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GAME OF DRONES:
Innovative Technologies to Expedite Gusset Plate Load Ratings

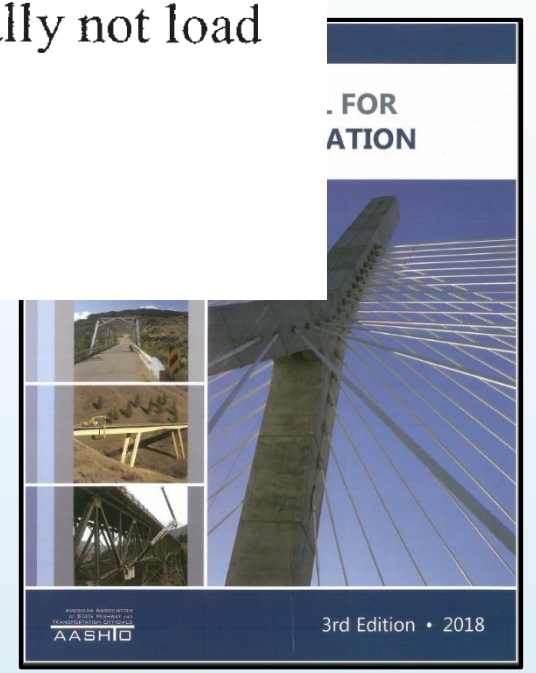
October 29, 2019

BURGESS & NIPLE
Engineers ■ Architects ■ Planners

- Gu

Secrets of the Load Rater

7. Minor section loss to gusset plates, rivets, and bolts generally does not have to be recording in great detail because the connections are typically not load rated. T



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- Necessary information for gusset plate load ratings
  - Geometry
    - Gusset plate dimensions
    - Splice plate dimensions
    - Orientation of connected members
  - Connectors
    - Number
    - Spacings
    - Size(s)
    - Edge distances
  - Material specifications
  - Loading

Shop drawings or measurements

Shop drawings or measurements

Plans, shop drawings, or testing
Analysis model

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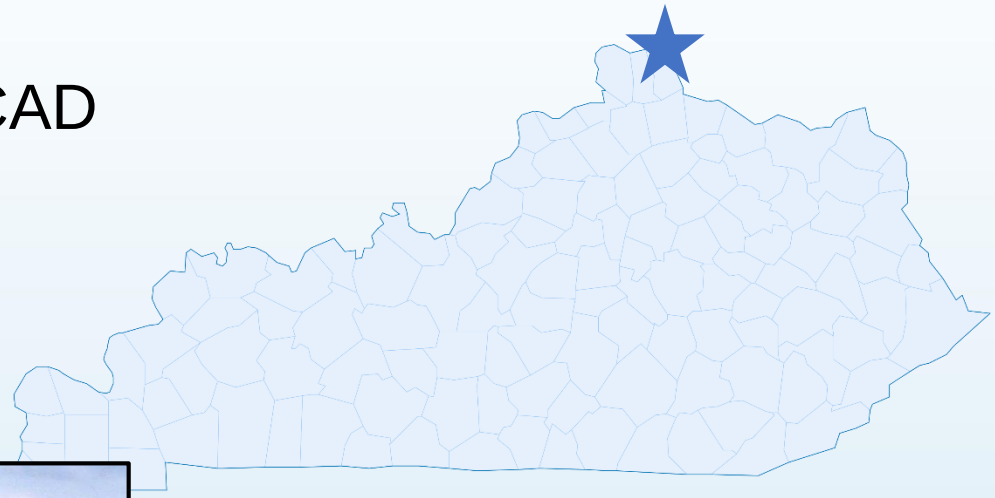
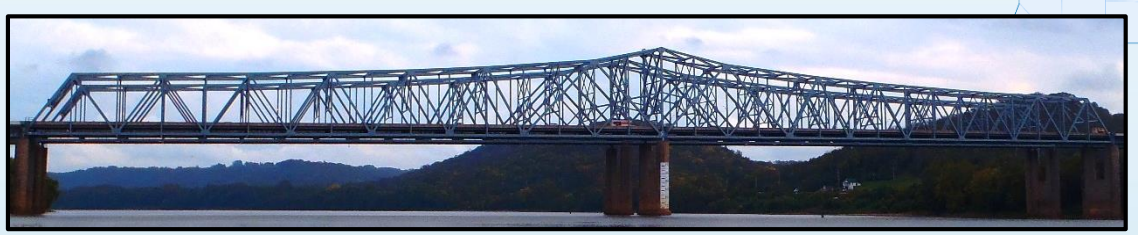
- Combs-Hehl EB and WB over Ohio River
  - Constructed 1979
  - Complete and legible design and shop drawings
  - Limited field verifications
  - Gusset plates reproduced in CAD



Two span continuous through truss
720’-720’



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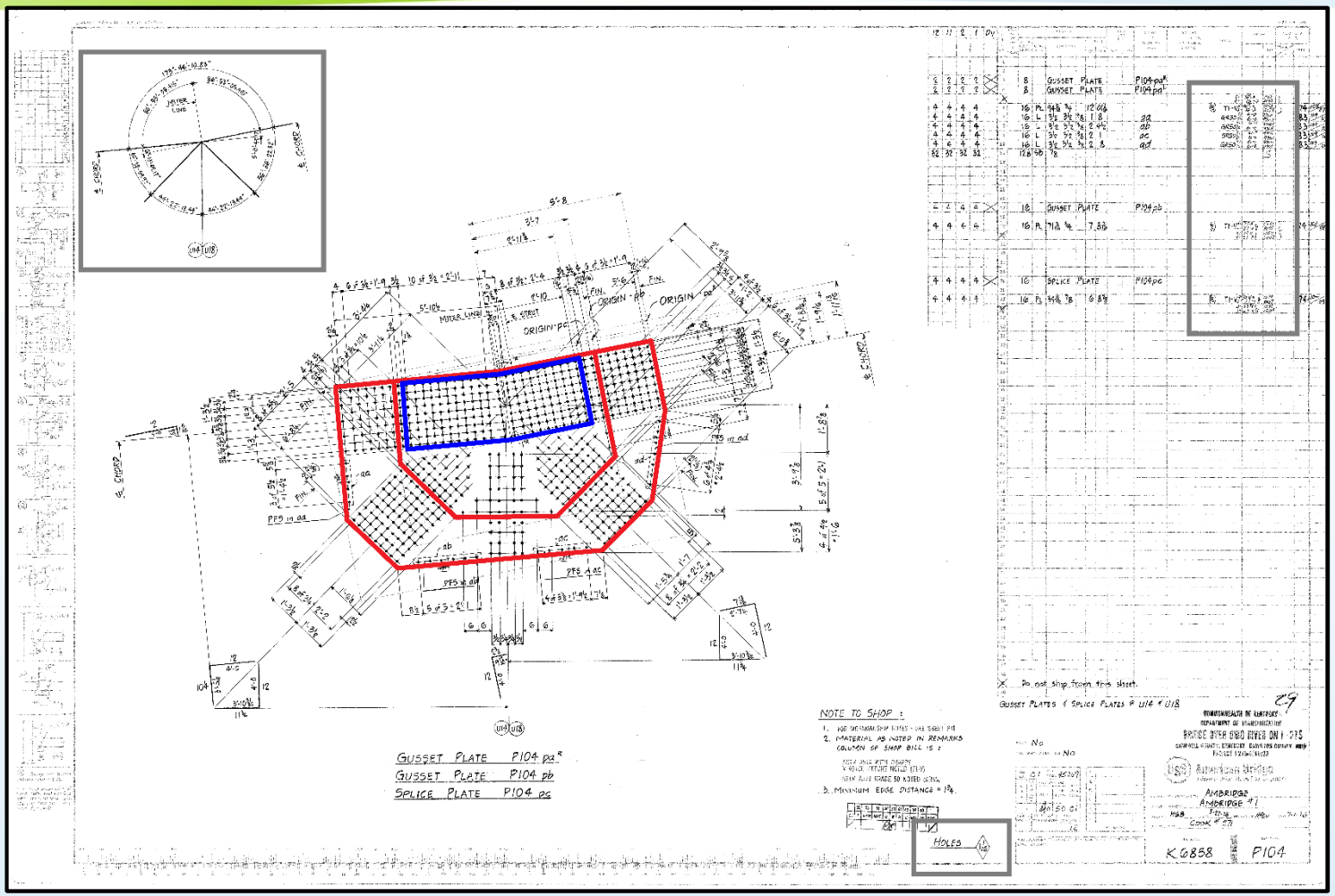

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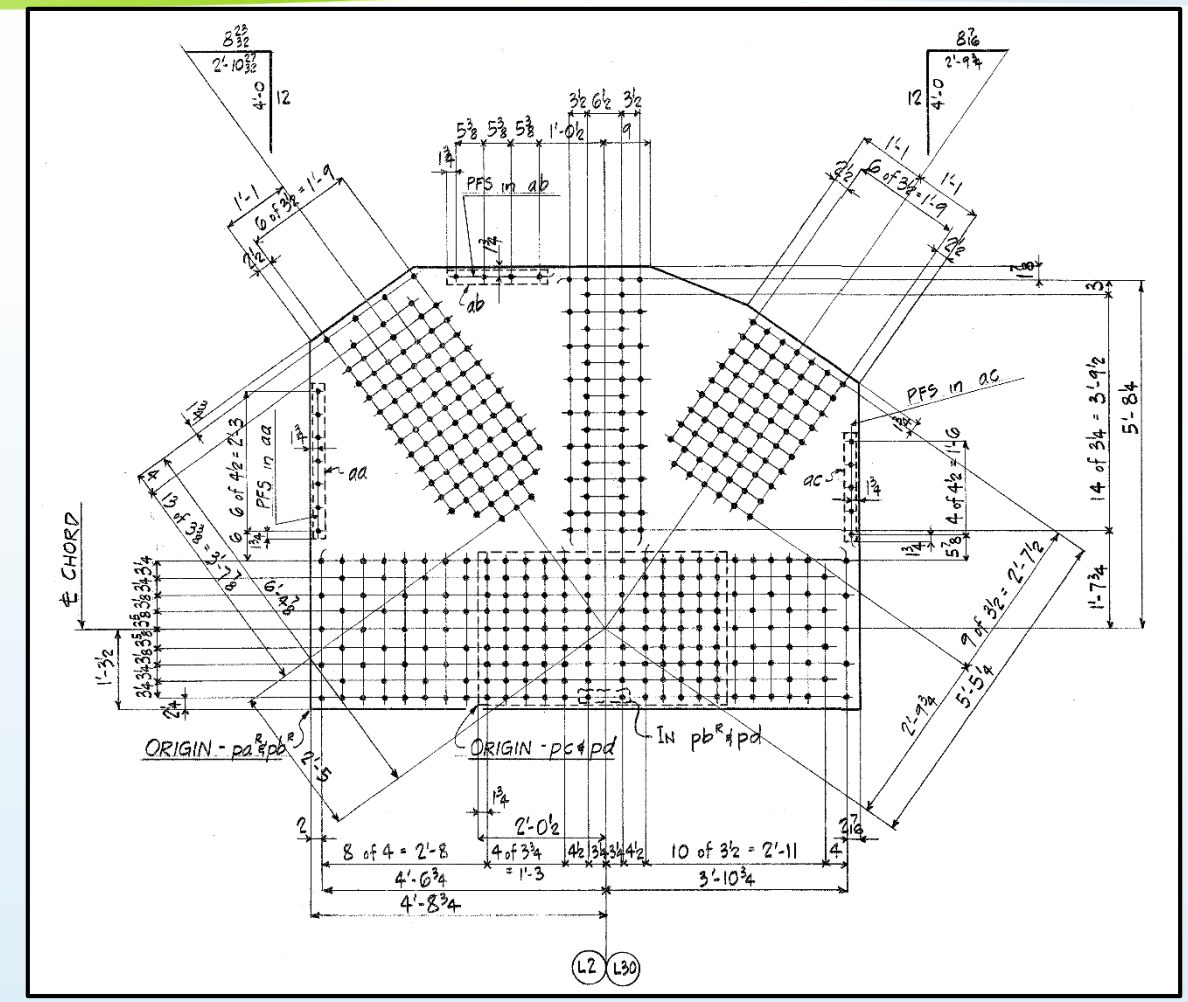

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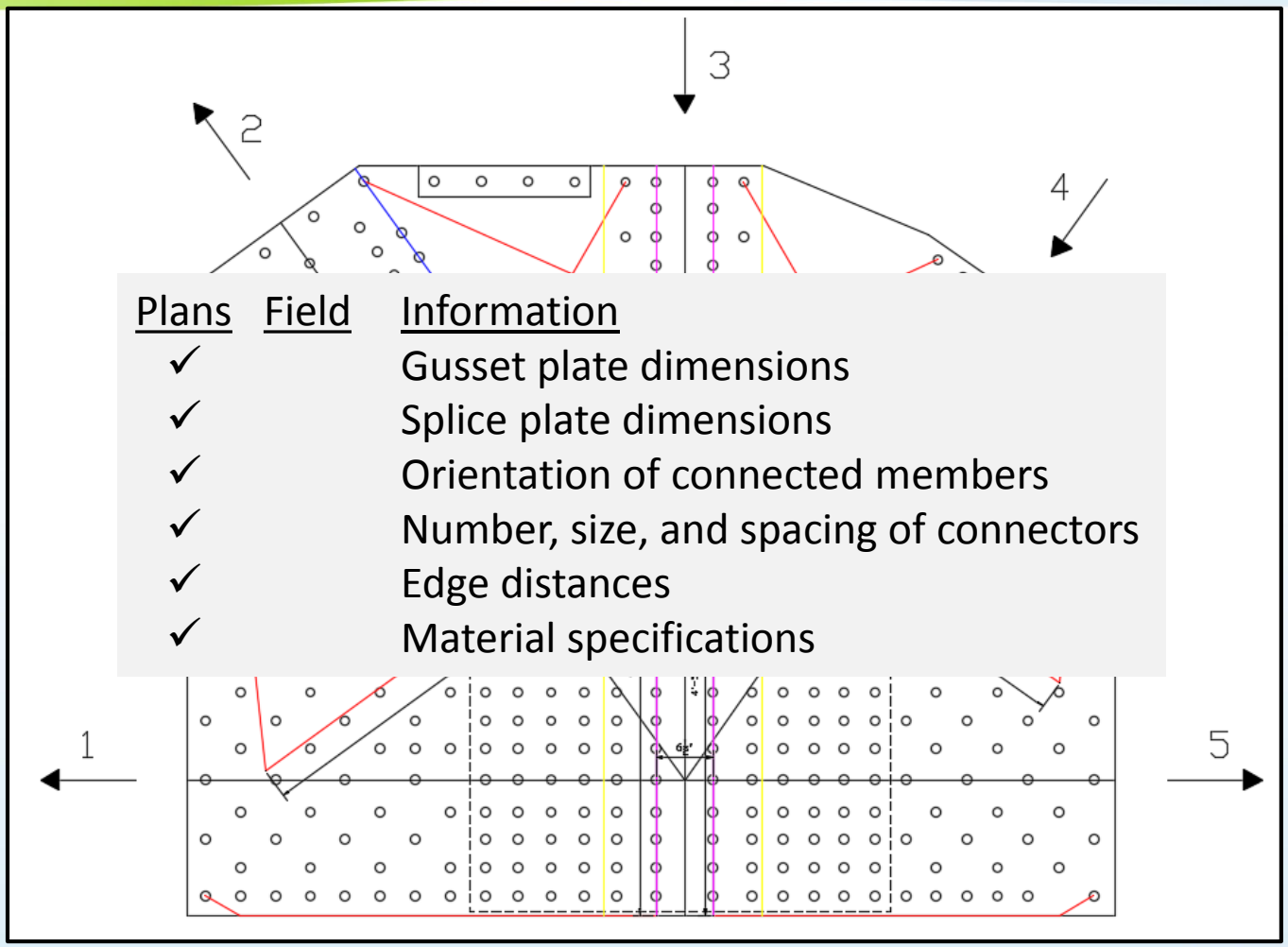

Plans	Field	Information
✓		Gusset plate dimensions
✓		Splice plate dimensions
✓		Orientation of connected members
✓		Number, size, and spacing of connectors
✓		Edge distances
✓		Material specifications

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- Clark Memorial over Ohio River
  - Constructed 1929
  - Complete design and shop drawings
  - Limited field verifications
  - Drawings imported into CAD

Seven through truss spans
360’-820’-498’; 498’-820’-360’; 373’

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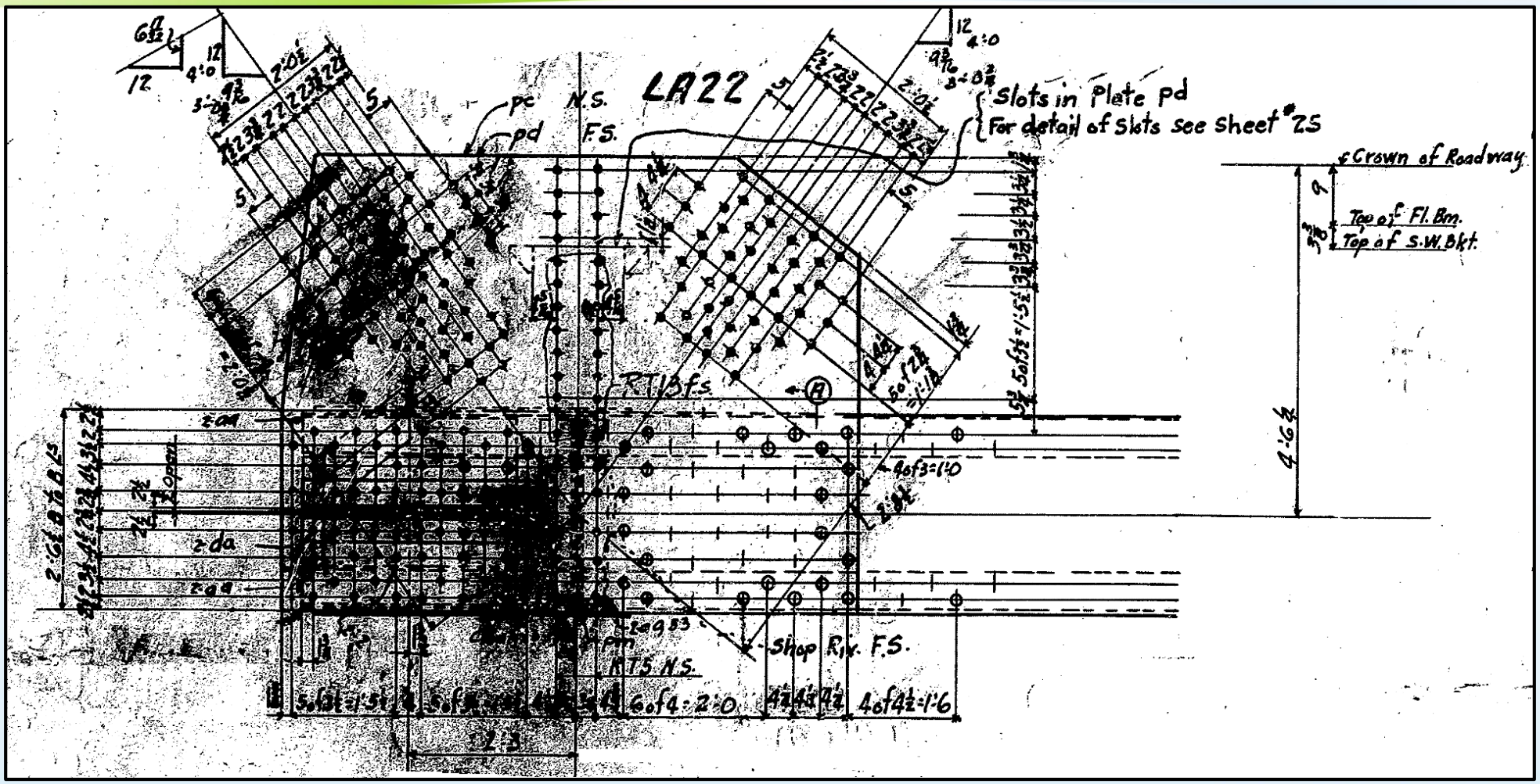

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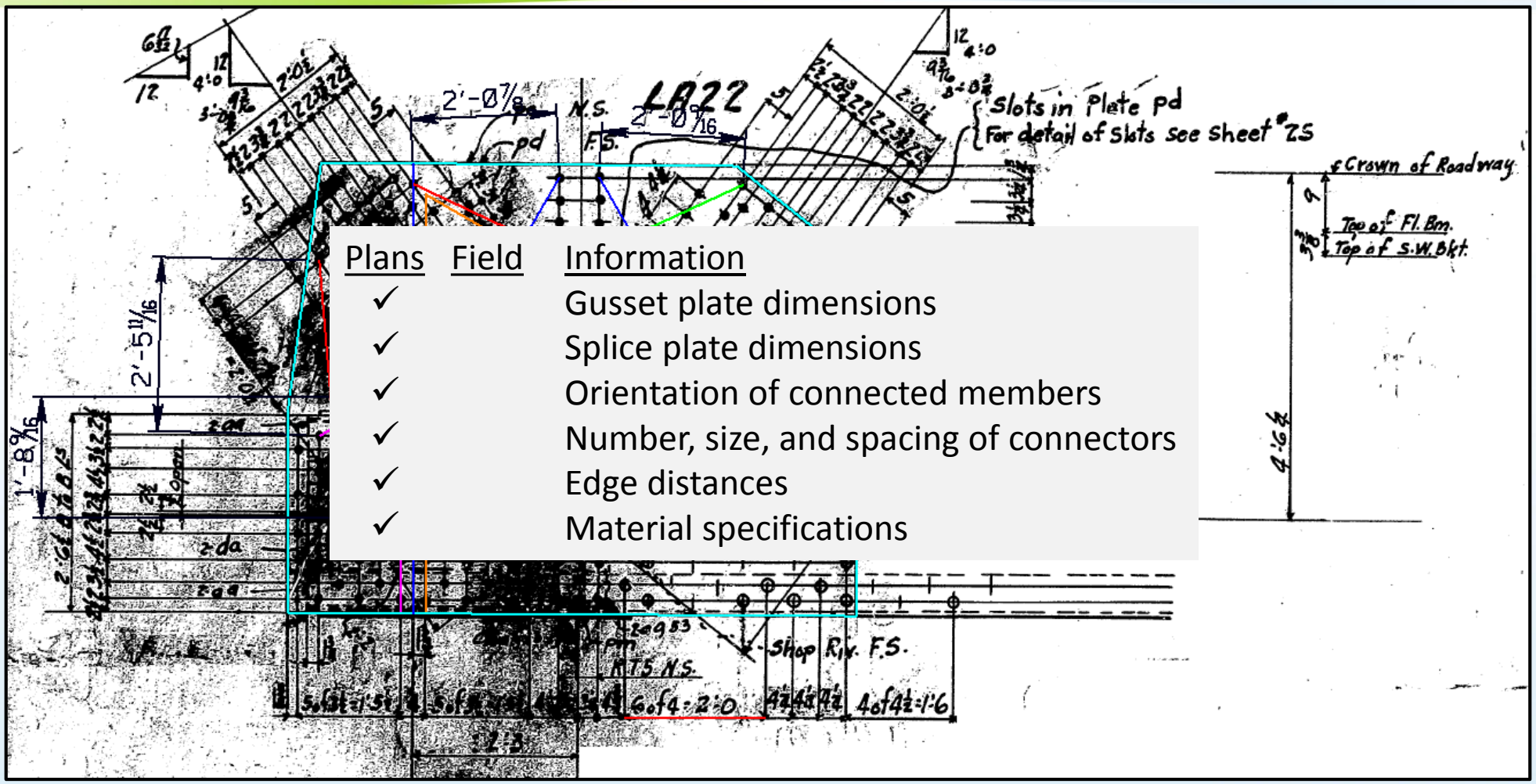

Plans	Field	Information
✓		Gusset plate dimensions
✓		Splice plate dimensions
✓		Orientation of connected members
✓		Number, size, and spacing of connectors
✓		Edge distances
✓		Material specifications

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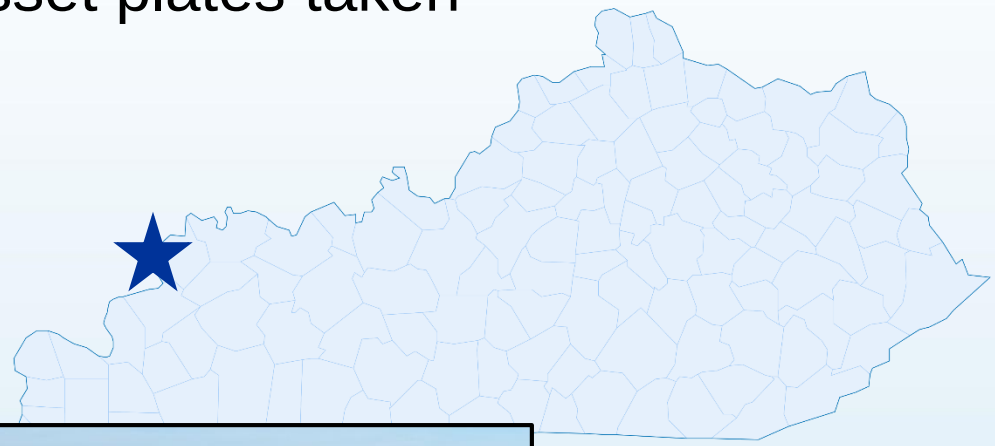
- Earle Clements over Ohio River
  - Constructed 1956
  - Complete design drawings; no shop drawings
  - Polester photos of marked gusset plates taken
  - Photos imported into CAD



Two span continuous through truss
825’-825’

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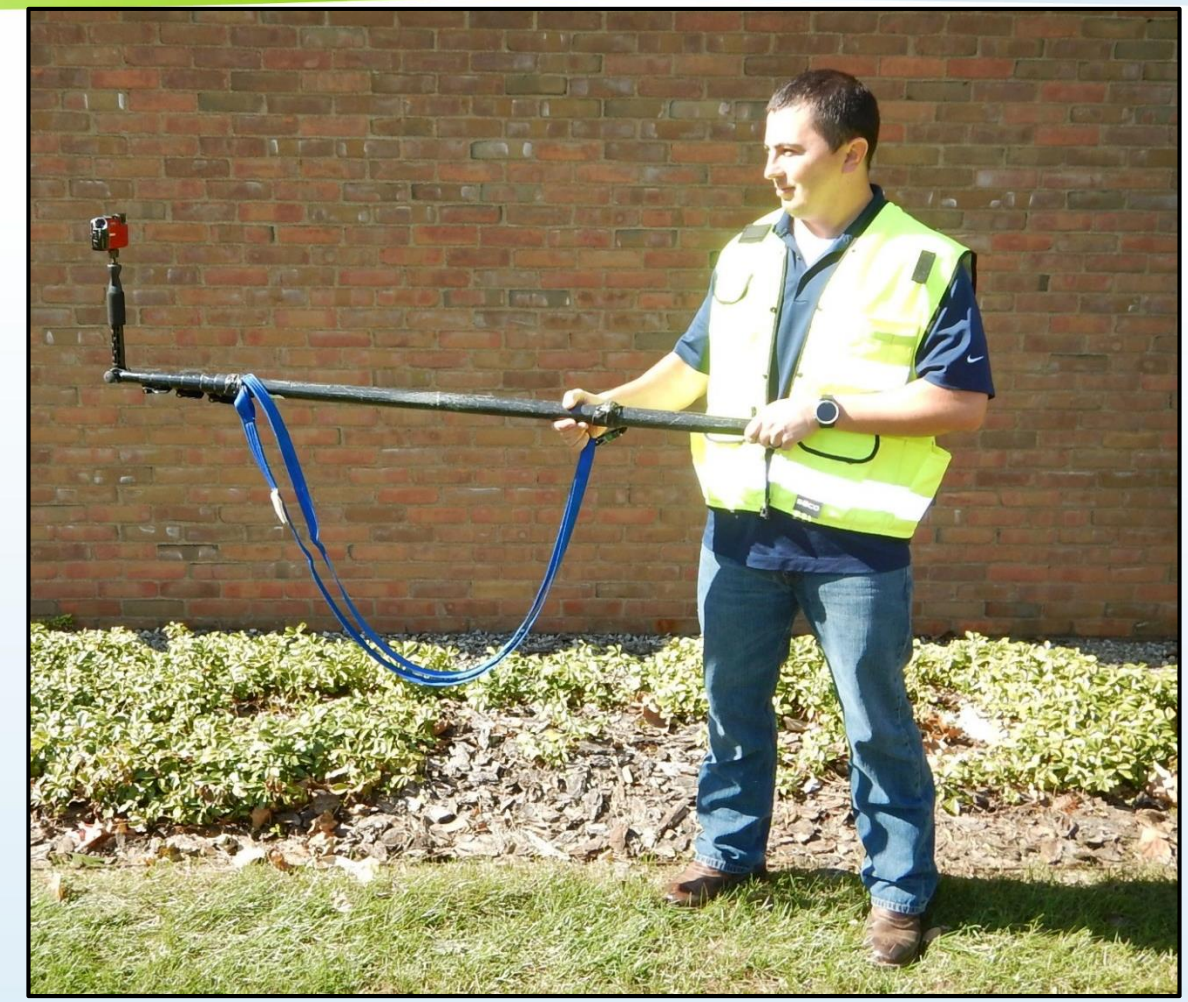

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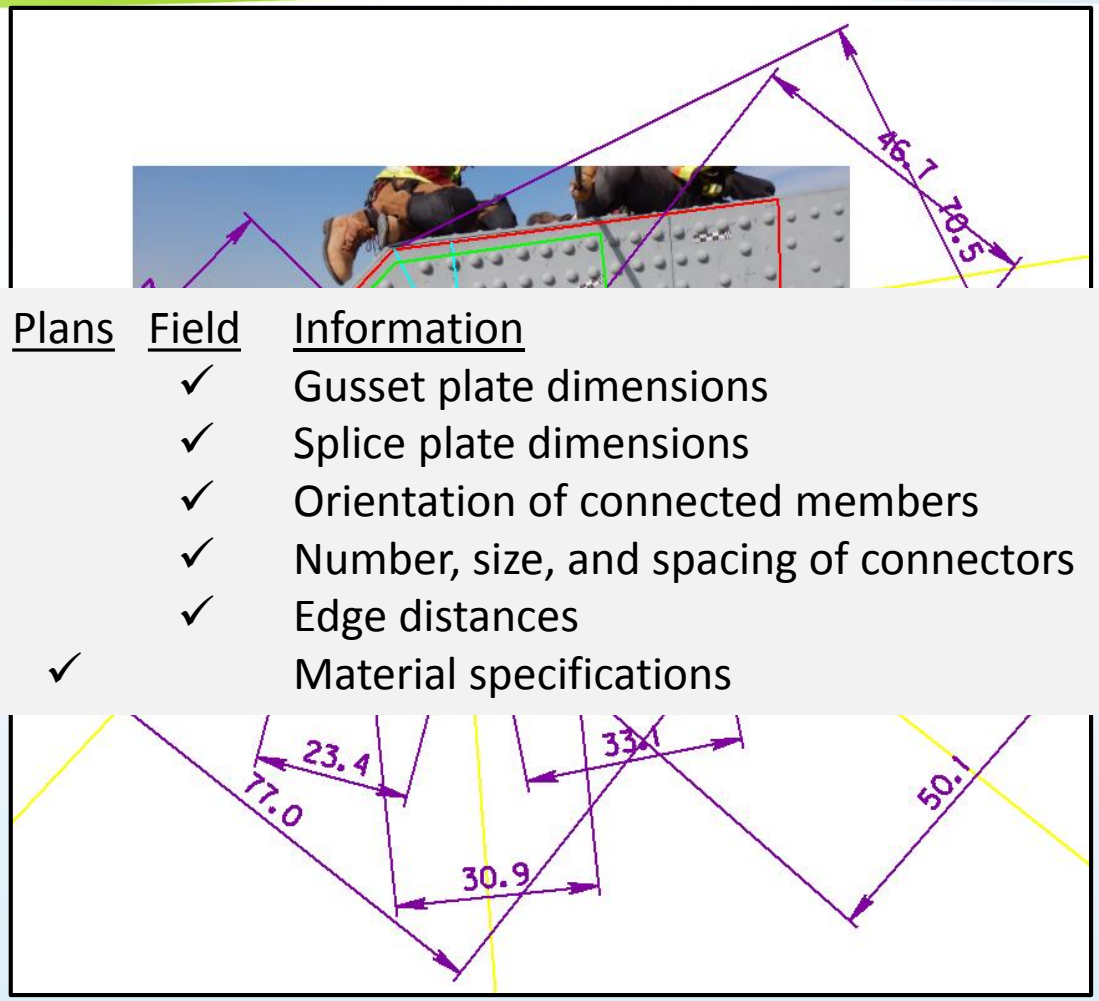

Plans	Field	Information
	✓	Gusset plate dimensions
	✓	Splice plate dimensions
	✓	Orientation of connected members
	✓	Number, size, and spacing of connectors
	✓	Edge distances
✓		Material specifications

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- Limitations
  - Difficult to
  - Takes ad
  - Difficult to
  - Bulky to t
  - Requires

- Possible alternatives to using Polester-mounted cameras
  - Handheld 3D scanners
  - Small unmanned aircraft systems (sUAS)

- DOT Product DPI-8 Scanner
  - Handheld scanner, Android tablet, Phi.3D Software
  - Collects point cloud data that can be imported into CAD software (Autodesk ReCap)

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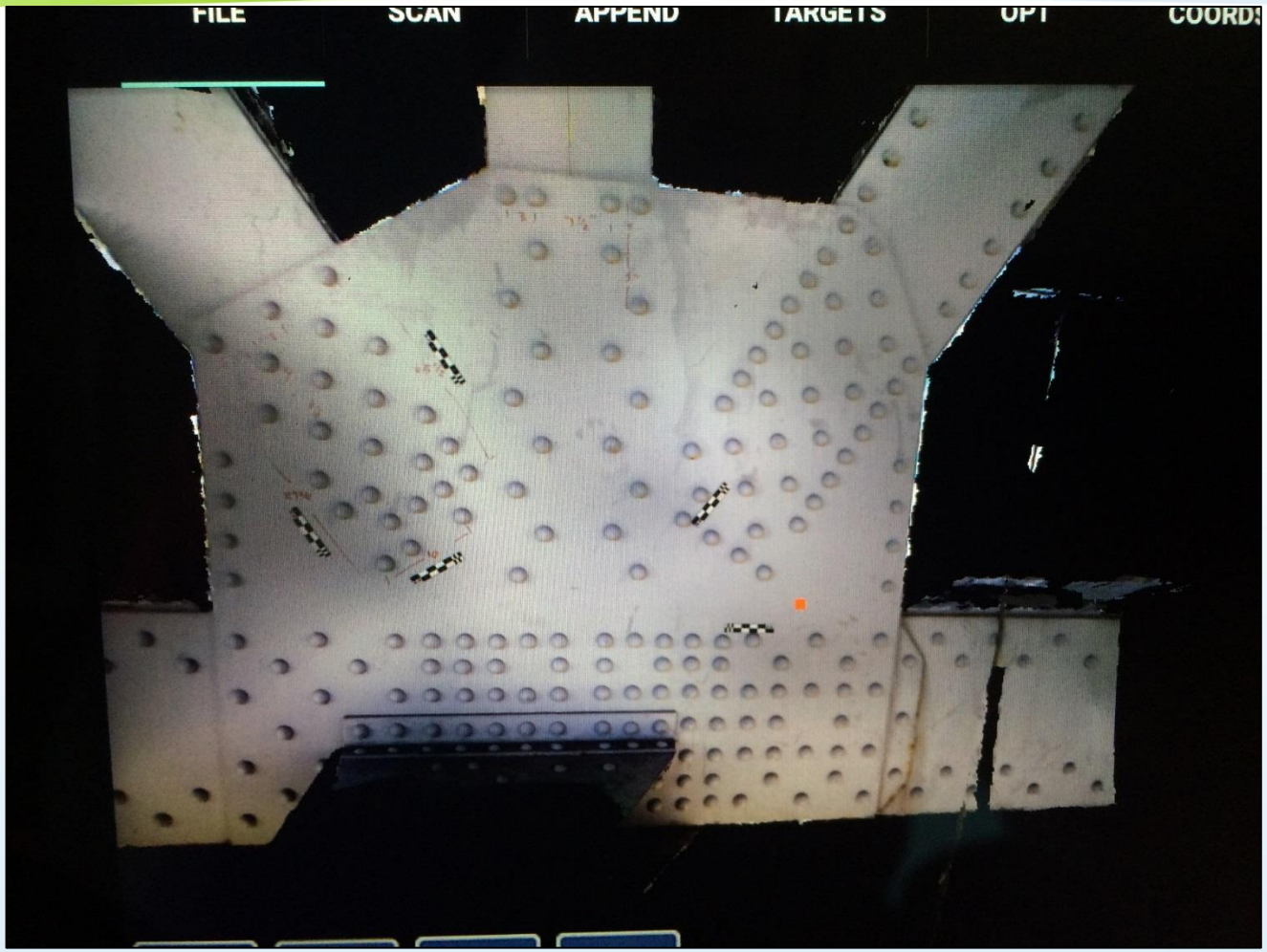

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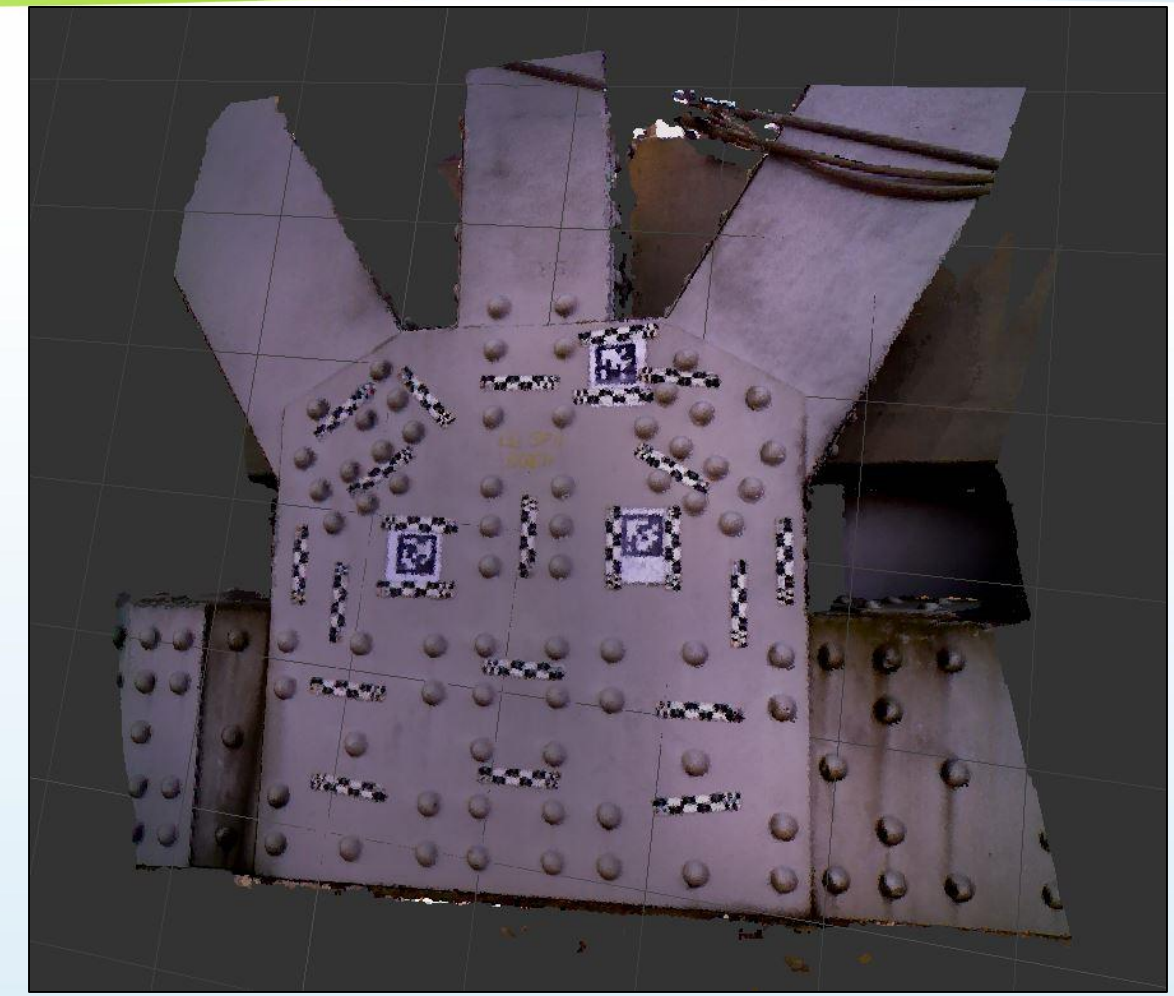

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- Benefits of using a handheld 3D scanner
  - Generates high quality images
  - Images can be viewed and rotated on the tablet or in CAD software
  - Measurements can be taken
  - Can append multiple data sets into one scan

- Shortcomings of using a handheld 3D scanner
  - Very delicate and expensive
  - Sensitive to direct sunlight
  - Scanning a large area can be cumbersome

- Could sUAS be a viable alternative to a Polester-mounted camera?
  - Efficiency
  - Battery life and recharge time
  - Photo quality
    - Sufficiently high resolution
    - Sun and shadows

DJI Phantom 4 Advanced, 3 batteries, iPad Air 2

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- Glover Cary over Ohio River
  - Constructed 1940
  - Partial design drawings; no shop drawings
  - Photos of marked gusset plates taken with a sUAS
  - Photos imported into CAD

Four span continuous through truss
Five simple span deck trusses
343’-629’-751’-278’; 5x168’

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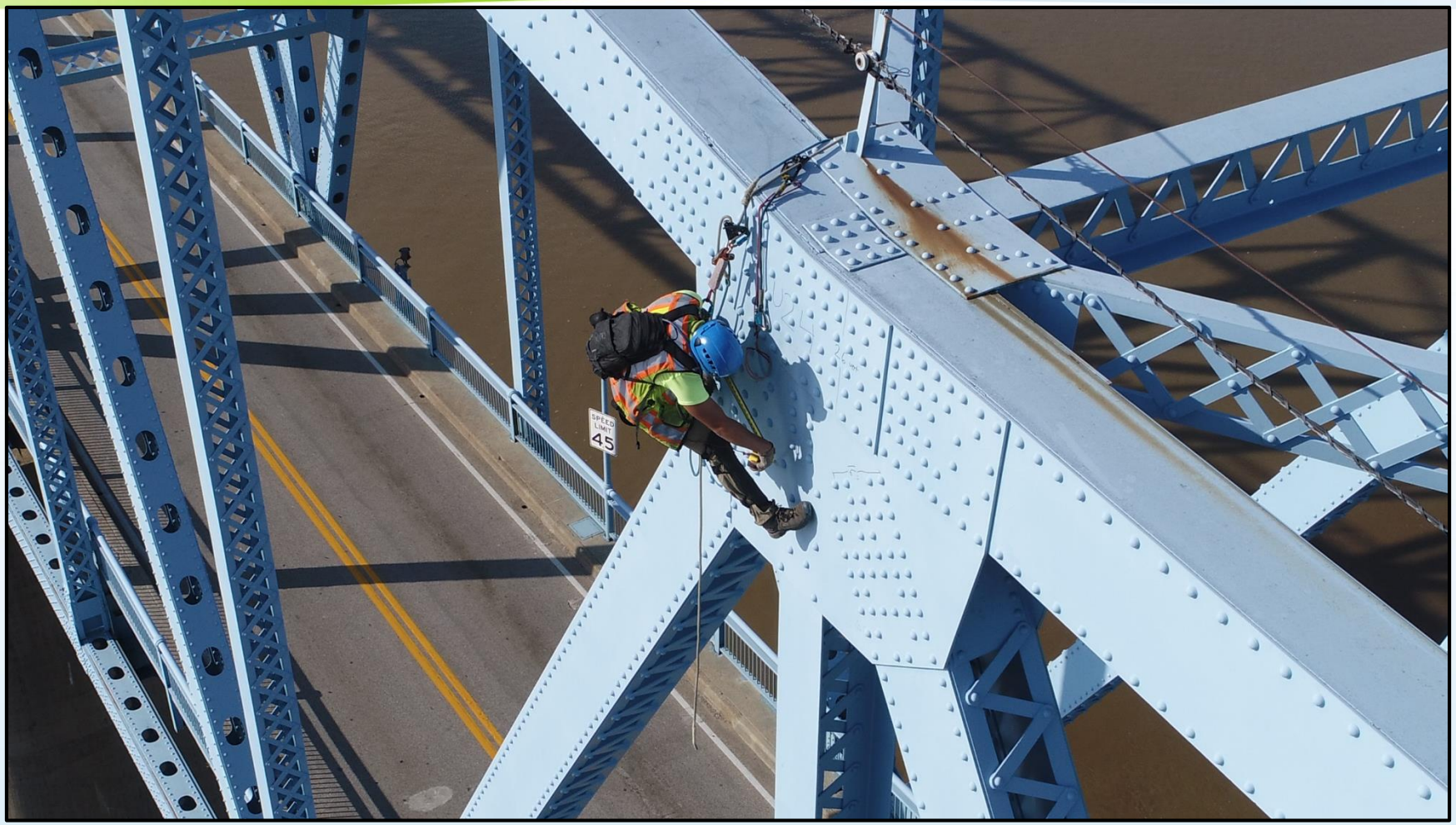
- Plan of attack
  - General
    - Take measurements and photographs on outboard face of the east (leeward) side of the bridge
  - Day 1
    - Travel, measurements, and trial run
  - Day 2
    - Photos in the morning and continue with measurements
  - Day 3 through completion
    - Repeat Day 2 process



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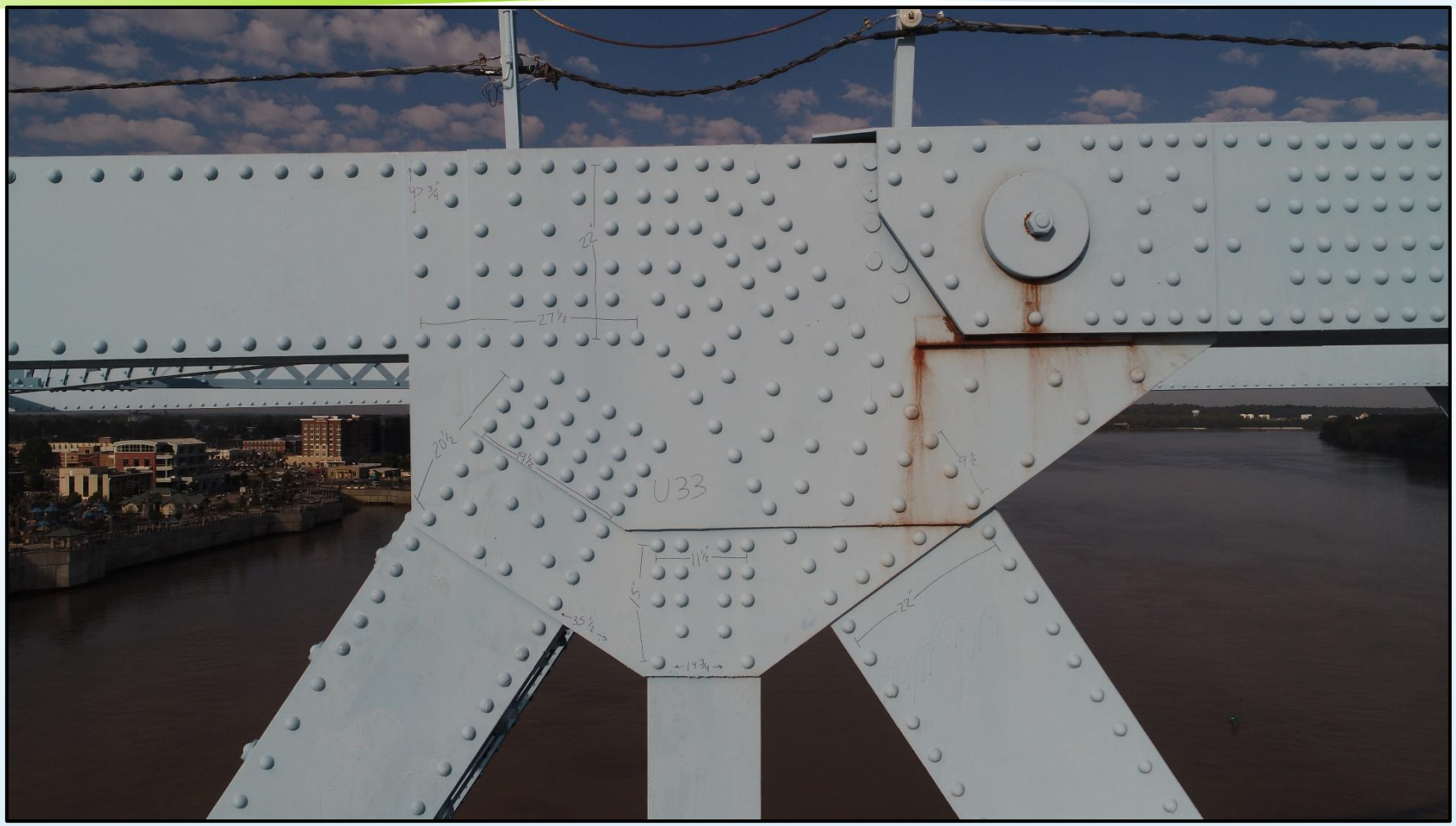
- Day 1 – Trial sUAS run – lessons learned
  - sUAS was stable in light wind
  - Photographed 30 gusset plates on one battery
  - “Delete” and “download” are adjacent in the menu, and delete does not have a confirmation



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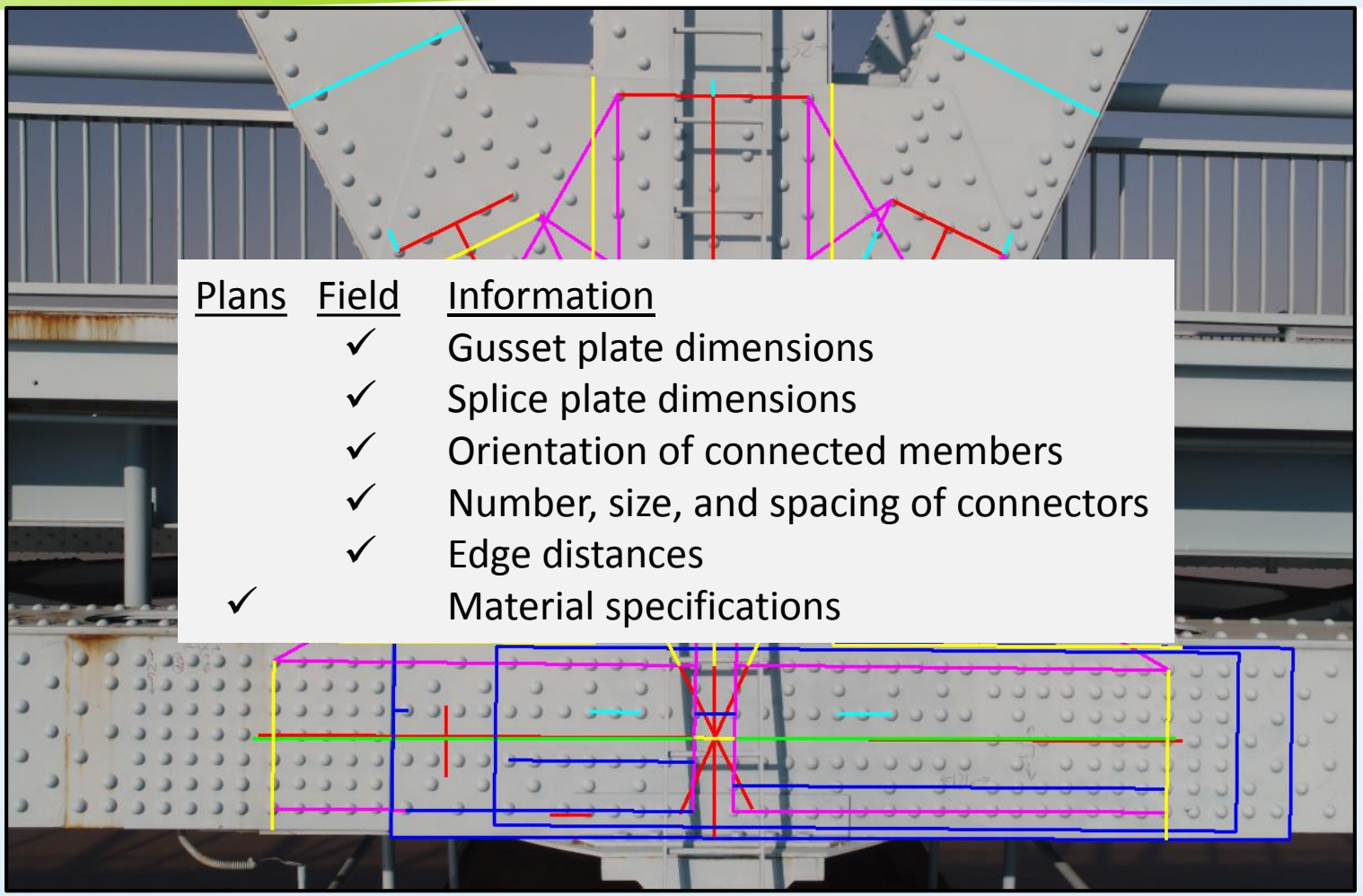

Plans	Field	Information
	✓	Gusset plate dimensions
	✓	Splice plate dimensions
	✓	Orientation of connected members
	✓	Number, size, and spacing of connectors
	✓	Edge distances
✓		Material specifications

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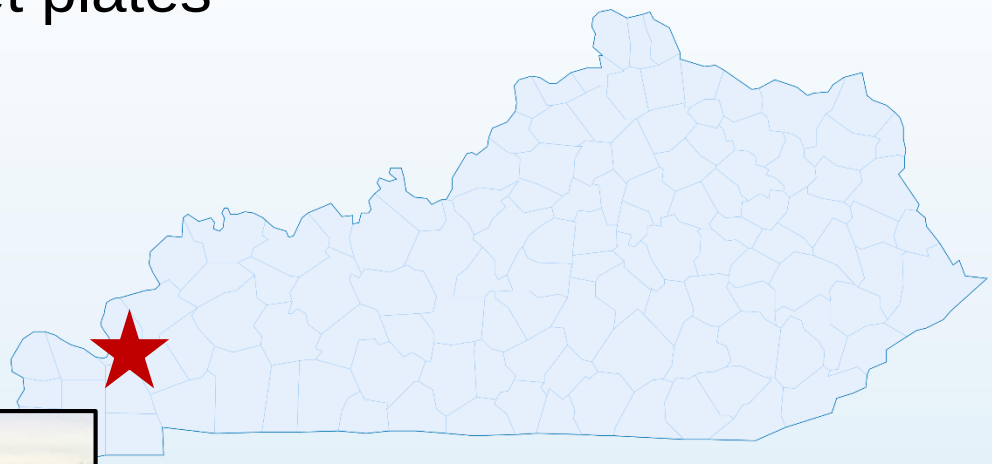
- U.S. 62 over Cumberland River
  - Constructed 1952
  - Complete design drawings; no shop drawings
  - sUAS photos of marked gusset plates
  - Photos imported into CAD

Three span continuous partial through truss
175’-350’-175’



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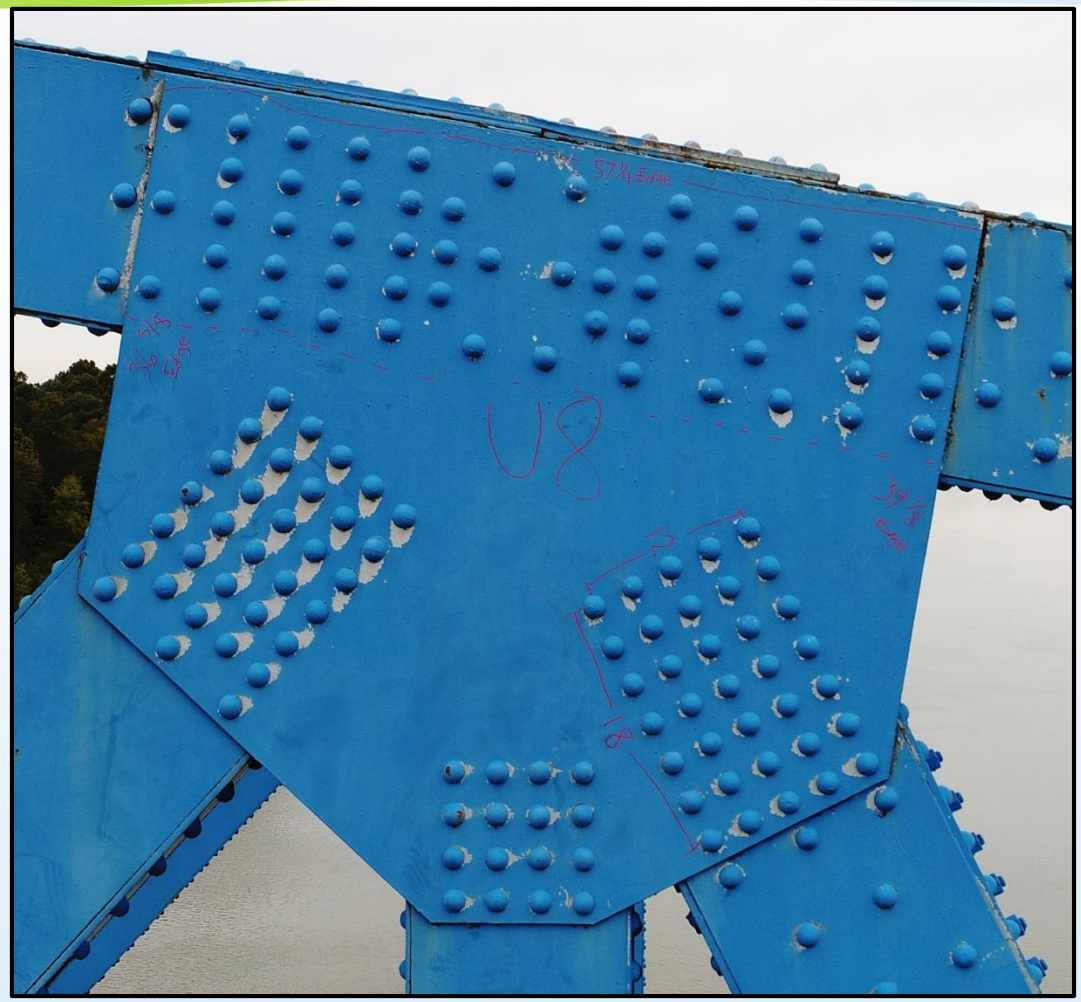

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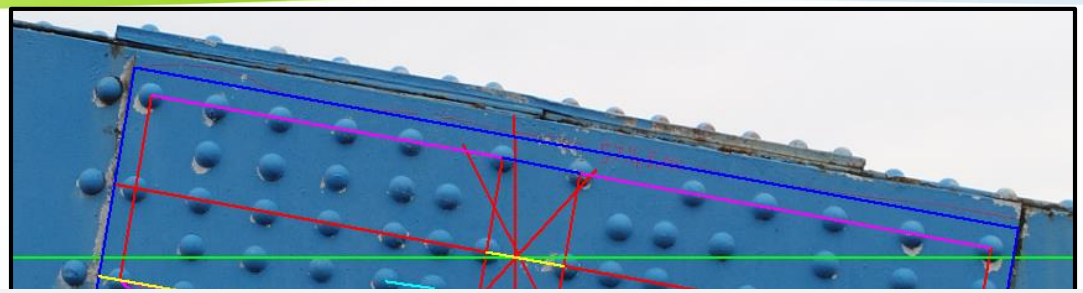

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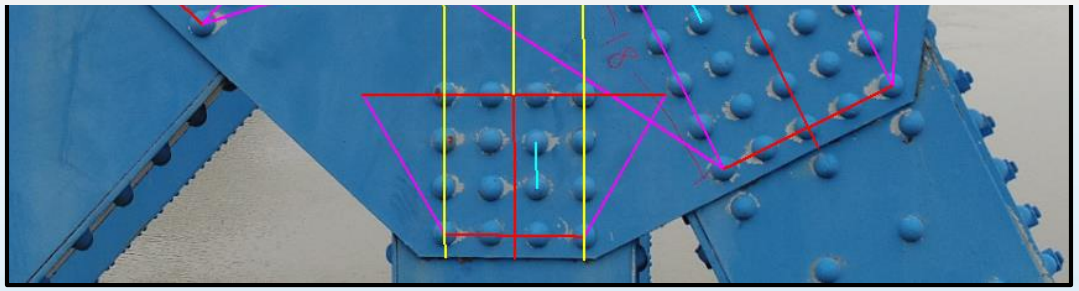

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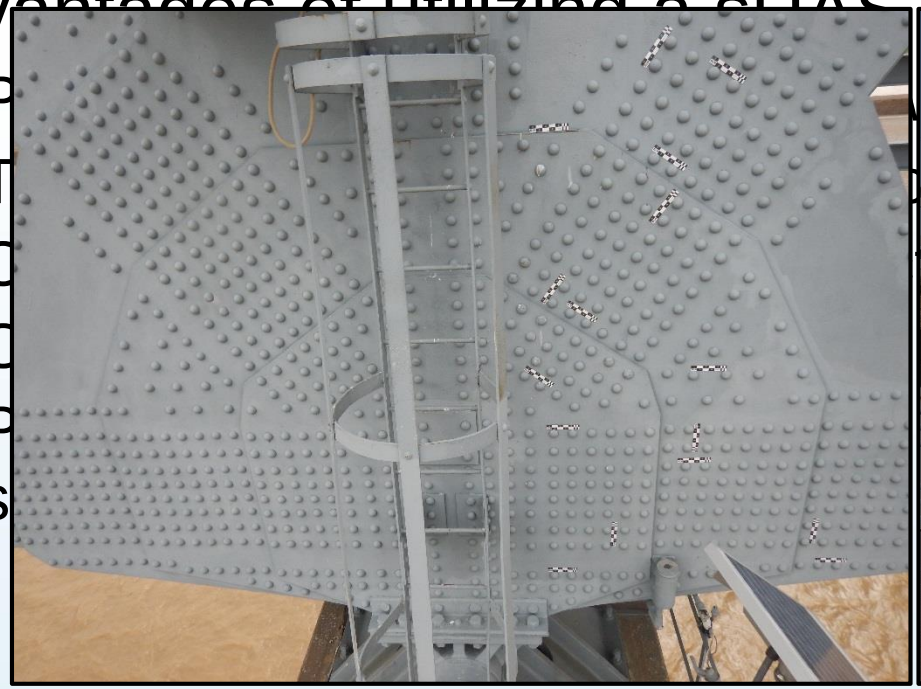

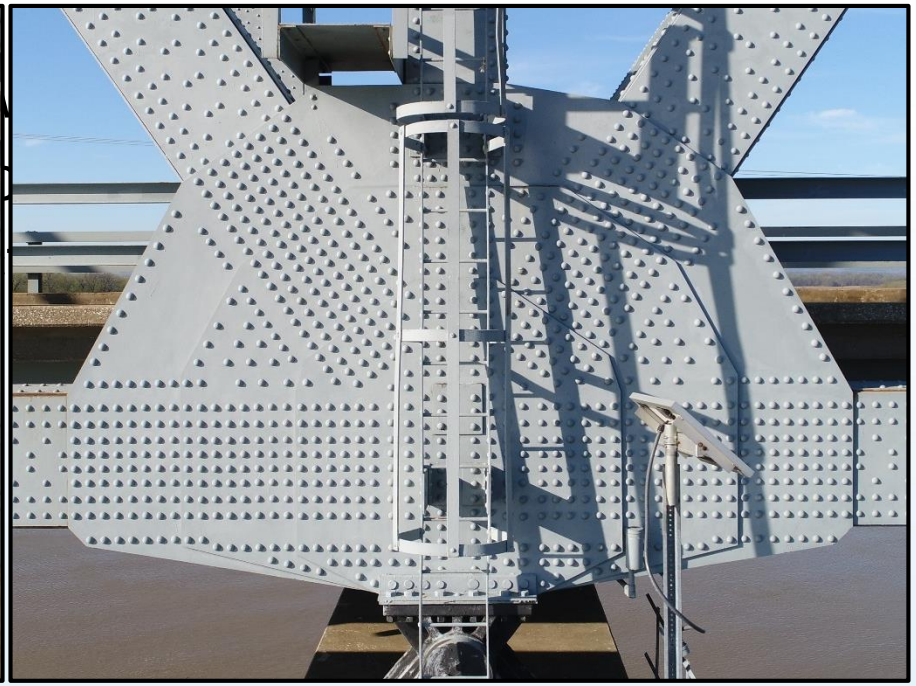

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- Summary of data collection time
  - Earle Clements (Polester)
    - 61 unique gusset plates documented
    - 172 person-hours / 2.8 person-hours per gusset plate
  - Glover Cary (sUAS)
    - 113 unique gusset plates documented
    - 90 person-hours / 0.8 person-hours per gusset plate
  - US 62 (sUAS)
    - 30 unique gusset plates documented
    - 18 person-hours / 0.6 person-hours per gusset plate

- Challenges
  - Requires
  - Potentially
  - Sensitive
  - Open, leve
  - Emergenc

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- Limitations
  - Inspectors oto in CAD and to rec
  - Interior sp
  - Generally nnections

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Additional Applications of sUAS

Barberton Reservoir

Wolf Creek

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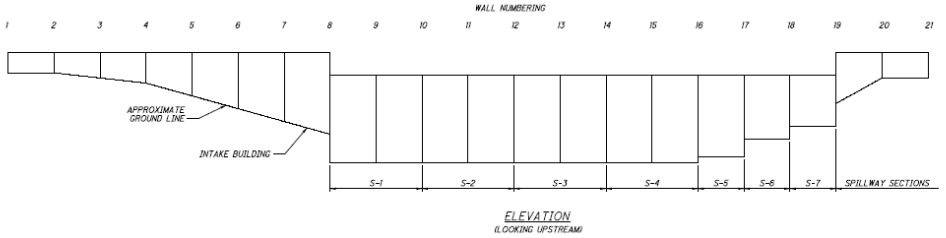

ELEVATION
(LOOKING UPSTREAM)

Note: The walls and sections of the dam are numbered and labeled according to the Dam Original Plans/Drawings used for this inspections. The buttresses (walls) have beenchanged to the term "wall" to simplify and ease the performance of the inspection while in the field. Any walkways, exterior/interior surfaces of the sloped area of the two Ambursen sections (reservoir side), and spillway section of the Dam is considered to be a "slab" element. Cells are labeled "1-2" for example, are oriented left to right from Wall 1 to Wall 2 in the drawings. The order of the sections for the drawings is as follows: South Ambursen section (non-spillway), Spillway section (exterior), North Ambursen section (non-spillway), Spillway section (interior).

LOCATION:	GENERAL ELEVATION	PHOTOS:

P:\095625\Inspection\MDR\Drawings\C1-1.0.dgn Sheet 7/25/2018 2:13:08 PM grande

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- Video link
- Drone used to capture footage, show access
- Opportunity for flying and testing

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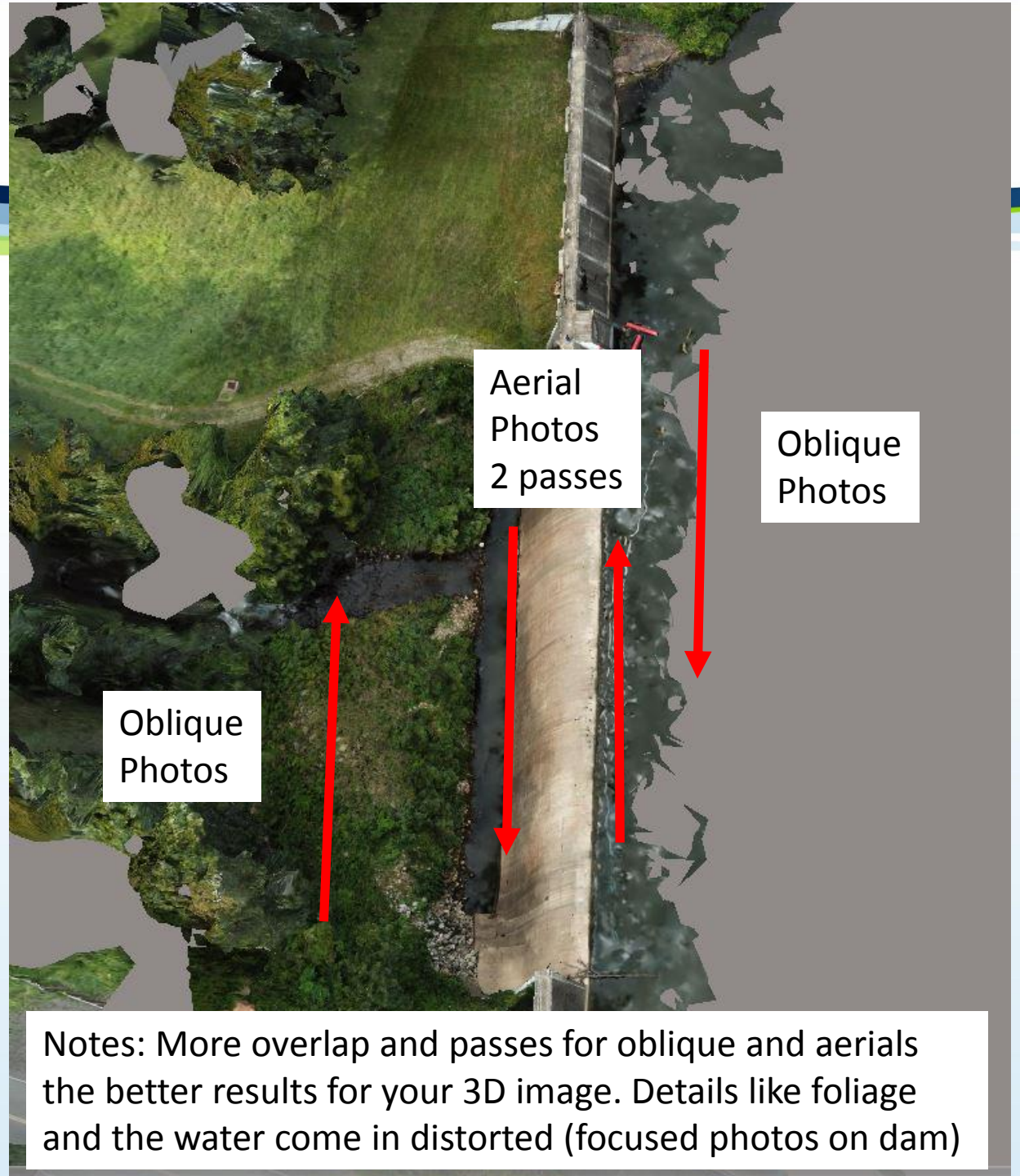
ContextCapture (3D Imaging)

- ContextCapture (3D)
  - Collect Oblique photos and aerial photos from overhead and both sides of the dam (DroneDeploy)
  - Input all the photographs into the software to create the 3D image.
  - With the 3D image, if a spatial reference system was used along with units of measurement you could measure areas of the dam and run the image through Acute 3D viewer (Bentley) which runs through ContextCapture.
  - Use for quantifying deficiencies
  - Initial testing phases of product to determine efficiency



Notes: More overlap and passes for oblique and aerials the better results for your 3D image. Details like foliage and the water come in distorted (focused photos on dam)

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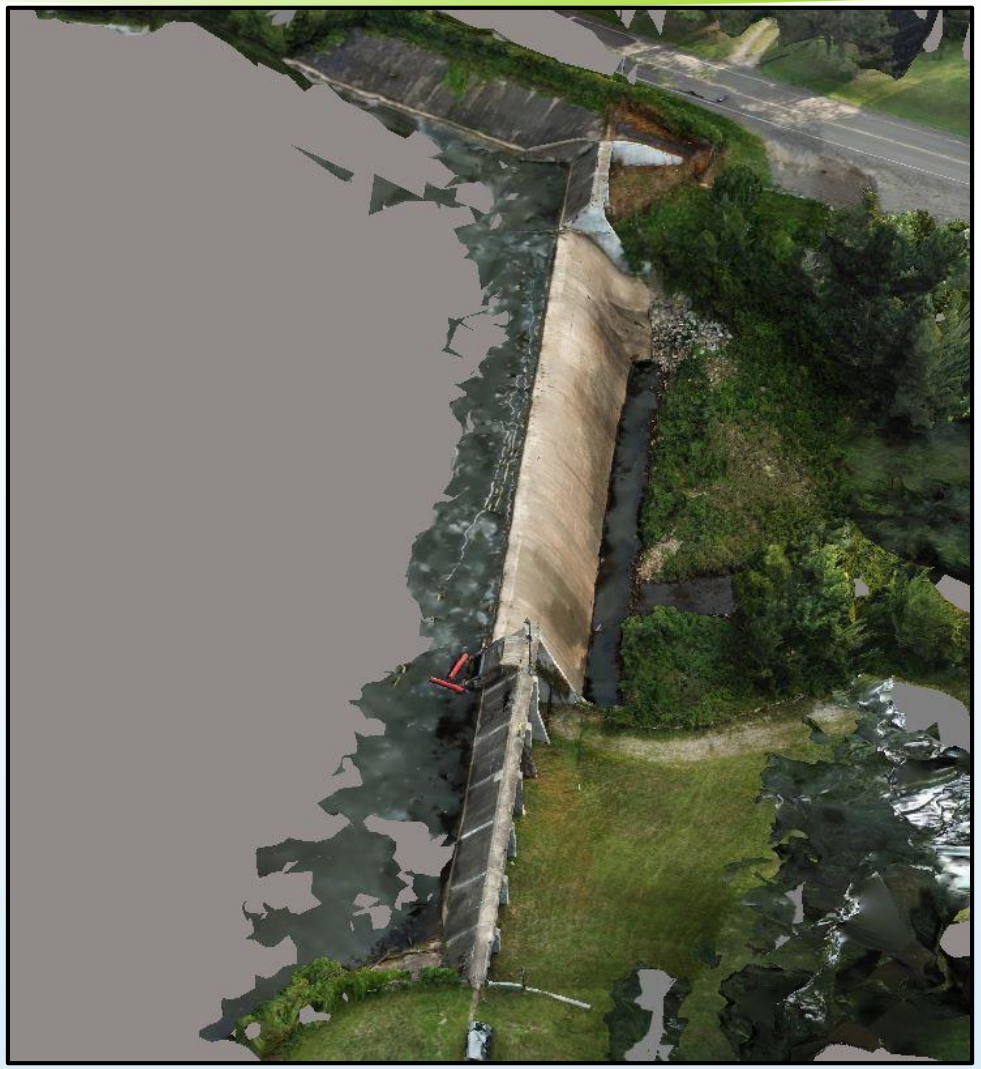

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Advantages of 3D Software

- Can measure up different aspects and features of the structure you are producing using photogrammetry.
- These 3D images can be integrated with other Bentley programs and inserted into Microstation and GEOPAK as a DGN file to manipulate.
- If ground survey is used along with this technology, high accuracy and detailed images can be produced by using the drone. Ground control points, and a Spatial Reference System can be input when producing the image in ContextCapture to tie units in with the measurements, and highly accurate data points for the survey.
- 3D Photo Logs of structures

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QUESTIONS?

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