

# Dent Mapping Efficiencies at Delta

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The logo for the event, featuring the Delta TechOps logo on the left, followed by an ampersand, the word "dent" in grey, a stylized checkmark icon with three wavy lines (green, blue, red) above it, and the word "CHECK" in grey.

## *What the hail happened?*

Scott Rainwater, David Piotrowski (Delta)  
Howard Chung, Arun Chhabra (8tree)

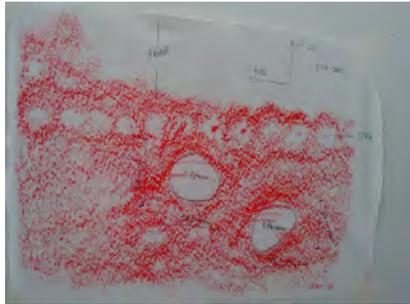


# OUTLINE

- **Dent mapping problem**
  - SRM flowchart
  - Dent dimensions
  - Location
- **OEM coordination**
- **A319 Hail event use case**
- **Efficiencies gained/ Benefits**



# Dent Mapping Problem



Subjective  
Inconsistent

Coarse

Inefficient

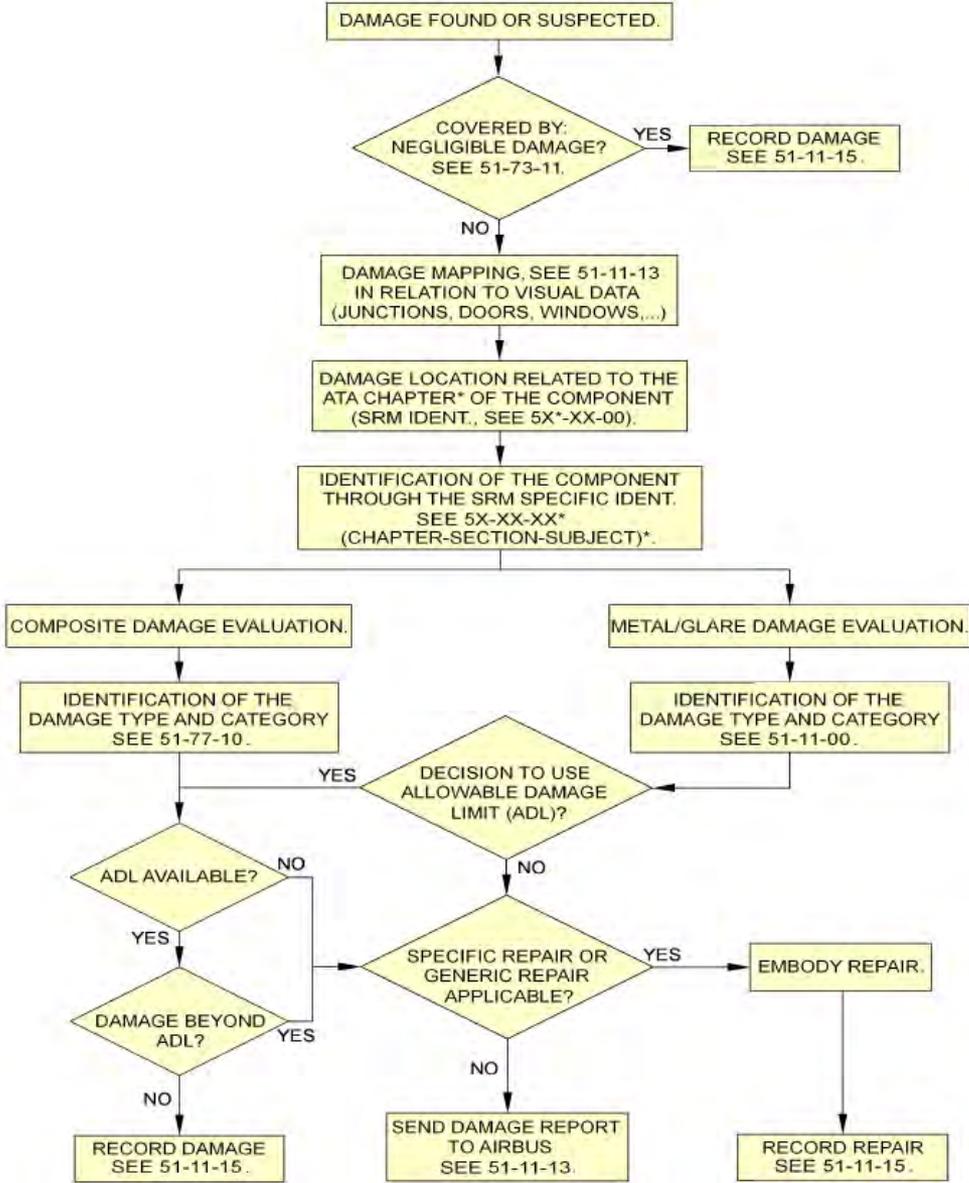
Time-Consuming

Dents cost the airline industry \$ 2.8b / year \*

\* Labor expense and Lost revenue due to Line Maintenance, Heavy Checks & Hail events.

Source: Air Transport Action Group 2014 study; A4A 2016 Carrier Delay Costs study; 8tree analysis

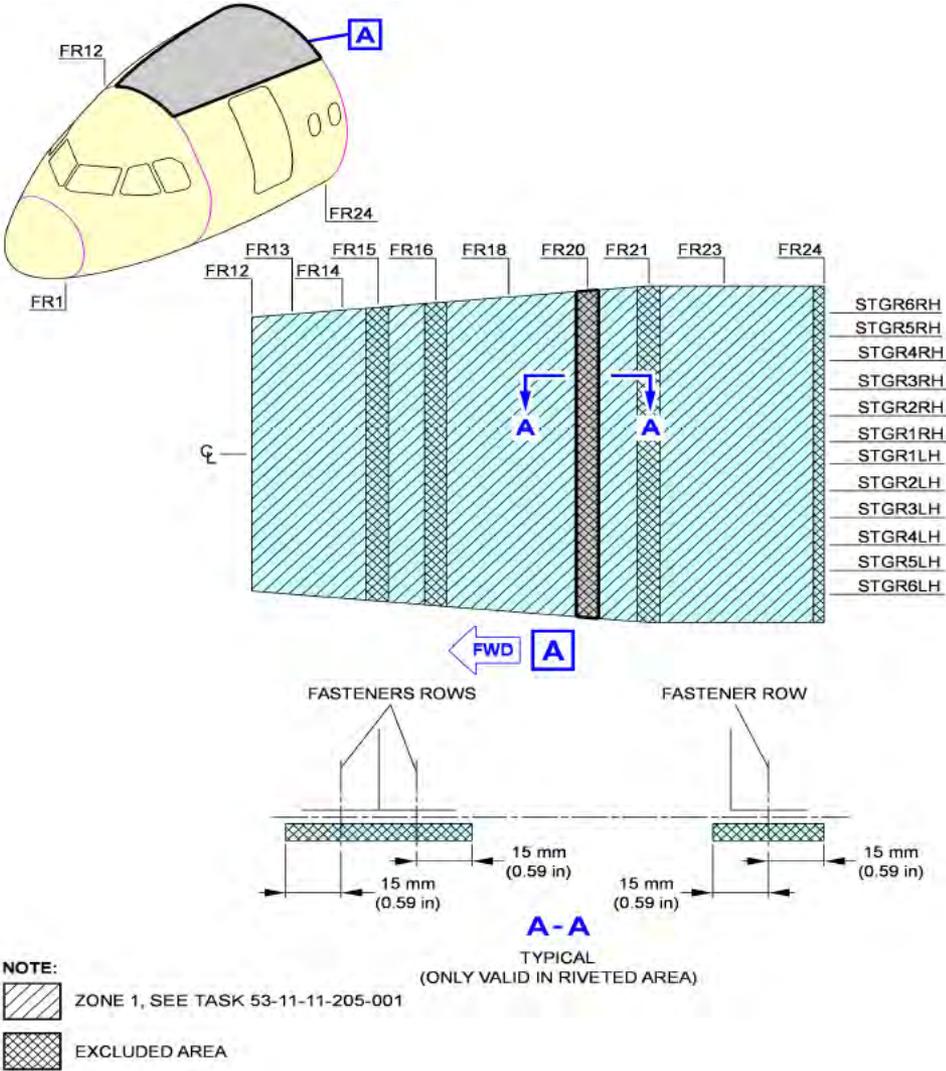
# Dent Details Required



# Dent Details Required - Location

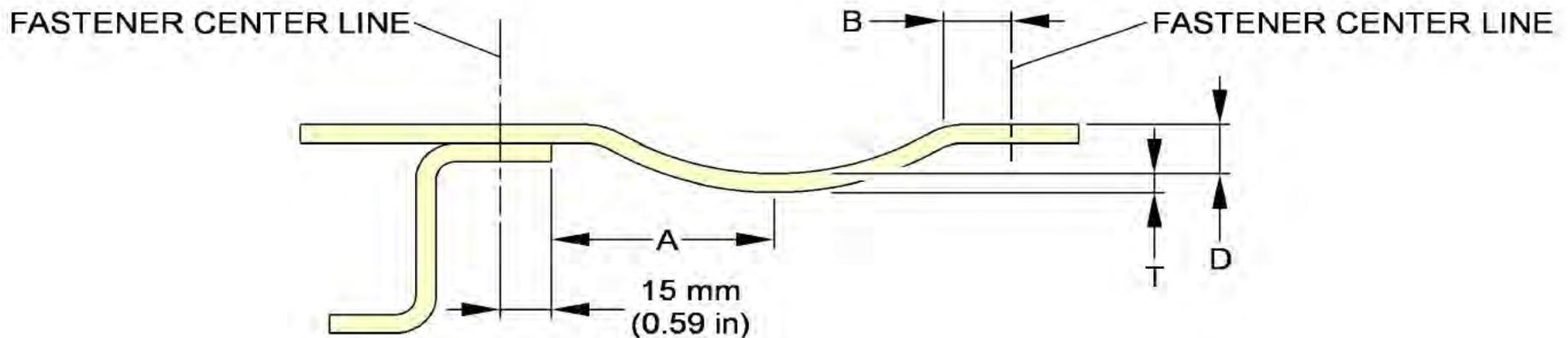
(1) The following dent evaluation criteria are applicable for all AIRBUS aircraft external aluminum alloy structures including GLARE except for the:

- wing primary structure,
- slats,
- spoilers,
- A320 wing leading edge skins between track 5 and 6 and between track 7 and 8 inter rib,
- static ports, pitot probes, total air temperature probes and angle of attack sensors and areas within 150 mm (5.91 in.) around these sensors,
- nacelle inlet cowl-lip skins.



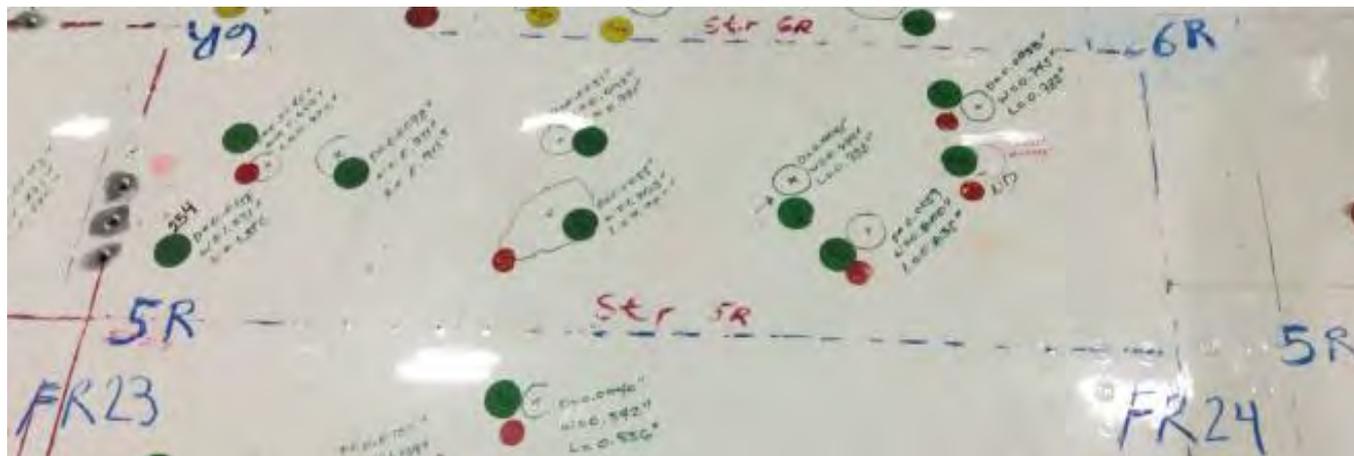
# Dent Details Required - Parameters

- (1) Maximum depth  $D$  does not exceed 0.1 mm (0.004 in.):  $D < 0.1 \text{ mm (0.004 in.)}$ . The following requirements shall be fulfilled:
- skin thickness is below or equal to 4 mm (0.16 in.),
  - the contour of the dent is smooth,
  - ratio  $A/D$  is equal to or greater than 25 (minimum size of dent),
  - the skin is free of cracks, confirmed by detailed visual inspection,
  - No debonding of bonded stringers,
  - no abrasion of unclad skin,

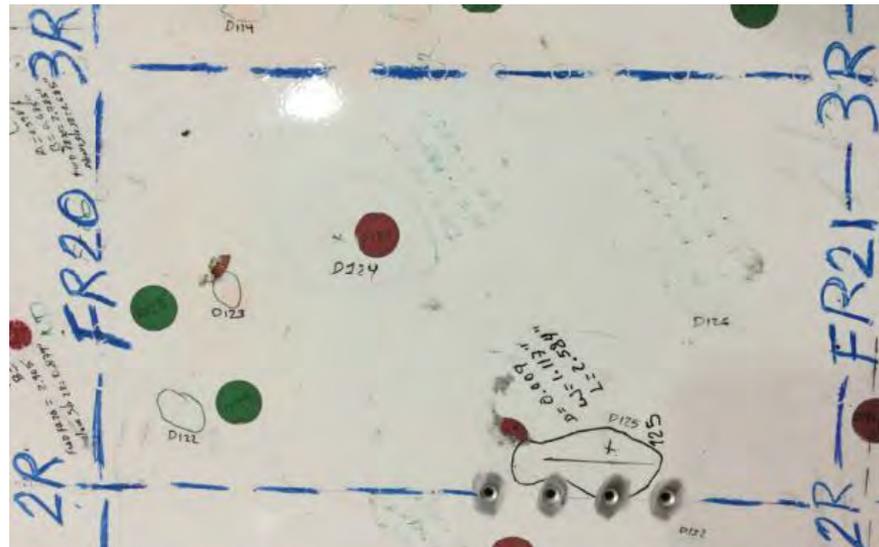
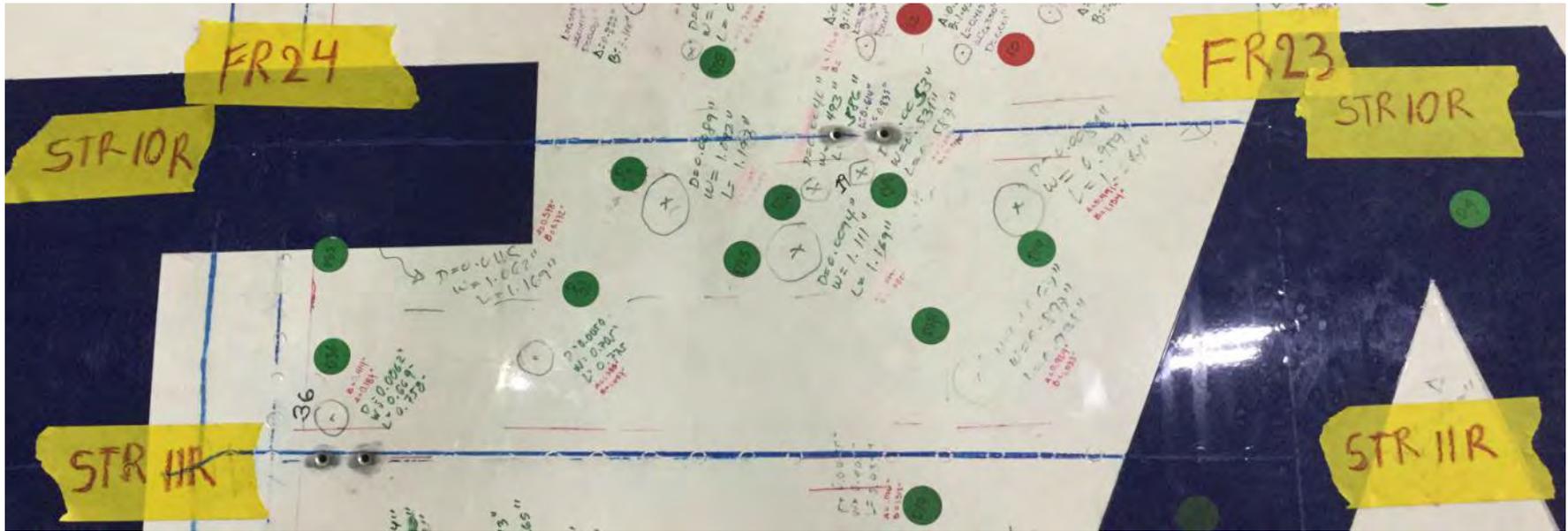


# What the hail happened?

1. Delta A319 was in line for take off in OMA when it encountered an extreme hail event.
2. Initial inspection revealed severe damage to fuselage, with over 1000 dents noted.
3. Secondary structure, along with replaceable structure, sustained severe damage.
4. Aircraft required significant effort even for a ferry flight to a nearby mtc base for work.
5. Aircraft out of service for 60 days due to hail event. Data collection and reiterations, remeasurement were the majority of this time.



# Delta's case study (Before dentCHECK)



# Manual measurements & recording

➤ ➤ ➤ Preliminary Repair Instructions <<<  
Fuselage Skin - Panel 4C - FR12/FR24 & LH RH upper STGR

| DENT | PROXIMITY TO FRAME (in)<br>Note: CIRCLE ONE OF "FWD" OR "AFT" FOR EACH DENT |    |     |    | PROXIMITY TO STRINGER (in)<br>Note: CIRCLE ONE OF "ABOVE" OR "BELOW" FOR EACH DENT |        |    |       | DEPTH | L  | W      | A for (ADL) | B      | DS 10%A<br>Ok? | A (Negligible) | A/D (Negligible) |        |
|------|---|----|-----|----|--|--------|----|-------|-------|----|--------|-------------|--------|----------------|----------------|------------------|--------|
|      | FWD/AFT   |    |     |    | Above/Below  |        |    |       |       |    |        |             |        |                |                |                  |        |
| D94  | 4.913"  | in | FWD | FR | 20   | 1.884" | in | Below | STGR  | 1L | 0.003" | 0.963"      | 0.513" |                | 2.502"         | OK               | 0.290" |
| D95  | 5.408"  | in | AFT | FR | 1F   | 1.128" | in | Above | STGR  | 3L | 0.002" | 0.736"      | 0.651" |                | 1.784"         | OK               | 0.324" |
| D96  | 4.448"  | in | FWD | FR | 20   | 1.263" | in | Below | STGR  | 2L | 0.005" | 0.596"      | 0.567" | 1.563"         | 1.848"         | OK               |        |
| D97  | 4.988"  | in | AFT | FR | 1F   | 1.106" | in | Above | STGR  | 4L | 0.003" | 0.790"      | 0.642" |                | 1.704"         | OK               | 0.415" |
| D98  | 8.391"  | in | FWD | FR | 20   | 0.274" | in | Below | STGR  | 3L | 0.004" | 0.764"      | 0.532" |                | 0.861"         | OK               | 0.251" |
| D99  | 4.439"  | in | FWD | FR | 20   | 2.065" | in | Above | STGR  | 4L | 0.003" | 0.723"      | 0.525" |                | 2.692"         | OK               | 0.297" |
| D100 | 2.933"  | in | FWD | FR | 20   | 1.237" | in | Above | STGR  | 5L | 0.002" | 0.924"      | 0.549" |                | 2.517"         | OK               | 0.412" |
| D101 | 3.236"  | in | FWD | FR | 21   | 0.730" | in | Below | STGR  | 2R | 0.007" | 0.928"      | 0.866" | 1.199"         | 1.360"         | OK               |        |
| D102 | 0.518"  | in | FWD | FR | 21   | 0.418" | in | Above | STGR  | 6R | 0.007" | 0.932"      | 0.923" | 0.863"         | 1.131"         | OK               |        |
| D103 | 2.376"  | in | AFT | FR | 20   | 0.429" | in | Above | STGR  | 5R | 0.003" | 0.730"      | 0.666" |                | 1.078"         | OK               | 0.916" |
| D104 | 4.149"  | in | AFT | FR | 20   | 2.122" | in | Above | STGR  | 5R | 0.007" | 0.943"      | 0.893" | 2.241"         | 2.753"         | OK               |        |
| D105 | 1.484"  | in | FWD | FR | 21   | 2.001" | in | Above | STGR  | 5R | 0.006" | 1.844"      | 1.513" | 2.082"         | 2.082"         | OK               |        |
| D106 | 4.077"  | in | AFT | FR | 20   | 0.588" | in | Above | STGR  | 6R | 0.003" | 0.790"      | 0.086" |                | 1.158"         | OK               | 0.372" |
| D107 | 2.242"  | in | FWD | FR | 21   | 0.808" | in | Below | STGR  | 5R | 0.005" | 0.584"      | 0.524" | 1.119"         | 1.453"         | OK               |        |
| D108 | 3.435"  | in | AFT | FR | 20   | 0.078" | in | Below | STGR  | 5R | 0.002" | 0.721"      | 0.529" |                | 1.168"         | OK               | 0.372" |
| D109 | 3.856"  | in | AFT | FR | 20   | 2.375" | in | Above | STGR  | 5R | 0.005" | 0.681"      | 0.624" | 2.665"         | 2.925"         | OK               |        |
| D110 | 2.325"  | in | FWD | FR | 21   | 0.226" | in | Below | STGR  | 4R | 0.007" | 1.310"      | 1.202" | 0.751"         | 0.816"         | OK               |        |
| D111 | 2.467"  | in | FWD | FR | 21   | 2.467" | in | Below | STGR  | 5R | 0.003" | 0.861"      | 0.659" |                | 3.007"         | OK               | 0.451" |
| D112 | 0.844"  | in | FWD | FR | 21   | 0.534" | in | Above | STGR  | 5R | 0.008" | 2.425"      | 1.453" | 1.379"         | 1.434"         | OK               |        |
| D113 | 1.071"  | in | AFT | FR | 20   | 0.613" | in | Above | STGR  | 4R | 0.005" | 0.709"      | 0.428" | 0.871"         | 1.471"         | OK               |        |
| D114 | 1.359"  | in | AFT | FR | 20   | 0.115" | in | Below | STGR  | 3R | 0.003" | 0.678"      | 0.432" |                | 0.705"         | OK               | 0.351" |
| D115 | 1.501"  | in | AFT | FR | 20   | 0.124" | in | Above | STGR  | 4R | 0.005" | 0.574"      | 0.324" | 0.445"         | 0.714"         | OK               |        |
| D116 | 2.245"  | in | AFT | FR | 20   | 2.327" | in | Above | STGR  | 4R | 0.002" | 0.723"      | 0.562" |                | 2.835"         | OK               | 0.377" |

Note: These instructions are considered preliminary only. Specific authorization via an E/A must be provided prior to final sign-off of the repair and release of the aircraft for service. Contact Engineering to determine the status of the E/A distribution.

Line Maintenance / Delta North

The PRI can not be stored and maintained with the log sheets or non routine cards. Therefore, all required signoffs for individual steps completed per the PRI must be made directly in the logbook or on the non routine cards. The PRI will not be part of the permanent record, and the copy may be discarded upon receipt of the E/A and completion of the final signoff.

# Delta's case study (Before dentCHECK)<sup>DELTA</sup> TechOps

## 1. Delta's typical experience with dent mapping and reporting before dentCHECK

- A dent would be reported "out of limits". Typically, a very minimum amount of information would be submitted (such as depth and a width). Submittal information varies by individual AMT and experience level.
- Liaison Engineering would then typically have to request additional information, with pictures (adjacent structure), and a rubbing of the area to help identify adjacent fasteners and from which we can get measurements. Dimensional information is manually written on the rubbing.
- Inaccurate measurements would require an additional iteration to get the required information. More back and forth.
- Large areas of primary structure add complexity and time to the data gathering stage for engineering review.



# Current tools clunky, inefficient



# Delta's search for a better methodology

- Several scanner technologies were initially evaluated, both optical and laser scanner systems.
- 8tree's dentCHECK™ was selected from overall impact to the mtc operation and reduction in total touch time.
- AMT's could quickly use the system, providing information quickly, simply, and consistently.
- Anything outside of published SRM limitations could be submitted quickly and efficient to Liaison engineering for additional evaluation.
- Customized reports can be generated from the AMT scan data by Liaison engineering.
- The 'back and forth' information gathering can be eliminated with this system.
- Service letter publication from Boeing – joint effort between Delta/8tree to gain acceptance from Boeing
  - Other airlines enlisted for support



BCS  
Customer  
Support

## SERVICE LETTER

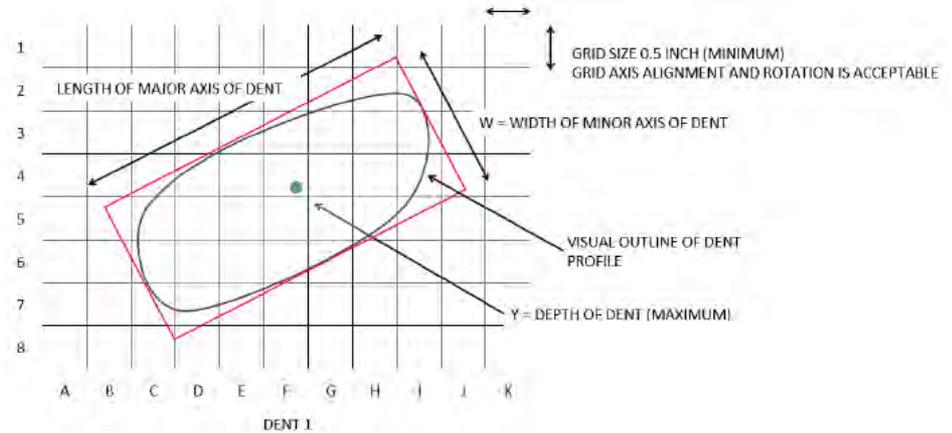
|               |                |                 |
|---------------|----------------|-----------------|
| 707-SL-51-033 | 757-SL-51-026  | DC-9-SL-51-114  |
| 717-SL-51-113 | 767-SL-51-041  | DC-10-SL-51-113 |
| 727-SL-51-045 | 777-SL-51-022  | MD-10-SL-51-112 |
| 737-SL-51-053 | 787-SL-51-006  | MD-11-SL-51-113 |
| 747-SL-51-056 | DC-8-SL-51-112 | MD-80-SL-51-114 |
|               |                | MD-90-SL-51-114 |

ATA: 5100-00  
25 June 2018

**SUBJECT:** 3D SCANNER SYSTEMS – REQUIREMENTS FOR RECORDING PHYSICAL ATTRIBUTES OF DENTS AND BLENDS

**MODEL:** 707, 717, 727, 737, 747, 757, 767, 777, 787, DC-8, DC-9, DC-10, MD-10, MD-11, MD-80, and MD-90 Series

**APPLICABILITY:** All Airplanes



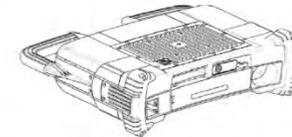
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Contact: [TechRequest.on.Airbus@airbus.com](mailto:TechRequest.on.Airbus@airbus.com)  
web site: [www.airbus.com](http://www.airbus.com)

Tool / Equipment Bulletin No: 320-A3497 TEB Issue No: 2

### RECOMMENDED MODIFICATION

**EFFECTIVITY:** A320 ALL  
**PART NUMBER:** dentCHECK 8TR-DC-002  
**DESIGNATION:** 3D SCANNER  
**DESCRIPTION:** This tool is used to assess dent damage on metallic parts and cabin floor composite panels.  
**TOOL STATUS:** N/A  
**NOTE:** Supplier Cage Code: 7E2T2



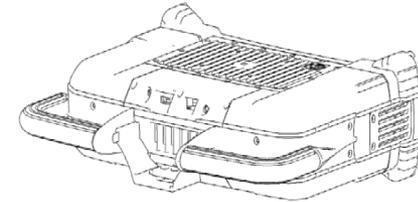
**REASON FOR CHANGE:**  
dentCHECK is now validated to assess dent on cabin floor composite panels

# How it works

- Point & click (1-button operation)
- Instant results



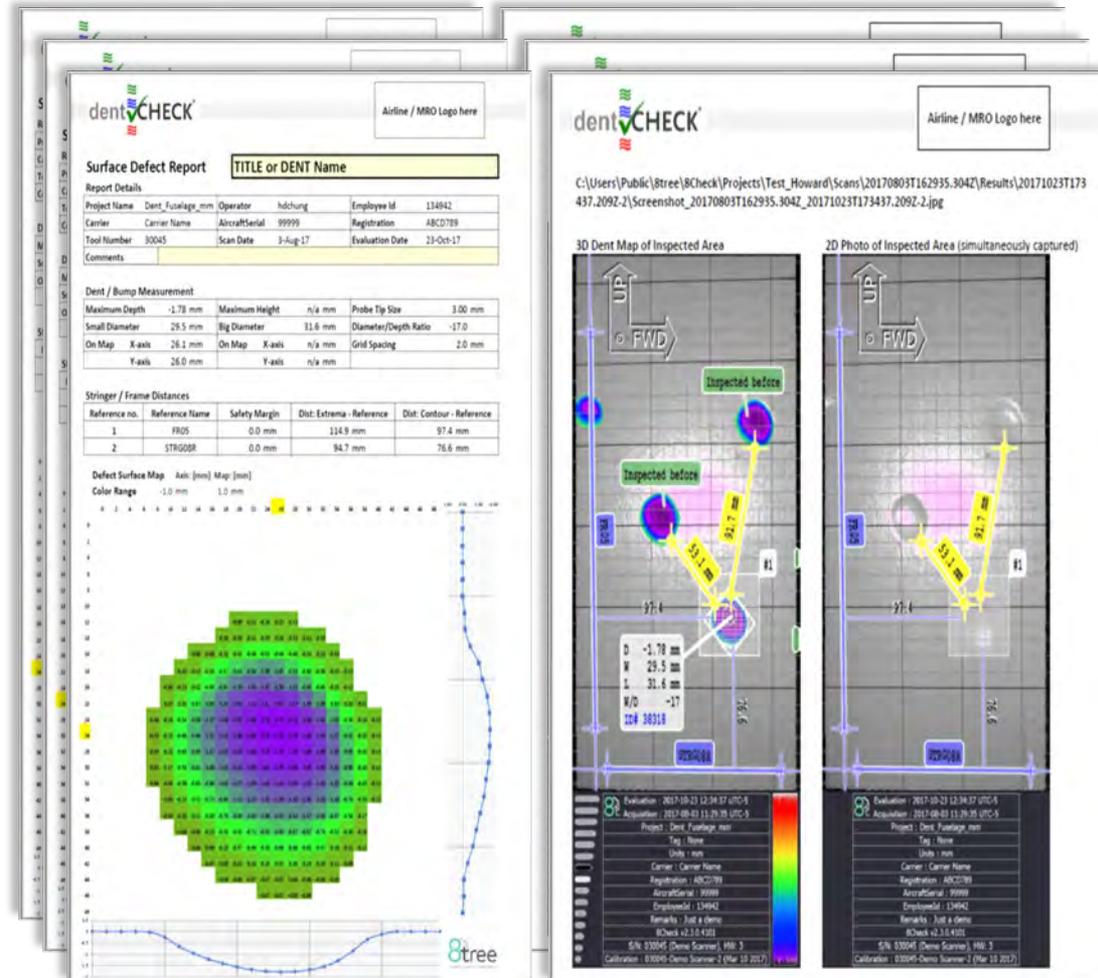
 DELTA  
TechOps  
dent ✓ CHECK



*Image source: Delta Tech Ops*

# How it works – Reporting dents

1. Engineering team PCs loaded with Dent Reporting Tool (DRT) software to receive incoming dent-maps
2. Using DRT = Detailed reports in < 5min
  - Vertical/horizontal cross-sections
  - Flexible grid sizes
  - Coordinate symbols
  - Distances to neighboring dents
  - Distance to adjacent frames/stringers
  - 3D and 2D photos for surrounding context
  - Dent severity profile information



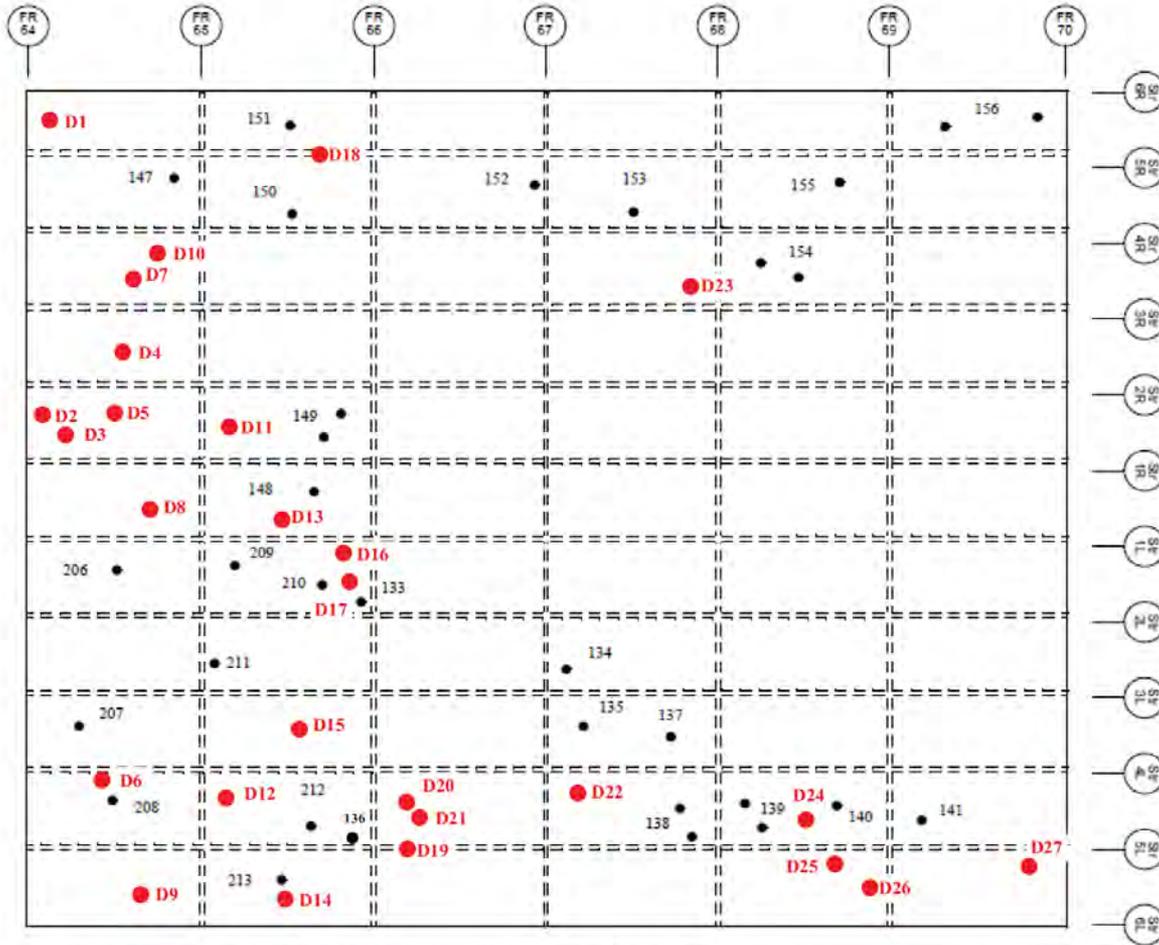
# Delta's case study (After dentCHECK)

1. At Heavy check, the aircraft had repetitive inspections from the event (approximately 6 years from incident).
2. The dentCHECK™ system was utilized to improve the process of measuring each dent.
3. Total scan time of fuselage primary structure was approximately 10 days (as opposed to the original 60 days using the standard method), resulting in approximately 1800 dents being scanned, measured, and evaluated.
4. Additional dent locations found that were not included in the initial inspections.
5. These measurements were used by the OEM for continued evaluation of the area.
6. To measure one dent with the tool it took less than 1 minute. Without the tool, just using caliper and depth gauge, it took approximately 4 minutes per dent.

**Reduced Mapping time by 75%**

**Reduced reporting time by 90%**

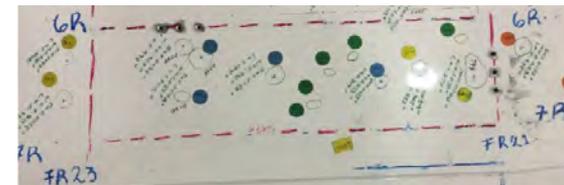
# Delta's case study (After dentCHECK) TechOps



Fuselage Skin Panel D53480011204, View Looking Down,

● NEW DENTS

● OLD DENTS PER RDAS 70552107/177/2012



# Additional benefits

1. More concise info; Less subjectivity
2. Visual with measurements
3. Digital; Wireless transfer to Engineering
4. Enables integration with other systems

## Delta Future:

1. Tracking system
2. Engineering/OEM coordination
3. 3D Visual representation
4. Less risk to operation –  
future delays (Line Mtc)
  - Augmented reality



# Summary

- Massive time savings
- Easy to operate
- Archiving
- Enables Digital integration
- Worked with OEMs for coordination/approvals