

Utilizing Unmanned Aircraft Systems (UAS) for Bridge Inspections

Presented by:

Sarah Sondag, MnDOT

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Midwest Bridge Preservation Conference

Minnesota Department of Transportation




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Phase I Project Background

- MnDOT Bridge Office identified Unmanned Aircraft Systems (UAS) as a potential useful technology
- Additional Research Dollars Available
- Project was scoped, funded and completed in two months

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Project Team

- Beverly Farraher, MnDOT State Bridge Engineer
- Sarah Zink, MnDOT Office of Bridge and Structures
- Bruce Holdhusen, MnDOT Research Services
- Nancy Daubenberger, MnDOT Engineering Services Division Director
- Cassandra Isackson, MnDOT Office of Aeronautics Services Director
- Tara Kalar, MnDOT Office of Chief Counsel
- Scott Thiesen, MnDOT Office of Bridges and Structures
- Joe Fishbein, MnDOT Office of Bridges and Structures
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- Chris Meyer, MnDOT Office of Aeronautics
- Barritt Lovelace, Collins Engineers
- Cory Stuber, Collins Engineers
- Garrett Owens, Collins Engineers
- Terrance Brown, Collins Engineers
- Keven Gambold, Unmanned Experts
- Dave Prall, Unmanned Experts
- Matthew Wichern, Unmanned Experts
- Dan Stong, RDO
- Adam Zylka, Sensefly

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Presentation Overview

- Project Scope
- FAA Rules
- Assessment of Current Practices
- Assessment of Phase I and Phase II UAS Technologies
- Project Planning
- Phase I Results
- Phase II Study
- Phase III
- Conclusions and Recommendations
- Public Response

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Demonstration Project Scope

- Evaluate UAS safety and effectiveness as it applies to bridge inspection.
- Utilize UAS technology in the inspection of four bridges at various locations throughout Minnesota.
- Investigate UAS effectiveness in improving inspections and reducing inspection costs.
- UAS technologies were investigated to evaluate their capabilities as they relate to bridge inspection.
- Research report written for the MnDOT Research Services Office.

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Flight Safety Restrictions

Previous FAA Rules

- Licensed pilot is required to operate the UAS.
- UAS must be operated within line of sight.
- UAS must not be operated within 5 miles of an airport unless prior authorization from the airport operator ***and*** the airport air traffic control tower is received
- Cannot fly within 500 ft. of non-participants.

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FAA Part 107 Rules– August 29th, 2016

- Remote pilot certificate with small UAS Rating.
  - Pass an aeronautical knowledge test and a TSA background check.
- UAS must be operated within line of sight.
- Operations during daylight and twilight if UAS has lights.
- Cannot fly directly over non-participants.
- Max speed 100 mph; Max height 400 ft.
- Operations in Class B, C, D and E airspace allowed with ATC permisison
- Some restrictions can be lifted with an FAA waiver

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Assessment of Current Practices

Access Methods

- Aerial Work Platforms (AWP's)
- Rope Access and Structure Climbing
- Ladders

NBIS and MnDOT Requirements

- Hands On Inspection
- Non Hands on Inspection
- Measurements/Testing

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Assessment of UAS Technology

- Phase I Technology
  - Not capable of looking up
  - Unable to fly without GPS
  - Photo, Video and Thermal Imaging
- Phase II Technology
  - Inspection-specific UAS
  - Object Sensing
  - Capable of looking up
  - Fly without GPS, under bridge decks
  - Photo, Video and Thermal Imaging

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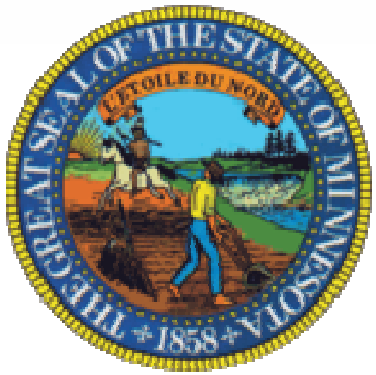
Project Planning

Approvals

- Governors Office
- FAA
  - 333 Exemption
  - Certificate of Authorization
- MnDOT Aeronautics
- National Park Service
- CN Railway
- Bridge Owners Coordination



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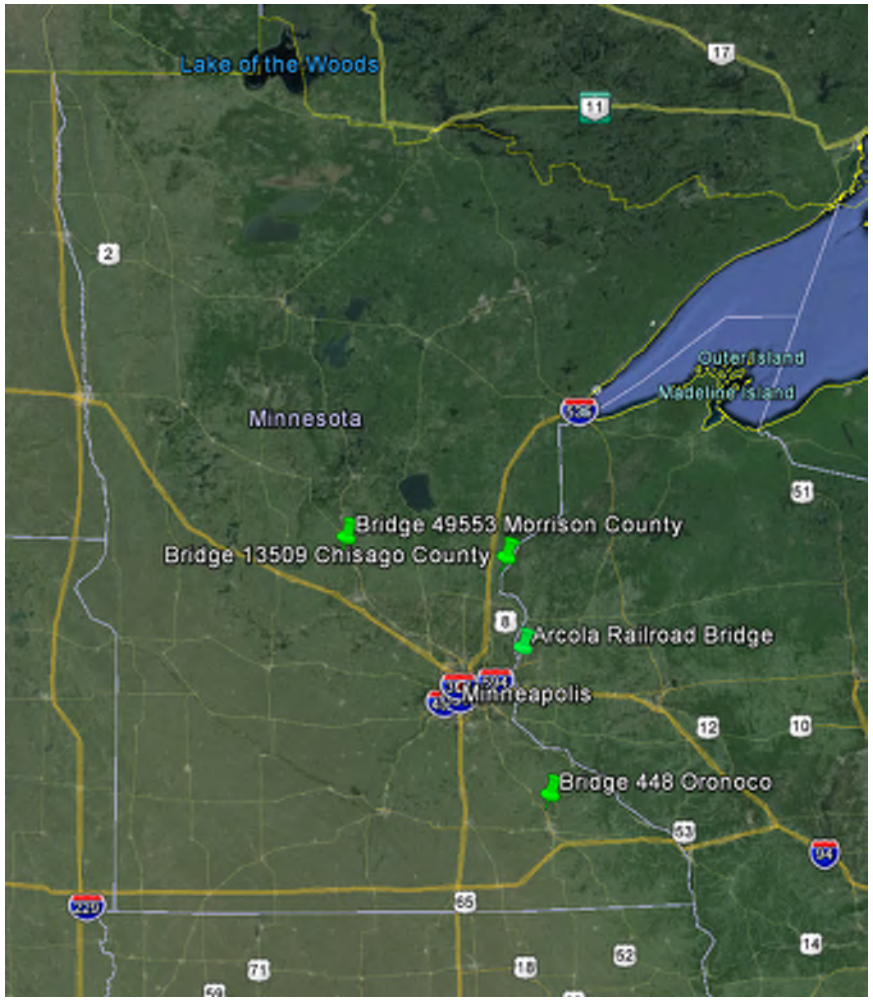
Project Planning

Bridge Selection Criteria

- Rural vs. Urban
- Variety of Bridge Sizes
- Variety of Bridge Types
- Bridge Location
- Bridge Owner Cooperation
- Limit Public Contact



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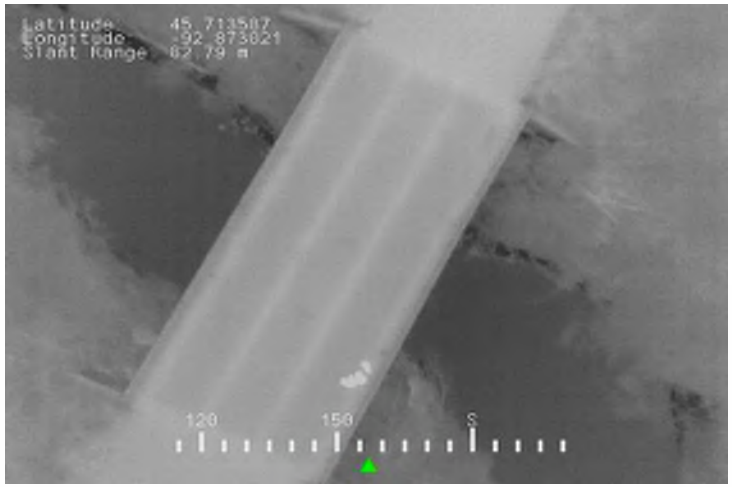
Bridge Inspection Methods and Results

Bridge 13509 – Chisago County

- Small Local Bridge
- Prestressed Concrete Beam Bridge
- National Park Service Permission
- Unable to Fly Under Bridge
- Infrared Images
- Orthographic Mapping



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Bridge Inspection Methods and Results

Table 5-1 Bridge 13509 Inspection Element Table

Bridge Element	Condition State	Previous Inspection Note	Discernable from UAV Video/Photo/IR Image
012 Top of Concrete Deck	2852 FT^2 CS 1	25 % of Deck	Yes, gravel is clearly visible in photos, now at 50%.
109 Prestressed Concrete Girder or Beam	312 FT CS 1	None	Yes, (fascia's only)
215 Reinforced Concrete Abutment	72 FT CS 1	None	No, unable to fly under deck.
311 Expansion Bearing	4 EA CS 1	Three anchor bolt nuts missing.	No, unable to fly under deck.
313 Fixed Bearing	4 EA CS 1	Five anchor bolt nuts missing.	No, unable to fly under deck.
331 Reinforced Concrete Bridge Railing	129 FT CS 1 32 FT CS2	Minor shrinkage cracks.	Yes
361 Scour Smart Flag	1 EA CS 1	None	Yes
380 Secondary Structural Elements	1 EA CS 1	Steel Diaphragms	No, unable to fly under deck.
387 Reinforced Concrete Wingwall	4 EA CS 1	None	Yes

Bridge Element Comparison

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Bridge Inspection Methods and Results

Bridge 448 – Oronoco Bridge

- Historical Concrete Arch Bridge
- Prestressed Concrete Beam Bridge
- Unable to Fly Under Bridge
- Able to fly in Rain

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Bridge Inspection Methods and Results

Table 5-2 Bridge 448 Inspection Element Table

Bridge Element	Condition State	Previous Inspection Note	Discernable from UAV Video/Photo/IR Image
26 Top of Concrete Deck - EPX	14521 FT^2 CS 1	Deck was chained and no delamination was found.	No, FAA requirements only allowed flight under the level barrier.
300 Strip Seal Joint	92 FT CS 1	South end: West side 1 7/8" East side 2". North end: West side 1 1/2", East side 1 3/8" at 30 deg.	No, FAA requirements only allowed flight under the level barrier.
333 Railing	520 FT CS 1 71 CS 2	Minor vertical 0.013" cracks in concrete both sides of bridge. The galvanizing on the rail is fading.	Yes
109 P/S Concrete Girder	409 FT CS 1 1 FT CS 2	North approach span east fascia beam bottom flange has a patched area on the east side of the beam 8' from the north abutment.	Yes
144 Concrete Arch	229 FT CS 1 188 FT CS 2	Spalls were repaired by MnDOT in July 2014. See history file attachment and photos and notes below.	Yes
155 Concrete Floorbeam	883 FT CS 1 9 FT CS2	There is a small delamination and crack in the north side of the center floorbeam against the east arch. The south end of the center floorbeam has small cracks against the arch.	Yes

Bridge Element Comparison

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Bridge Inspection Methods and Results

Bridge 49553 –Morrison County Pedestrian Bridge

- Large Steel Truss
- Difficult to access with UBIV
- Great detail in images
- Pack rust visible
- Concrete deterioration visible

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Bridge Inspection Methods and Results

Table 5-3 Bridge 49553 Inspection Element Table

Bridge Element	Condition State	Previous Inspection Note	Discernable from UAV Video/Photo/IR Image
31 Timber Deck	8450 FT^2 CS 2	Constructed 13' wide x 4" thick x 650' treated timber deck and replaced 33 RR ties. Also placed 2" treated timber wear course.	Yes
407 Bituminous Approach	2 EA CS 1	Paved 2" bituminous in November, 2006. 8/28/13 - West approach failure repaired by MCHD. Good condition. Erosion on East approach repaired w/ quarry run riprap.	Yes
334 Metal Rail Coated	1299 FT CS 1	Placed 1,300' of coated chain link fence in November, 2006. 8/27/12 - Missing (1) end cap on East end.	Yes
117 Timber Stringer	3251 FT CS 1	Constructed 5- 4"x 8" treated timber stringers.	Yes, partially
131 Painted Stl Deck Truss	351 FT CS 2 299 FT CS 2	10/4/04 - All steel corroding & in need of rehab.	Yes
311 Expansion Bearing	1 EA CS 1 8 EA CS 2 1 EA CS 3	10/11/05 - Bearings show movement is possible. Significant corrosion is present, but bearings appear functional. 8/27/12 - Extensive crack in lower portion of bearing on South bearing on East abutment. 8/28/13 - Changed quantity to	Yes

Bridge Element Comparison

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Bridge Inspection Methods and Results

Bridge 49553 –Morrison County Orthographic Mapping

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Bridge Inspection Methods and Results

Bridge 49553 –Morrison County Orthographic Mapping

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Bridge Inspection Methods and Results

Arcola Railroad Bridge

- Large Complex Bridge
- Normally inspected using rope access
- National Park Service Permission
- Difficult to access

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Bridge Inspection Methods and Results

Arcola Railroad Bridge – Image Detail

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Bridge Inspection Methods and Results

Arcola Railroad Bridge – Image Detail

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Bridge Inspection Methods and Results

Arcola Railroad Bridge – Image Detail

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Bridge Inspection Methods and Results

Arcola Railroad Bridge – Image Detail

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Bridge Inspection Methods and Results

Arcola Railroad Bridge

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Phase II Study

- Cost comparison with UBIVs, traffic control
- Explore inspection specific technology including the Sensfly eXom
- Compile a best practices document
- Incorporate into an actual inspection
- Use UAS in the planning of an inspection
- Use a secondary display for bridge inspector
- Deck surveys with zoom camera
- Culvert and Box Girder Inspection
- IR Deck Delamination Assessment at Dawn
- Paint Assessment
- Data on how many hours UAS vs. other methods

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Phase II Study

Blatnik Bridge Inspection

- Second Largest Bridge in Minnesota
- Crosses Duluth Harbor adjacent to Lake Superior
- Challenging wind and weather

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Phase II Study

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Phase II Study

Nielsville Bridge 5767

- Infrared Imaging
- Thermal Camera results were similar to high end Flir cameras
- Drone has the ability to map chain drag markings for quantities in CAD

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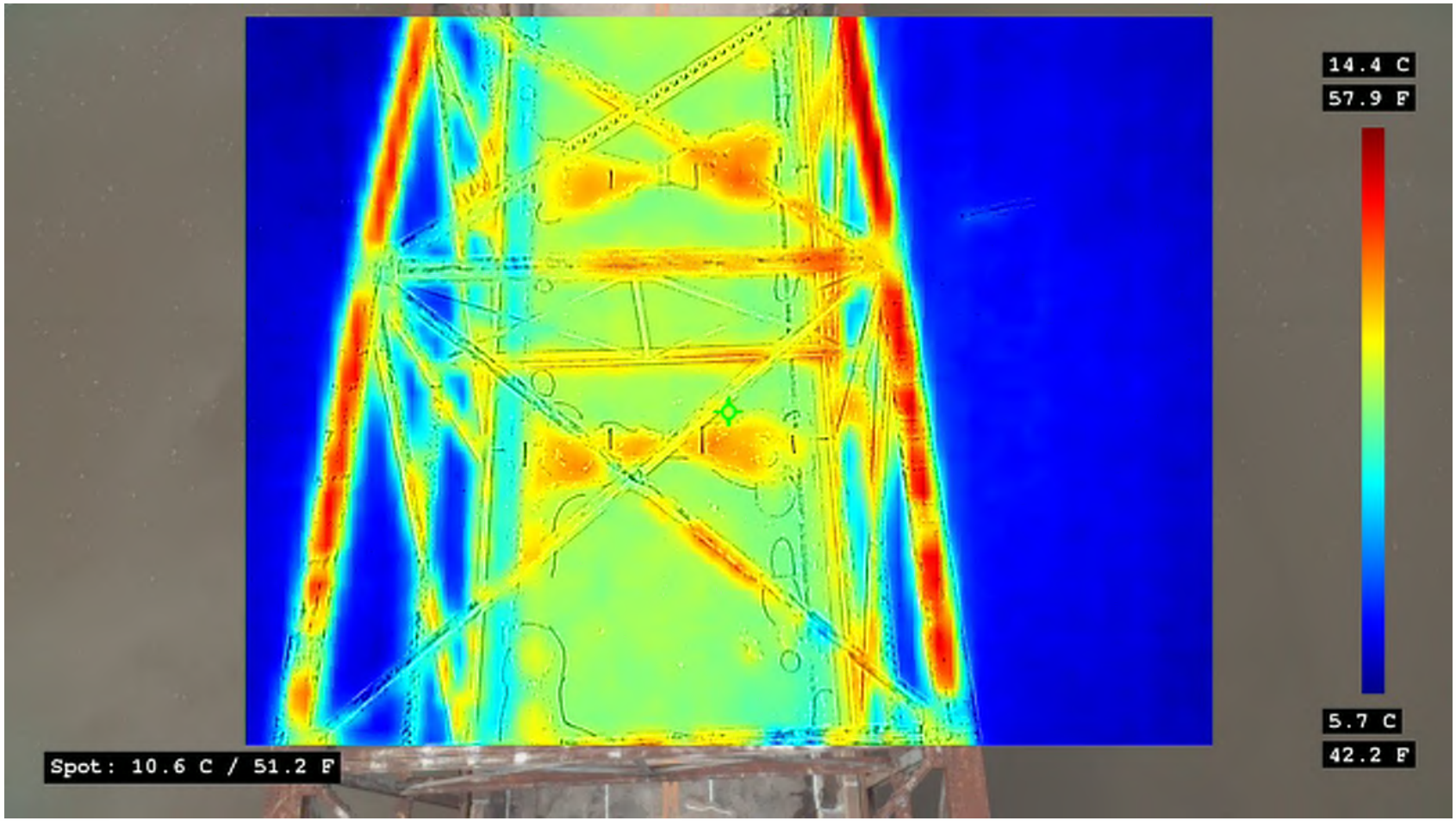
Phase II Study



Nielsville Bridge 5767

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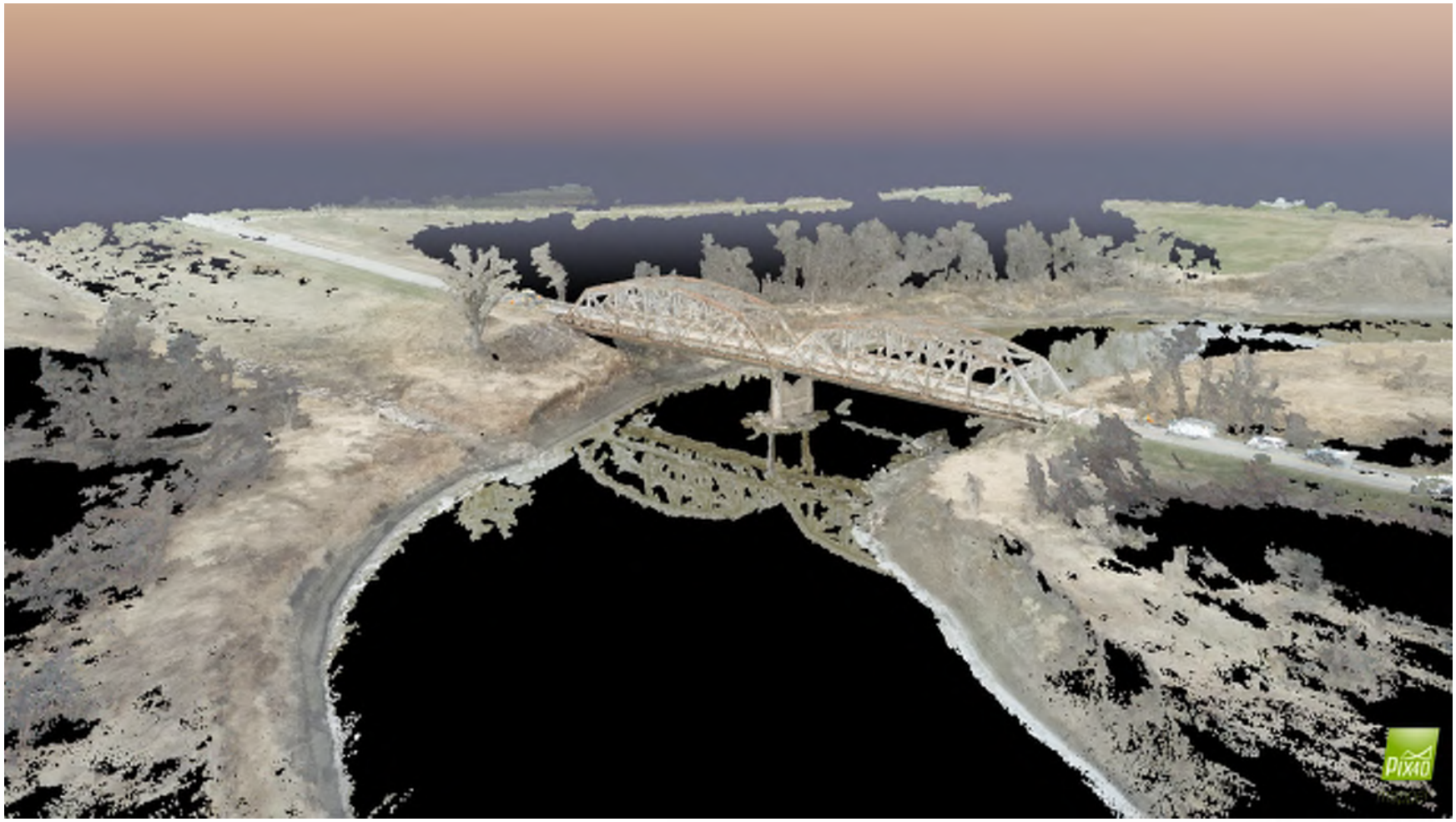
Phase II Study



Bridge 5767 3D Point Cloud

Phase II Study

City of St. Paul Culvert 62513

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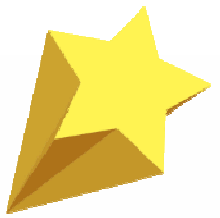
Phase III – Project Goals

- Statewide UAS Inspection Contract – based on the MnDOT Bridge Access Inspection Policy list
- Overall Cost Effectiveness – at a statewide level for both District and local agency bridges
- Inspection Quality and Safety Improvements – close-up, 3D, and thermal imagery
- Identification of Sustainable Future Funding



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Phase III – Schedule & Cost

- **Task I** – Finalize Bridge Work Plans/Approvals
  - 9 months beginning **August 2016**
- **Task II** – Field Work and Evaluation
  - 9 months – **April to December 2017**
- **Task III** – Documentation/Final Study Report
  - 6 months – **Ending June 2018**
- **COST** - $100,000
  - Task I - $30,000
  - Task II - $50,000
  - Task III - $20,000

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Conclusions

- UAS can be used in the field during bridge inspections safely.
- Image quality allows for the identification of defects.
- Tactile functions cannot be replicated using UAS.
- UASs can be cost effective.
- UASs can provide a very efficient way to collect infrared images
- Safety risks could be minimized with the use of UASs.
- UASs can be utilized to determine channel conditions.
- UASs can provide important pre-inspection information.
- “Off the shelf” UAS’s have limited inspection capability.
- FAA rules are improving.

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Recommendations

- Based on the information presented in this report the following recommendations are made:
- The use of UASs for bridge inspection should be considered when a hands on inspection is not needed.
- Should be considered for routine inspections to improve the quality of the inspection.
- Should also be considered where they can increase safety for inspection personnel and the traveling public.
- A set of best practices and safety guidelines should be prepared.
- Should be considered for interim inspections or to monitor areas of concern.
- Should be considered for emergency inspections.

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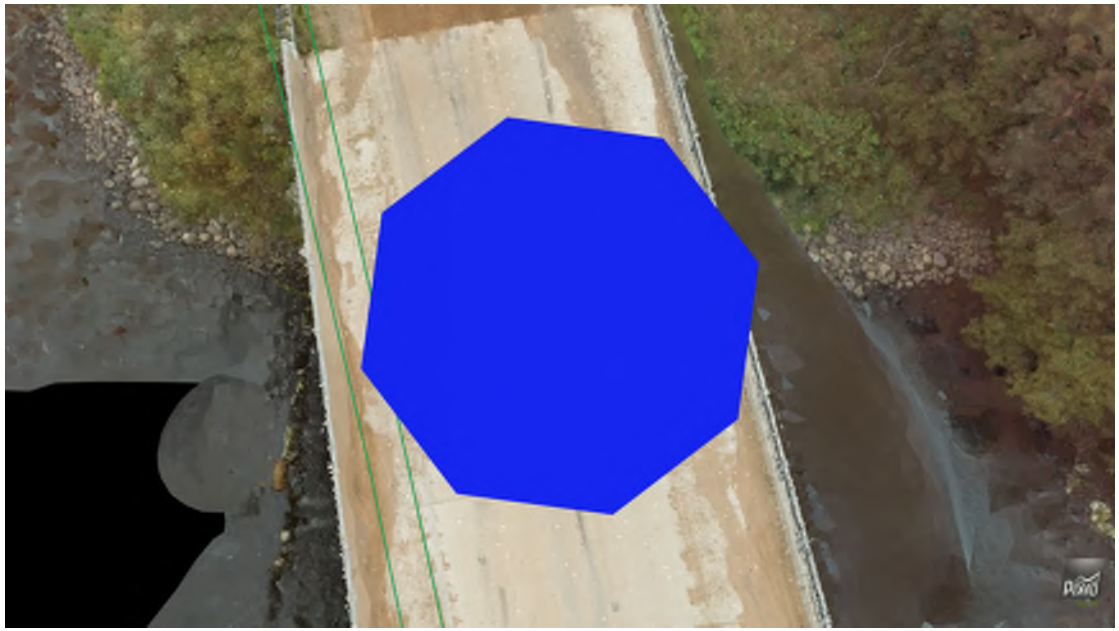
Other Civil Engineering Uses

- 3D Mapping
- Dam Inspection
- Earthwork Volumes
- Traffic Control Monitoring
- River/Stream Inspections
- RR Track Inspection
- Pavement Inspection
- High Mast Light Inspection
- Utility Inspection
- Construction Site Assessment



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Public Response

- Almost 100 news articles and stories
- Overwhelmingly positive
- Safety, reduced closures and cost efficiency valued by public

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Bridge Owners

A special thank you to all the bridge owners who made available their bridges for the inspection phase of the study:

- Joe Triplet, Chisago County
- Mike Sheehan, Olmsted County
- Kaye Bieniek, Olmsted County
- Benjamin Johnson, Olmsted County
- Jeff Busch, Olmsted County
- Kent Haugen, Olmsted County
- Cain Duncan, City of Oronoco
- Steve Backowski, Morrison County
- John Kostreba, Morrison County
- DJ Prom, Morrison County
- Sergio Zoruba, Canadian National Railway
- Peter de Vries, Canadian National Railway
- Albert Hines, Canadian National Railway
- Kevin Rohling, MnDOT District 1
- Brent Christiansen, City of St. Paul
- Rich Sanders, Polk County

CN

POLK COUNTY Minnesota

Chisago County MINNESOTA

SAINT PAUL

COUNTY OF Olmsted

MORRISON COUNTY

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Sensefly Albris Demonstration

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