Dent Mapping Efficiencies at Delta

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DELTA TechOps & dentCHECK

What the hail happened?

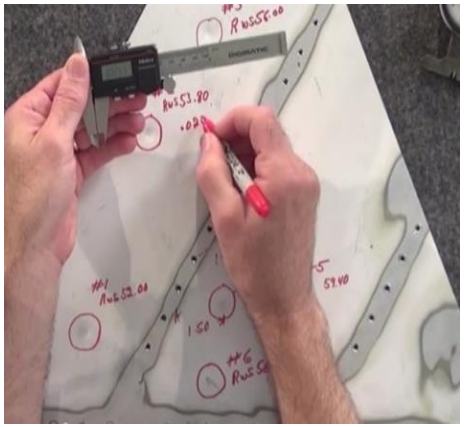
Scott Rainwater, David Piotrowski (Delta)
Howard Chung, Arun Chhabra (8tree)

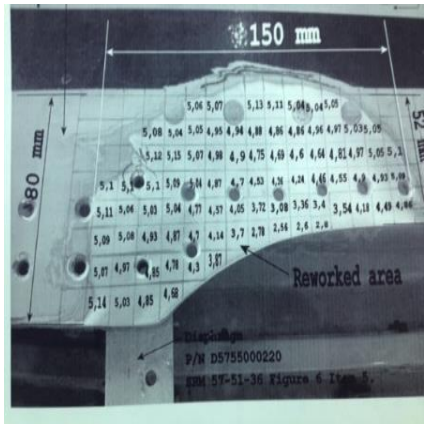
NDT NONDESTRUCTIVE TESTING FORUM

OUTLINE

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

Dent Mapping Problem



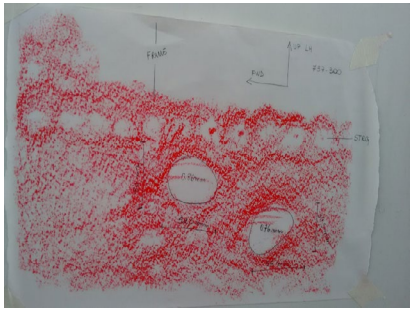


Subjective
Inconsistent

Coarse

Inefficient

Time-Consuming

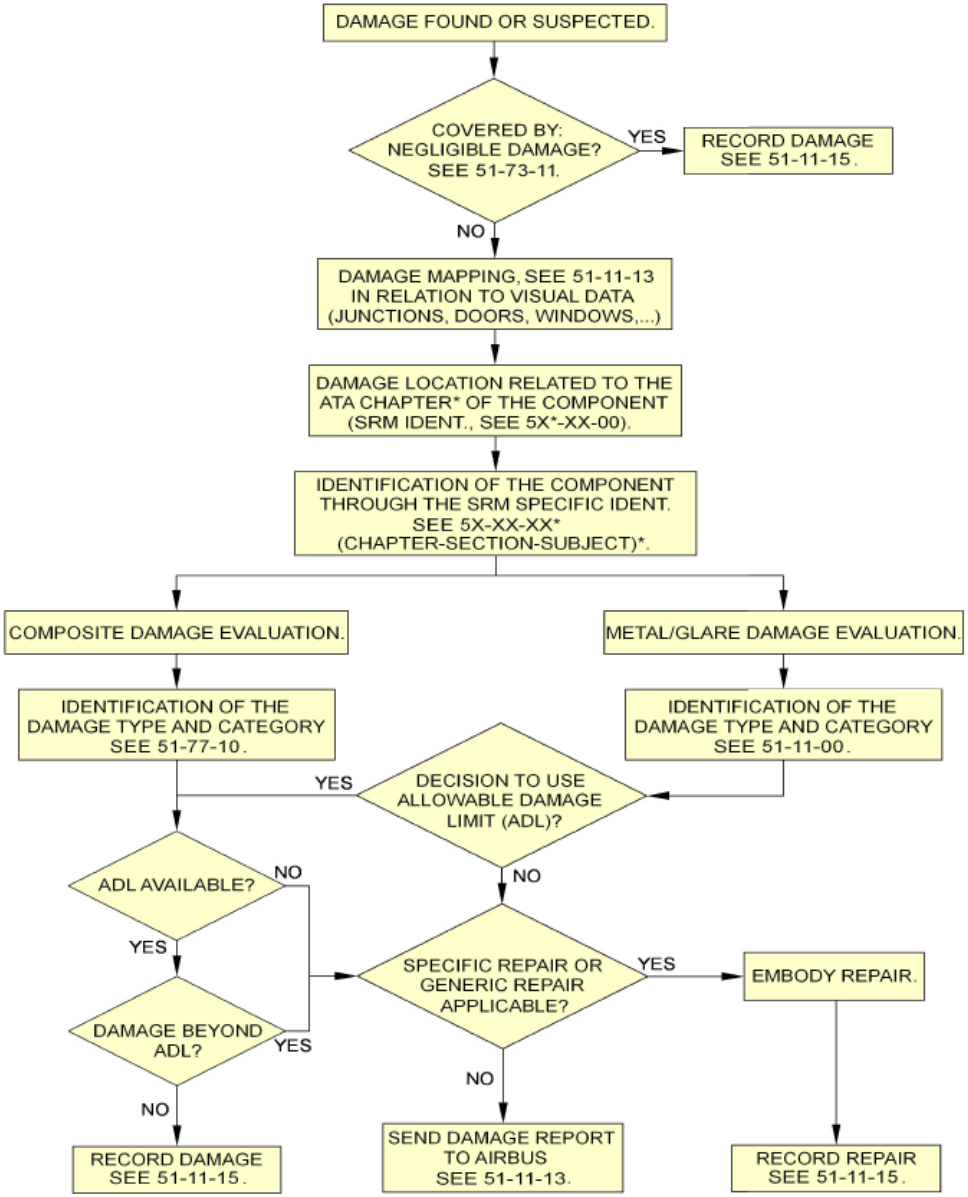


Dents cost the airline industry $ 2.8b / year *

* 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

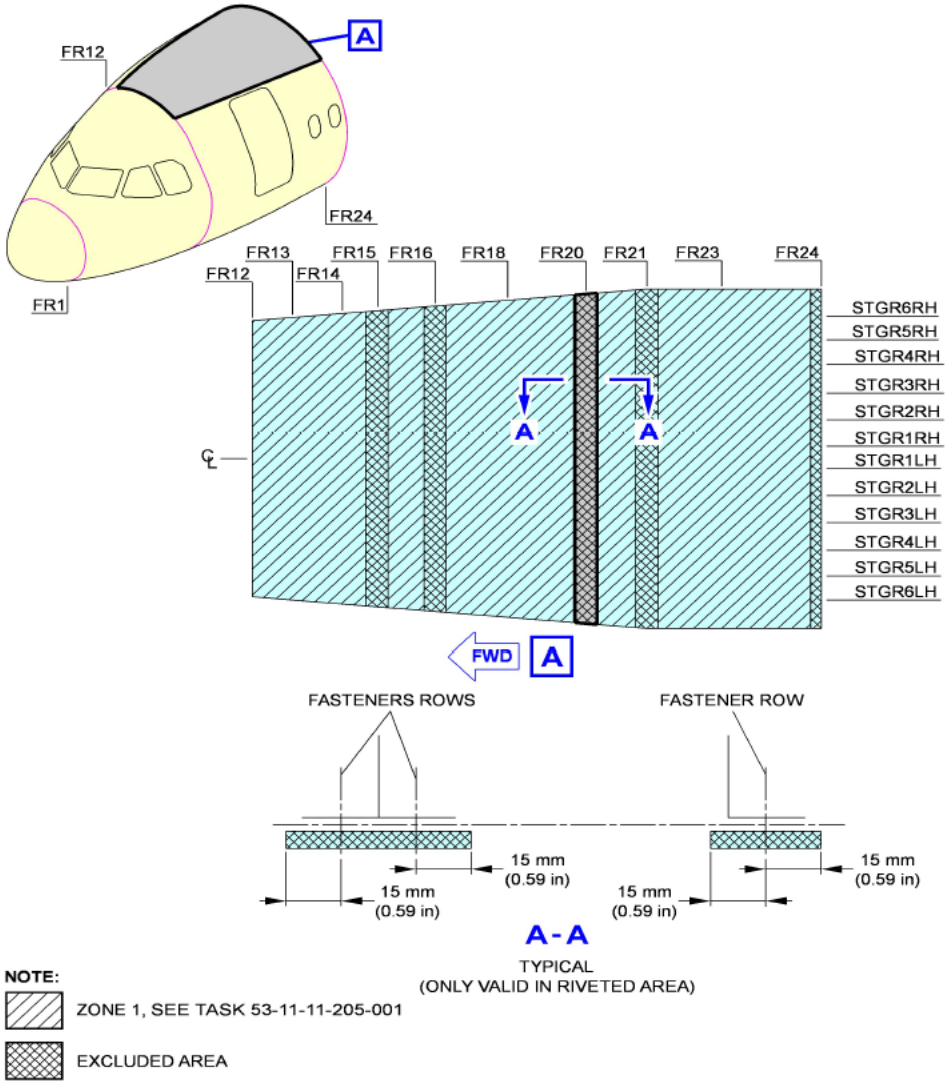
Dent Details Required



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:

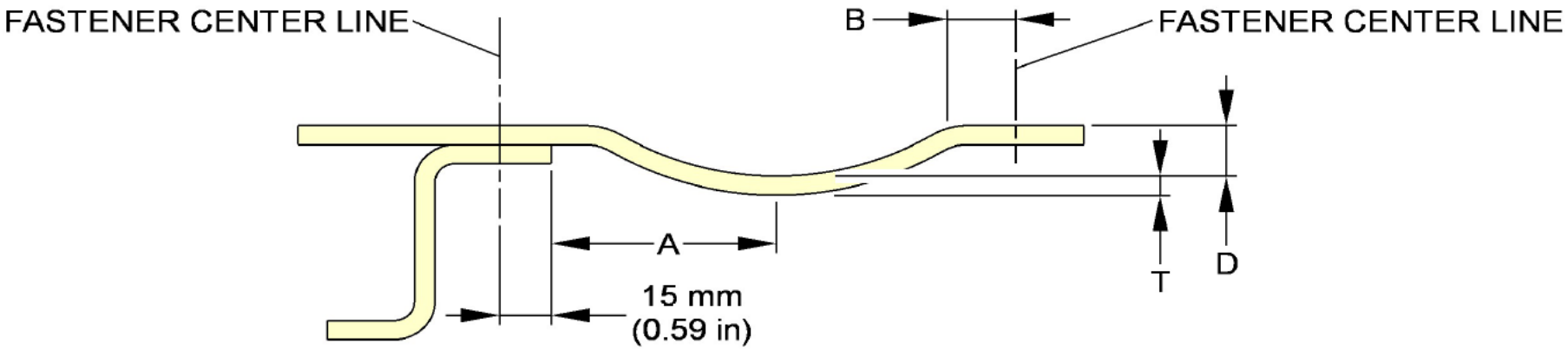
- wing primary structure,
- slats,
- spoilers,
- A320 wing leading edge skins between track 5 and 6 and between track 7 and 8 inter rib,
- static ports, pitot probes, total air temperature probes and angle of attack sensors and areas within 150 mm (5.91 in.) around these sensors,
- nacelle inlet cowl-lip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



Dent Details Required - Parameters

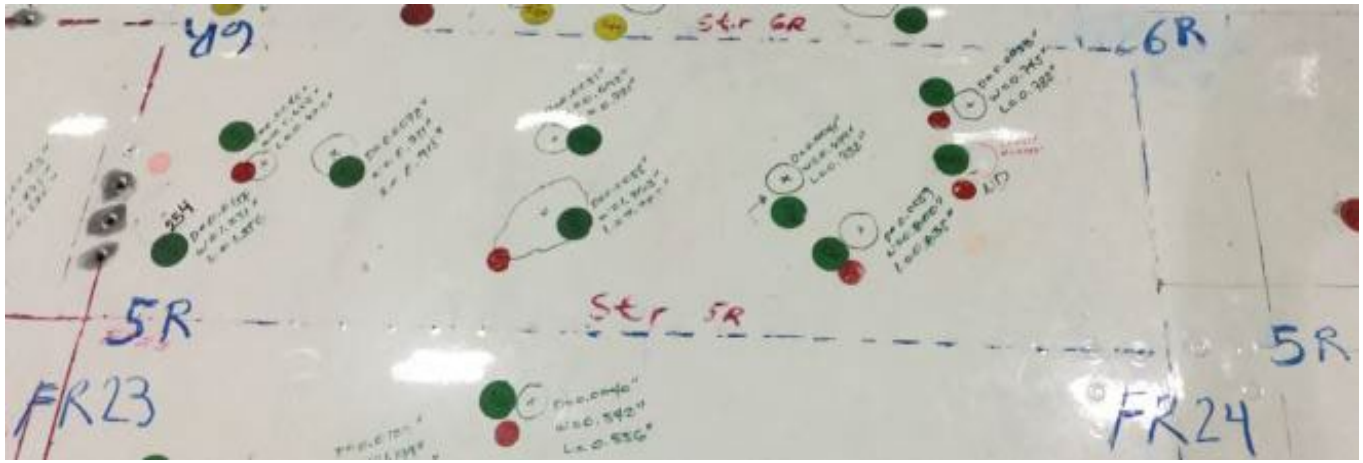
(1) Maximum depth D does not exceed 0.1 mm (0.004 in.): D < 0.1 mm (0.004 in.). The following requirements shall be fulfilled:

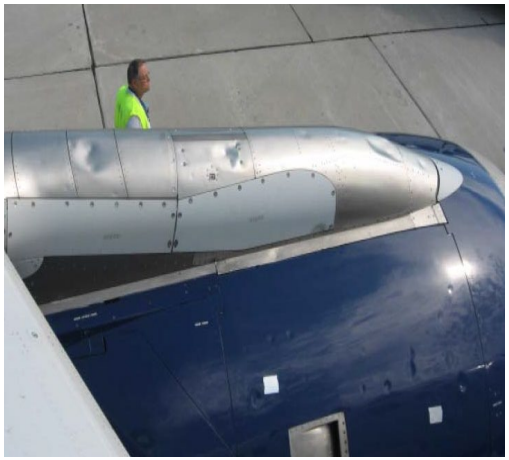
- skin thickness is below or equal to 4 mm (0.16 in.),
- the contour of the dent is smooth,
- ratio A/D is equal to or greater than 25 (minimum size of dent),
- the skin is free of cracks, confirmed by detailed visual inspection,
- No debonding of bonded stringers,
- no abrasion of unclad skin,



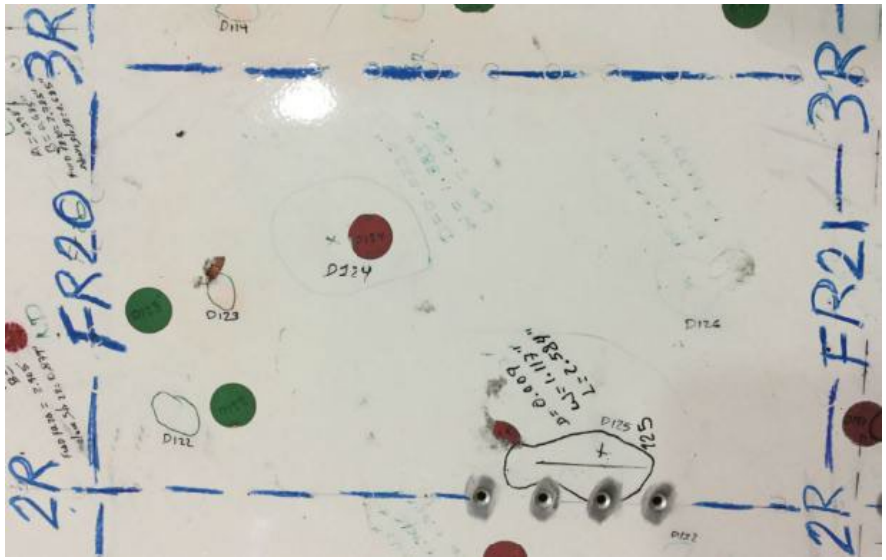
What the hail happened?

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

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➤ ➤ ➤ Preliminary Repair Instructions ➤ ➤ ➤

Fuselage Skin - Panel 4C - FR12/FR24 & LH RH upper STGR

DENT	PROXIMITY TO FRAME (in) Note: CIRCLE ONE OF "FWD" OR "AFT" FOR EACH DENT		FWD /AFT			PROXIMITY TO STRINGER (in) Note: CIRCLE ONE OF "ABOVE" OR "BELOW" FOR EACH DENT		Above/ Below			DEPTH	L	W	A for (ADL)	B	D≤ 10%A Ok?	A (Negligible)	A/D (Negligible)
D94	4.913"	in	FWD	FR	20	1.884"	in	Bellow	STGR	1L	0.003"	0.963"	0.593"		2.502"	OK	0.290"	
D95	5.408	in	AFT	FR	18	1.128"	in	Above	STGR	3L	0.002"	0.736"	0.651"		1.724"	OK	0.324"	
D96	4.448"	in	FWD	FR	20	1.263"	in	Bellow	STGR	2L	0.005"	0.596"	0.567"	1.563"	1.848"	OK		
D97	4.988"	in	AFT	FR	18	1.106"	in	Above	STGR	4L	0.003"	0.790"	0.642"		1.704"	OK	0.415"	
D98	5.391"	in	FWD	FR	20	0.274"	in	Bellow	STGR	3L	0.004"	0.764"	0.537"		0.861"	OK	0.251"	
D99	4.439"	in	FWD	FR	20	2.065"	in	Above	STGR	4L	0.003"	0.723"	0.529"		2.692"	OK	0.297"	
D100	4.973"	in	FWD	FR	20	1.937"	in	Above	STGR	5L	0.002"	0.924"	0.549"		2.517"	OK	0.412"	
D101	3.736"	in	FWD	FR	21	0.730"	in	Bellow	STGR	7R	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"	0.924"	0.923"	0.863"	1.131"	OK		
D103	2.376"	in	AFT	FR	20	0.439"	in	Above	STGR	5R	0.003"	0.730"	0.666"		1.078"	OK	0.96"	
D104	4.149"	in	AFT	FR	20	2.122"	in	Above	STGR	5R	0.007"	0.943"	0.893	2.741"	2.753"	OK		
D105	1.484"	in	FWD	FR	21	2.001"	in	Above	STGR	5R	0.006"	1.544"	1.513"	2.082"	2.087"	OK		
D106	4.077"	in	AFT	FR	20	0.568"	in	Above	STGR	6R	0.003"	0.790"	0.086"		1.138"	OK	0.372"	
D107	2.742"	in	FWD	FR	21	0.808"	in	Bellow	STGR	5R	0.005"	0.584"	0.524"	1.119"	1.453"	OK		
D108	3.435"	in	AFT	FR	20	0.078	in	Bellow	STGR	5R	0.002"	0.721"	0.529"		1.168"	OK	0.377"	
D109	3.856"	in	AFT	FR	20	2.335"	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	Bellow	STGR	4R	0.009"	1.310"	1.202"	0.751"	0.816"	OK		
D111	2.467"	in	FWD	FR	21	2.467"	in	Above	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"	1.339"	1.434"	OK		
D113	1.071"	in	AFT	FR	20	0.613"	in	Above	STGR	4R	0.005"	0.709"	0.428"	0.881"	1.471"	OK		
D114	1.359"	in	AFT	FR	20	0.115"	in	Bellow	STGR	3R	0.003"	0.678"	0.432"		0.905"	OK	0.351"	
D115	1.501"	in	AFT	FR	20	0.129"	in	Above	STGR	4R	0.005"	0.574"	0.524"	0.445"	0.714"	OK		
D116	2.245"	in	AFT	FR	20	2.387"	in	Above	STGR	4R	0.002	0.723"	0.562"		2.435"	OK	0.377"	

10① Note: These instructions are considered preliminary only. Specific authorization via an ER/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 ER/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 ER/A and completion of the final signoff.

Delta's case study (Before dentCHECK)

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

OEM efforts – Guidance and approvals

BOEING

BCS Customer Support

SERVICE LETTER

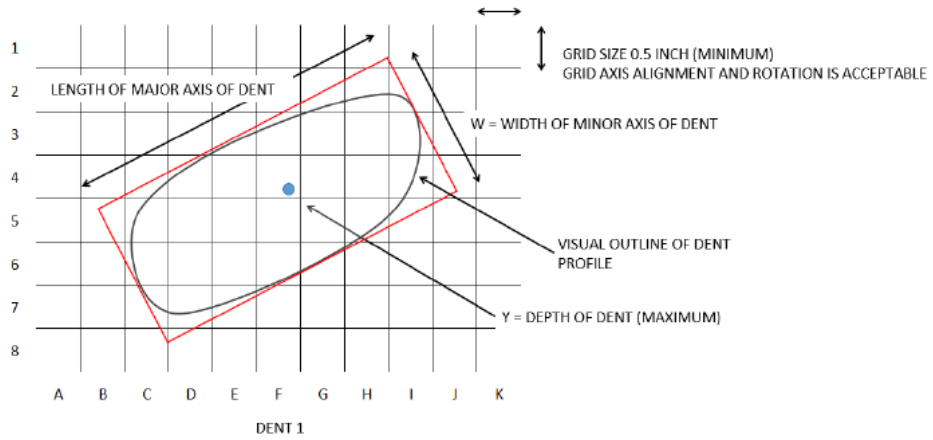
707-SL-51-033	757-SL-51-026	DC-9-SL-51-114
717-SL-51-113	767-SL-51-041	DC-10-SL-51-113
727-SL-51-045	777-SL-51-022	MD-10-SL-51-112
737-SL-51-053	787-SL-51-006	MD-11-SL-51-113
747-SL-51-056	DC-8-SL-51-112	MD-80-SL-51-114
		MD-90-SL-51-114

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



AIRBUS

GSE&Tools Technical Liaison Manager
Customer Services
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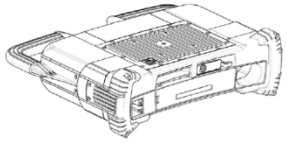
31707 Blagnac Cedex – France

Contact: TechRequest via AirbusWorld
web site: www.airbus.com

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

RECOMMENDED MODIFICATION

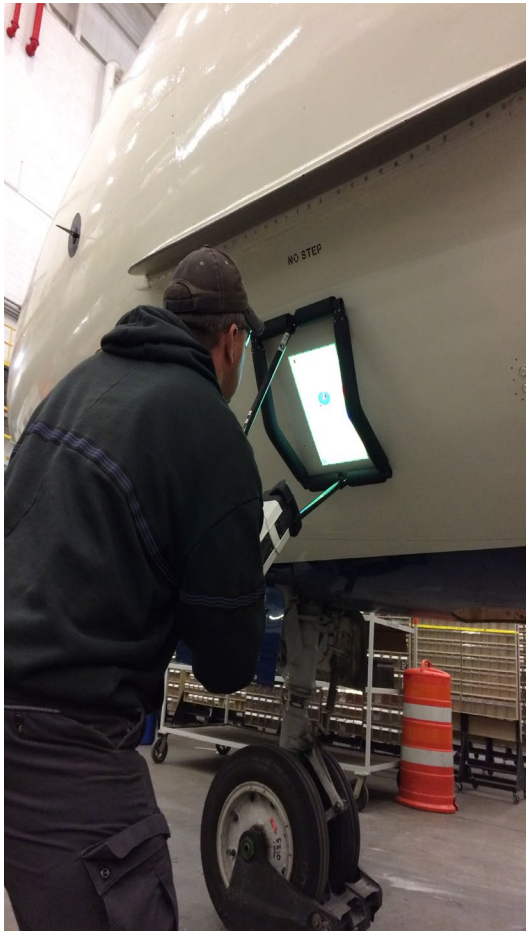
EFFECTIVITY:	A320 ALL
PART NUMBER:	dentCHECK 8TR-DC-002
DESIGNATION:	3D SCANNER
DESCRIPTION:	This tool is used to assess dent damage on metallic parts and cabin floor composite panels.
TOOL STATUS:	N/A
NOTE:	Supplier Cage Code: 7E2T2



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



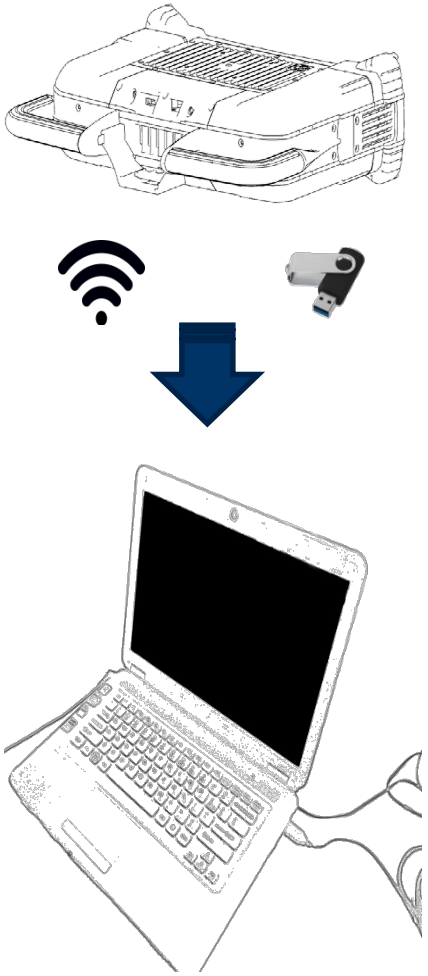
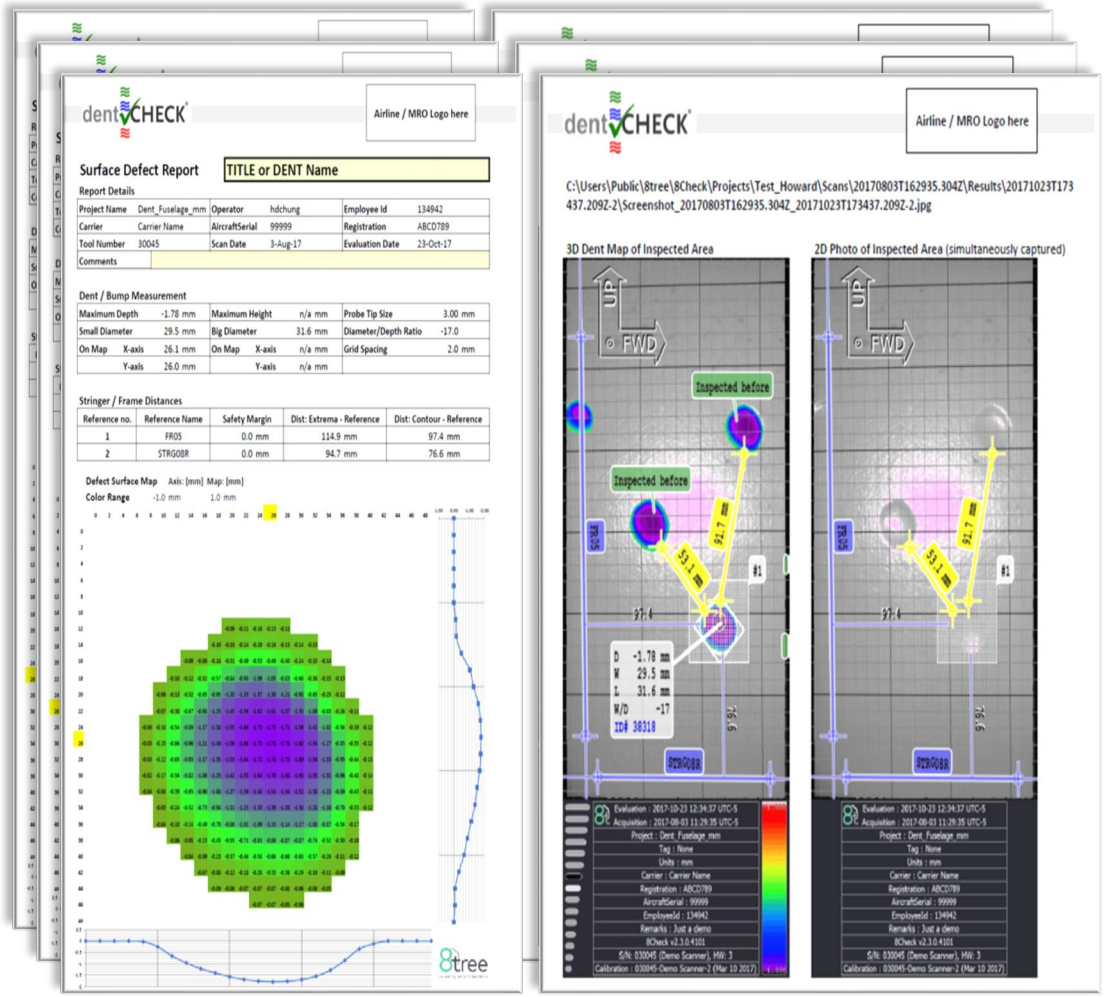


Image source: Delta Tech Ops

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



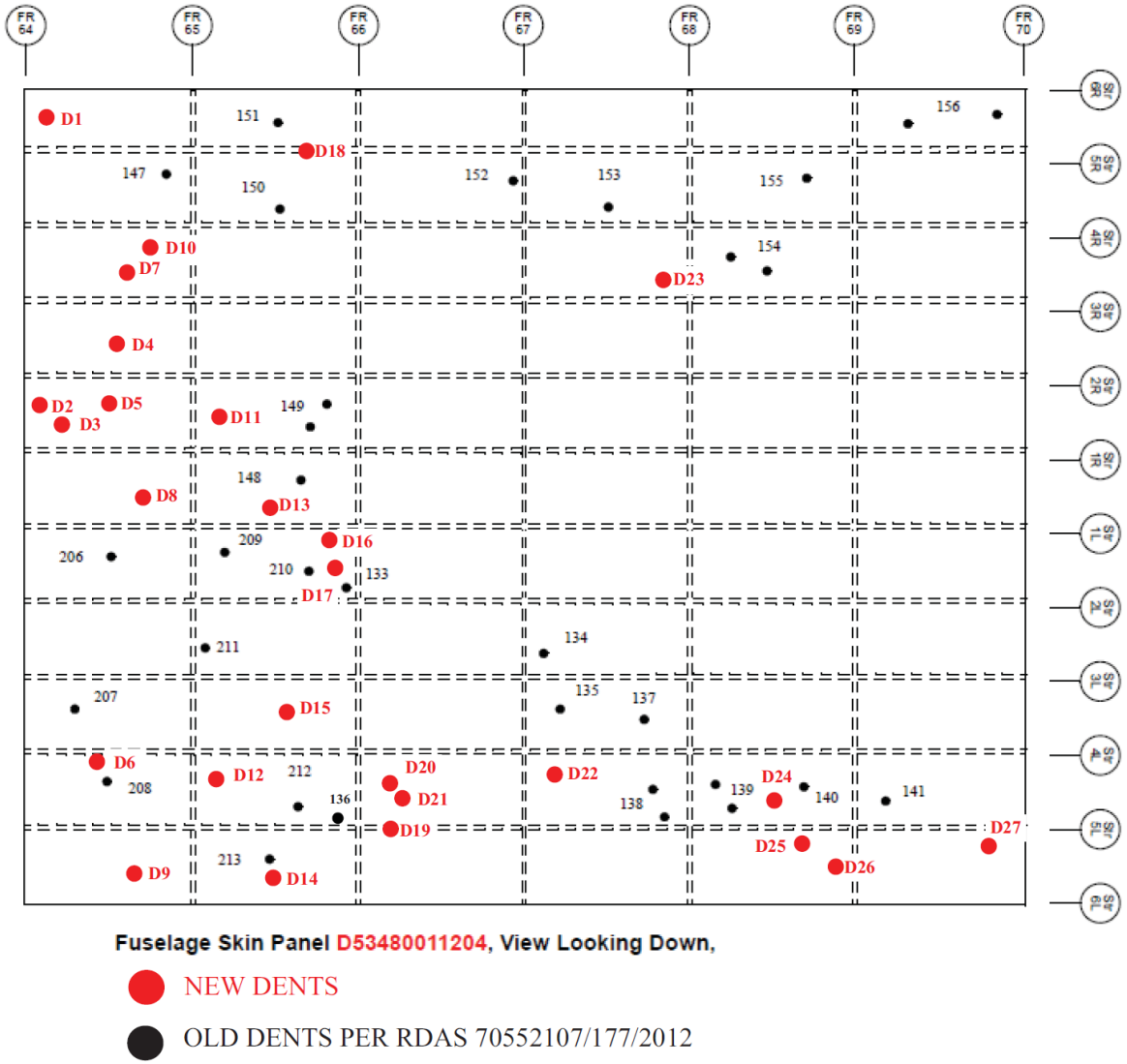
Delta's case study (After dentCHECK)

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%

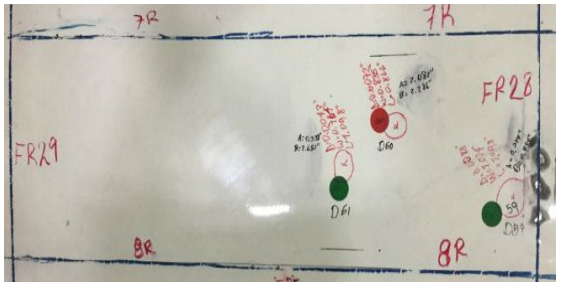
Delta's case study (After dentCHECK)

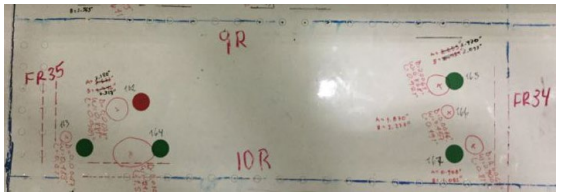


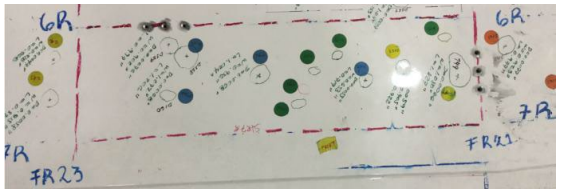
Fuselage Skin Panel D53480011204, View Looking Down,

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