ge Inspections Utilizing AS - Implementation Program

r Wells, PE - Minnesota State Bridge Inspection Engineer

entation Outcomes

derstand Benefits and Limitations

rn current and future drone technologies that are effective fo
lge inspection

derstanding of how to successfully implement drone technolo

derstand the costs associated with implementing drones and t
t savings that can be realized compared to traditional method

derstand drone data needs

derstand how to utilize drone data into digital twins

essment of UAS Technology

- nspection-specific UAS
- Object Sensing
- Capable of looking up
- ly without GPS, under bridge decks
- Photo, Video and Thermal Imaging
- Confined Space

ssment of UAS Technology

nmercial Drones ($20,000 -
,000)

tel Falcon 8+

I Matrice 210

yability Elios

efits

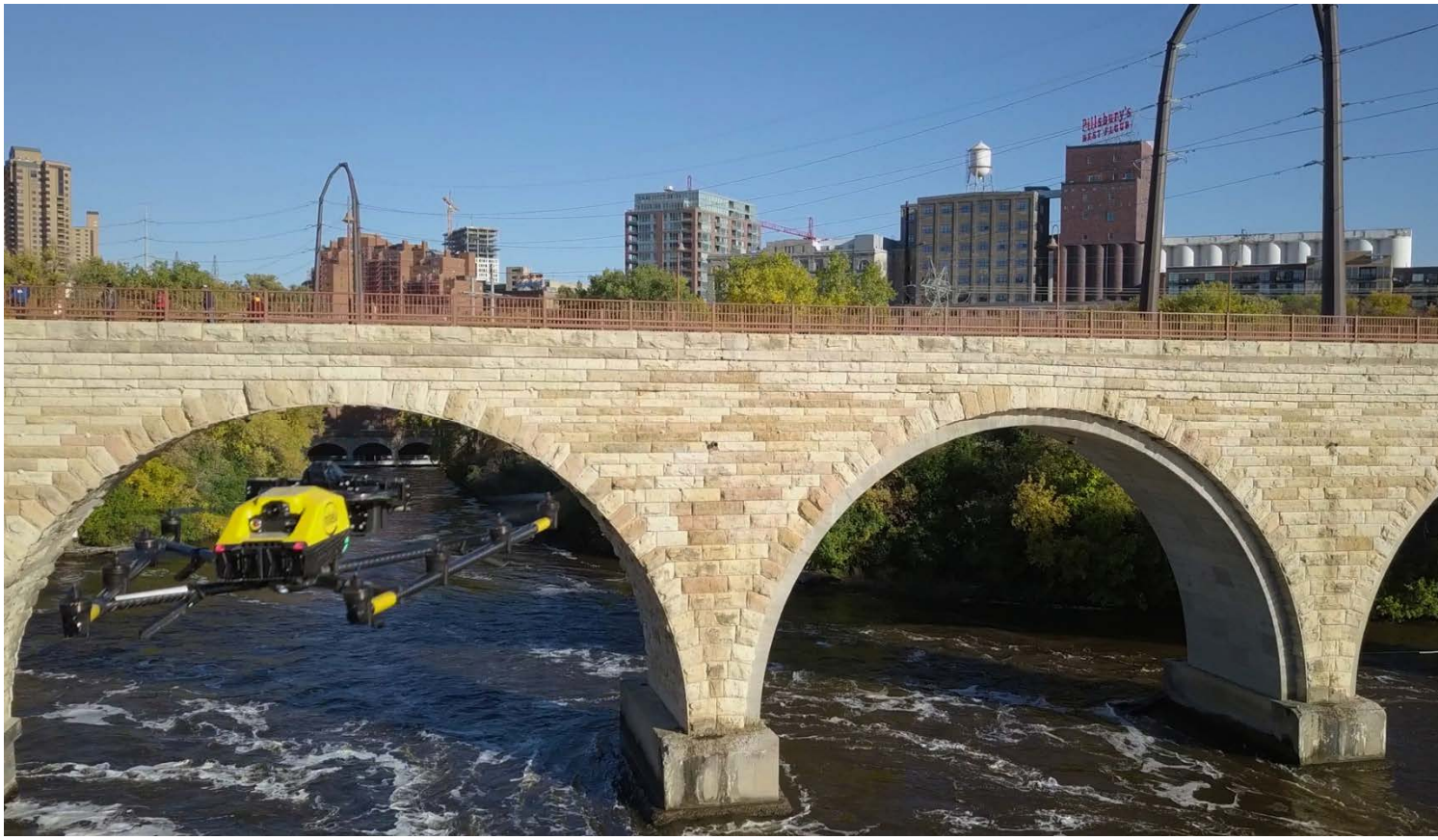
ensor Size

eliability

Dual Batteries

urability

urpose Built for Inspection



ssment of UAS Technology

nsumer Level Drones ($500 2000)

JI Mavic

Object Avoidance

arrot Anafi

Thermal

nefits

ow cost

mall size

lore risk tolerance

Limitations

- Non-professional perception
- Reliability
- Small sensor sizes
- Less sophisticated flight planning


DEPARTMENT OF TRANSPORTATION
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Sensor Size Importance

ssment of UAS Technology

- peller Aeropoints
- utomatic Ground Control oints
- ovides precision ground ntrol
- dds ability to accurately eolocate assets and spection results

dge Inspection Goals

nspection Planning

Detect Conditions and Deficiencies

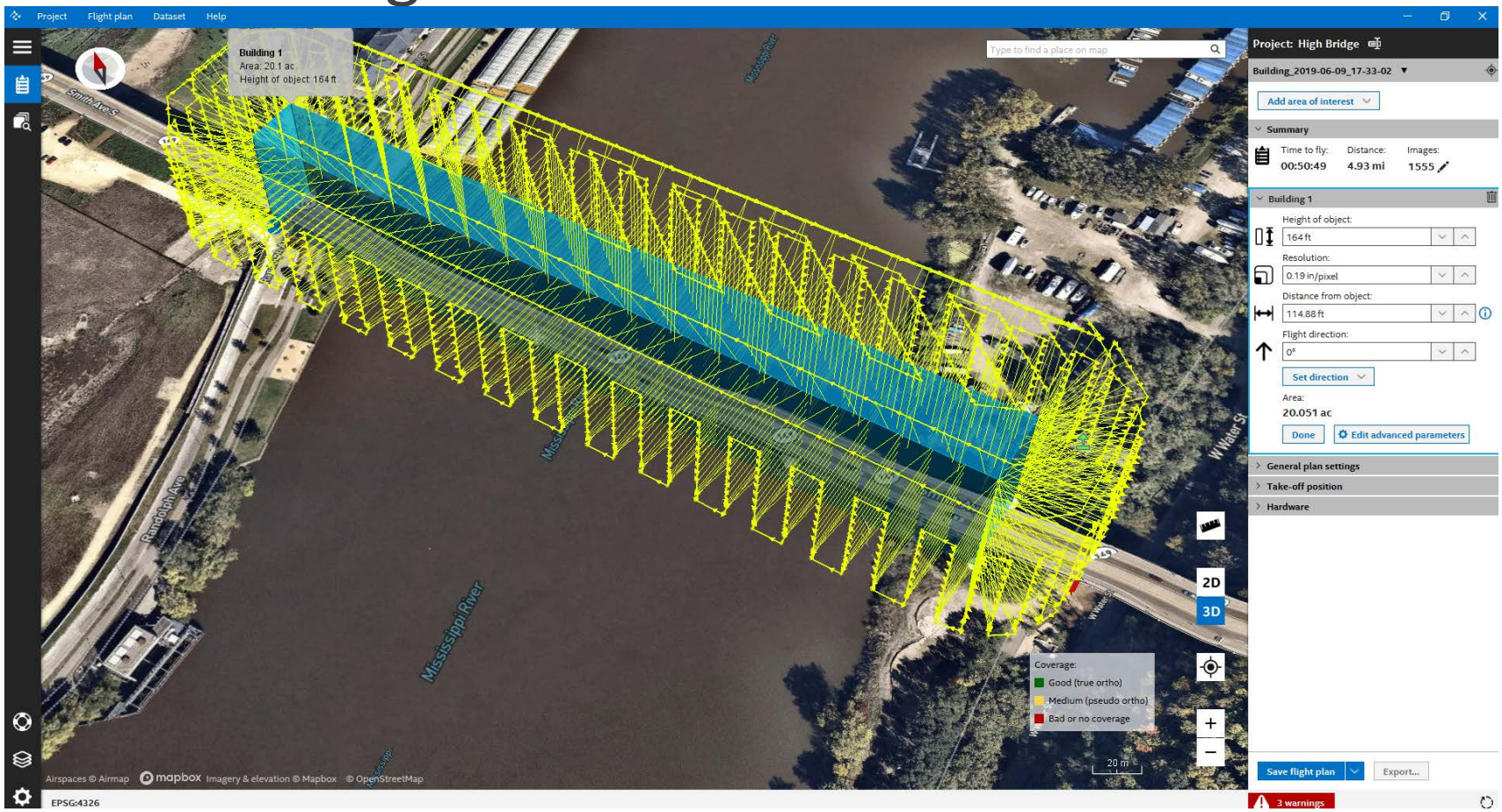
Document

Communicate

spection Planning with UAS

ght Planning

D Autonomous Flights



Detection of Defects and Deficiencies

- se UAS as an access tool
- raditional Access Tools
  - Aerial Work Platforms (AWP's)
  - Rope Access and Structure Climbing
  - Ladders
  - Binoculars

ocument Conditions and Deficiencies

eality Modeling Software

- Pix4D
- Context Capture

put

- Images
- Ground Control

utput

- Orthomosaics
- GeoTIFF, DSM, DTM
- Point Clouds
- Classified by AI
- 3D Mesh
- CAD

ocument Conditions and Deficiencies

iverables – Orthomosaic

ommunicate Conditions and Deficiencies

raditional Reporting

BR 3459 -- Span #3 Field Notes		
Location	**North (upstream) Truss**	**South (downstream) Truss**
L0-L1 Bottom Chord (4 angles, 5" x 3-1/2" x 5/16")	[2004] Bottom chord angles reinforced (bolted plates) at L0, L1 and at the center. [2008] There is pitting and section loss (painted over) just west of the center section reinforced in 1994 - the horizontal legs of the two exterior angles have rusted through. [2011] No change. [2015] Through corrosion top horizontal leg of bottom exterior angle west of retro fit. **[2017] Pitting on the upper legs of the chord inside the panel point.** (Photo 20)	[2008] Upper angle is bent at mid-panel. [2008] The horizontal legs of the truss bottom chord angles have pack rust (minor section loss) at L0. [2008] The vertical leg of the bottom interior angle has pack rust (section loss) along the edge of the interior L0 gusset plate. [2011] No change. [2015] Pitting 3/16" deep at L0. Through corrosion on bottom interior angle horizontal leg inside panel point L0. Pitting ¼" deep on top interior horizontal legs inside L1.
L0-L1 Lower Lateral Bracing	[2004] Lower lateral bracing members replaced. [2011-2015] No deficiencies noted.	
L1 Gusset Plates (1/2" thick)	[2004] Repainted - L0/L1 & L1/L2 connections reinforced (bolted plates). [2011] No deficiencies noted. [2013-2015] 1/8" bow on EGP from PR.	[2004] Repainted. [2010] Minor corrosion. [2011] No change [2013-2015] IGP has 1/4" PR distortion over upper angle of lower chord, E side.
L1-U1 Vertical (4 angles, 3" x 2-1/2" x 1/4")	[2008] Vertical has minor section loss at L1. [2011] No deficiencies noted. [2013] NC to section loss @ L1. [2013-2015] Paint failures over upper half of N face of both flanges. **[2017] 3/16" pitting at L1N** (Photo 21)	[2011] No deficiencies noted. [2015] Paint failure throughout.

ommunicate Conditions and Deficiencies

efits

- ety Improvements
- spectors
- ublic
- lity Gains
- t Savings

enges

- rning Curves
- Hands On
- eptance
- es and Regulations
- a Storage

ety Analysis

- emove inspectors from harms way
  - Heights
  - Traffic
- educed traffic control improves safety for inspectors and publ
- undreds of Inspection Flights with no incidents or close calls
- Vork zone accident occurs every 5.4 minutes in the United Stat
- 2014 669 Fatalities in Work Zones
- AS are a way to remove personnel from the ROW
- AA is focused on airspace safety but need to look at overall ris

t Savings

st Savings up to
%

ost cost savings
here traffic
ntrol and
cess equipment
n be reduced or
minated.

Structure	Traditional Inspection Cost	UAS Assisted Inspection Cost	Savings +/-	Savir Percen
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

dge Candidates

orks Well

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

oes not Work Well

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

a Storage

per Computer

per Storage

curity

oneData

Name

- CO
- D1
- D2
- D3
- D4
- D6
- D7
- D8
- METRO
- System Volume Information

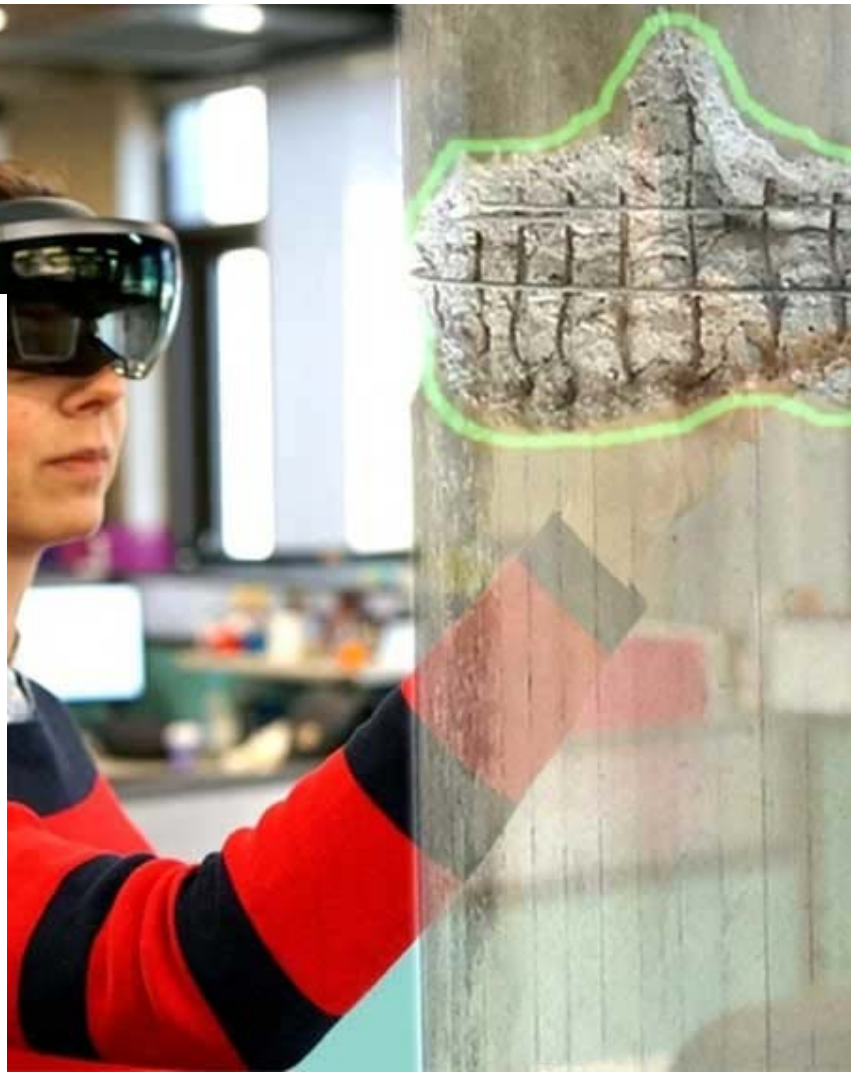
& Digital Twins

crosoft HoloLens

dge Digital Twins

Microsoft HoloLens

Mixed-r



averse

tual space where we
visit, meet and
borate

ered around a digital

, measure, annotate
share

orm virtual inspections

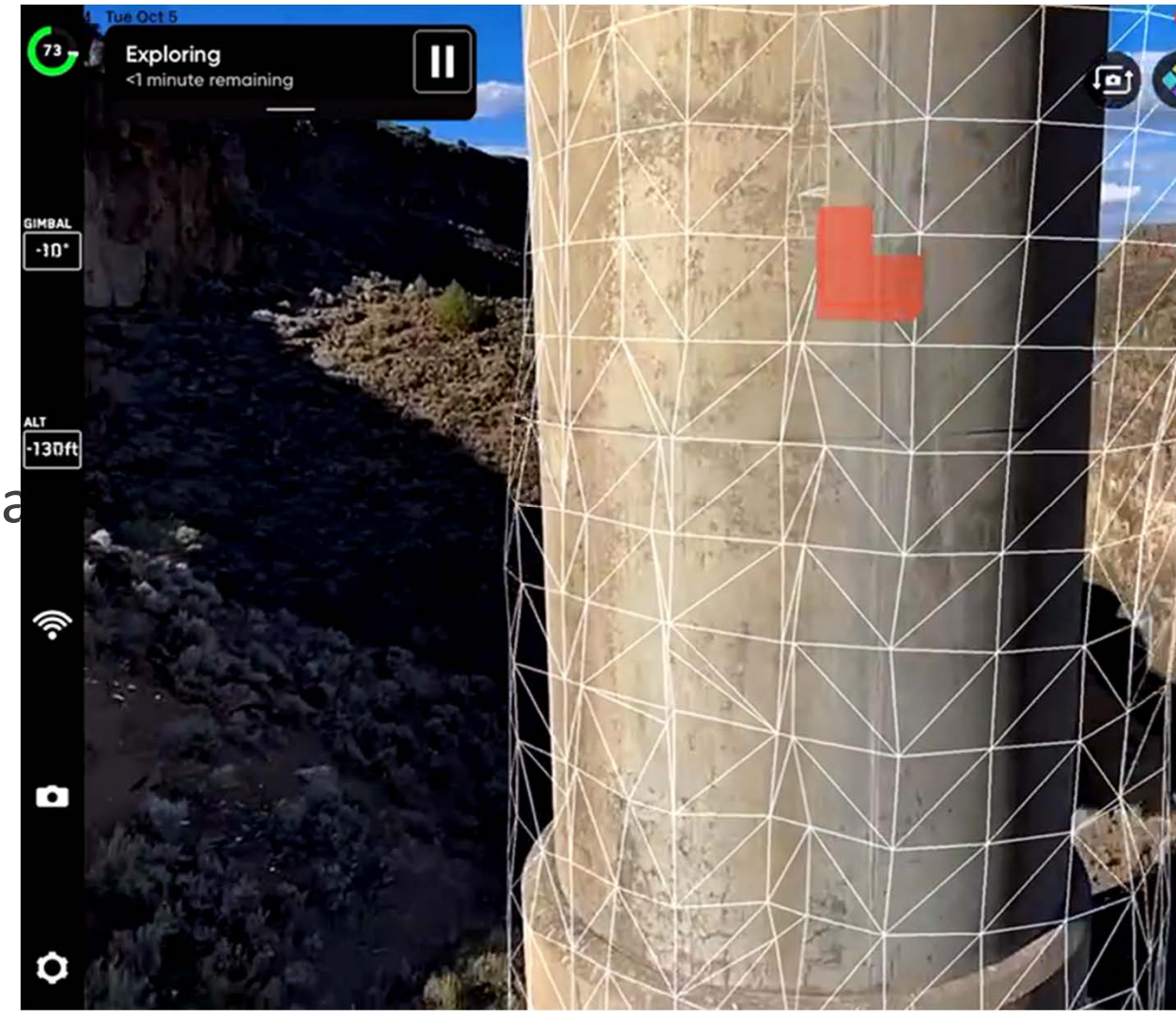
e for design and load
g

r Data Collection

es collect data orders of
nitude faster than humans

es utilize sensors and input
GPS, Inertial Measurement
(IMU), compass, cameras,
sonic to fly with only directiona
t from pilot

es and robots can now collect
t data almost entirely
nomously



e Rehabilitation UAS Workflow

AS Field Data Capture

gital Twin Creation

eld Inspection

ehabilitation Design and ans

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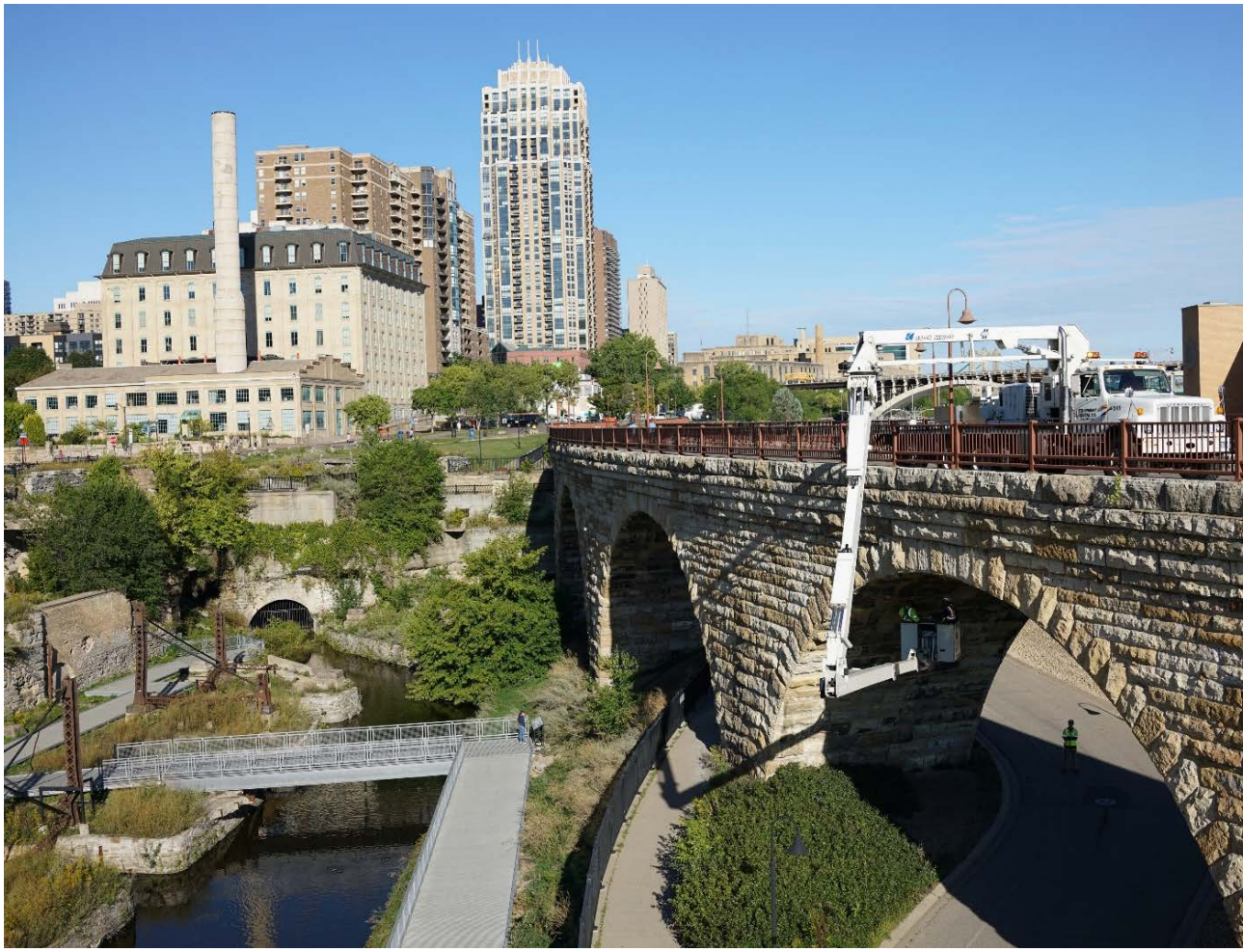
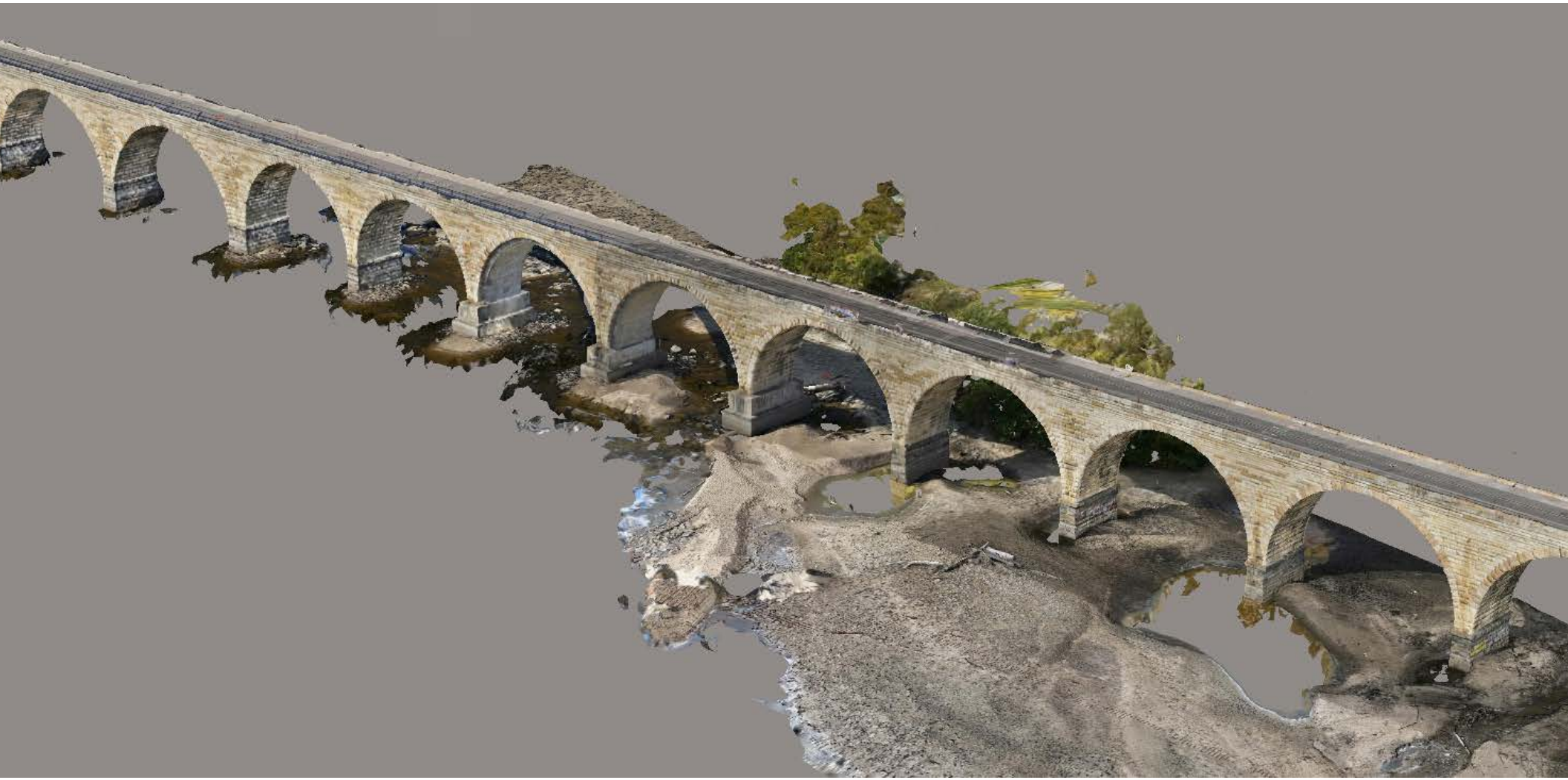
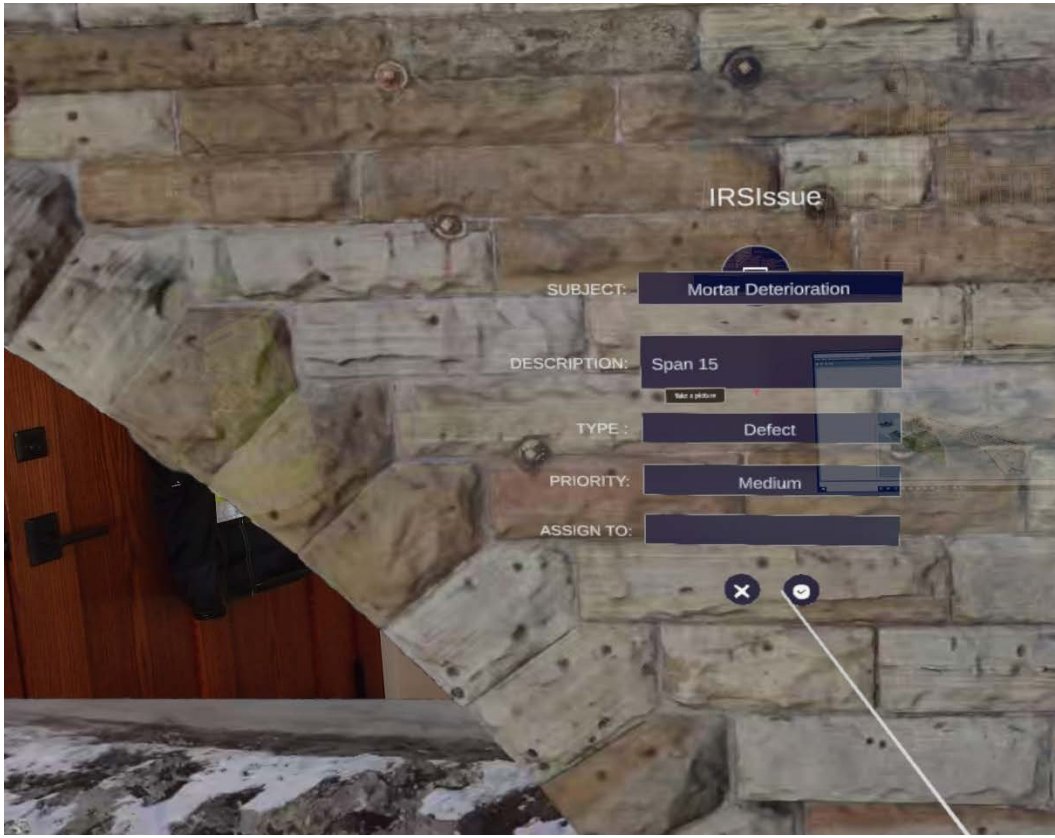


y Model with Field Notes

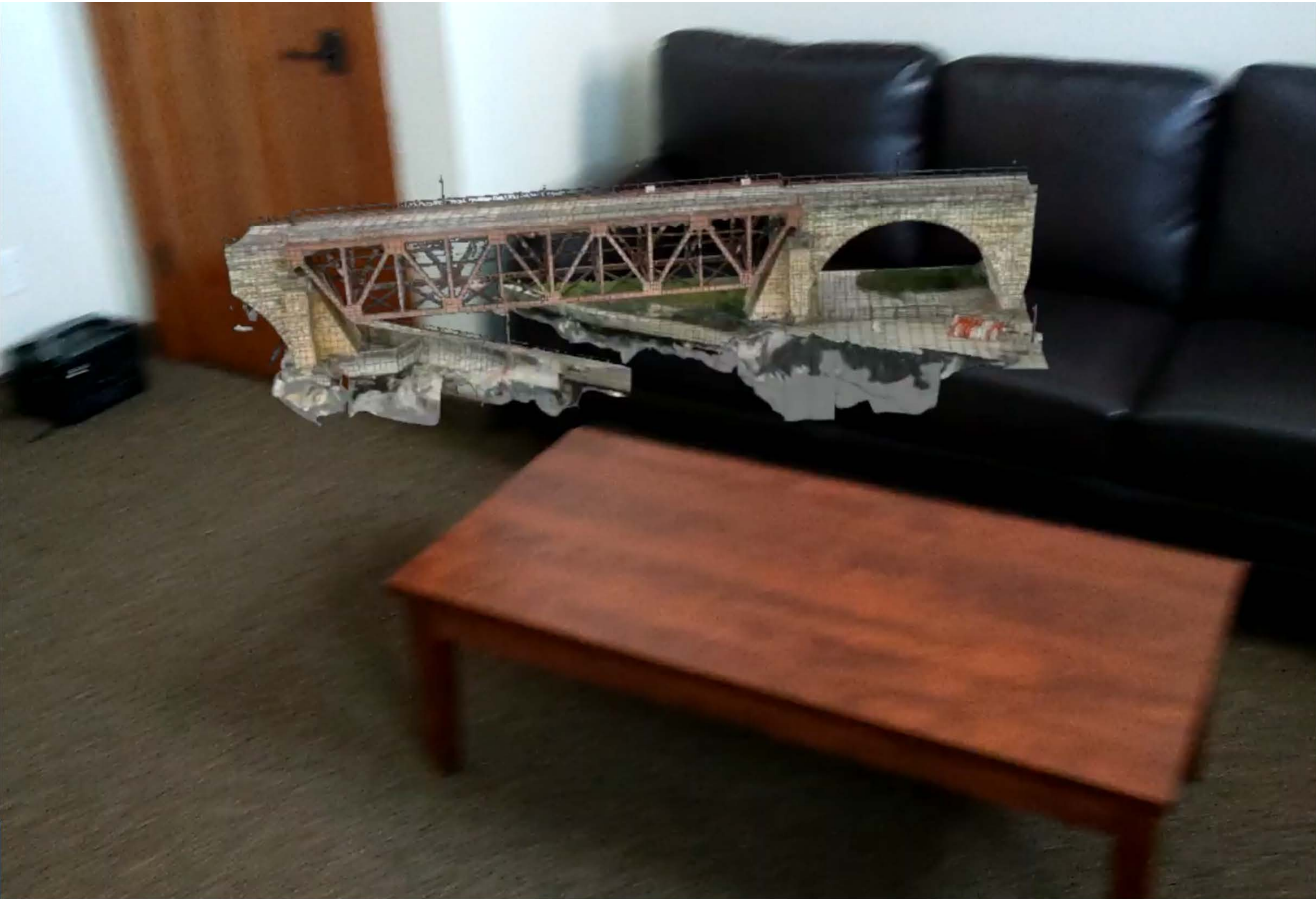
e Arch Bridge Digital Twin



ed Reality Inspections



entley – Microsoft Hololens 2



Arch Bridge Digital Twin Benefits

roved Data Quality

uced Risk for Designers

uced Risk for Contractors

er Collaboration/Inclusion

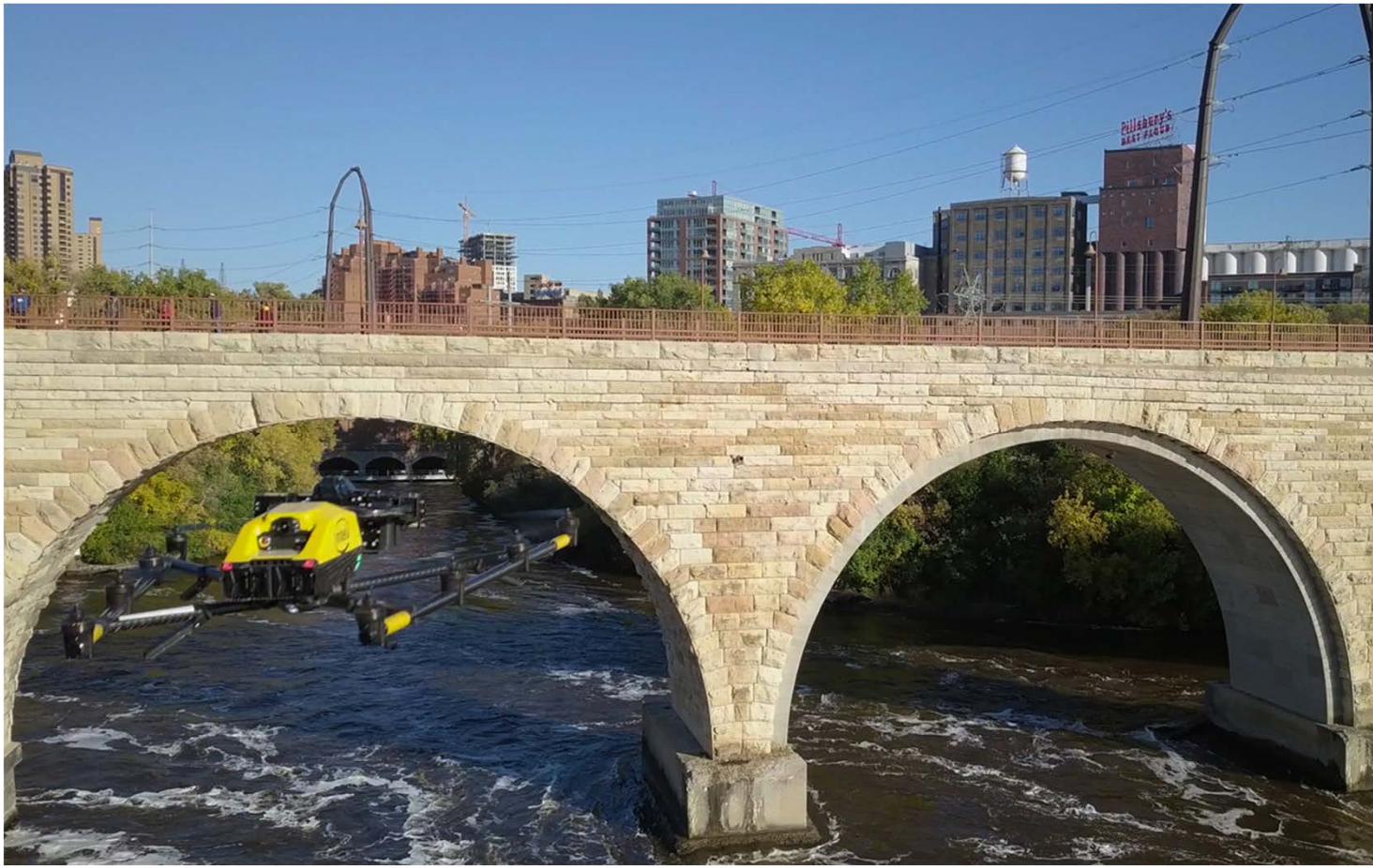
ety Improvements

a Increase

ditional Bridge Report 6
gabytes

tal Twin Bridge Inspection
ort 2 Terabytes

,333 x more data



nclusions

- now your intended purpose for the drone – “off-the-shelf” UA as limited inspection capabilities
- sing UAS for access is important but documentation and ommunication of results is more compelling
- AS can supplement inspections as a tool
- oes not need to replace entire inspection
- ollaborate with other owners to share knowledge and promot uture advancement
- now where to store data and how to utilize it effectively

ditional Information

se III Report Published

p://www.dot.state.mn.us/research/reports/2018/201
6.pdf

se IV Report Published

ps://www.dot.state.mn.us/research/reports/2021/20
13.pdf

DOT Office of Aeronautics
S Policy/Info

p://www.dot.state.mn.us/aero/drones/index.html

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QUESTIONS?