Statewide Drone Implementation

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MWBPP Meeting – Bismarck ND

October 15, 2019

DEPARTMENT OF TRANSPORTATION

Agenda

- Project Background
- Drone Applications
- Funding
- Tasks
- Equipment
- Timeline
- Field Work Examples
- Lessons Learned
- Next Steps

Project Overview

- Phased research began in 2015
  - Phase III completed in summer 2018
  - Published report - http://www.dot.state.mn.us/research/reports/2018/201826.pdf
- Metro District drone purchase – Elios
  - Phase IV - Implementation is underway
- FHWA EDC – 5 UAS Committee Participation
  - STIC Grant

Cost Savings

Cost Savings

- Cost Savings up to 40%
- Most cost savings where traffic control and access equipment can be reduced or eliminated.

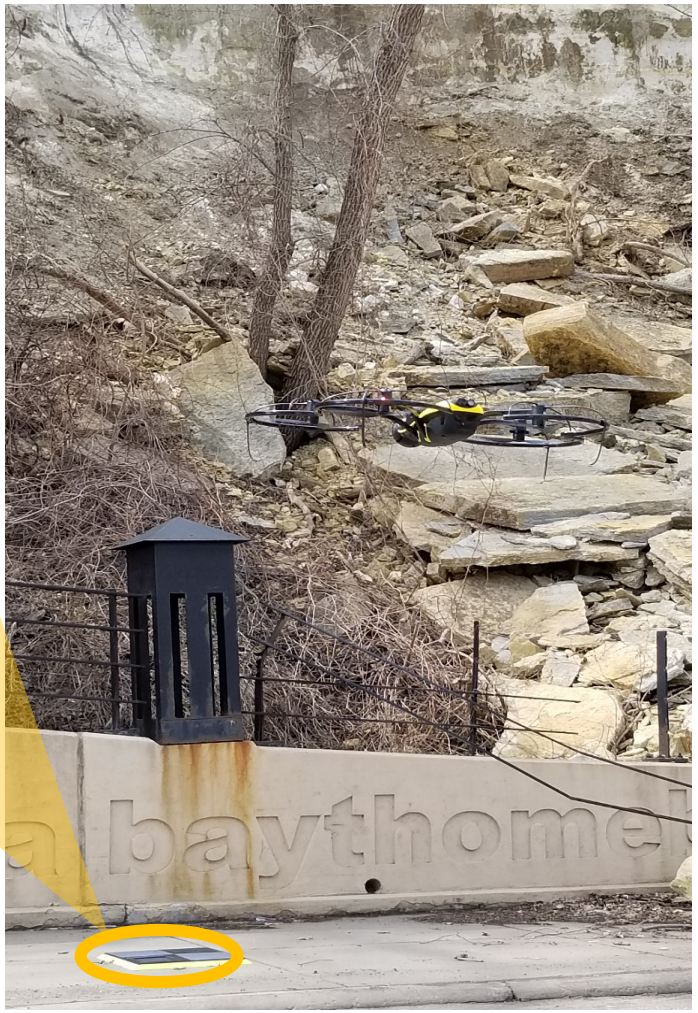
Structure	Traditional Inspection Cost	UAS Assisted Inspection Cost	Savings +/-	Savings Percentage
19538	$1,080	$1,860	-780	-72%
4175	$15,980	$13,160	2,820	18%
27004	$6,080	$4,340	1740	29%
27201	$2,160	$1,620	540	25%
MDTA Bridges	$40,800	$19,800	21000	51%
2440	$2,160	$1,320	840	39%
27831	$2,580	$540	2040	79%
82045	$2,660	$1,920	740	28%
92080	$2,580	$1,350	1230	48%
92090	$2,410	$1,570	840	35%
62504	$3,660	$1,020	2640	72%
82502	$3,240	$2,400	840	26%
			Average Savings	**40%**

Project Overview

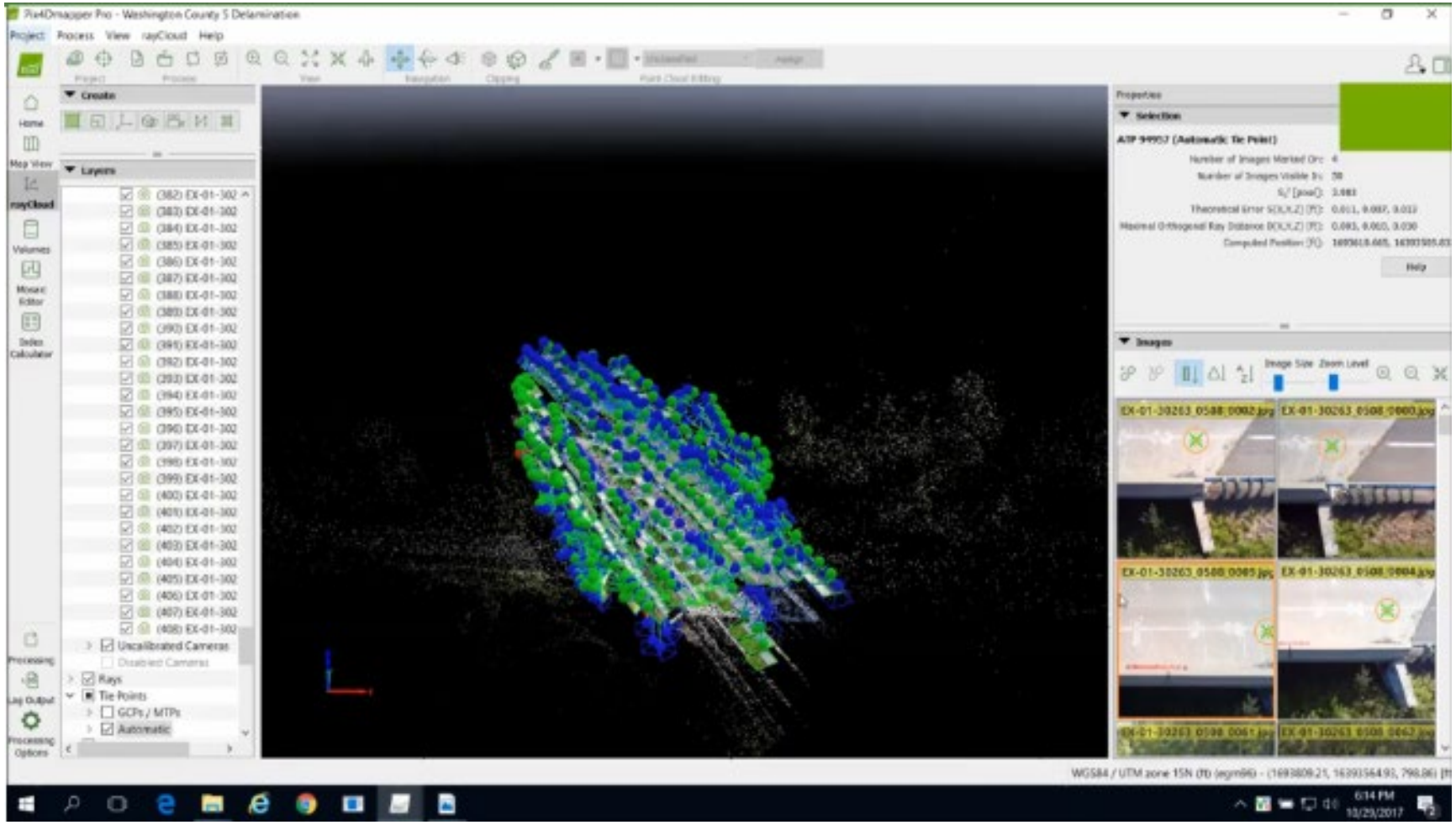
- Overall Cost Effectiveness – at a statewide level for both District and local agency bridges
- Successful Inspection
  1. Ability to detect conditions and deficiencies
  2. Documentation of deficiencies
  3. Communicate deficiencies
- Drones help us with all three of these
- Emphasis now on implementation and data analysis/presentation
- Project Manager – Jennifer Wells

Drone Applications

- Inspection-specific UAS
  - Object Sensing
  - Capable of looking up
  - Fly without GPS; under bridge decks
  - Photo, Video & Thermal Imaging
  - Confined Space
- Propellor Aeropoints
  - Aerial Ground Control Points
  - Provides precision ground control
  - Accurately geolocate assets and inspection results



Drone Data/Applications



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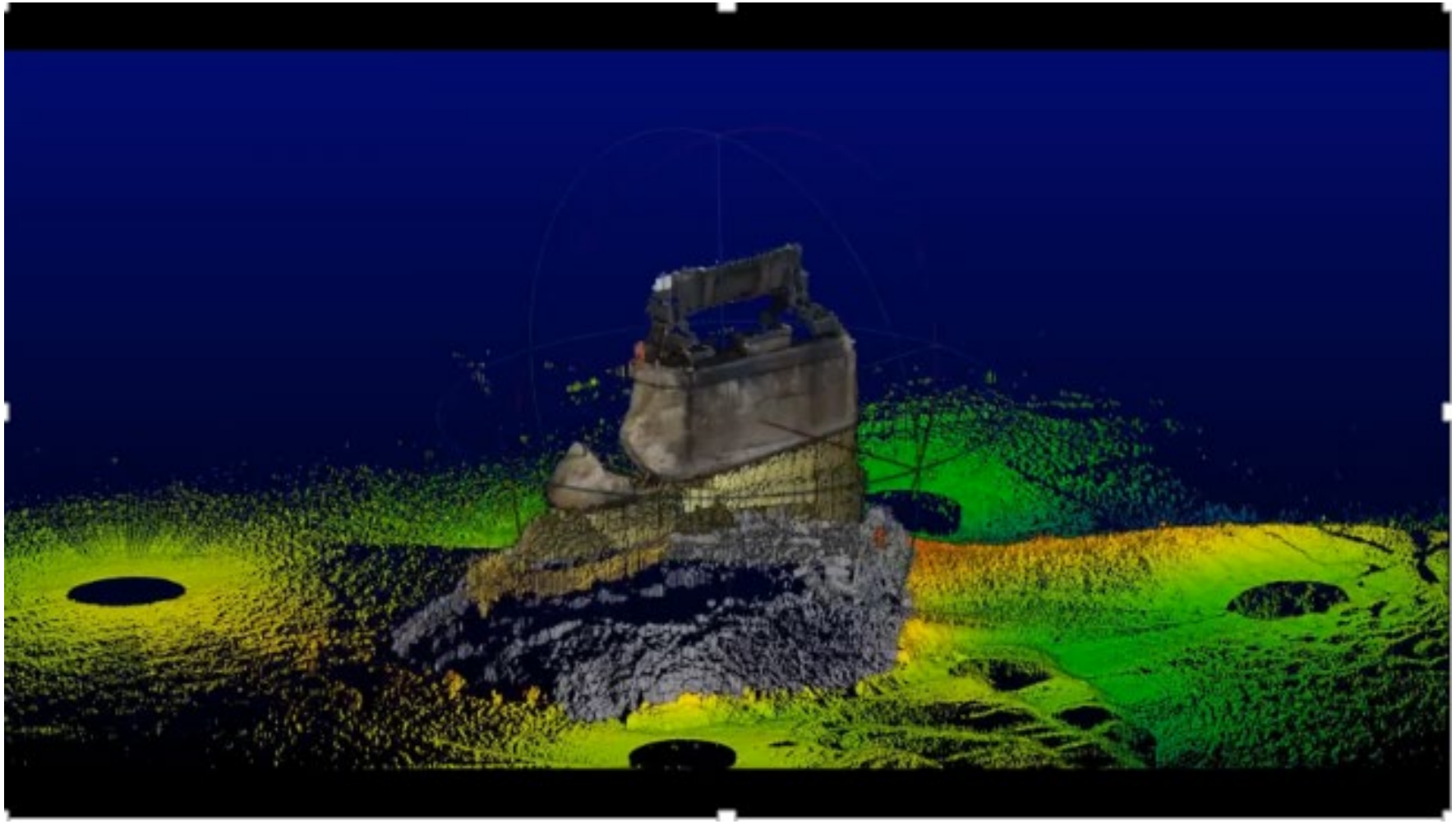

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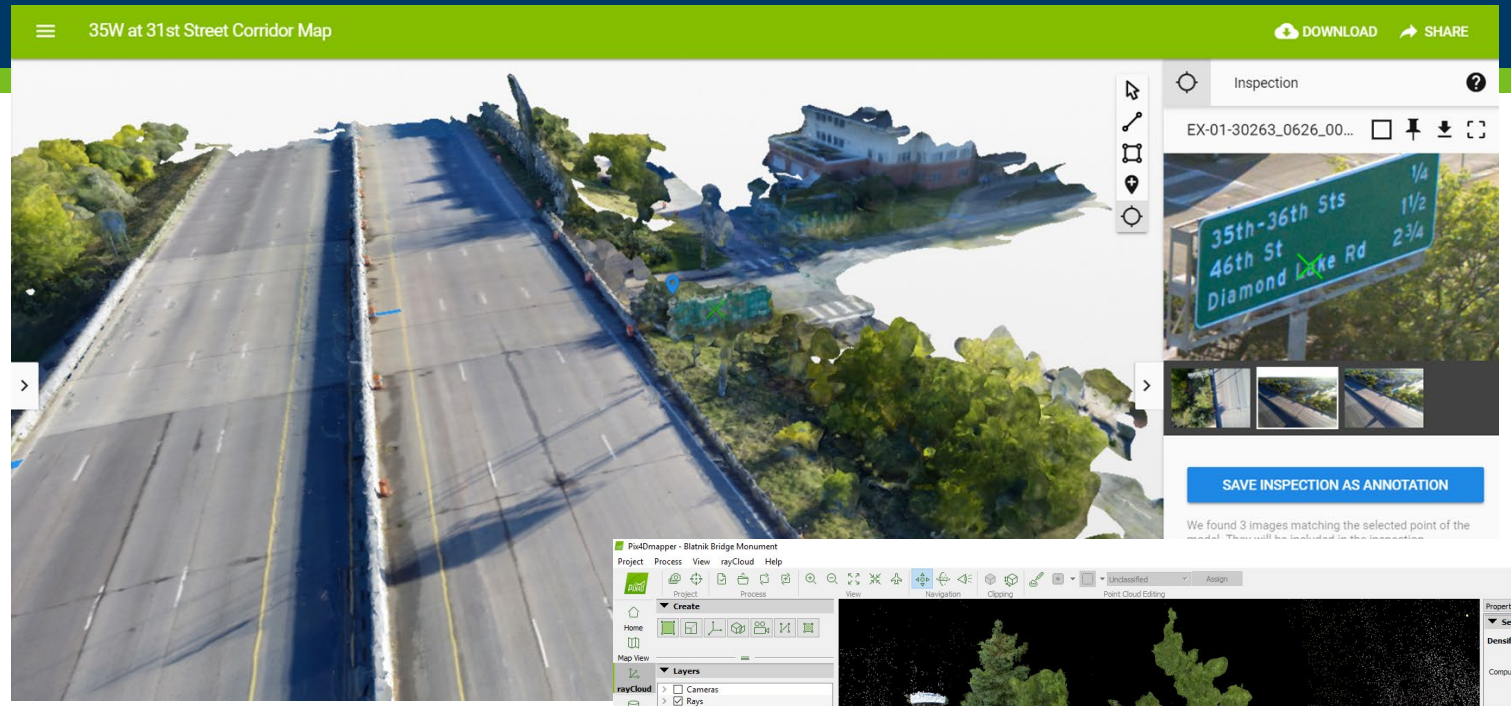

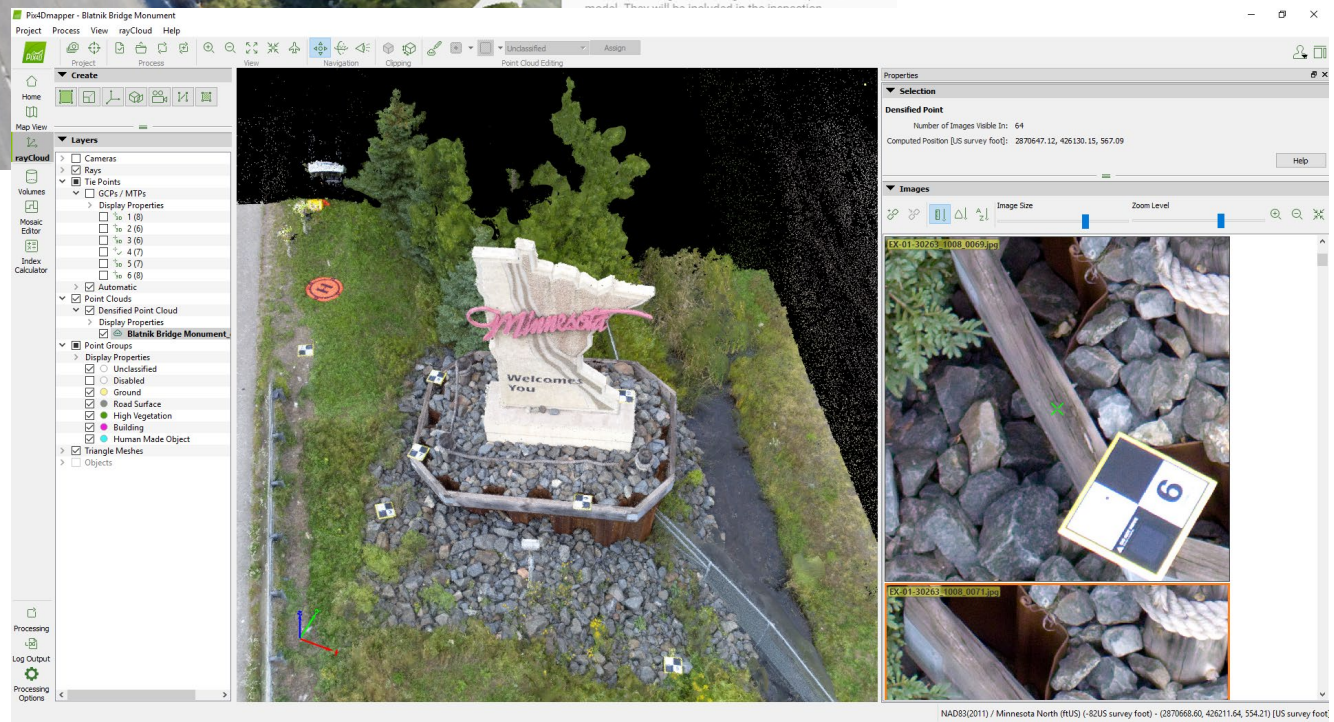

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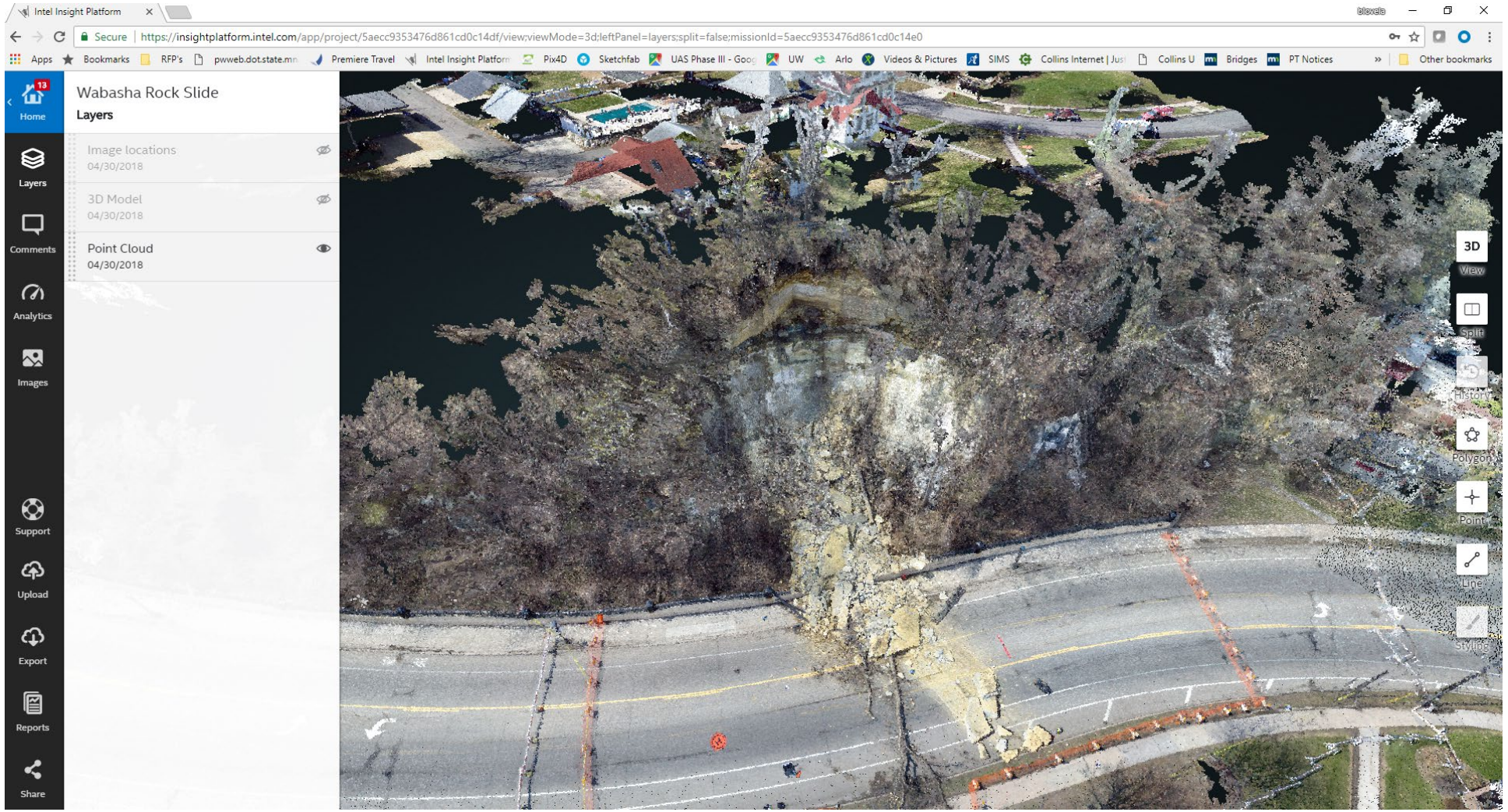


Funding

- $225,000 (Combination of Phase IV Metro & STIC)
  - $100,000 Federal STIC
  - $25,000 State Match
  - $100,000 Research $
- Scientific Equipment Budget
  - Source of state match

Implementation Project Tasks

1. DISC
2. Operations Manual
3. Drone Bridge List
4. Equipment Purchasing – drones, add-ons, software, computer
5. Develop and implement FIELD training requirements and frequency.
6. Conduct Field Work
7. Project Deliverables – report, operations manual, drone bridge list (statewide)

Goal:
Long Term Funding

Current Equipment

SPECIALTY UAS:

- Flyability Elios - $33,560 (necessary for confined space; includes training) www.flyability.com/elios
- senseFly albris - $15,000 (necessary for infrared camera, high end camera imaging – 30+MP) **NOW OBSOLETE** https://www.sensefly.com/drone/albris/
- Intel Falcon 8+ - $35,000 (necessary to replace albris capabilities) https://www.intel.com/content/www/us/en/products/drones/falcon-8.html
    - https://newsroom.intel.com/news/intel-drone-solutions-modernize-increase-efficiency-u-s-bridge-inspections/

STIC Drone - DJI Matrice 210 RTK V2

- 13.5 pound weight (FULL)
- 24-33 minute flight time
- Speed – 46-50 mph
- Full Range Camera
- Hover mode
- Object sensing
- Self-heating batteries!
- 6 Different CAMERA options
- 4K Video
- Zoom – 30x optical; 6x digital
- Thermal Option
  - FLIR
- Wind Resistance
  - up to 27 mph
- Temp Range
  - -4 to 122 degrees F
- SD Cards
- MONITOR
- $20k-$30k

STIC Acquisition Drones – Mavic 2

- 2.5 pound weight
- 31 minute flight time
- Speed – 30-45 mph
- Hover mode
- Object sensing
- Self-heating batteries!
- 12 MP camera
- 4K Video
- Ocusync
- Zoom Option
- Thermal Option
  - FLIR
- Wind Resistance
  - up to 25 mph
- Temp Range
  - 14-104 degrees F
- SD Cards
- MONITOR
- $2000-$3000

STIC Drone Add-Ons

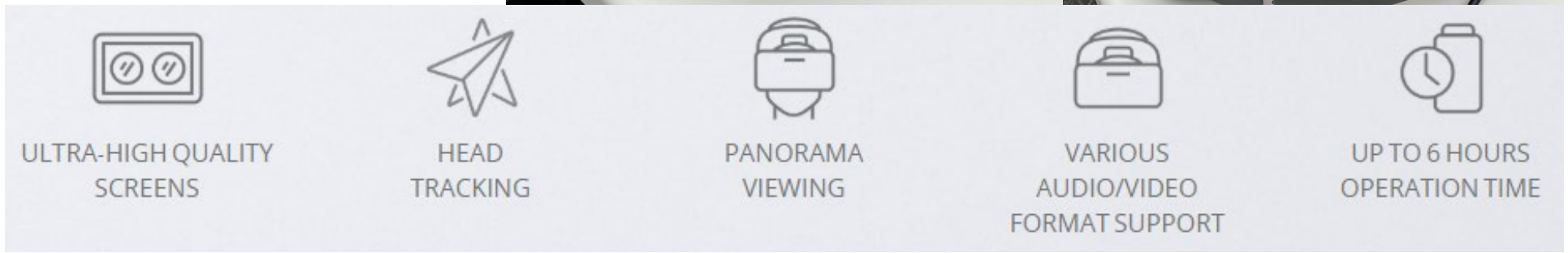
CrystalSKY

- Ultra-BRIGHT
- Smoother Video
- Interchangeable
- Power Supply
- 4K
- Dual SD Slots
- Extreme Temps
- 5-6 HR Run Time
- $469

STIC Drone – Add-Ons

FPV Goggles

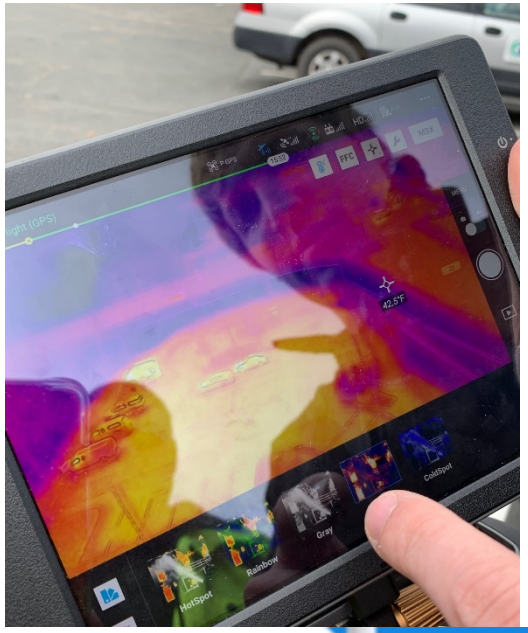
- 360 degrees
- Wireless - Consumer
- Low Lag
- High Resolution
- Head Tracking
- Touchpad
- Super LIGHT
- Fits over glasses…
- 6 HR Run Time
- $349
- Compatible

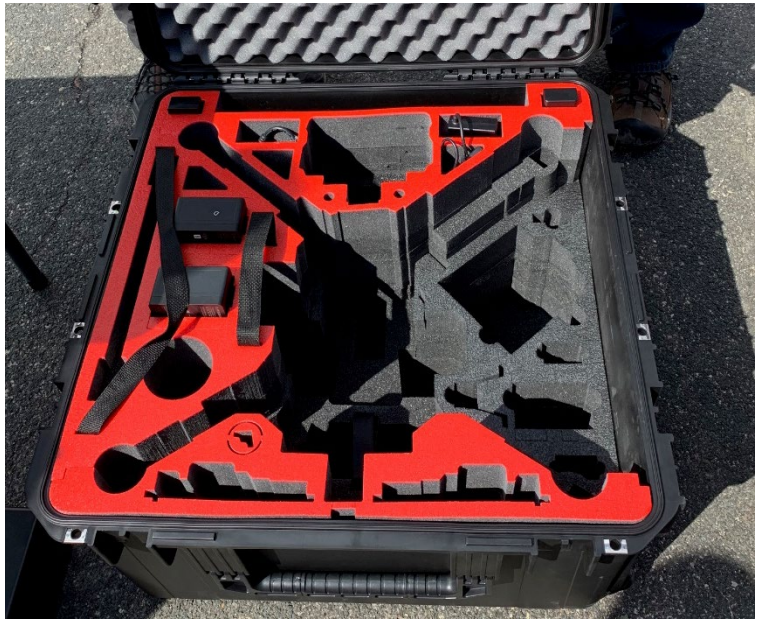


STIC Drone – Add-Ons

Other Items

- Cases
- Batteries
- Datalink
- HDMI





Other Cost Effective Drones Looked At…

COST EFFECTIVE INSPECTION UAS

Name	Image	Camera	Range	Time	Cost
5. Yuneec Typhoon H		4K	1500m	25min	$800-$1,300
4. Autel Robotics X-Star Premium		4K	2000m	25min	$800-$1,000
3. Yuneec Tornado H920		Panasonic GH4	1500m	24min	$2,800
2. DJI Mavic Pro		4K	7000m	27min	$1,000
1. DJI Inspire 2		5.2K	7000m	27min	$3,000

ADDITIONAL EQUIPMENT

SUPER COMPUTER – 3D Post Processing Capability (paid for with Bridge Office funding)

POST-PROCESSING SOFTWARE:

- Pix 4D – estimated at $10,000 https://pix4d.com/

LICENSING/REGISTRATION/INSURANCE:

- Licensing - $150/pilot (for two years) https://www.faa.gov/uas/
- UAS FAA Registration - $5/UAS (annually) https://faadronezone.faa.gov/#/
- UAS MnDOT Registration – No COST
- INSURANCE Required? YES!

FIELD SUPPLIES:

- Extra batteries, external hard drives, power cords, communication devices, etc. - $1,000

EQUIPMENT

EXAMPLE COST OPTION

*2 pilots/2 Mavic per District (1, 2, 3, 6) plus Bridge

Purchase	Unit Cost	Quantity	Total
Elios UAS	$33,560	1 (Bridge Office)	$33,560
Falcon 8+	$35,000	2 (Bridge & Metro)	$70,000
DJI Mavic UAS	$1,000	10	$10,000
Pix 4D Software	$10,000	1	$10,000
Pilot License	$150 (initial)	8 (Jen & Mike licensed)	$1,200
UAS Registration	$5	13 UAS	$55
UAS Insurance	TBD	TBD	~$10,000
Field Supplies	$500	13	$6,500
		TOTAL:	**$141,315**

STIC - $125,000

PHASE IV - $100,000 (overlap)

Super Computer – separate cost funded by Bridge Office (~$5k)

TIMELINE

Milestones (Tasks)	Target Date	TOTAL COST	Federal Cost	State Cost	$100k Research
1. DISC Formation and Task Submittal	12/31/18	$5,000	$2,222+	$555+	$2,222+
2. UAS Bridge List Submittal	12/31/18	$10,000	$4,444+	$1,111+	$4,444+
3. UAS Purchase Completion	1/31/19	$95,000	$42,222+	$10,555+	$42,222+
4. Inspection Schedule Submittal	1/31/19	$10,000	$4,444+	$1,111+	$4,444+
5. Field Work & Safety Plans	2/28/19	$10,000	$4,444+	$1,111+	$4,444+
6. UAS Field Training Development	7/31/19	$10,000	$4,444+	$1,111+	$4,444+
7. Field Work Completion	10/31/19	$50,000	$22,222+	$5,555+	$22,222+
8. UAS Operation Manual Draft Submittal	1/31/20	$15,000	$6,666+	$1,666+	$6,666+
9. Final Report Draft Submittal	5/1/20	$15,000	$6,666+	$1,666+	$6,666+
10. Final Report Publication	6/30/20	$5,000	$2,222+	$555+	$2,222+
	TOTAL:	**$225,000**	**$100,000**	**$25,000**	**$100,000**

$100,000 from current Phase IV research contract, $100,000 Federal STIC grant, and $25,000 State match.

Field Work - Bridge Candidates

Bridge Candidates

Works Well

- Large Bridges
- Bridges in open areas
- Bridges that depend on traffic control and UBIV's for inspection

Does Not Work Well

- Bridges over high ADT roadways
- Bridges in heavily wooded areas

REQUIREMENTS FOR ROUTINE BRIDGE ACCESS

02-07-2017

The National Bridge Inspection Standards (NBIS) definition of a routine inspection is as follows.

- Regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements.

The AASHTO Manual for Bridge Evaluation states that "Special equipment, such as under-bridge inspection equipment, rigging or staging, is necessary for routine inspection in circumstances where its use provides for the only practical means of access to areas of the structure being monitored".

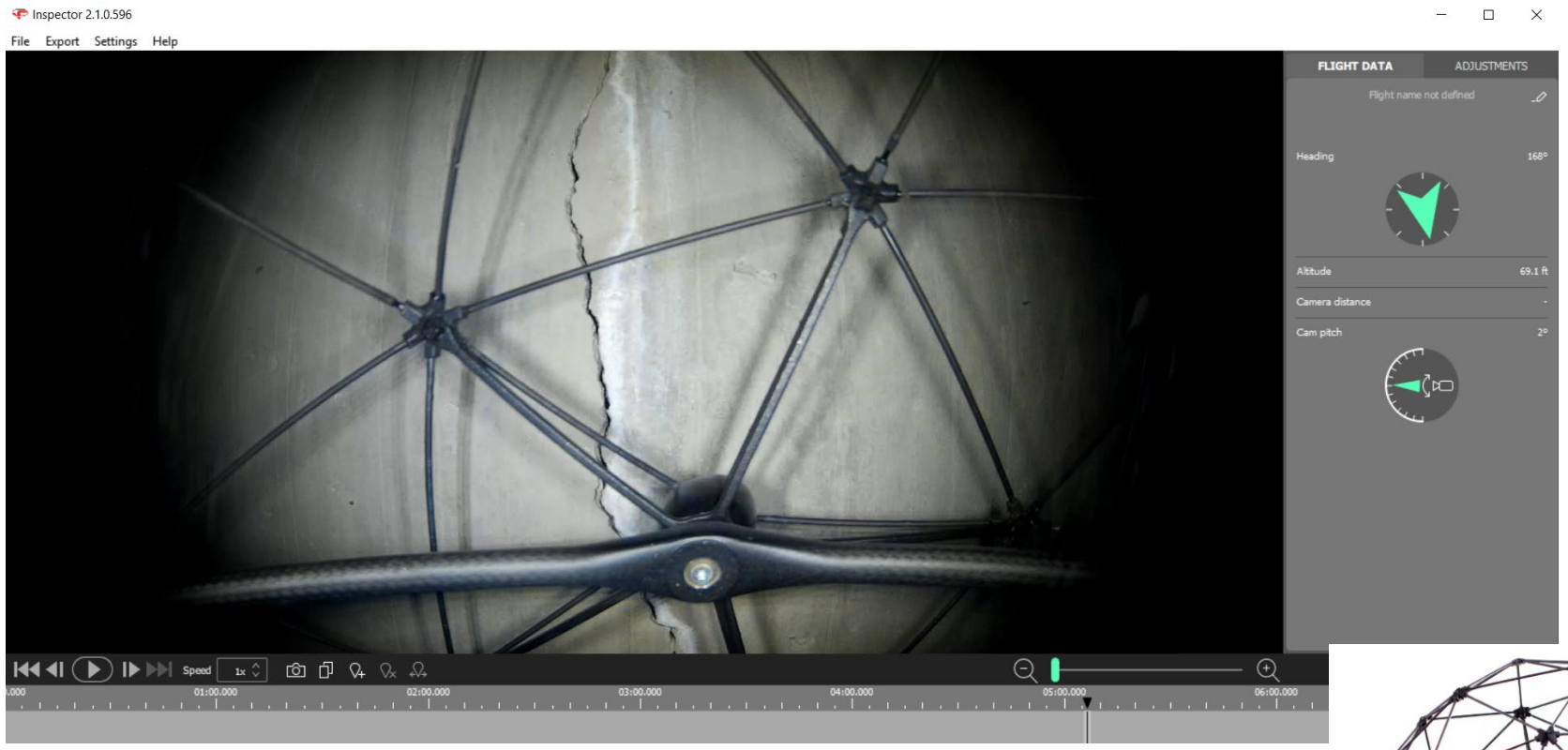
There are times when the typical means of access for a routine inspection is not sufficient to satisfy the NBIS requirements. When routine inspection methods are not sufficient, inspections are expected to be conducted utilizing snoopers, lifts, ladders, barges, magnification optics, etc. as necessary to carefully and completely identify any condition changes.

The following requirements were created to establish criteria for when bridge owners are expected to be taking a closer look at bridges, either due to deteriorated conditions of one or more elements or the element's location makes it difficult to assess its condition. The following criterion is for determining which bridges require enhanced inspection access techniques:

1) Any bridge that meets the following condition based criteria requires enhanced inspection access to more thoroughly evaluate the condition state of the affected element.
   a. Any bridge with a Superstructure (FHWA Item #59) or Substructure (FHWA Item #60) with an NBI condition rating of 4 or less.
   b. Any bridge with a Defect Element which represents elevated levels of deterioration per the following table:

DEFECT ELEMENT	CONDITION STATE(S)
Element #880 – Impact Damage	2, 3, or 4
Element #881 – Steel Section Loss	3 or 4
Element #882 – Steel Cracking	2, 3, or 4
Element #883 – Concrete Shear Cracking	2, 3, or 4
Element #884 – Substructure Settlement	3 or 4
Element #885 – Scour	3 or 4

Field Work Examples



Field Work Examples

Document Conditions and Deficiencies – Orthomosaic

Field Work Examples

Document Conditions and Deficiencies – Point Clouds

Lessons Learned

Benefits

- Safety Improvements
- Access
- Quality Gains
- Cost Savings
- Reduced Public Impact
- Assist with Data Driven Decisions

Challenges

- Learning Curve
- Not Hands On
- Acceptance
- Rules and Regulations
- Lots of Data!

Next Steps

- Develop UAS Operation Manual
- Purchase Equipment
- Perform Statewide Training
- Develop Drone Inspection List Criteria
- Publish Final Report

We feel the NEED…the need…for SPEED!

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