



## Incorporating Autonomous Drones with Assisted Defect Recognition into Airline Maintenance Programs

Emma Galarza – Senior Technology Development Engineer, Delta Air Lines

Floris Straver – Robotics Software Engineer, Mainblades Inspection

# Impacting The Business



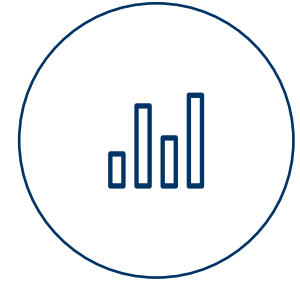
## INCREASED A/C AVAILABILITY

Average time to accomplish a full airframe GVI is 8.5 hours.  
Autonomous inspection via drone can do the same **inspection in <1 hour for a narrow body and < 2 hours for a widebody**



## SAFETY FIRST, ALWAYS

Automated inspection tools, such as the drone, **remove our people inspections at height**; drone comes equipped with full suite of sensors and safety features to prevent run away or impact to an aircraft



## NOVEL DATA SOURCE

Inspection via camera technologies provide opportunities to include new data streams into the business; visual data repositories provide **enhanced capabilities to track overall fleet condition** and make more informed engineering decisions

# User Priorities – Survey Results

## Drone Program Priorities Ranked by Importance

Time of Inspection

Mobility / Ease of Set-Up

Photo Clarify / Resolution

Environmental Needs

If nearby obstacles (ladders / people) need to be removed

Damage Location ID

Photos / damage linked to a frame / stringer location

Mobile Interface For  
Damage Review

Battery Swaps  
Required

## Current GVI Procedure Statistics

16

Man Hours

On average, an upper body GVI for a lightning strike inspection requires 4 hours of work with an average of 4 people

4

People

On average, 4 people are required to conduct an upper body GVI

High

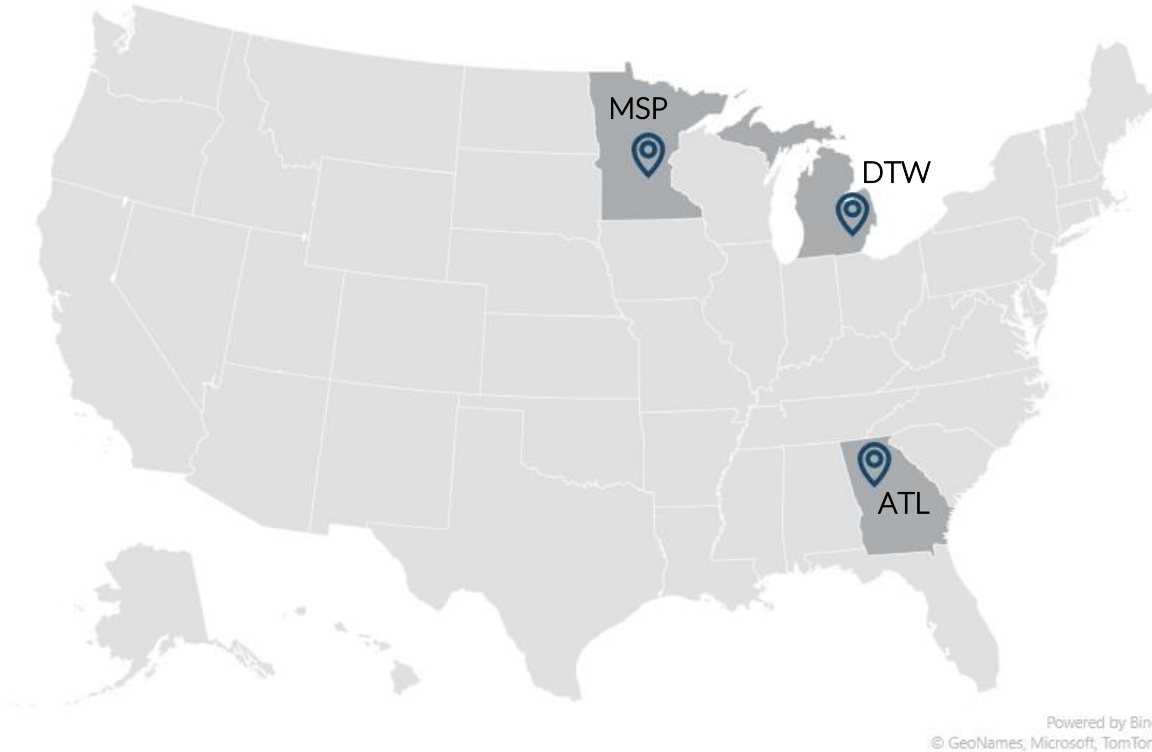
Safety Hazard Risk

63% Rated an upper body GVI as a High-Risk activity while the remaining 37% rated Medium due to risk of fatality



Survey included Base Maintenance, Line Maintenance, IMA, and Inspection (ATL&MSP)

# Outdoor Flight Approvals



## Approved Airports:

- Hartsfield-Jackson Atlanta International Airport (ATL)
- Minneapolis-Saint Paul International Airport (MSP)
- Detroit Metropolitan Wayne County Airport (DTW)

## Regulatory Approvals:

- Federal Aviation Administration
- Department of Transportation
- Department of Homeland Security
- Airport Authorities
- Transportation Security Administration
- City Authorities

# Autonomous Flight Capabilities

## Widebody

146 / 146 aircraft mapped



## Narrowbody

702 / 702 aircraft mapped



Updated  
Lidar-mapped aircraft models  
developed by



# Inspection Setup



# Inspection Setup

The screenshot shows the 'Inspection Setup' screen of the Delta TechOps MainBlades app. The top status bar displays the time '12:55 PM', the date 'Wed Sep 6', and system icons for signal strength, Wi-Fi, and 95% battery. The main interface is divided into two panels. The left panel, titled 'Inspection', features a vertical progress indicator with four green dots and a blue circular button at the bottom. Below the indicator are five status items: 'Remote controller cable' (green dot), 'Flight computer power' (grey dot), 'Flight computer internet' (grey dot), 'Geozone status' (green dot), and 'Drone battery' (green dot). Underneath these are two light blue buttons: 'Asset' (with subtext 'Select your asset') and 'Flight path' (with subtext 'Select flight path'). At the bottom of this panel is a grey button labeled 'Start preflight checks'. A small text note at the bottom left of the left panel reads 'Backend: https://api.mainblades.com/v1'. The right panel, titled 'Add', has a sub-header 'Select asset registration' and a search bar with the placeholder text 'Registration or identification number'. A loading spinner is centered in the right panel. The bottom navigation bar contains four icons: 'History' (envelope), 'Inspection' (drone icon), 'Assets' (airplane icon), and 'Settings' (gear icon). A large black circular camera viewfinder is positioned in the bottom right corner.



# Inspection Setup

12:56 PM Wed Sep 6



## Inspection



- Remote controller cable ●
- Flight computer power ●
- Flight computer internet ●
- Geozone status ●
- Drone battery ●
- Asset** ✓  
N377NW
- Flight path** ✓  
General visual inspection upp...
- Location** ✓  
Hangar (indoor)
- Drone setup** ✓  
Drone home area selected

Start preflight checks

Backend: <https://api.mainblades.com/v1>



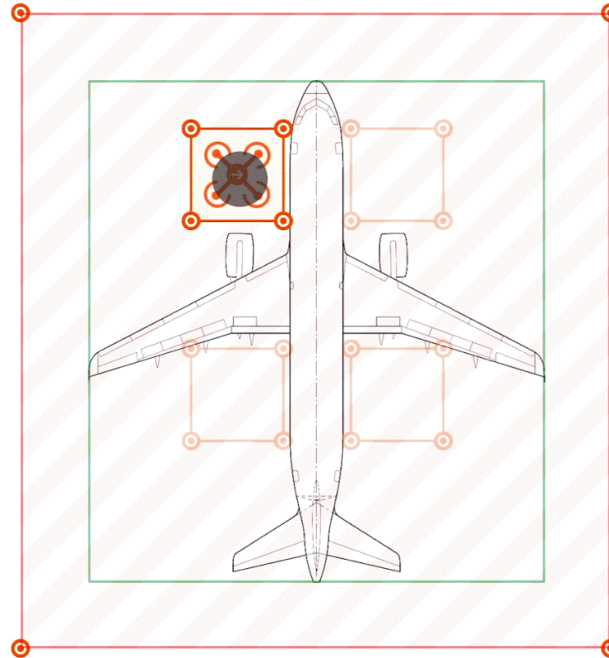
History

Inspection

Assets

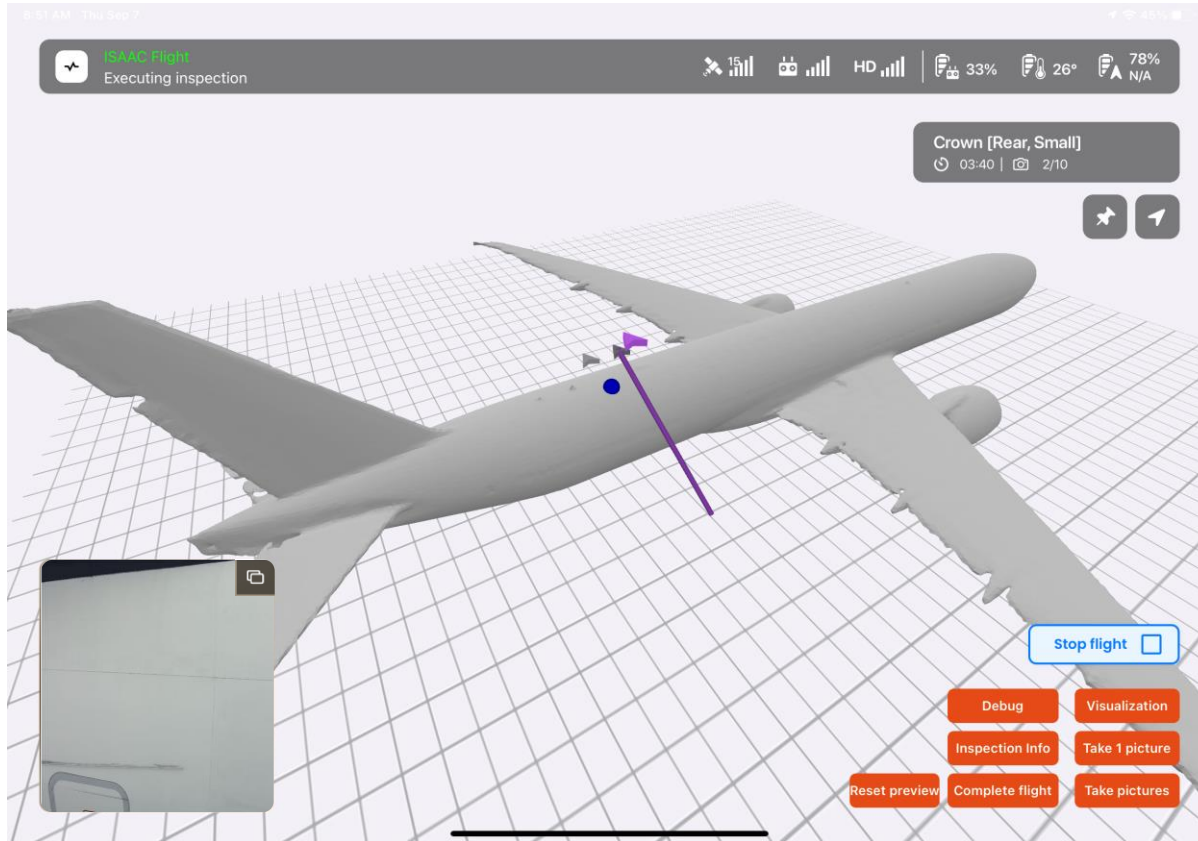
Settings

Ensure all areas are clear of people and obstacles

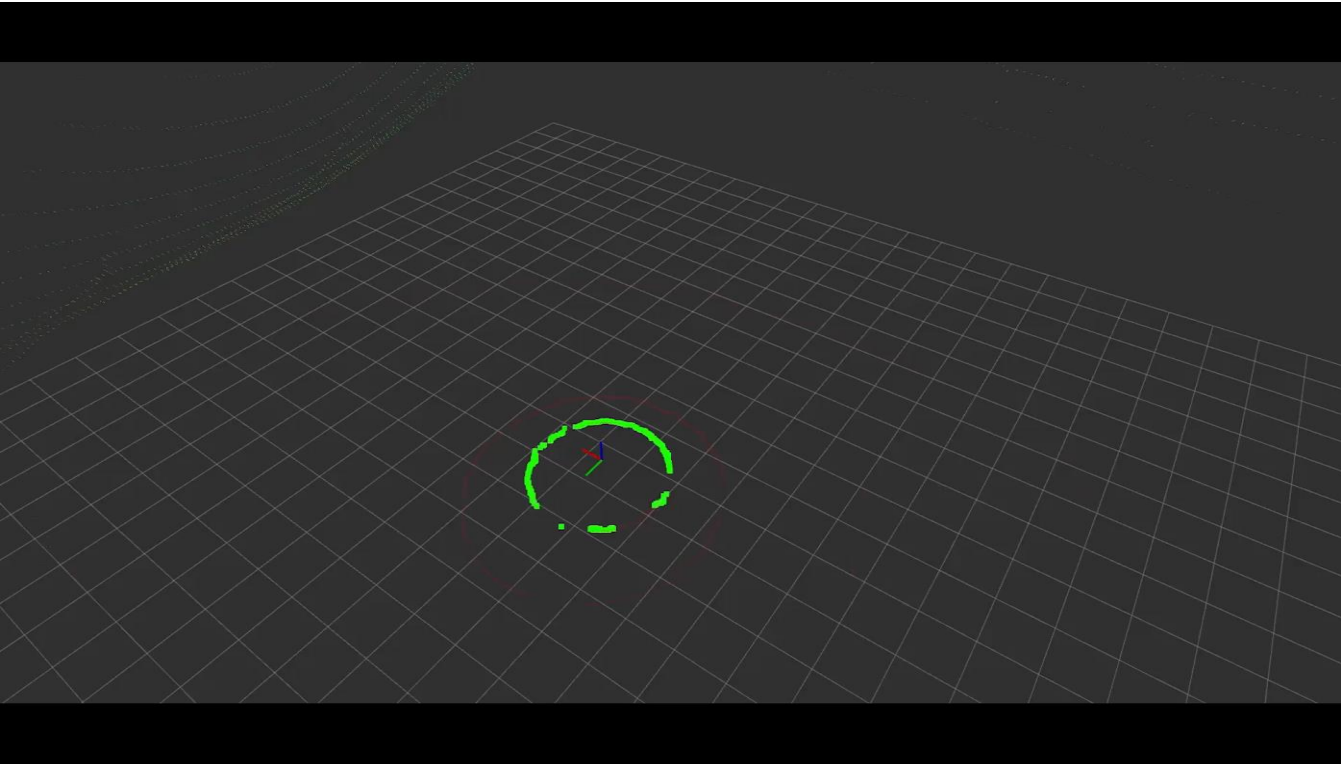




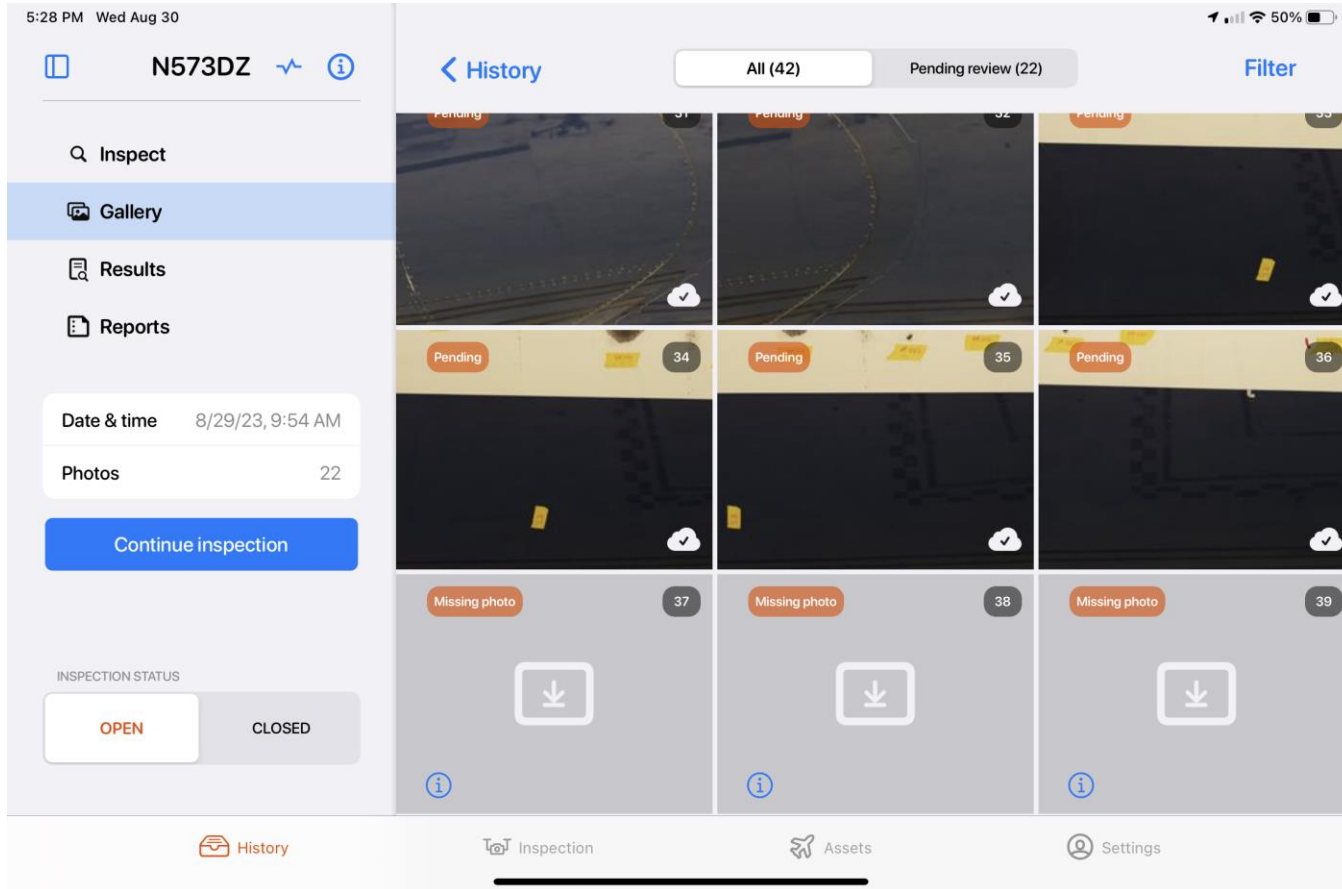
# Inspection Flight



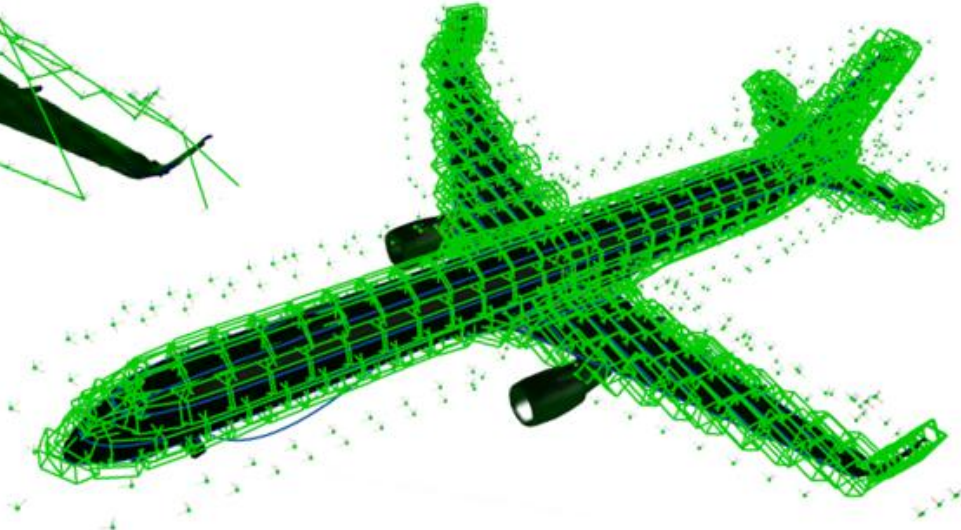
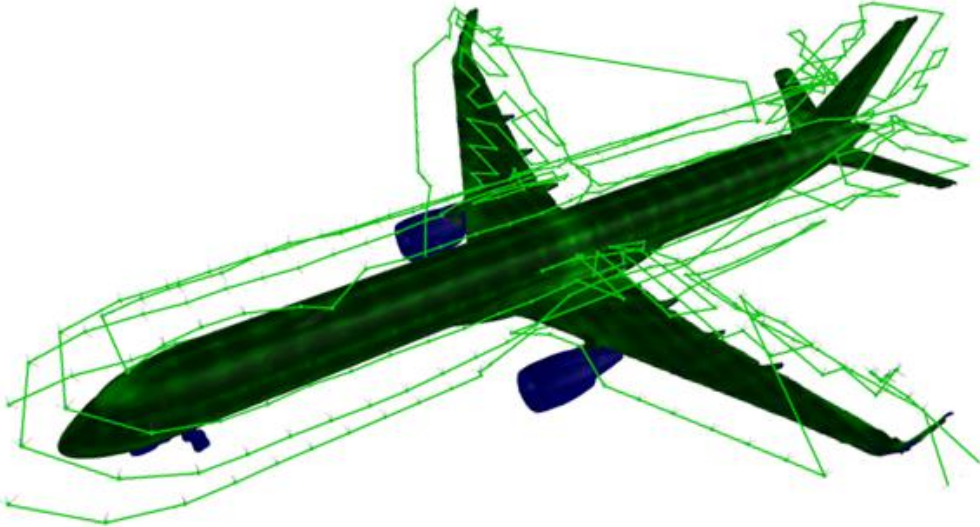
# Inspection Flight



# Inspection Result



# Flight Path Coverage



## General Visual Inspection Extract (MSG-3)

### An inspection is:

#### A. GENERAL VISUAL INSPECTION (GVI)

A visual examination of an interior or exterior area, installation or assembly to detect **obvious damage, failure or irregularity**. This level of inspection is made from **within touching distance**, unless otherwise specified. A mirror may be necessary to enhance visual access to all exposed surfaces in the inspection area. This level of inspection is made under **normally available lighting conditions** such as daylight, hangar lighting, flashlight or drop-light and may require removal or opening of access panels or doors. Stands, ladders or platforms may be required to gain proximity to the area being checked.

## Advisory Circular 43.13 on Visual Inspection

*“The use of optical aids for visual inspections is beneficial and recommended. Optical aids magnify defects that cannot be seen by the unaided eye and also permit visual inspection in inaccessible areas”*

# Experimental Design – Gage R&R



## Current GVI Procedure

Inspectors set up to perform standard GVI on A/C and report maximum resolution from the resolution target.



## Drone Assisted GVI Procedure

Drone flies autonomous path capturing photos of targets. Inspectors review photos and report maximum resolution from resolution target.



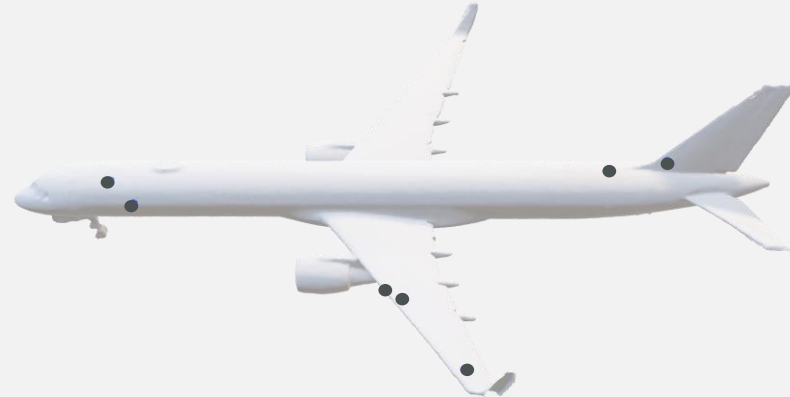
## Gage R&R Measurement

Asses the reproducibility and repeatability of current GVI procedures and drone assisted GVI procedures.

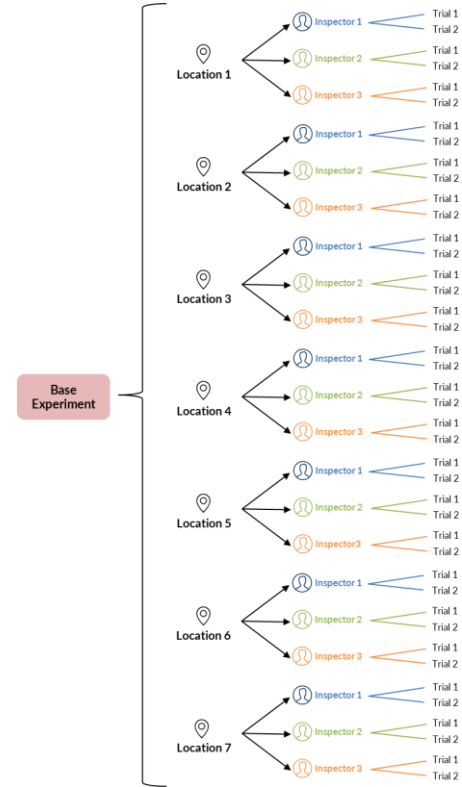
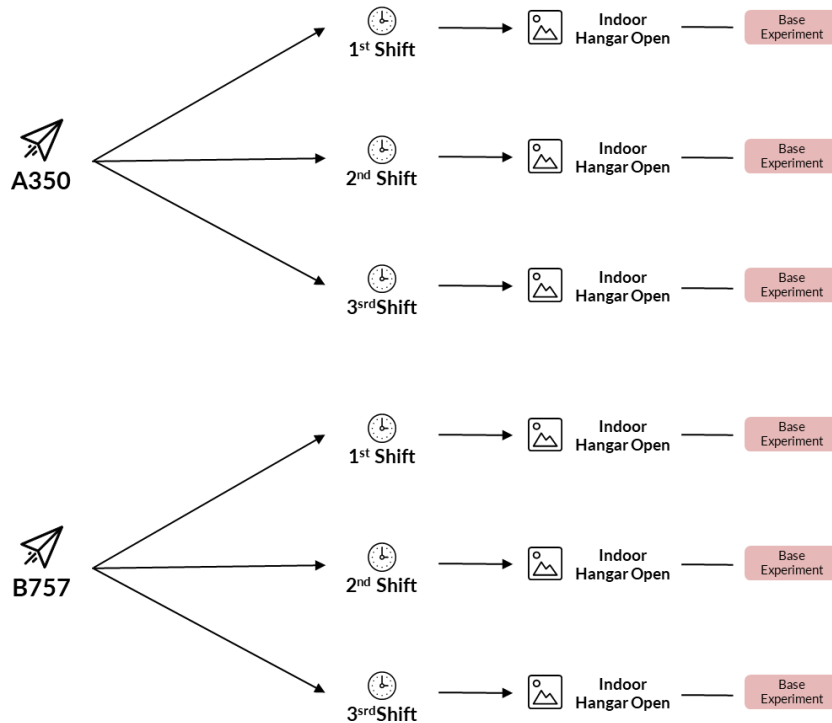
USAF-1951 Resolution Target



Experiment Target Placements



# Experimental Design – Gage R&R





# Experimental Results



# Experimental Results

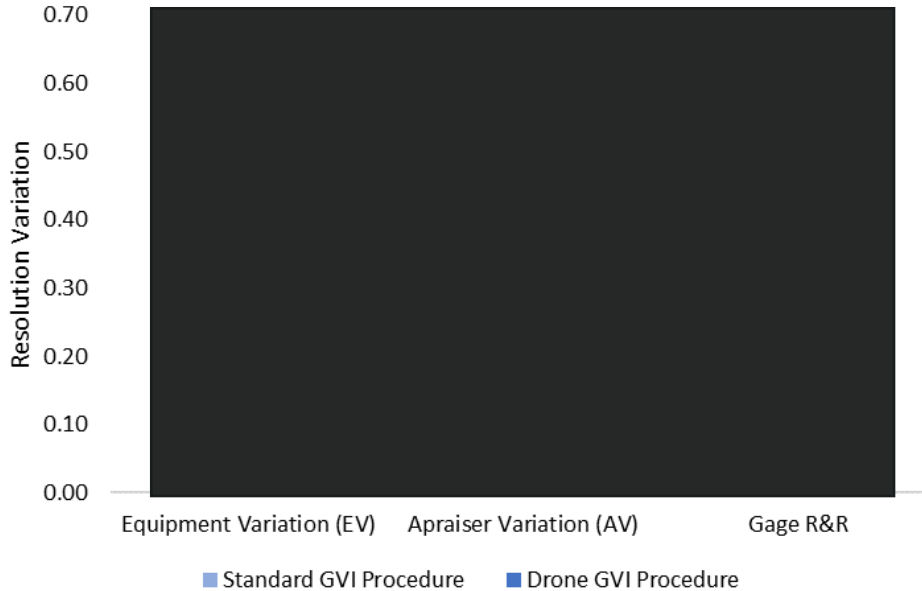
## USAF-1951 Resolution Target Examples



Photo Comparison of 7 Targets placed at varying locations of the aircraft

# Experimental Results

## Process Variation Results



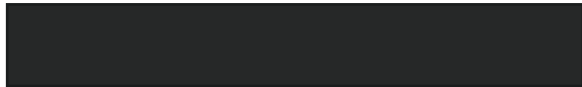
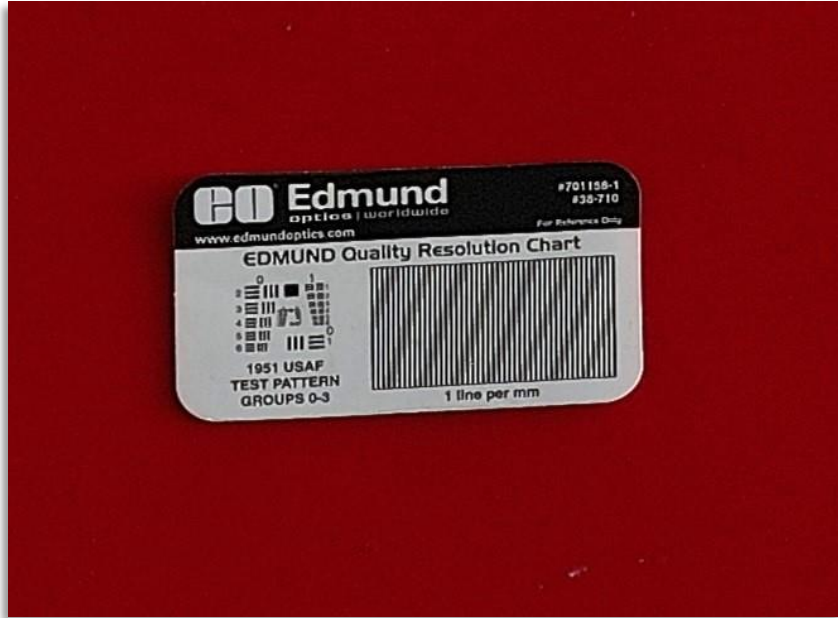
$$\text{Gage R\&R} = \sqrt{EV^2 + AV^2}$$

Gage R&R Results	Standard GVI Procedure	Drone GVI Procedure
Process Variation Due to Measurement Procedure	[Redacted]	[Redacted]

The drone assisted GVI performed [Redacted] than current GVI procedure in process Repeatability and Reproducibility

# Resolution Results - Range

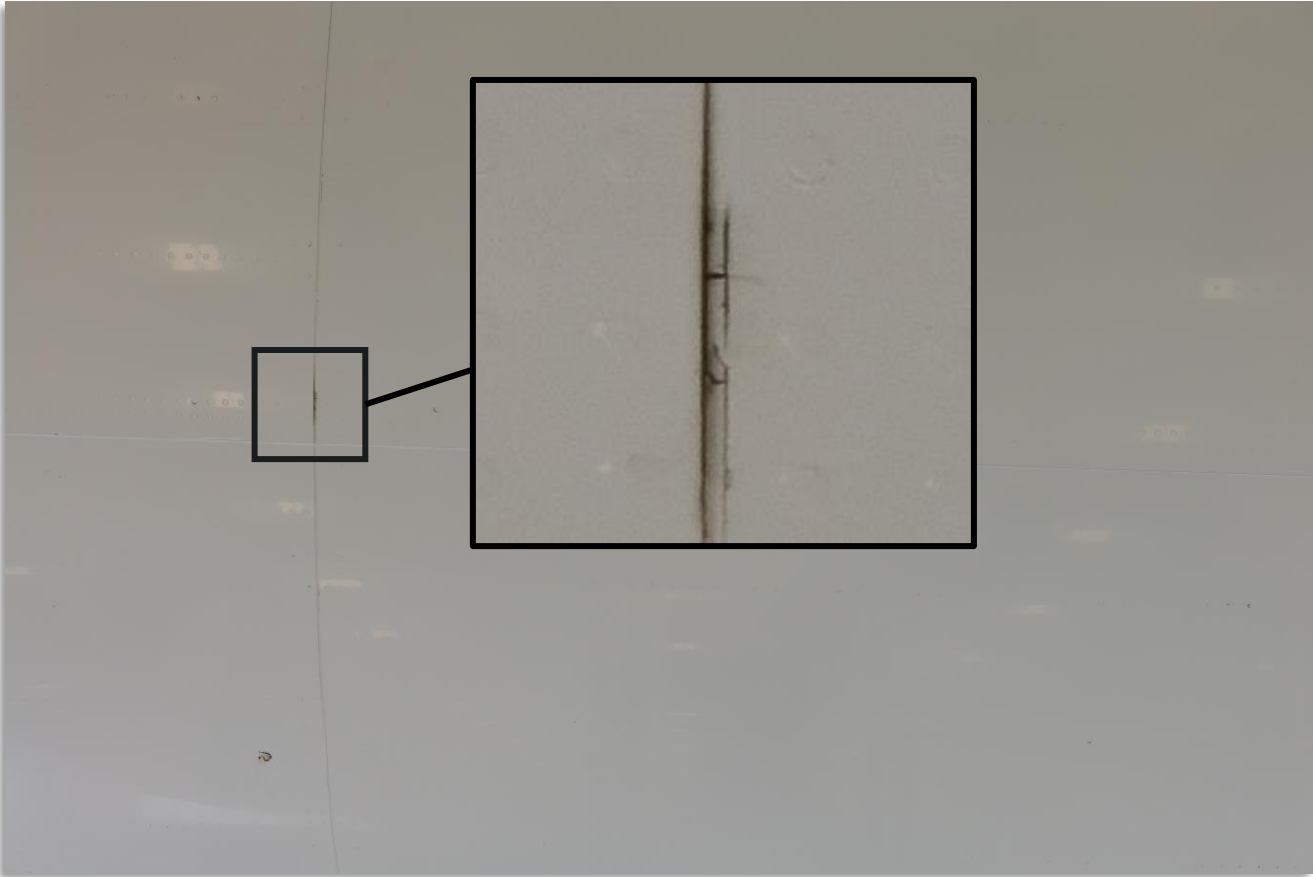
High Resolution Representation



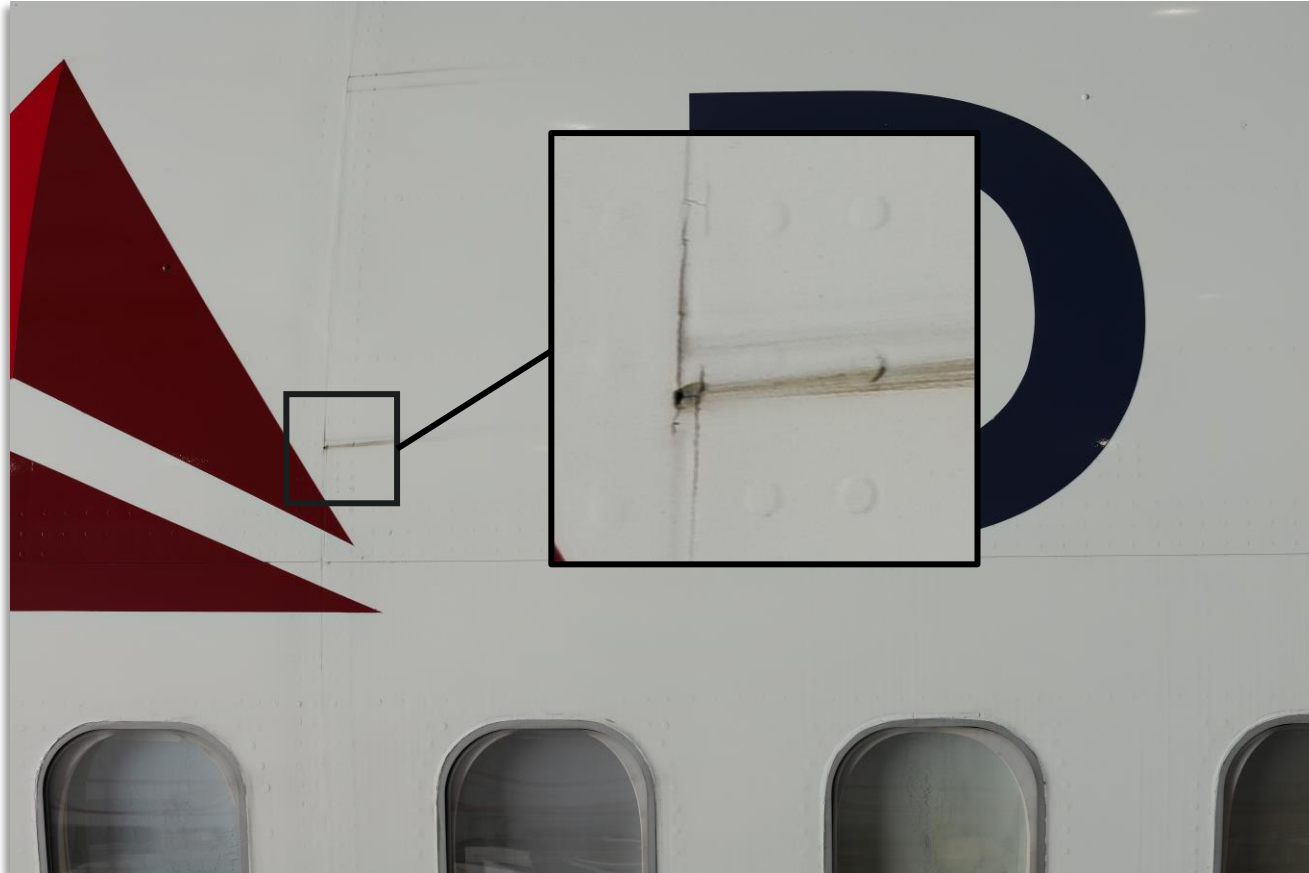
Low Resolution Representation



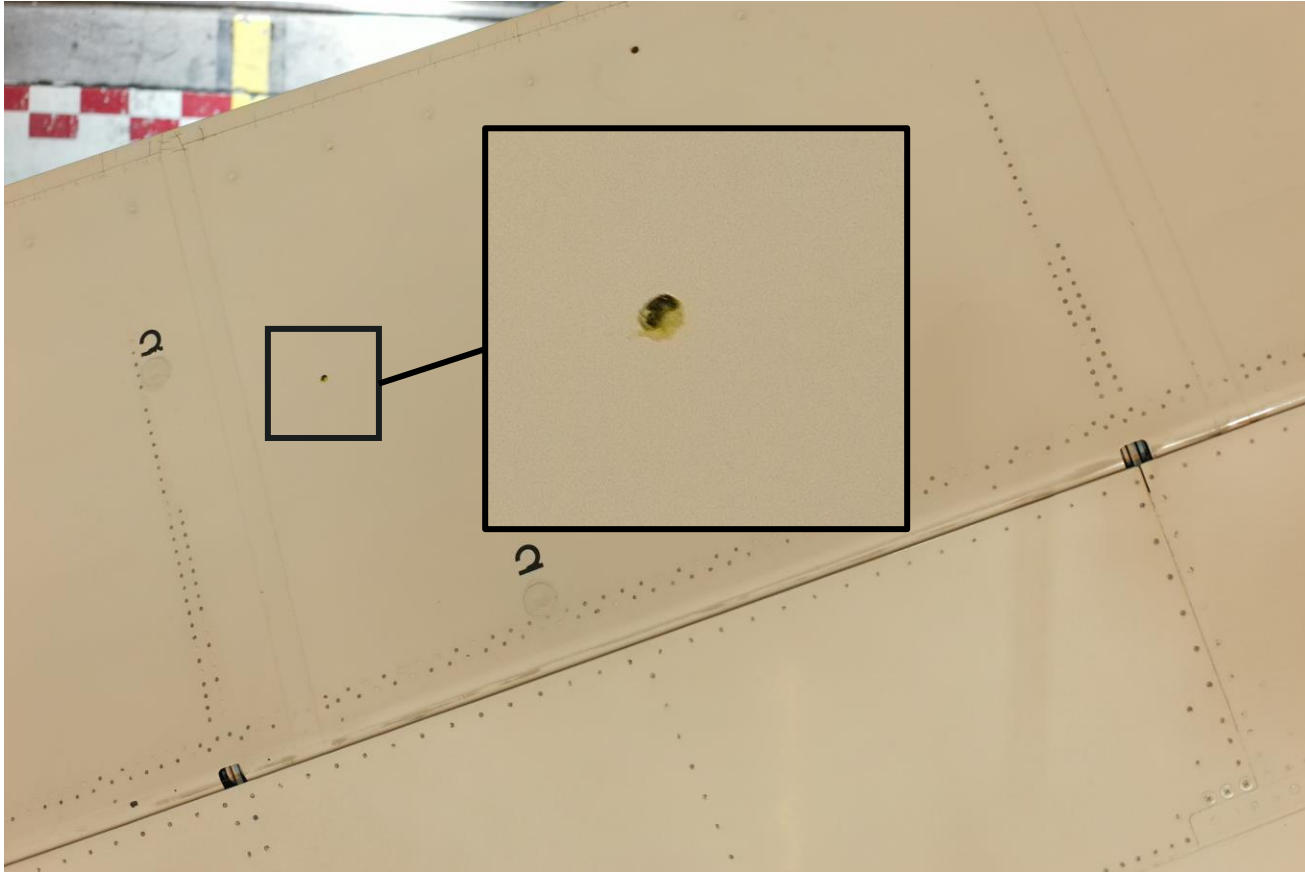
# Damage Findings - Crack



# Damage Findings - Lightning Strike

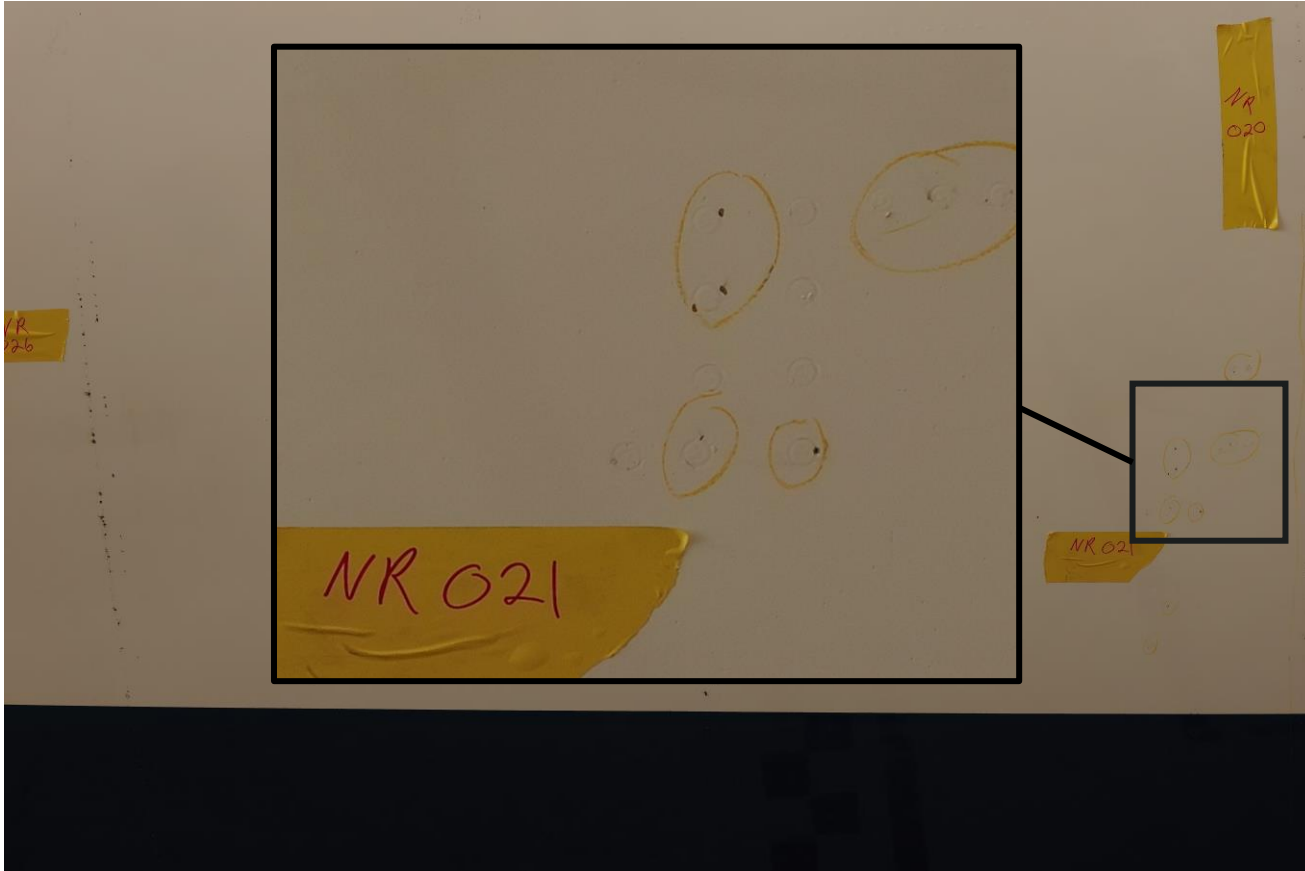


# Damage Findings - Lightning Strike

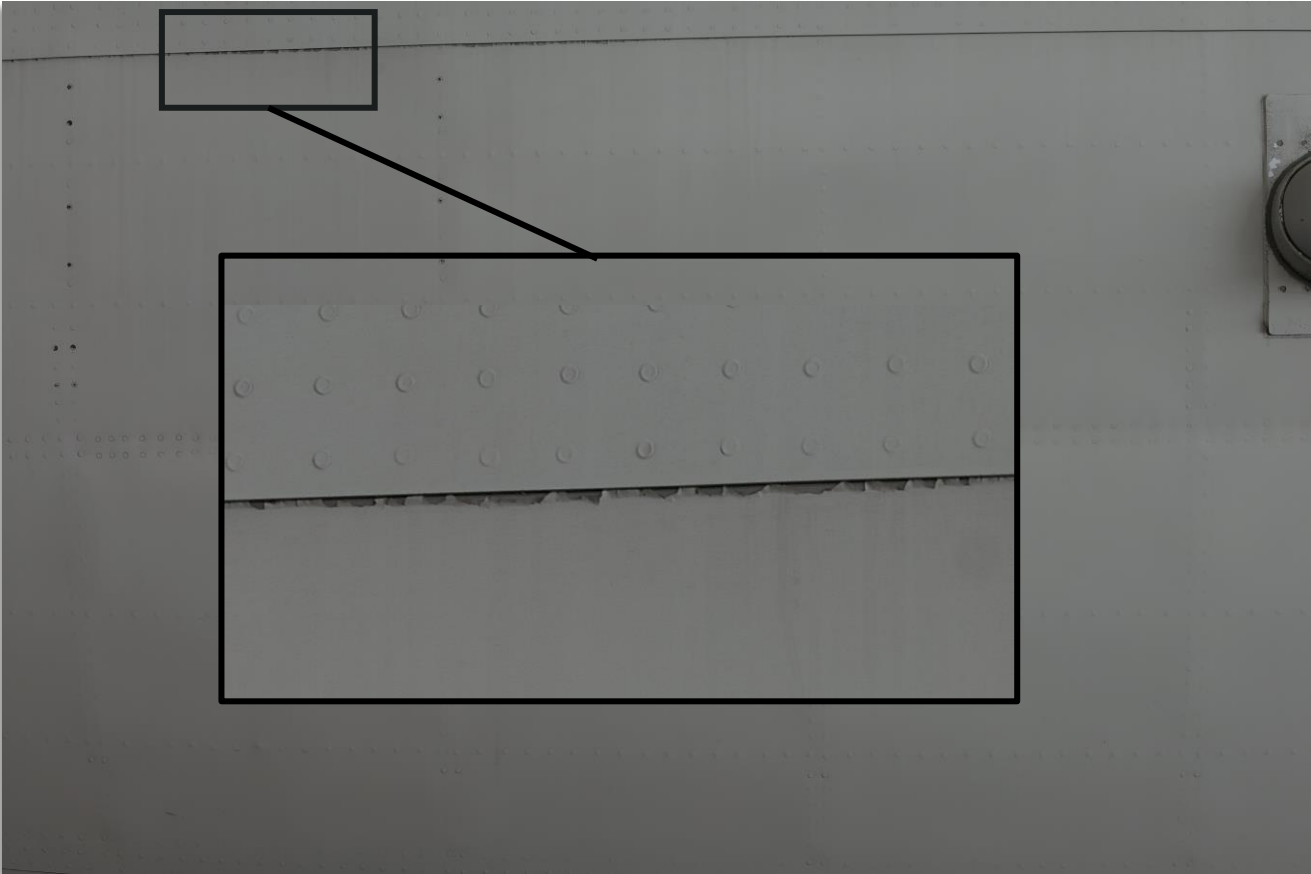




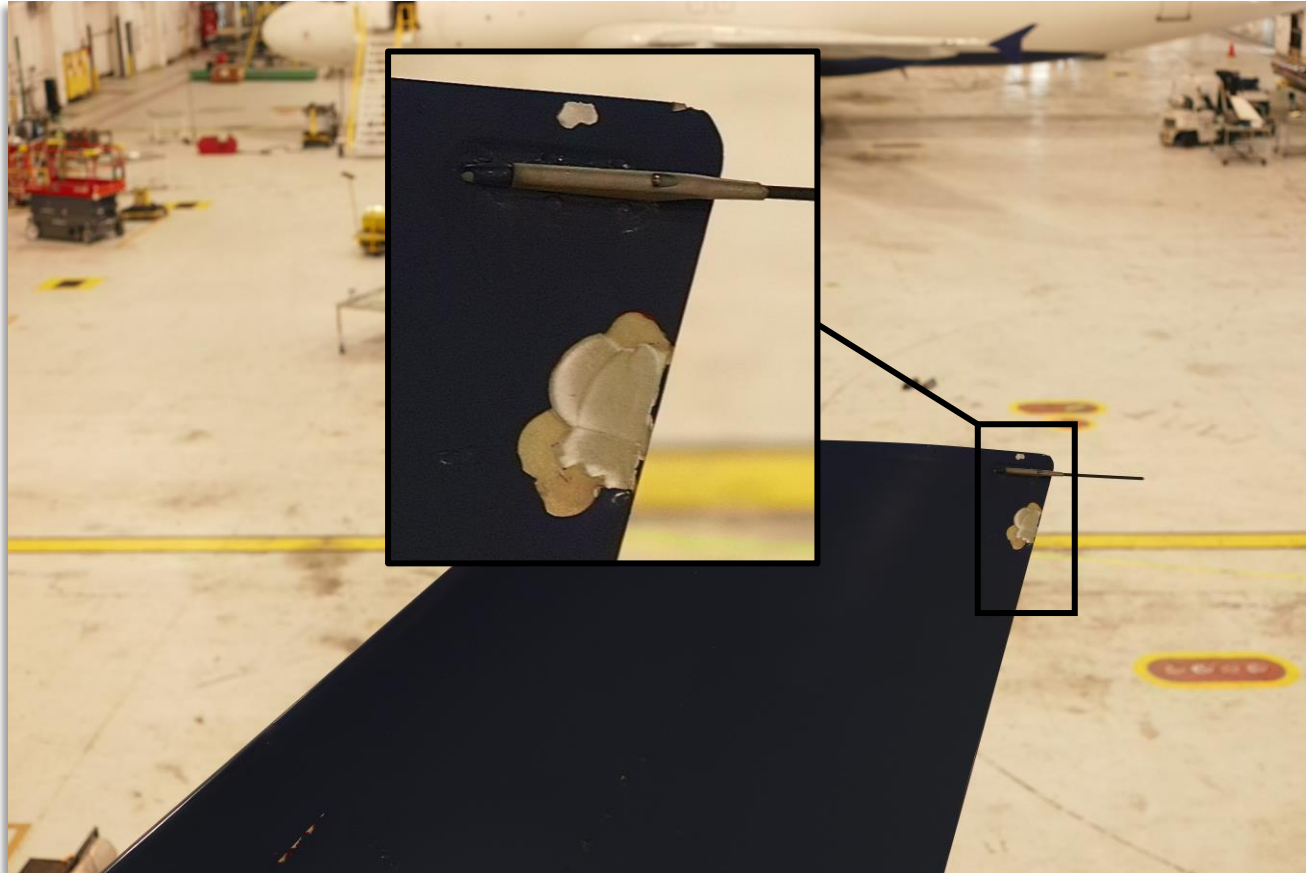
# Damage Findings - Lightning Strike



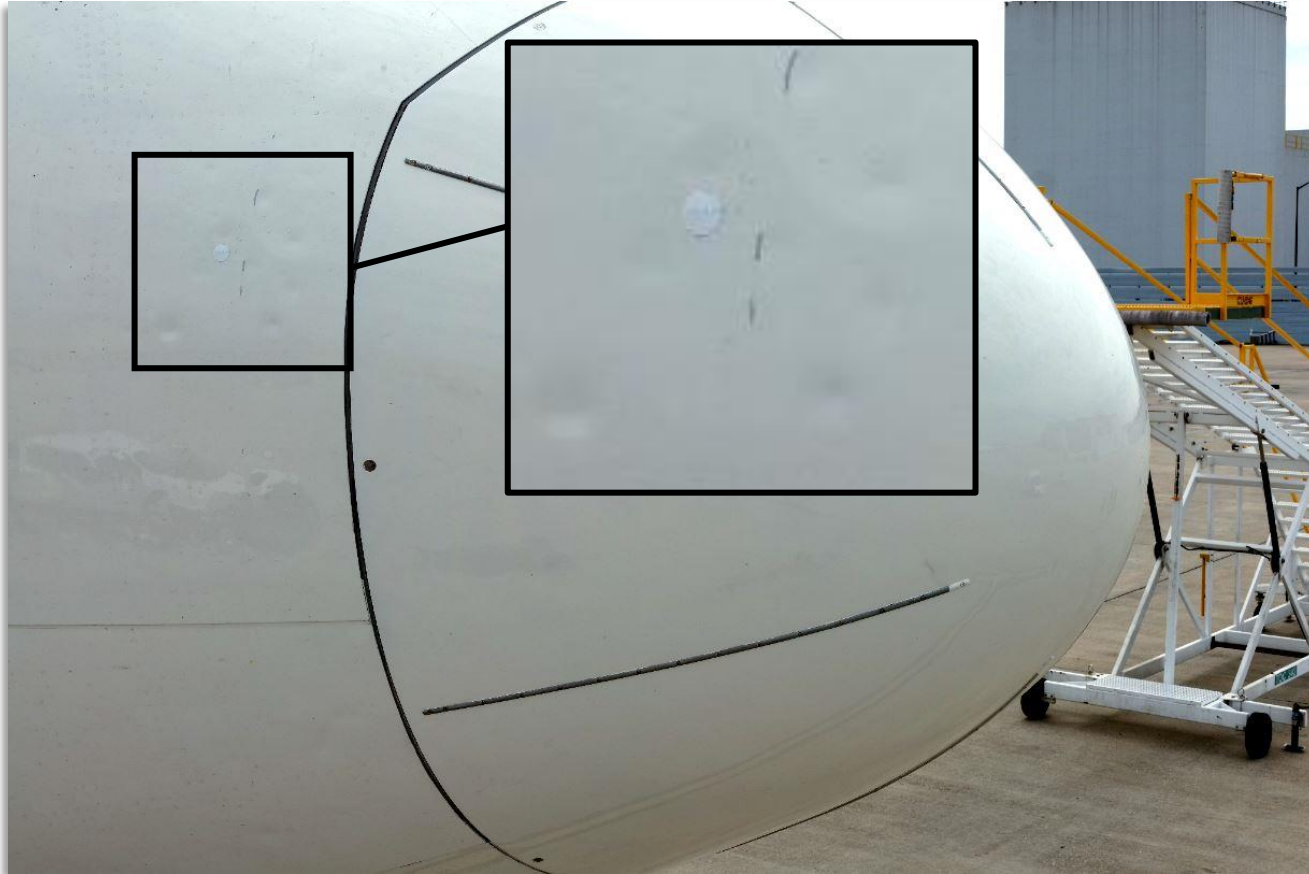
# Damage Findings - Sealant



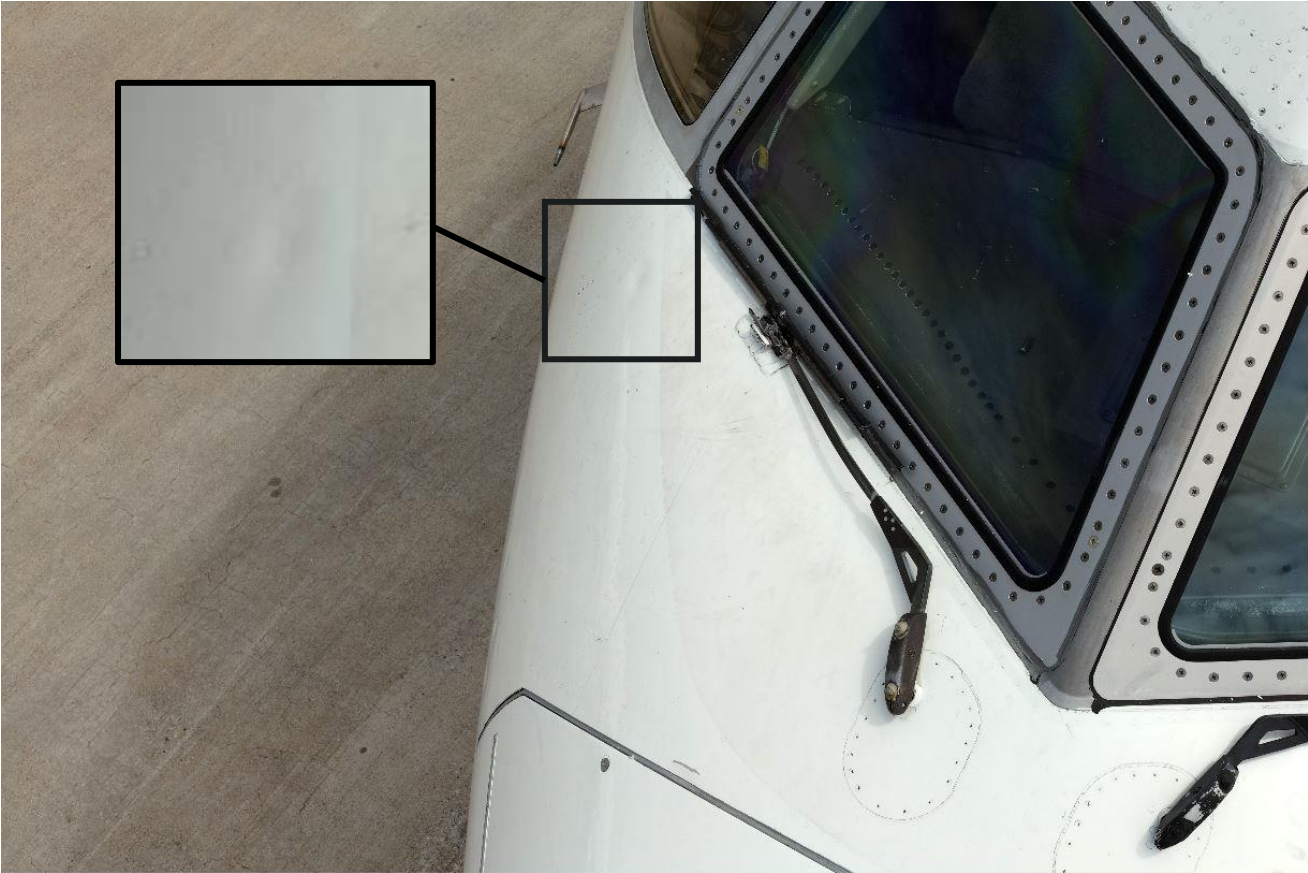
# Damage Findings – Exposed Surface



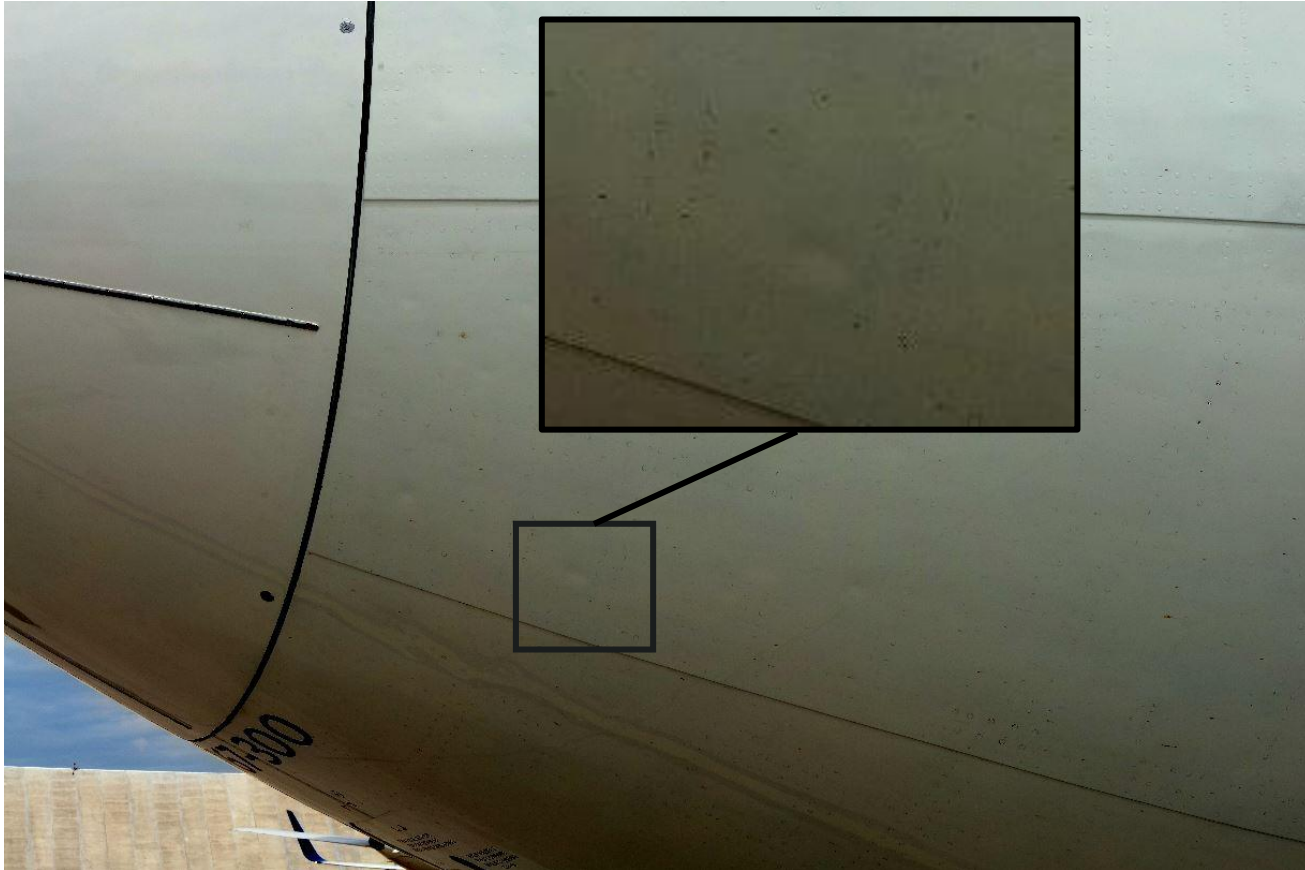
# Damage Findings - Dents



# Damage Findings - Dents



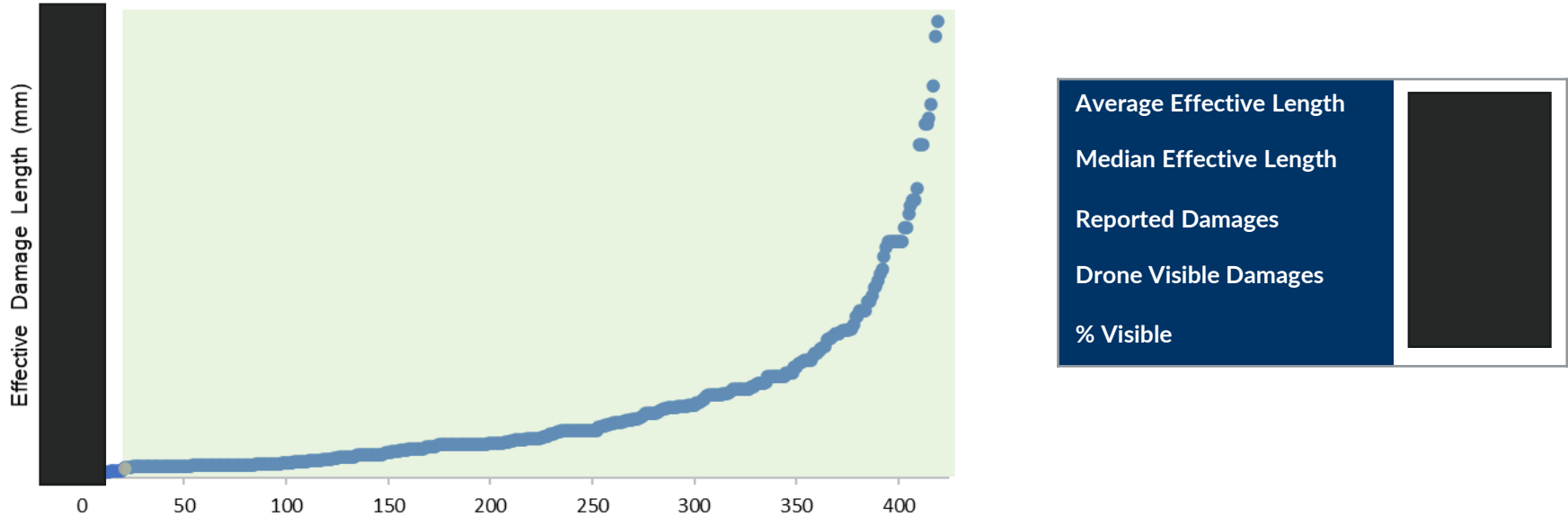
# Damage Findings - Dents





# Historical Damage Sizing

## Reported Lightning Strike Damage Size

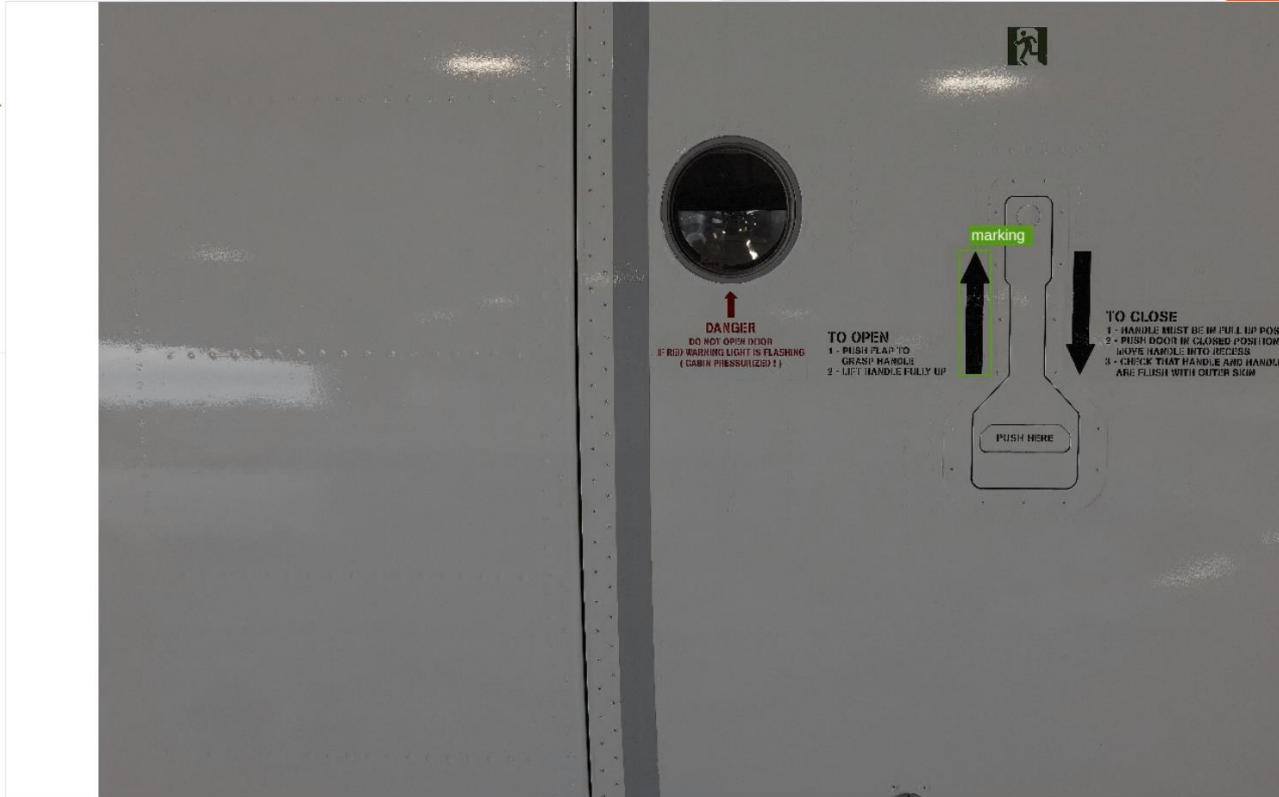


Results indicate drone assisted GVI technology has a [redacted] of lightning strike damage



# Photo Review

Image 16/40 Pending Reviewed Reset Compute 100% Filter by Next Reviewed and next



Floris Straver  
1/Sep/2023 8:27

Image center location  
RIB 64-65, STGR 21-22

Findings (27) +

- 22. Marking
- 23. Light source
- 24. Water drop
- 25. Rivet/screw rash
- 26. Text
- 27. Marking

Type:  
Marking

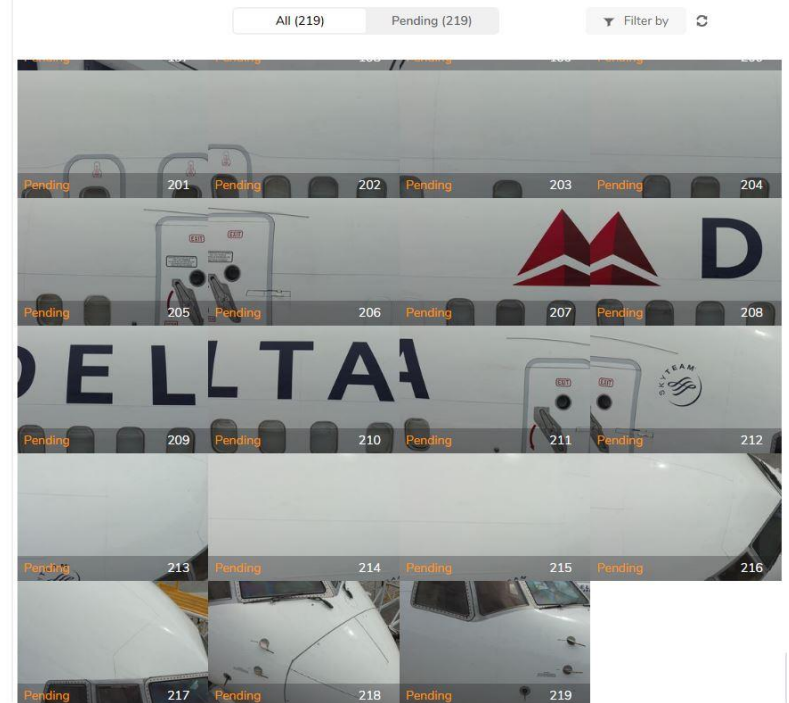
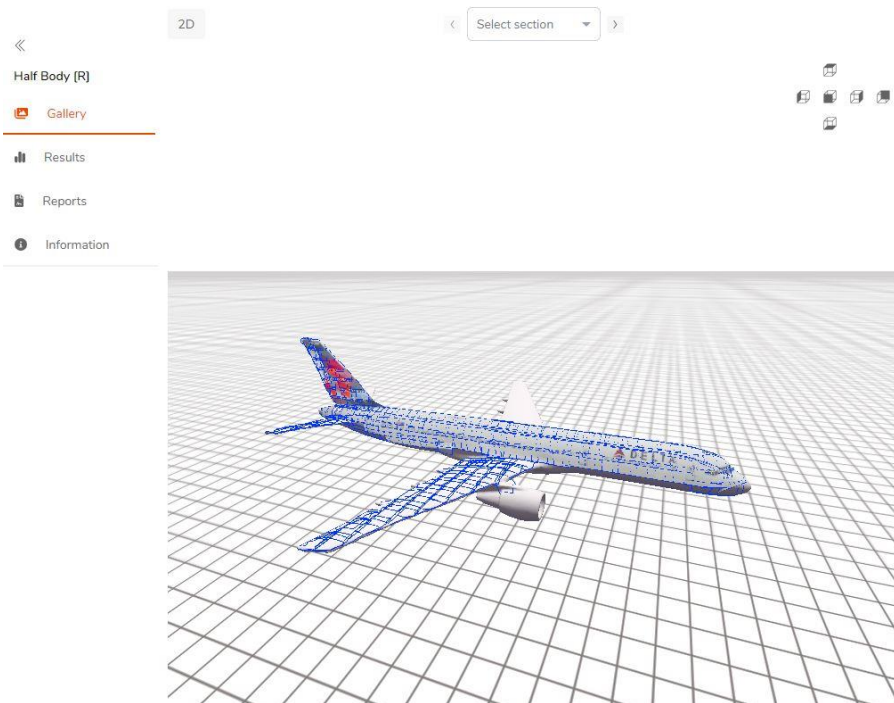
Depth:  
N/A

Width: Length:  
N/A N/A

Area:  
N/A

Location:  
N/A

# Photo Review



# Assisted Damage Detection

## Assisted Damage Detection Statistics



139 Inspections over 6 Months



Over 2.5K Total Inspection Photos

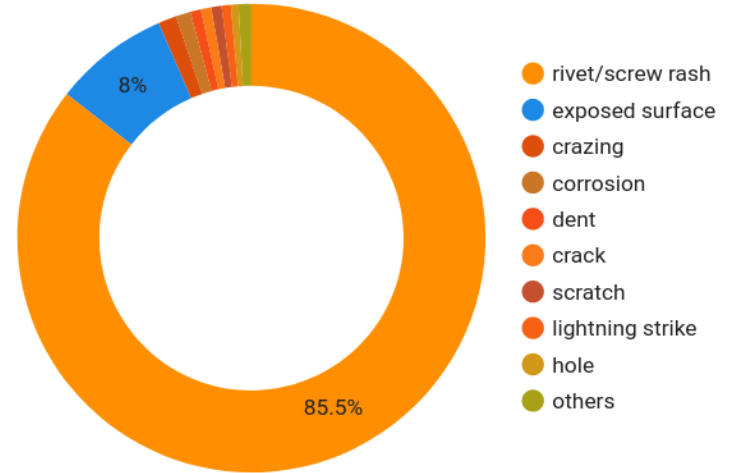


5:34 Average Inspection Duration



18.5 Average Photos Per Inspection

## Accepted Damage Finding Distribution



# Assisted Damage Detection

Image 16/40 Pending Reviewed Reset Compute 100% Filter by Next Reviewed and next

Annotations: light source, rivet/screw rash, water drop, marking, light source, light source, text, marking, rivet/screw rash, marking, text, sticker, text, text, text, text, TO OPEN, TO CLOSE, PUSH HERE, dirt, dirt, light source, light source.

Findings (25)

- 1. Rivet/screw rash
- 2. Light source
- 3. Text
  - Type: Text
  - Depth: N/A
  - Width: 5mm Length: 25.1mm
  - Area: 125.8mm<sup>2</sup>
  - Location: RIB 64-66, STGR 20-21
- 4. Rivet/screw rash
- 5. Marking
- 6. Light source





6714



ervices



# QUESTION & ANSWER