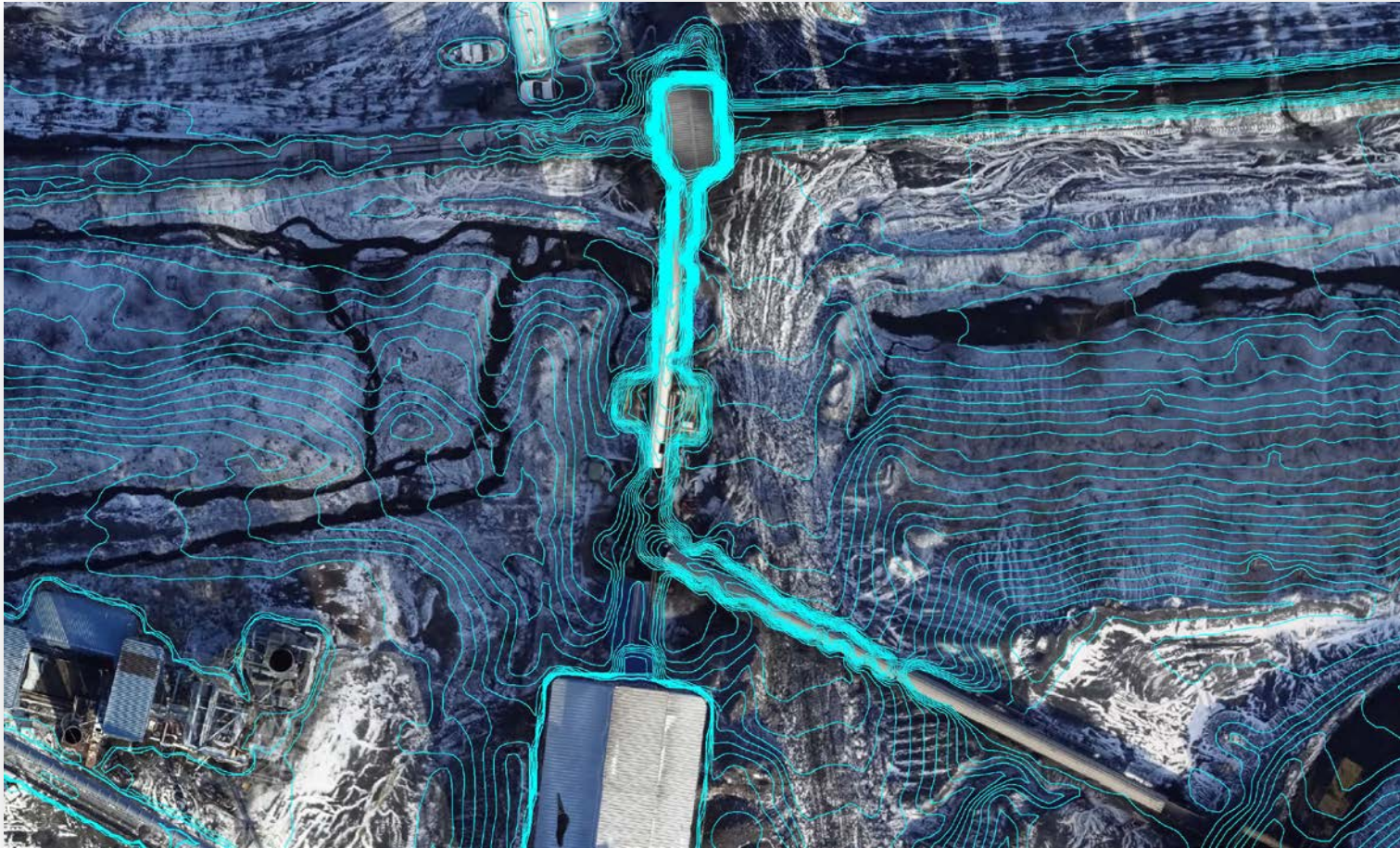
Cut (C.Y.) / Area (acres): 8012.57
Fill (C.Y.) / Area (acres): 10224.89

Max Cut: 120.882 at 1658471.796,244005.531
Max Fill: 73.905 at 1658570.906,246360.036



DATA PROCESSING

- ▶ **Data conditioning to correct around buildings and site equipment**
- ▶ **Manual vs. point cloud interpretation**





CHALLENGES

- ▶ **Weather conditions – wind, precipitation**
- ▶ **Mobilization on site**
- ▶ **Current vs. prior survey comparisons – “not all control is made equal”**
- ▶ **Data degradation:**

1.5 cm elevation model -- 2' contours -- back to elevation model?

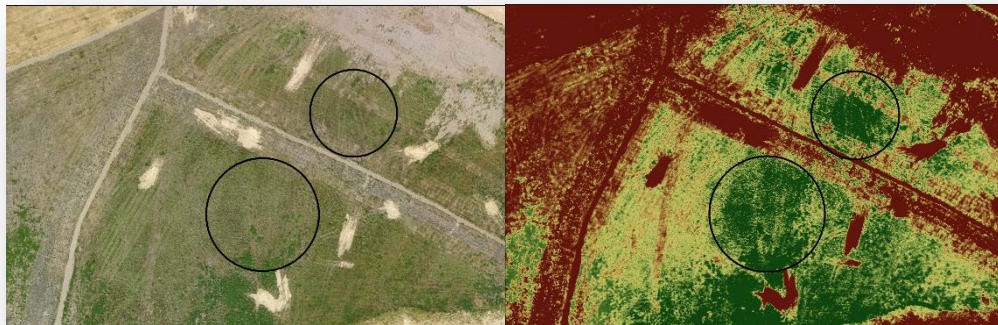


Source: NextEra Energy Resources



SUMMARY

- ▶ Mine reclamation modeling and stockpile estimation an excellent use of UAV technology
- ▶ Rapid mobilization, deployment, and processing of data
- ▶ Advances in technology – improvements in battery life (flight times), processing speed, interpolation methods (3D)
- ▶ Understand accuracy requirements – choose best tool for job
- ▶ Industry changes – softening of FAA restrictions on drone operator requirements – still focus on...
...airspace, private / public property, visual observer
- ▶ Other UAS products for reclamation – vegetation detection



QUESTIONS?



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