Placer River Trail Bridge Inspection Using Small Unmanned Aircraft Systems

Fall Tactical Fire Remote Sensing Advisory Committee
October 29, 2015
Boise, Idaho

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G O A L S

1) Use a UAS to collect high resolution natural color stereo pair and video imagery of the Placer River Trail Bridge to evaluate as an alternative or supplemental tool to traditional structure inspection techniques

2) Evaluate dense Structure from Motion (dSfM) image processing techniques to produce a measurable 3D wireframe bridge model

3) Compare dSfM point cloud to laser scanner point cloud

UAS image data collection: June 9 and 10, 2015

COOPERATION

Forest Service Region 10, Washington Office, and Glacier Ranger District, Chugach National Forest: implementation, planning, coordination

University of Alaska Fairbanks: UAS, pilots, lead researcher

George Mason University: data collection, processing, analysis

LOCATION

Anchorage

Girdwood

89-km (55 miles)
south of Anchorage

Placer River Trail Bridge

ABOUT THE BRIDGE

- Longest clear span, glued-laminated, timber truss pedestrian bridge in North America at 280 feet
- Anticipated operational service life of 75-years
- Completed in July 2013
- Managed for pedestrian use (Glacier Ranger District)
- Remote site; accessible via Alaska Railroad

UAS PLATFORM

Purpose built hexacopter “Ptarmigan”
Based on DJI S800 airframe

Gyrostabilized Sony Nex7 and GoPro
~20 min/flight (LiPo batteries)

A higher order data collection tool.

UAS PLATFORM

Two pilots (one acting as spotter) and generator to power equipment
<1 hr to set up and have safety briefing

UAS CONTROL

Base station

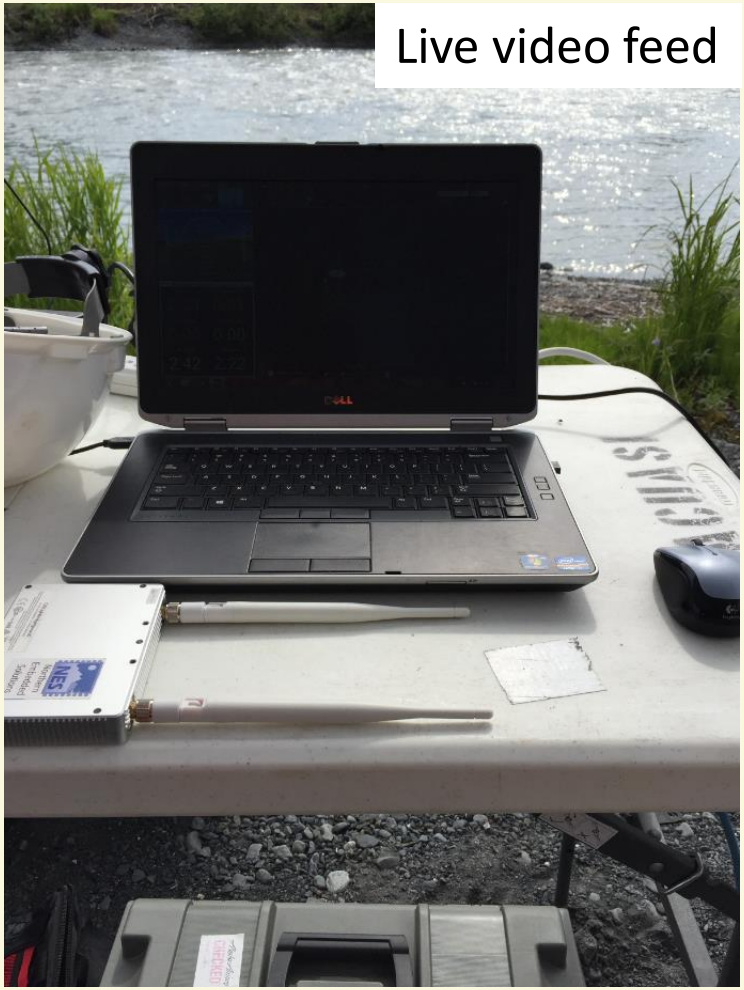
Programmable flights

GPS or GNSS signal essential (if lost, return home function)

Live video feed

Programming flight

Live video feed



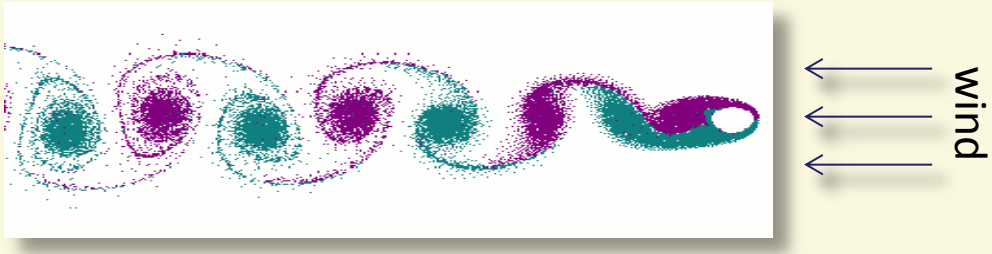
DATA COLLECTION

FARO Focus laser scanner set up in 12 locations

DATA COLLECTION

Imaging sides of structure

Vortex shedding was a UAV stability concern, but not an issue



DATA COLLECTION

Upward-looking GoPro video imaging beneath structure

Lighting is a minor issue

Mostly manual control

DATA COLLECTION

Imaging top of structure

DATA COLLECTION

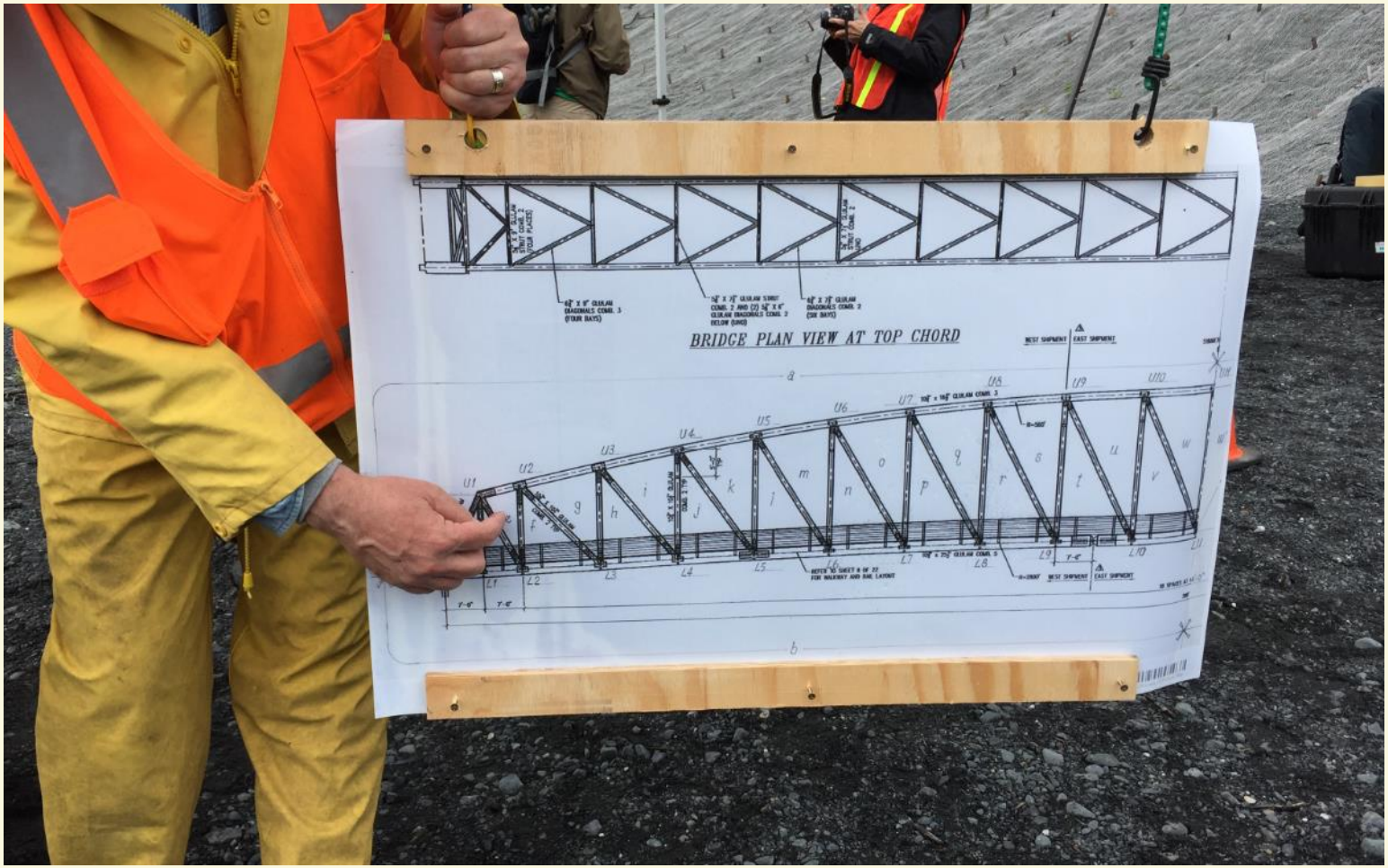
Table 1 Summary of Data Acquisition Mission

Type of Data	Sensor Type	No. of Images/Scans	Size (GB)	Note
Imaging	Nikon D800E	2222	34.9	Ground-based imagery
	Sony Alpha NEX-7	2626	24.7	UAS-based imagery
Video	GoPro	10	7.57	-
Laser scanning	FARO Focus^{3D}	24	4.26	-
3D Point Clouds	-	5	13.71	-

- Still frames collected with nominal 90% overlap
- >90% imagery useable for SfM (Photoscan Pro)
- ~4 hrs total flight time

90GB and 5000 images, video, and laser scans

DATA COLLECTION



Bridge plans used for point of reference and to assist with autopilot navigation

Data Analysis

DATA ANALYSIS

Goals

- Recreate flaws
- View underside of deck
- Track long-term camber/motion

Challenges

- Massive data set
- Confusing data
- Image degradation
- High contrast scene

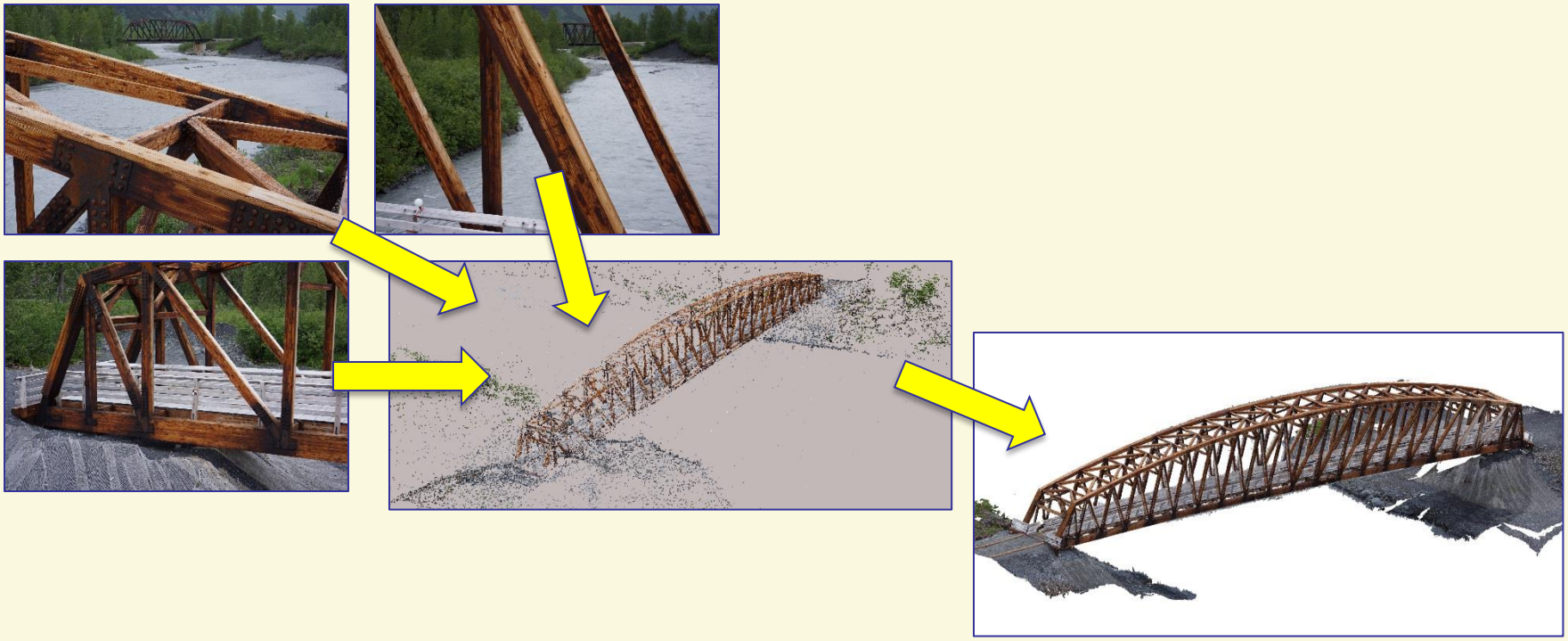
RECREATING FLAWS

Gap between end of kerf plate and sawn kerf in brace

DECK UNDERSIDE

BUILDING A MEASUREABLE MODEL

- Images to 3D model: Structure-from-Motion
  - triangulate features across image set
  - Software: Photoscan and SURE
- Small details, big model



HPCG MODEL GENERATION

1. Separate clouds for big and small details
   - Image capture plan is critical!
2. Merge the sparse models
3. Generate dense reconstruction
   - SURE vs Photoscan

Geometry Cloud **Intermediate Clouds** **High-res Clouds**

HPCG MODEL GENERATION

Dense Point Clouds

Geometry cloud

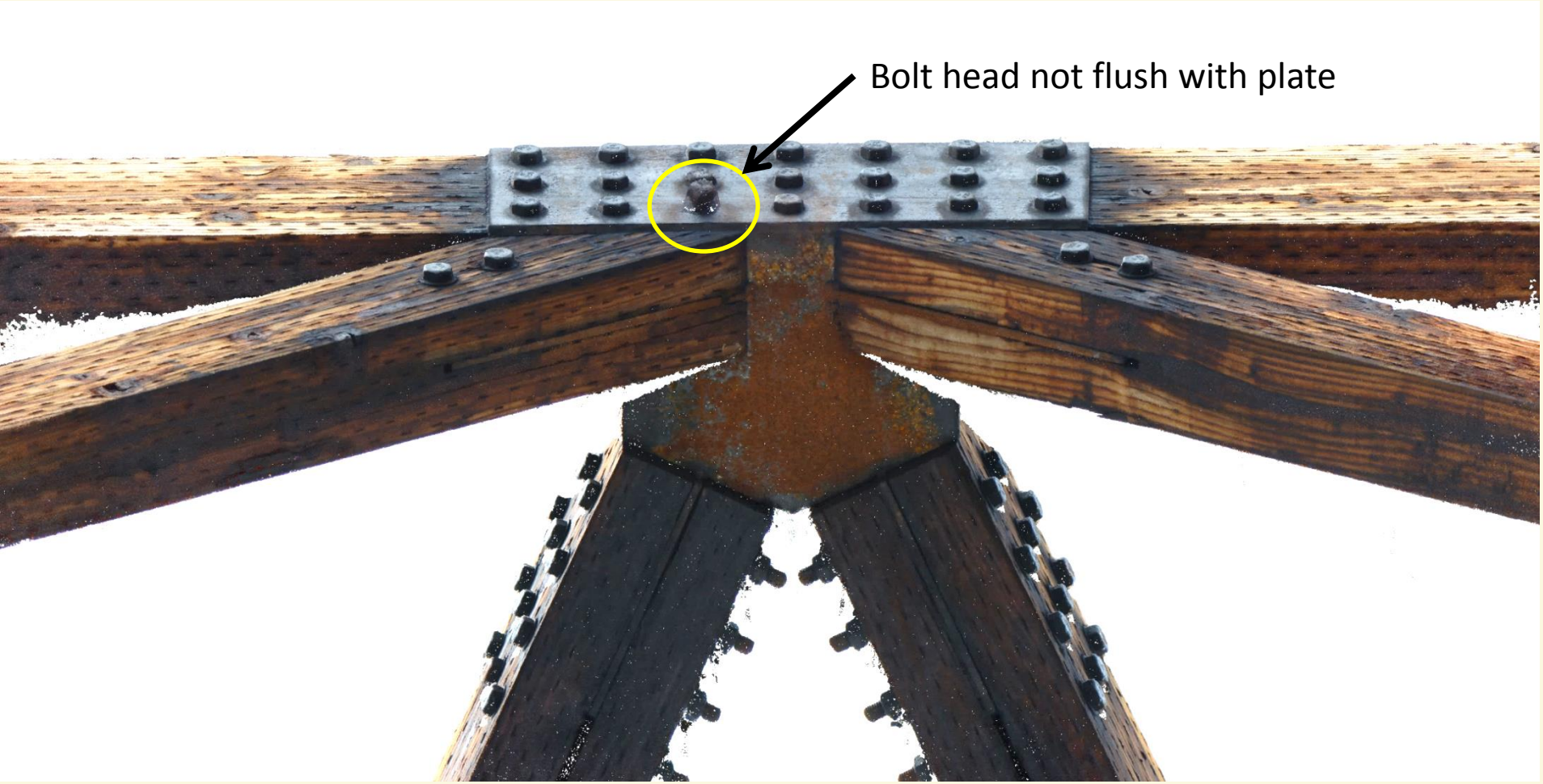
Intermediate clouds

High-res clouds

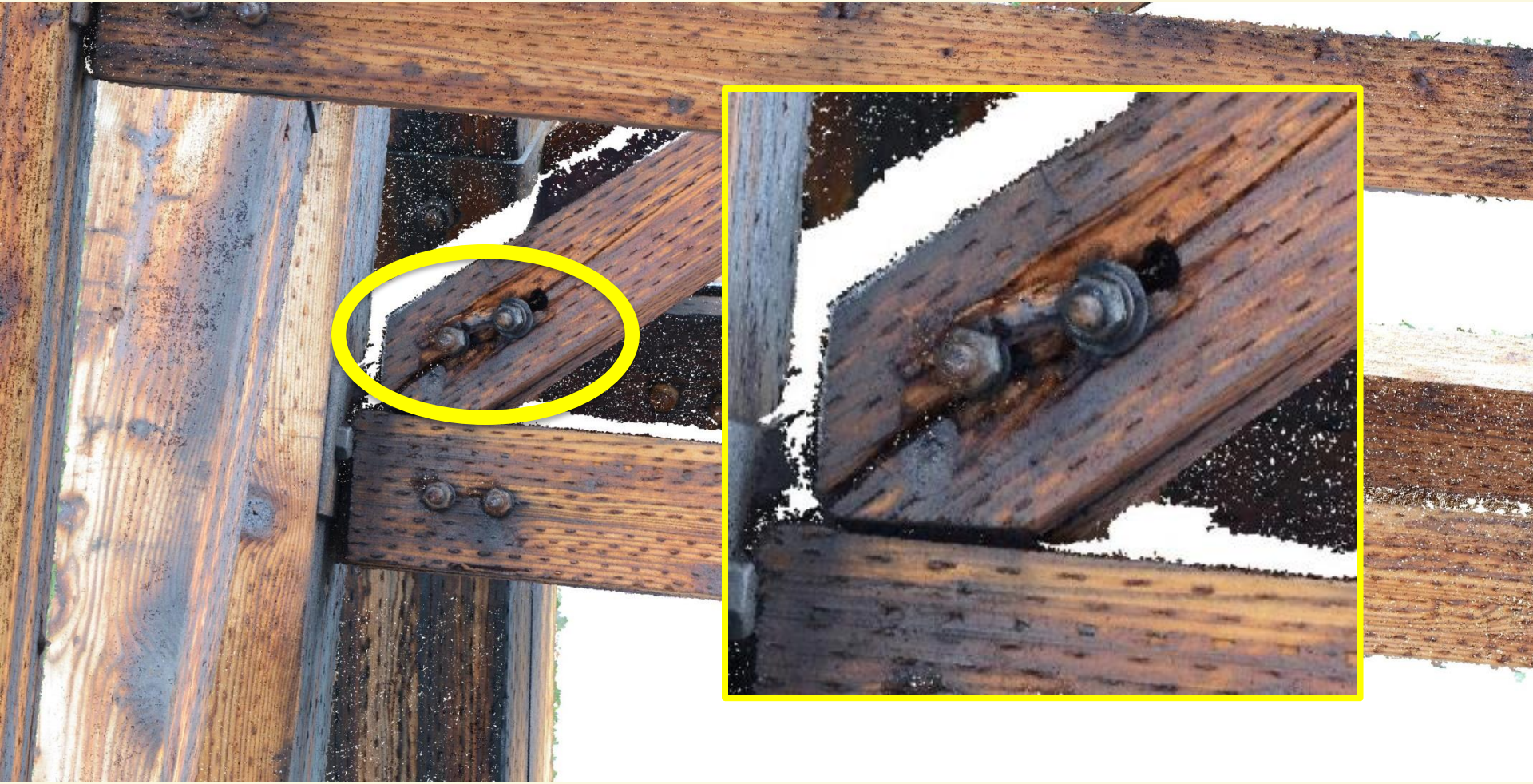
RESULTS

- 500 hours of computation time
- 14 billion points
- Need good rendering support!

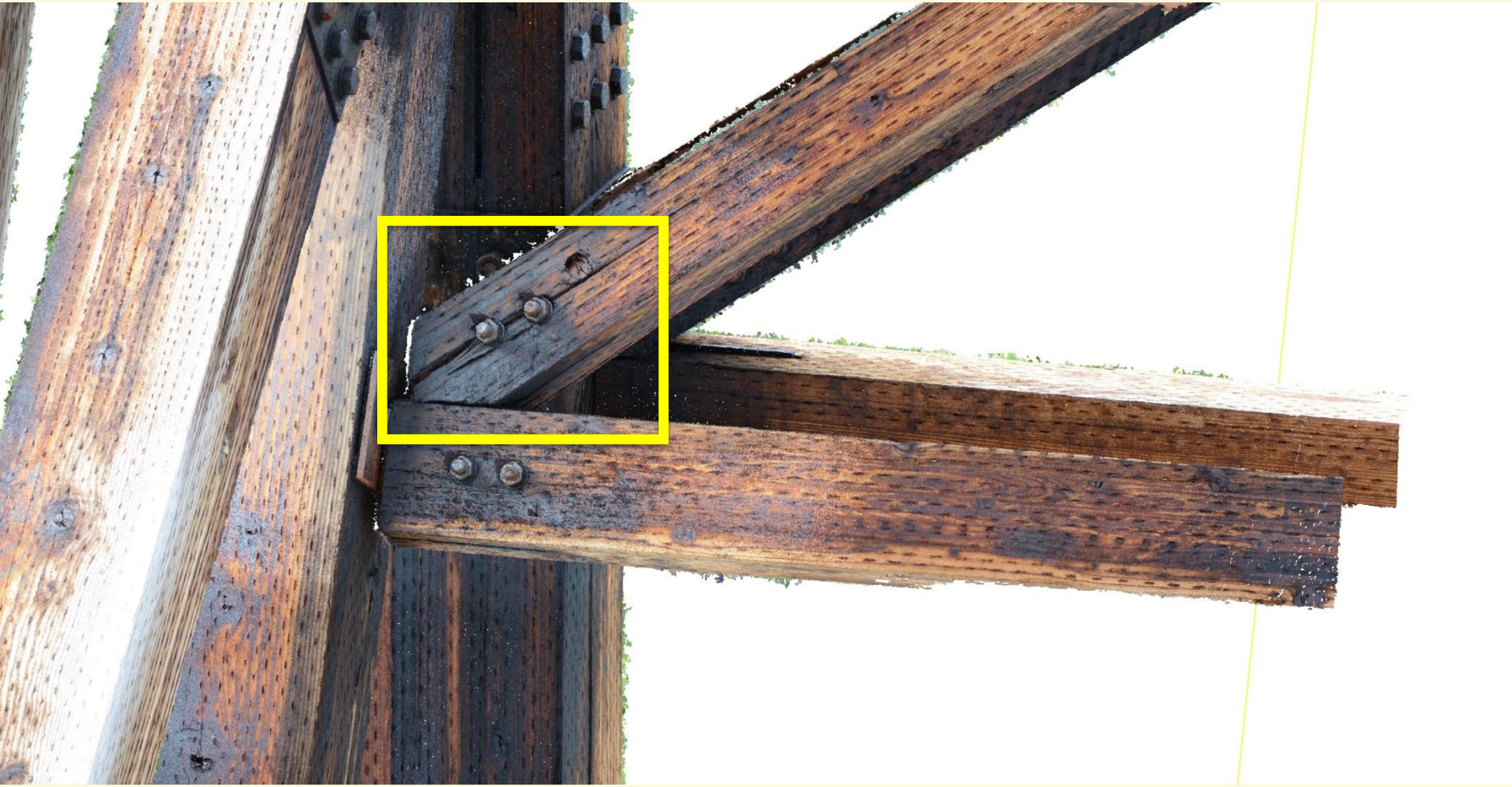
RECONSTRUCTING FLAWS



POINT CLOUD RECONSTRUCTION



POINT CLOUD RECONSTRUCTION



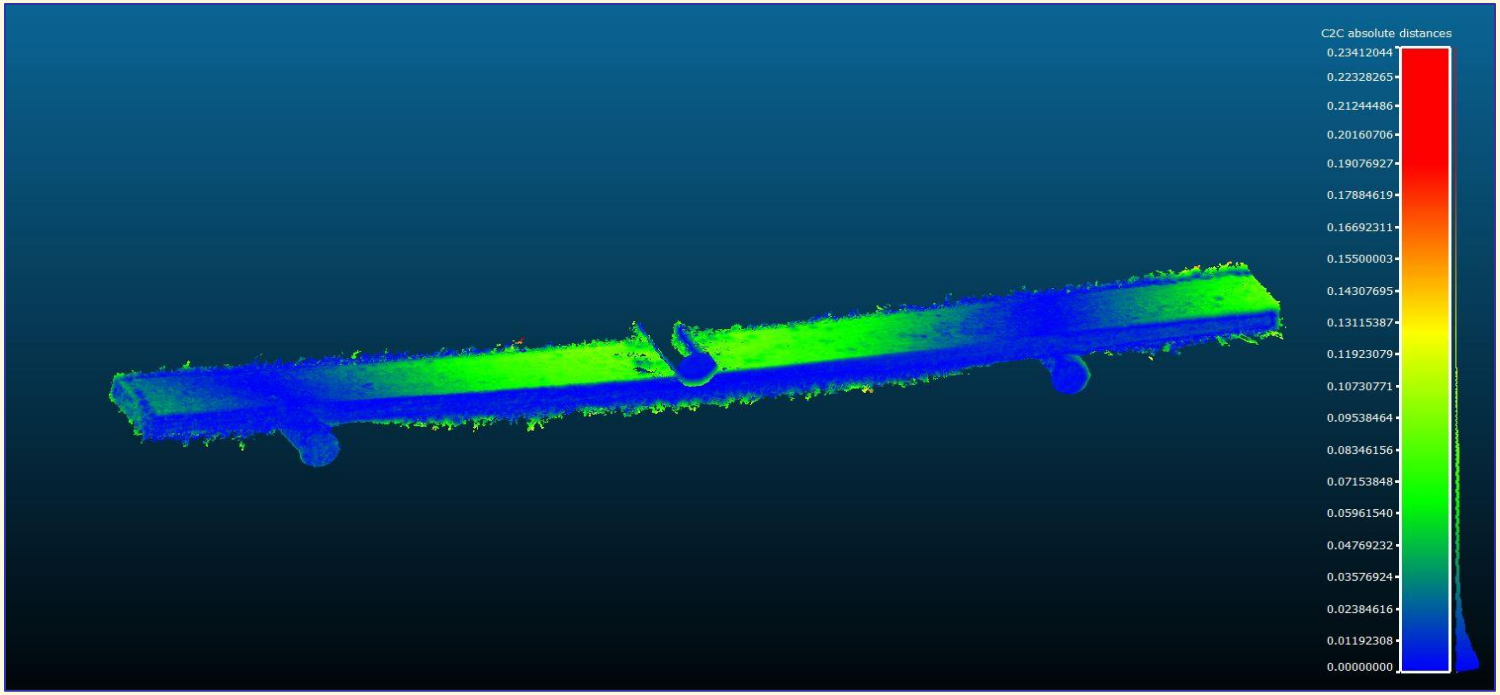
POINT CLOUD RECONSTRUCTION

CAMBER TRACKING

- As bridge ages, it sags
  - does it age gracefully?
- Rate of sag is a health indicator
- Required level of accuracy ≤ 10mm

CAMBER TRACKING

- Point cloud deviation analysis
- Models from repeated inspections
- Accuracy based on cloud resolution
- Sub-millimeter measurement is possible

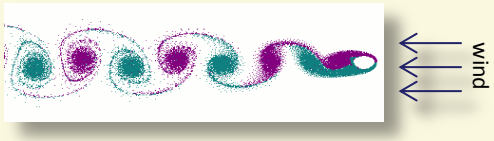


OBSERVATIONS AND TAKEAWAYS

1) Angle of incidence for most of the structure is achievable only with a UAS

2) A UAS is an effective means to obtain thousands of high resolution (~0.5-cm) stereo pair images of a structure in a short amount of time

3) For this bridge, and with low wind speeds, vortex shedding was a minor, surmountable issue



OBSERVATIONS AND TAKEAWAYS

4) Dense Structure from Motion (dSfM) image processing techniques are [currently] the most effective way to produce highly detailed and accurate measureable **multispectral** 3D models in a short period. Depending on collection parameters, dSfM can produce a denser point cloud than lidar.

5) For this remote location, privacy was not a concern

6) Proposed FAA rules are sufficient for this type operation

OBSERVATIONS AND TAKEAWAYS

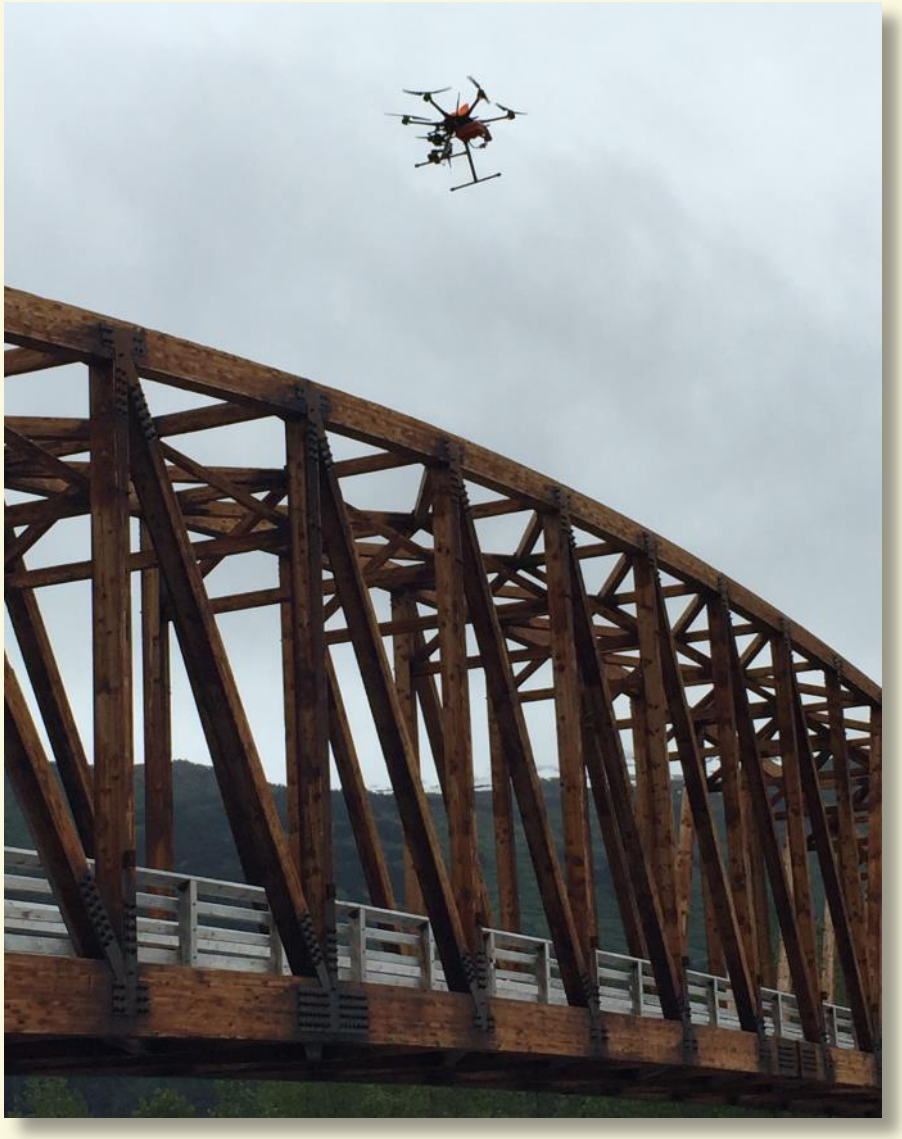
7) Proof-of-concept costs are not reflective of future costs; costs will decrease for subsequent projects

8) The mission was successful and is replicable for other similar projects

OBSERVATIONS AND TAKEAWAYS

9) Could not get interior of bridge with UAS as it was too bulky to operate safely; a hand-held Nikon D800E was used to collect stereo imagery for dSfM processing

10) Takes a powerful computer and several weeks of processing to produce accurate and detailed dSfM models



C O N C L U S I O N S

A sUAS **minimizes the time spent on site and increases safety** by removing potential points of failure - such as suspended platforms, ladders, and harnesses - and potentially dangerous situations from the conventional inspection equation

Proposed FAA rules will be sufficient for 90% of Forest Service sUAS operations **across multiple disciplines**

Cost of using sUAS for project work, such as structure inspections, **will decrease** as Forest Service sUAS policy evolves and methods mature

A sUAS is a **higher order data collection tool** that needs to be more effectively utilized by the Forest Service

NEXT STEPS

1) **Science**: processing, analysis, reporting, technology development

2) **Policy Development**: Forest Service and FAA

3) **Effective Implementation**: Guidelines and new projects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