Aerospace Structures

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REPAIRS

Main Objectives

- The main objective is to be able to assess the **structural damage**, then **design and analyze a repair** without relying solely on standard, pre-approved repairs.

- The use of this methods will **increase the likelihood that the engineer's repair will be approved** by the governing regulatory authority.

Introduction

The airline structures design engineer is:

- **Limited by the parameters of the local structure** in the damage area and
- Must **design repairs** to **restore structural integrity** with limited resources **under stringent maintenance deadlines** and **often during unscheduled downtime**

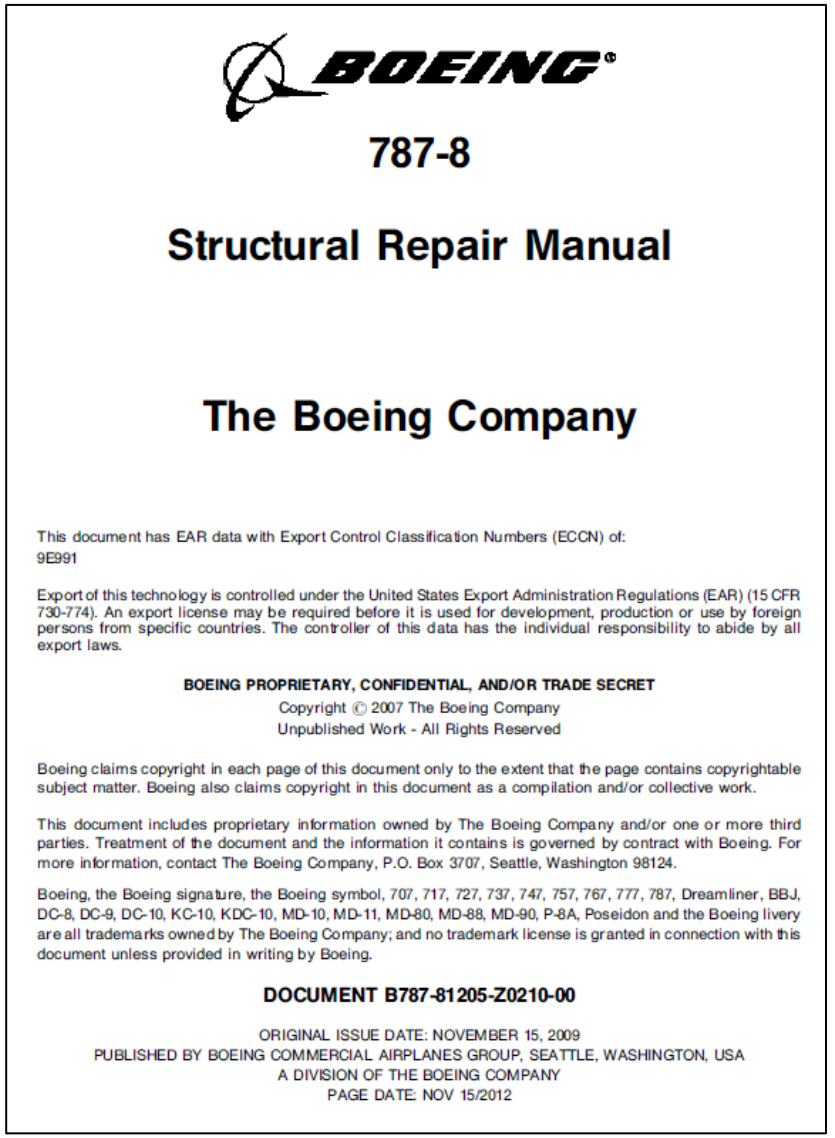
Introduction

The structural repair manual SRM, provide **allowable damage limits** and **field repairs procedures** approved by the regulatory authority to assist the airplane engineer damage evaluation and repair design.

In this course, this information is limited to **metal structure and repair using mechanically fastened joints**.

Using the SRM

- Locate applicable data
- Identify airplane parts
- Identify structure type and category
- Find allowable damage, rework data and operational limits
- Identify repair types, categories, and post repair inspection requirements
- Prepare a repair proposal for approval by the manufacturer



BOEING®

787-8

Structural Repair Manual

The Boeing Company

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Manual arrangement and number system

- The standard numbering system for the structural repair manual conforms to ATA 100

- This numbering system has three elements with two numbers in each element.
  - **First element (Chapter)**: Identify major areas of the airplane structure
  - **Second element (Chapter)**: Section numbers are subset of the major areas
  - **Third element (Chapter)**: Identify the skin, stringers, or another basic structural elements

Manual arrangement and number system

FIRST ELEMENT (Both numbers given by ATA 100)	**SECOND ELEMENT** (First number given by ATA 100, second number by the commercial company, Boeing)	**THIRD NUMBER** (Both numbers given by the commercial company)
55 – 10 – 05		
CHAPTER (Stabilizers)	**SECTION** (Horizontal stabilizers)	**SUBJECT** (Spars)

Manual arrangement and number system

- The second digit of the section number often identifies data concerning **significant model differences such as various engine options or wing components**.
- An example could be a variety of engine options for one plane, such as General Electric, Prat Whitney and Rolls Royce, then a section in the chapter 54 could be:
  - 54 00 General
  - 54 10 Inlet cowl PW 4000
  - 54 12 Inlet cowl RR Trent 800
  - 54 13 Inlet cowl GE 90 100 series
  - 54 20 Fan cowl PW 4000
  - 54 22 Fan cowl RR Trent 800
  - 54 23 Fan cowl GE90 100 Series

ATA chapters

ATA Number	ATA Chapter name
ATA 51	STANDARD PRACTICES AND STRUCTURES GENERAL
ATA 52	DOORS
ATA 53	FUSELAGE
ATA 54	NACELLES/PYLONS
ATA 55	STABILIZERS
ATA 56	WINDOWS
ATA 57	WINGS

ATA 51 Standard practices, general

- Gives data for those subjects which are applicable to all of the airplane structure.

- Standard practices, general procedures, typical repairs and other data applicable to more than one chapter.

ATA 51 Standard practices, general

00	General
10	Inspection and removal of damage and aerodynamic smoothness
20	Processes and procedures
30	Materials
40	Fasteners
50	Support of airplane for repair and alignment check procedures
60	Control surface balancing
70	Repairs
80	Electrical bonding

ATA 52 Doors

00	General
10	Passenger/crew
20	Emergency exit
30	Cargo
40	Service and miscellaneous
50	Fixed interior
60	Entrance stairs
70	Monitoring and operation
80	Landing gear

ATA 53 Fuselage

Includes information for all structure common to the fuselage, such as floor beams, frames skin and stringers.

00	General
10 thru 90	(As required) Fuselage sections

ATA 54 Nacelles/pylons

Includes information relative to the nacelles ad pylons including spare engine pod for some models.

00	General
10 thru 40	(As required) Nacelle section
50 thru 80	(As required) Pylons

ATA 55 Stabilizers

Includes information for both the horizontal and vertical stabilizers and flight control surfaces.

00	General
10	Horizontal stabilizer or canard
20	Elevator
30	Vertical stabilizer
40	Rudder

ATA 56 Windows

Provide information for all windows, including passenger, cockpit and entry door windows.

00	General
10	Flight compartment
20	Passenger Compartment
30	Door
40	Inspection and observation

ATA 57 Wings

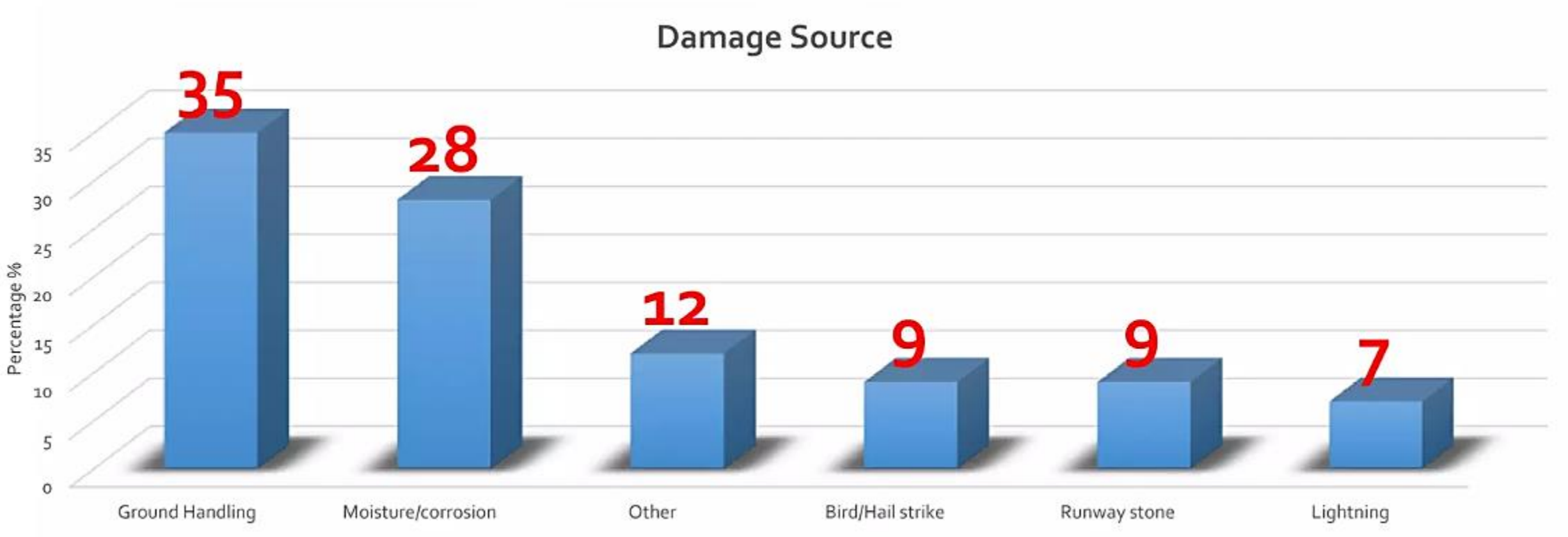
00	General
10	Center wing
20	Outer wing
30	Wing tip
40	Leading edge and leading edge devices
50	Trailing edge devices
60	Ailerons and elevons
70	Spoilers
80	As required
90	Wing folding systems

Damage classification

The term damage includes any and every type of permanent deformation or alteration to any cross section of a structural component.

https://www.flightradar24.com/blog/putting-ed-force-one-back-together-again/

Damage classification



Damage classification

1. Allowable damage: is defined as damage that is permitted with no longer other flight restriction.

2. Repairable damage: is defined as damage that can be reworked or repaired.

3. Replacement of damaged parts: is defined as damage where the part must be replaced.

- As an MRO engineer you must decide what type of damage has occurred to a structural member or to a structural material
- The definitions of the different type of damage that can occur to the external skin of the airplane panels can be classified

Damage classification

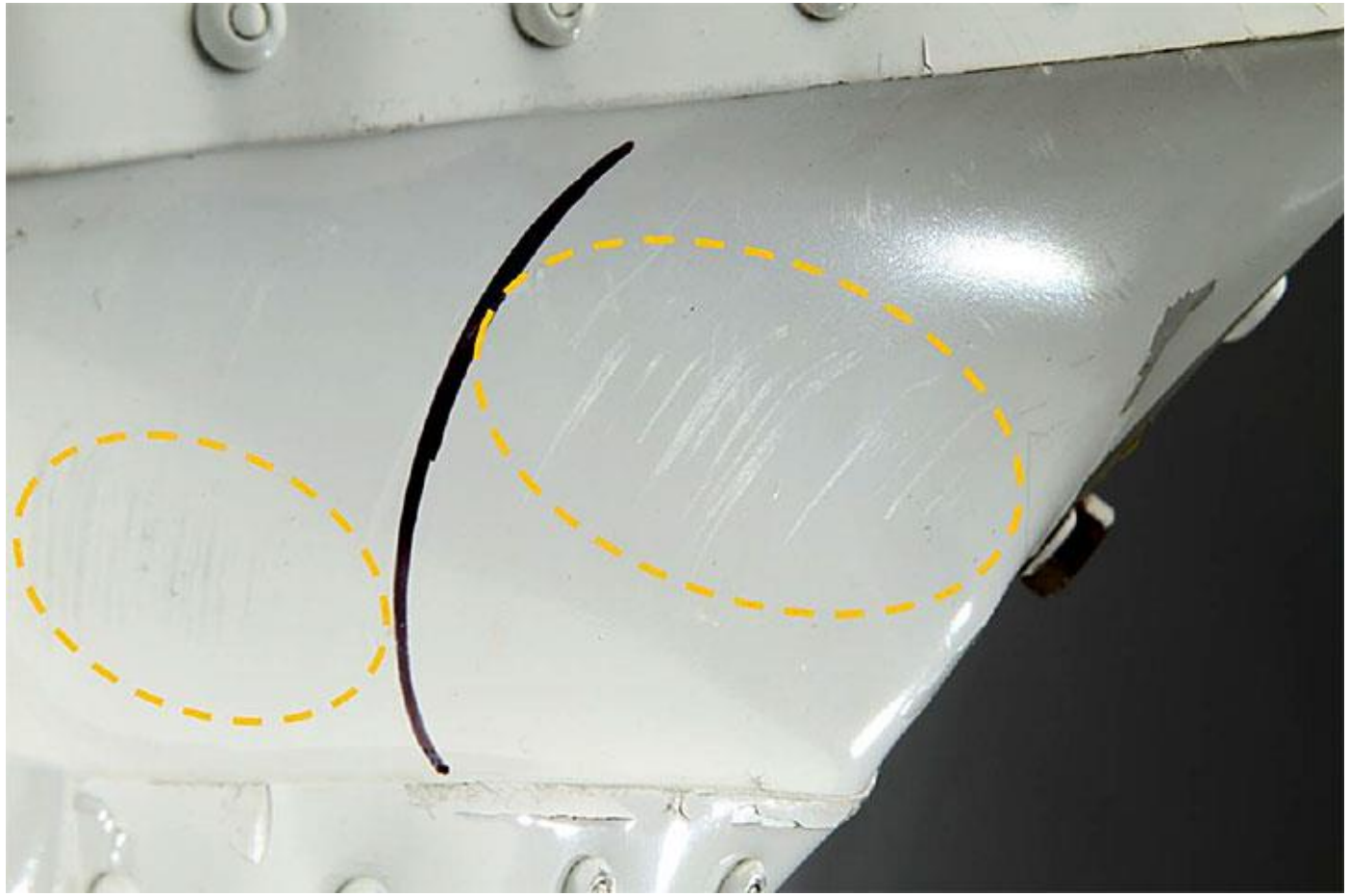
Abrasion

A damaged area that is the result of scuffing, rubbing, or other surface erosion This type of damage is usually rough, and it has an irregular shape.

Damage classification

Scratch

A line of damage in the material where the result is a cross sectional area change. This damage is usually cased by contact with a very sharp object.



Damage classification

Nick

A local gouge with sharp edges. You can consider a series of nicks in a line pattern to be equal to a gouge.

Damage classification

Nick

A local gouge with sharp edges. You can consider a series of nicks in a line pattern to be equal to a gouge.

Damage classification

Gouge

Is a damaged area where the result is a cross sectional change caused by a sharp object and gives a continuous sharp or smooth groove in the material.

Damage classification

Crack

A partial fracture or a full brake in the material that causes a significant change in the cross-sectional area.

This damage usually has an irregular line and is often the result of fatigue in the material

Damage classification

Crease

A damaged area that is depressed or folded back so that its boundaries are sharp or with well defined lines or ridges. Consider a crease to be equal to a crack.

Damage classification

Dent

A damaged area that is pushed in from its normal contour with no change in the cross-sectional area of the material.

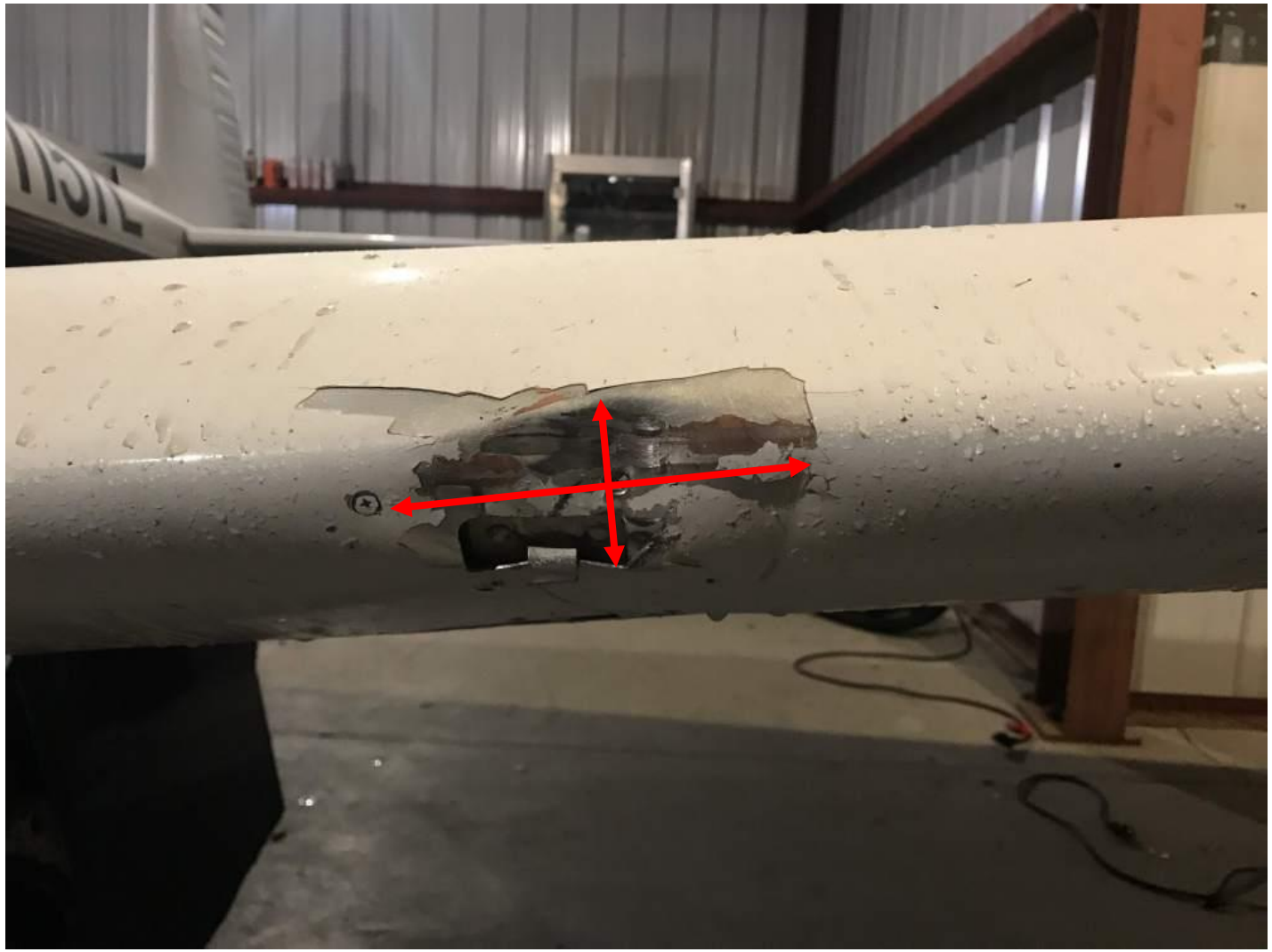
The edge of the damaged area are smooth. This damage is usually caused by a hit from a smoothly contoured object.

Damage classification

Dent

The length of the dent is the longest distance from one end to the other end.

The with of the dent is the second longest distance across the dent, measured 90 to the direction of the length.



Damage classification

Dents can cause:

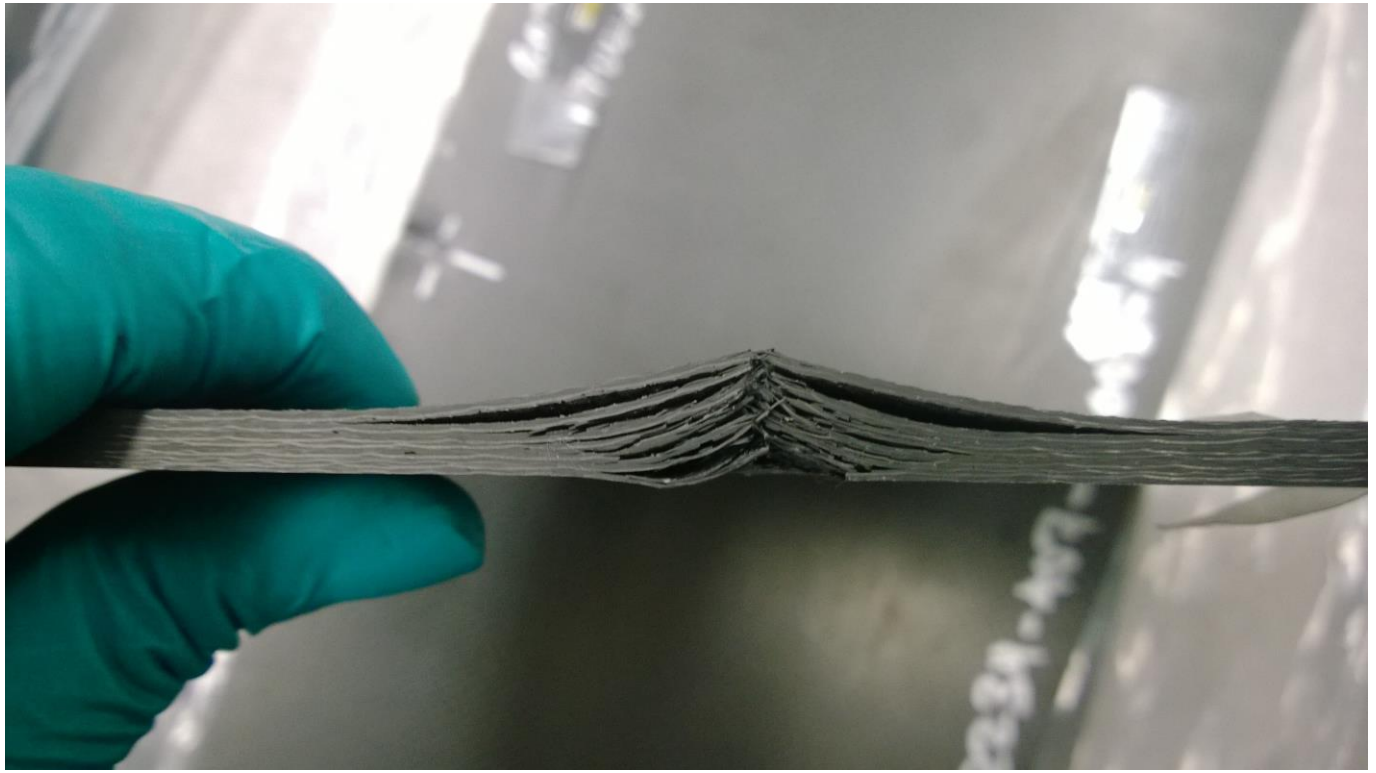
- A decrease in the flight performance
- An effect on the flight qualities of the airplane that is not satisfactory
- An increase in stall speed of the airplane
- Buffeting

Damage classification

Disbond or Debonding

Occurs when there is a separation between two or more plies of bonded material.

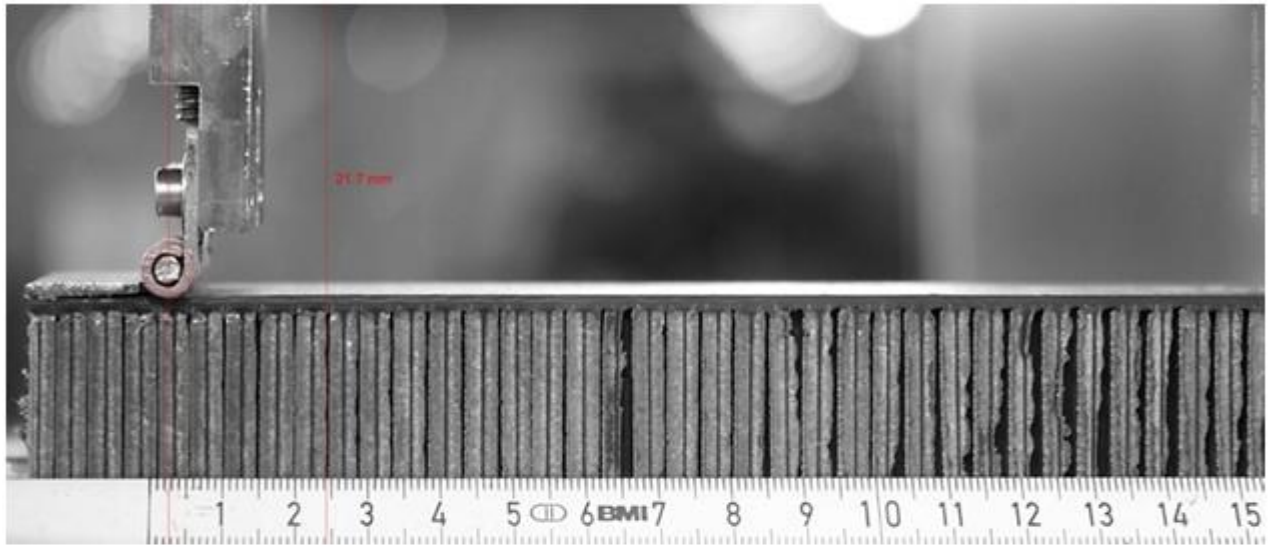
Also a disbond occurs when there is a separation between bonded skin and core. A disbond does not have to occur across the full surface.

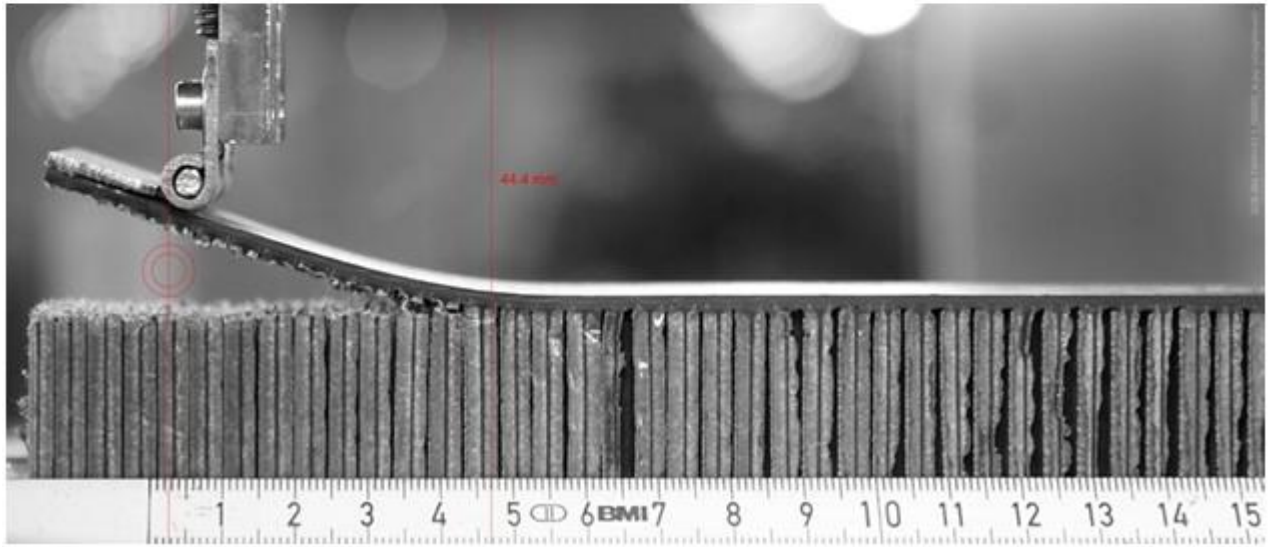


Delamination

A type of disband that occurs between adjacent plies of material

Damage classification





Damage classification

Puncture

Is a damage that goes fully through a part thickness and has no regular shape. For example, a puncture can occur when a part is hit by a sharp object.

A repair of the damage must be less than the allowable damage limits.

Damage classification

Hole

A puncture or cutout that is fully surrounded by undamaged material.

Other types of damage can be removed by making oversized hole or hole that has an irregular shape. If this hole stays in the allowable damage limits or can be repaired with an approved procedure

Damage classification

Burn mark

A localized indication of excessive heating (paint and/or surface black discoloration) after lighting strike. Scorch mark pitting or local melt through-in addition to paint and or surface black discoloration can be seen on metallic skin or fasteners

On composite structures in addition to paint discoloration, puncturing or delamination/ debonding can occur.

The size limit for visual inspection is the limit of paint discoloration.

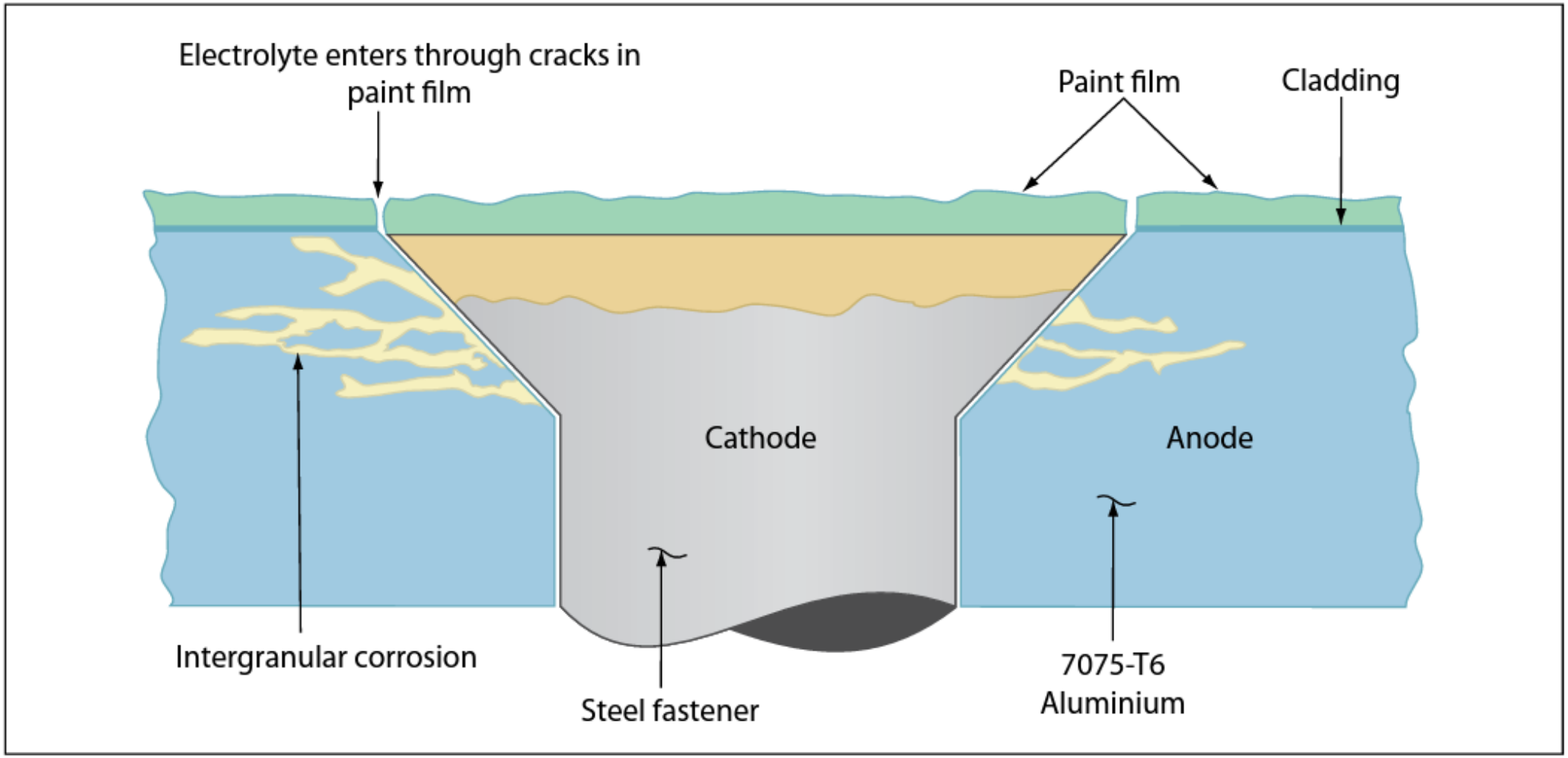
Damage classification

Corrosion

Damage that is the result of a complex electromechanical action and gives a cross sectional area change. The depth of this damage must be determined by a cleanup or removal operation

This type of damage occurs on the surface, hole bores, or edges of structural elements.

Damage classification



Intergranular corrosion of 7075-T6 aluminum adjacent to steel fastener.

Damage classification

Locations for Corrosion

The conditions, which follow, have an influence on where and when corrosion can occur:

- Density of corrosive agents
- Properties of the corrosion protections
- Corrosion resistance of the material

These conditions are not the same at every location of the aircraft structure. There are areas where corrosion can be expected earlier than in others.

Locations for Corrosion

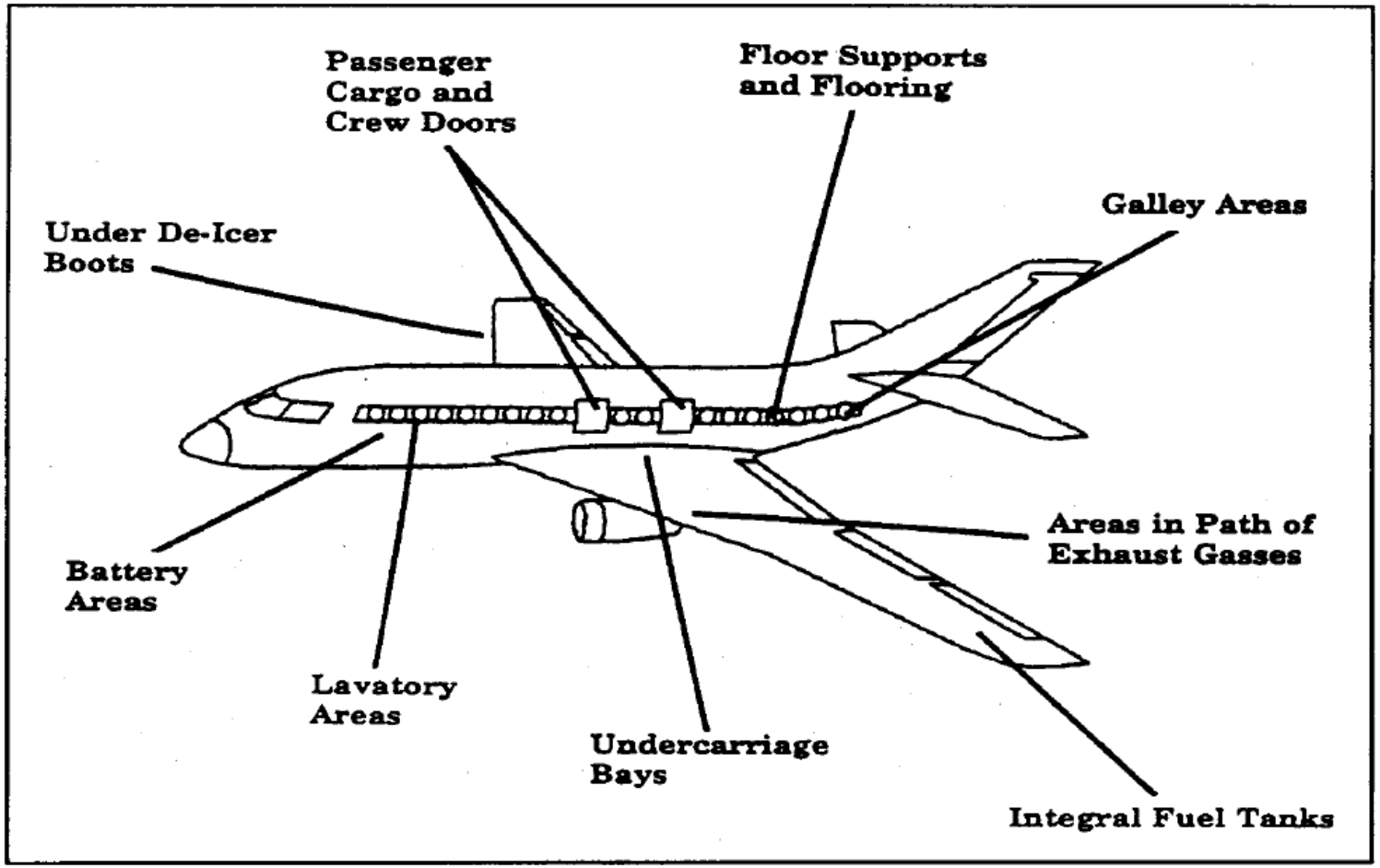
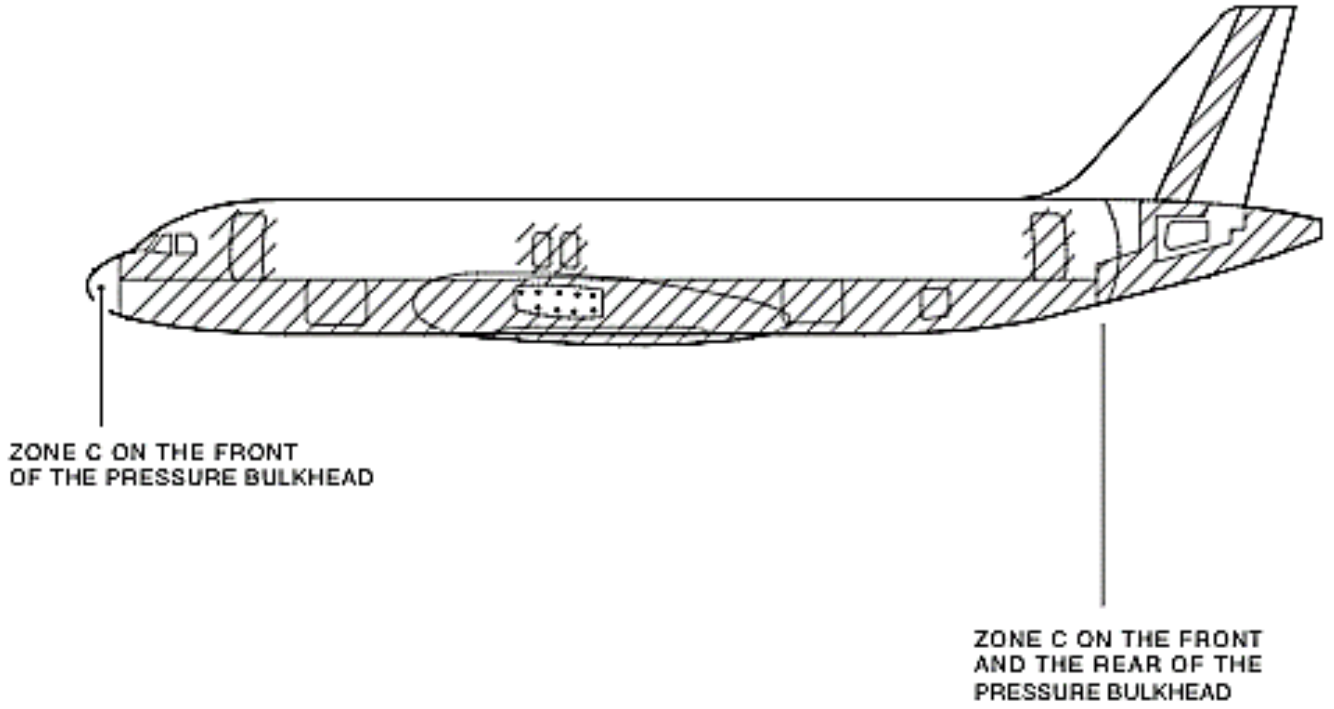


FIGURE 1-5. AREAS MOST SUSCEPTIBLE TO CORROSION

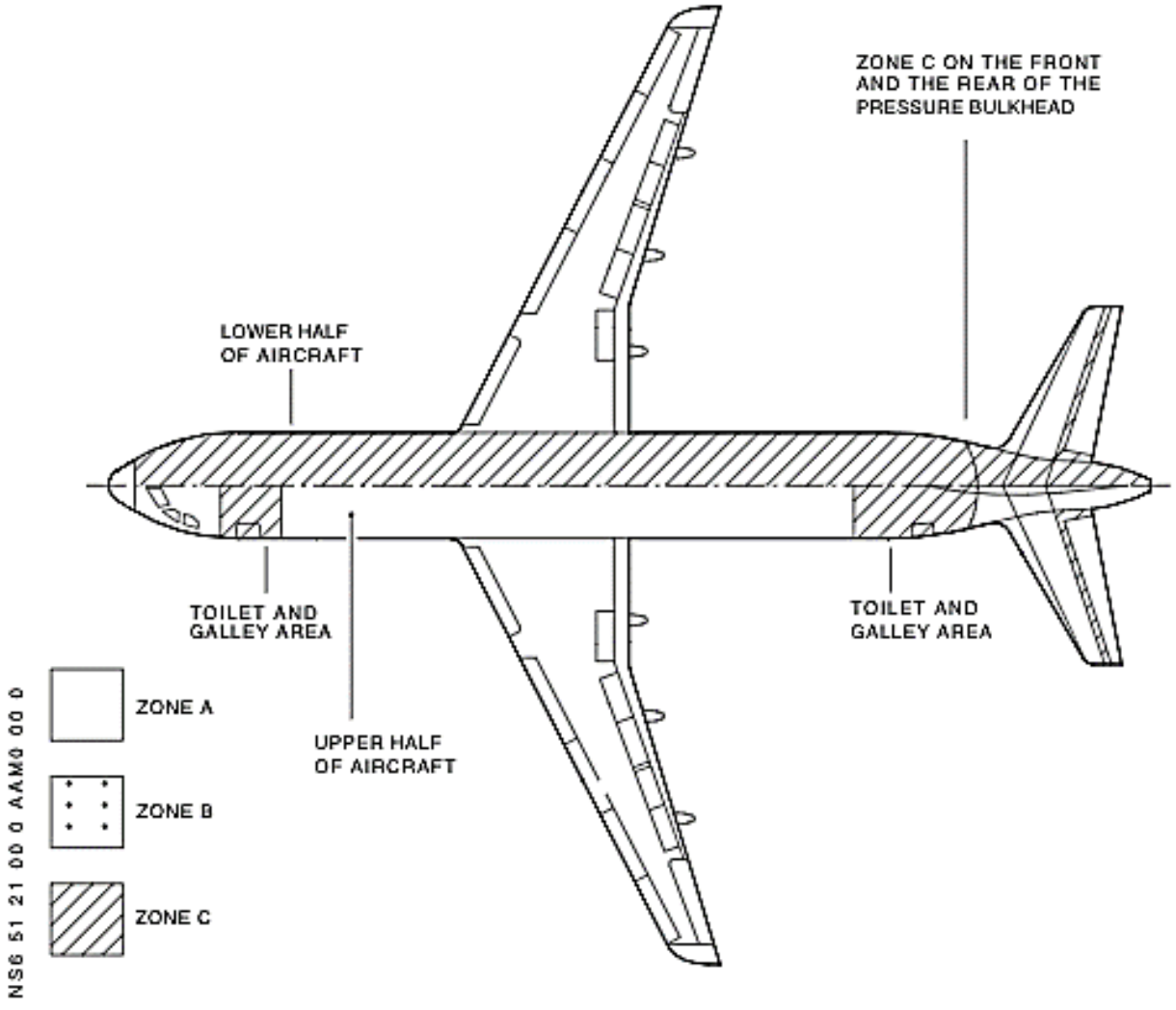
Locations for Corrosion

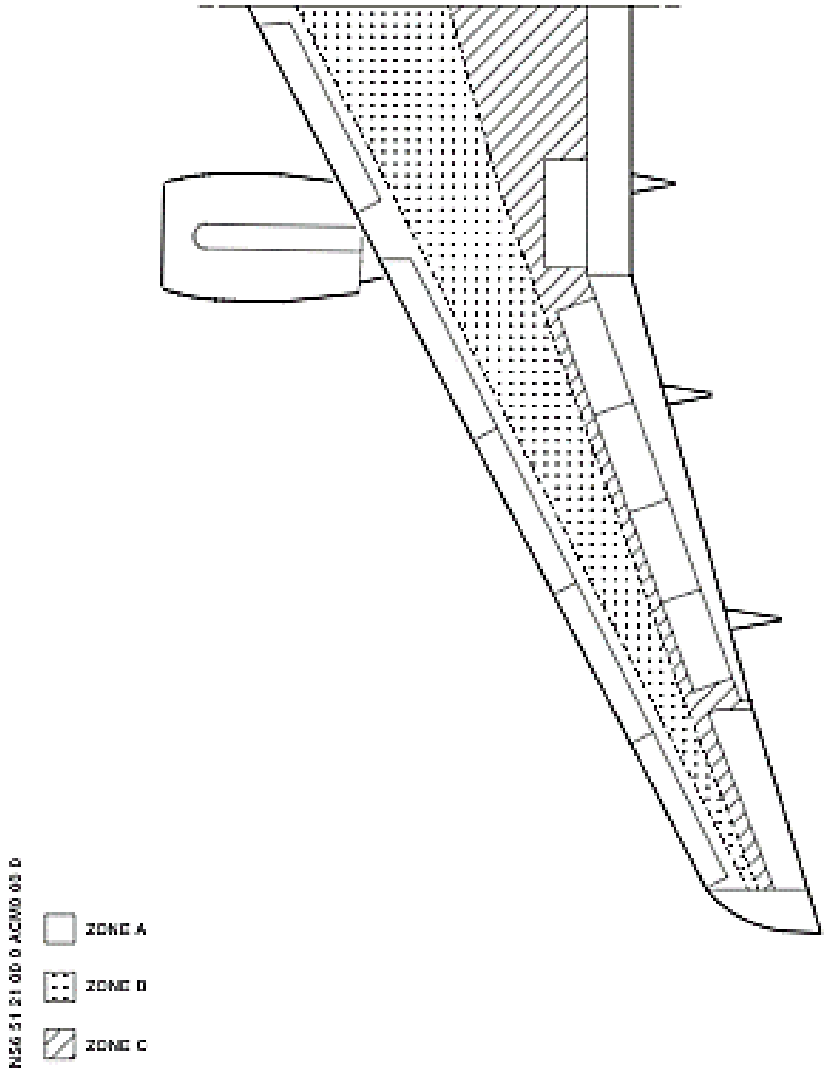
Location of the structure where corrosion may occur sooner than otherwise expected e.g. in and below galleys, toilets or battery stowage compartments.

These areas are indicated as Category C

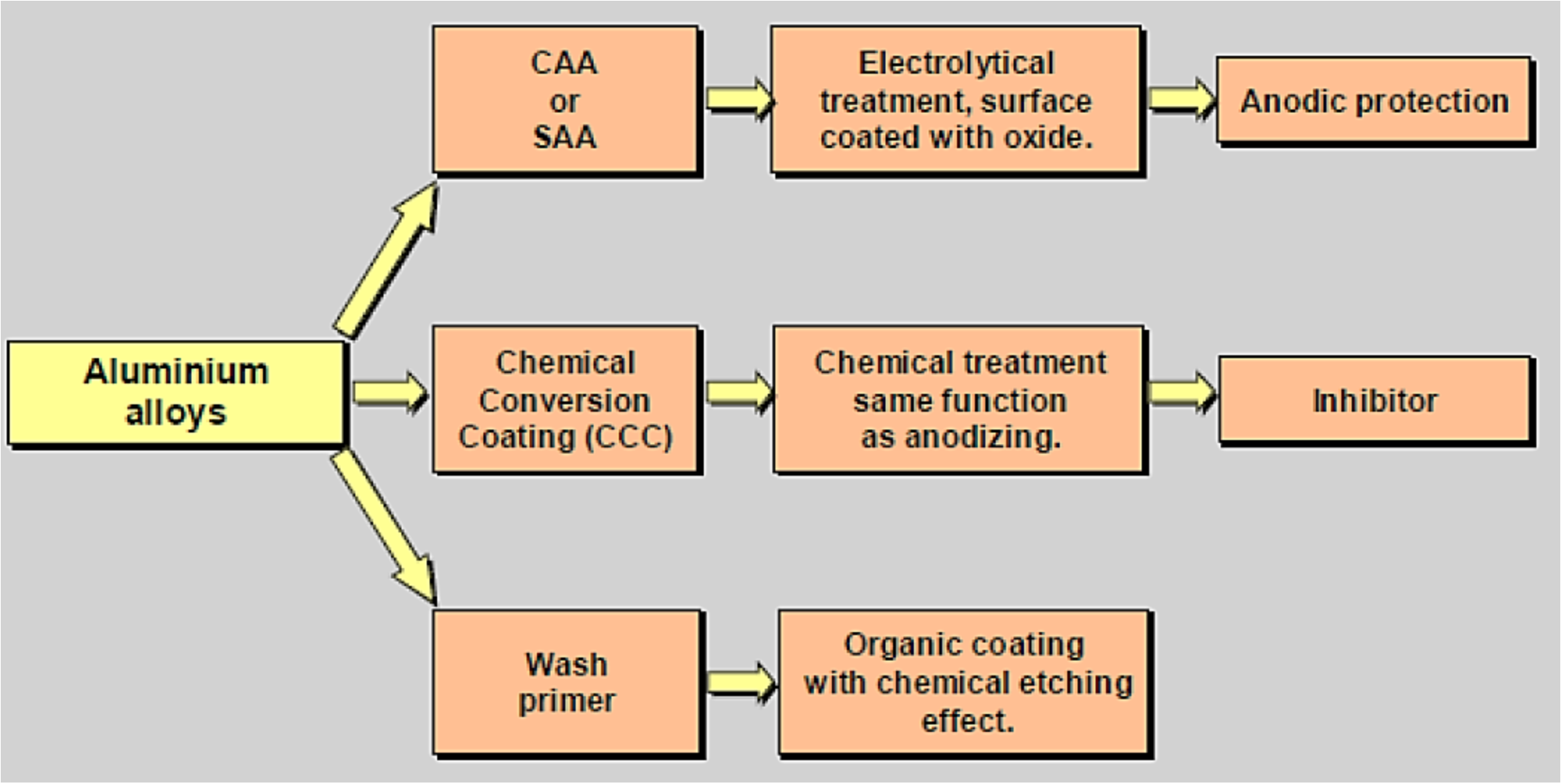


Locations for Corrosion





Corrosion protection



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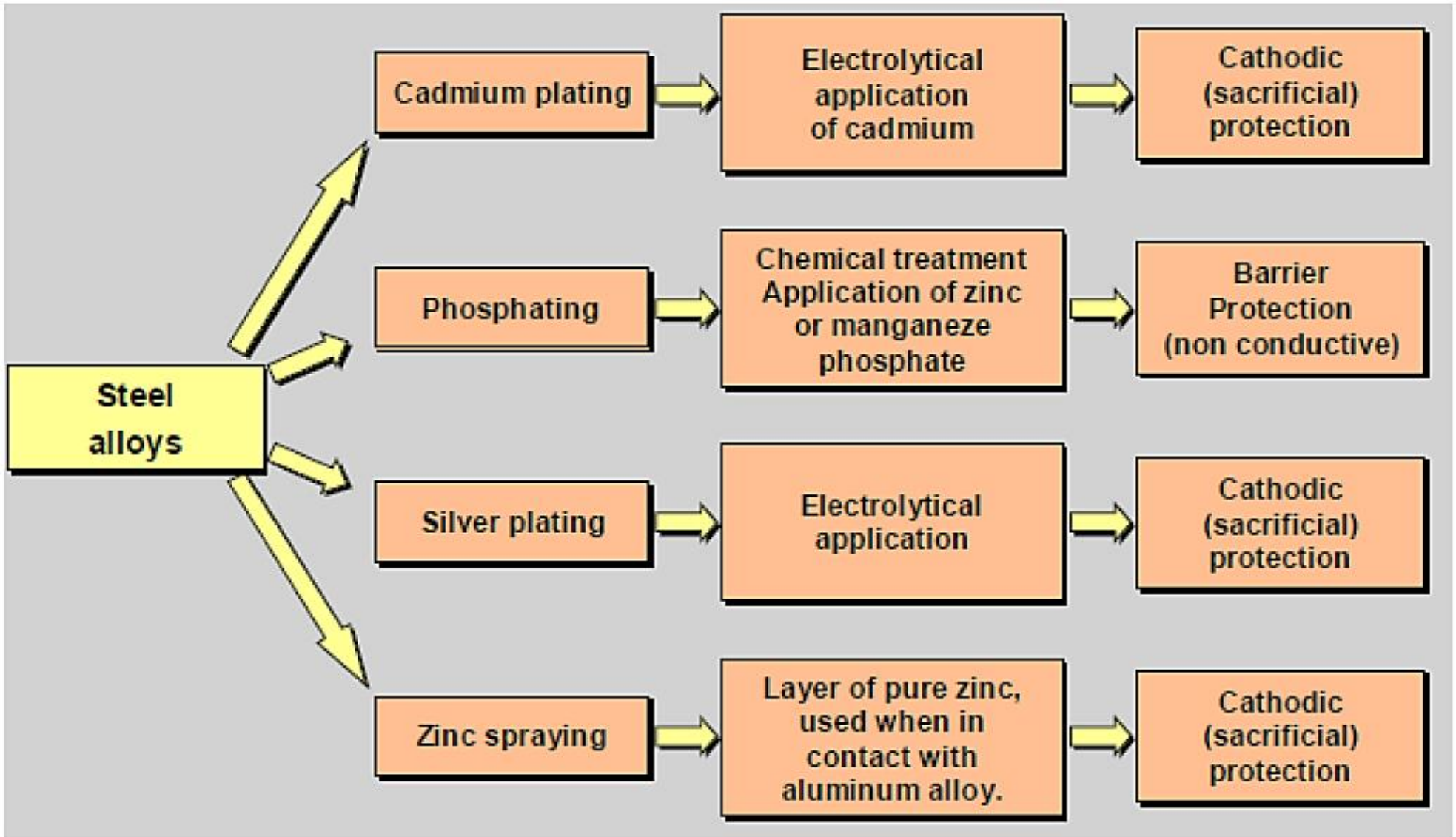
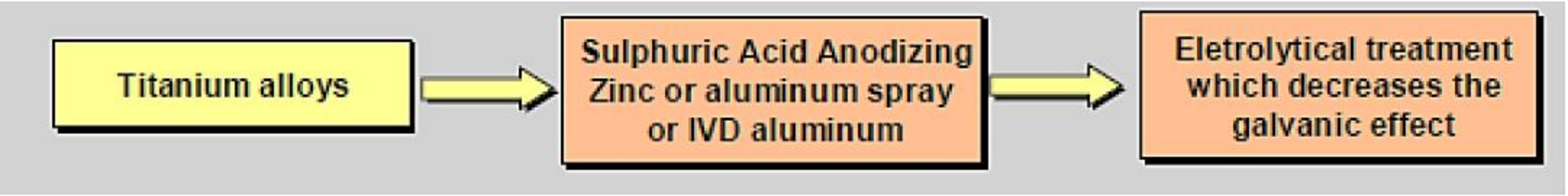
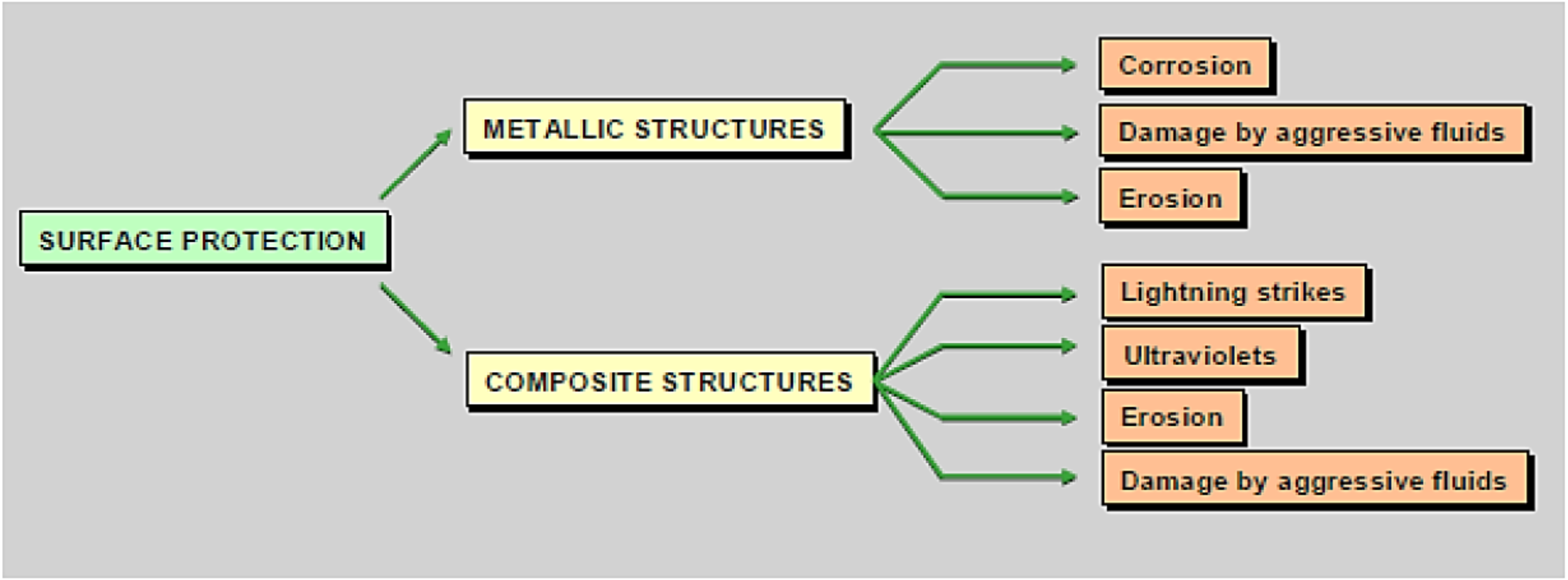


Corrosion protection



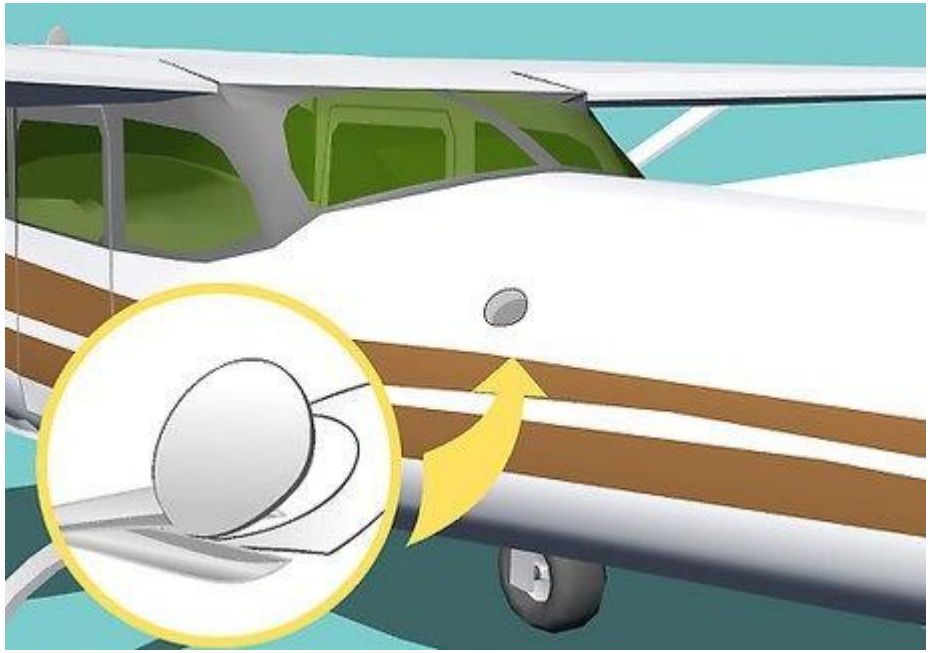
Corrosion protection

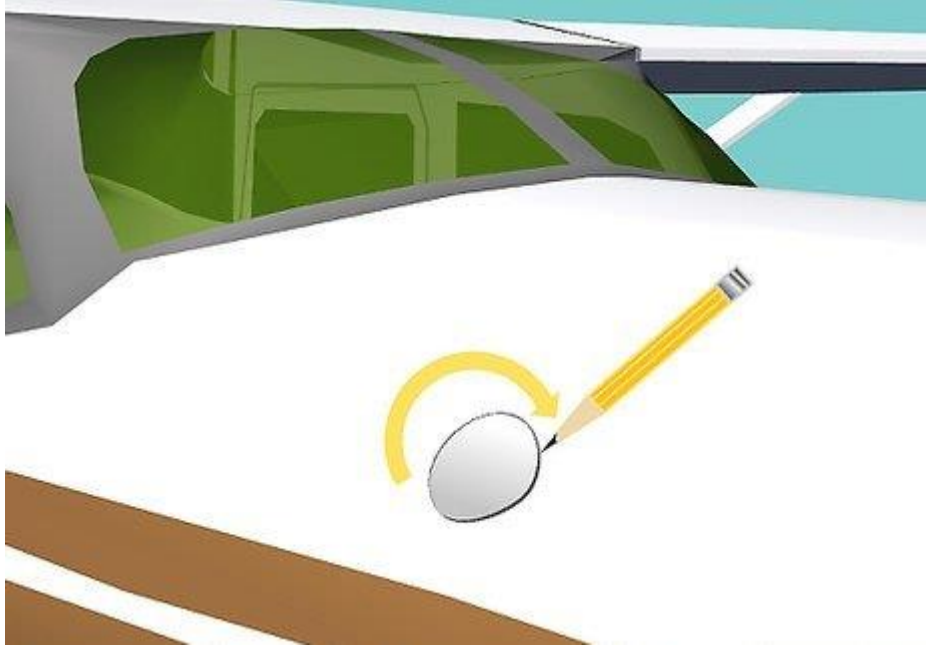


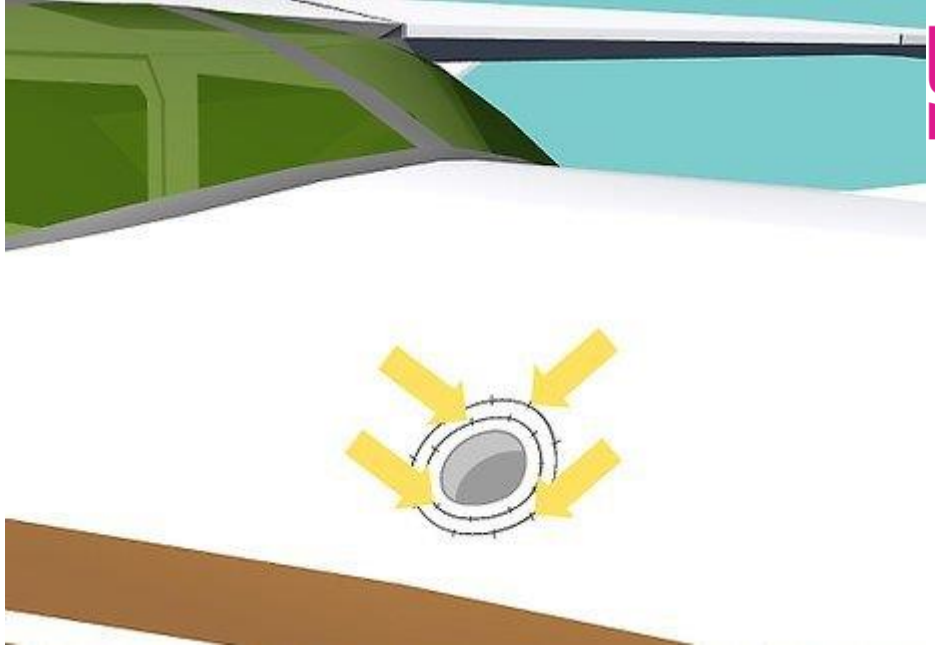
Inspection for corrosion

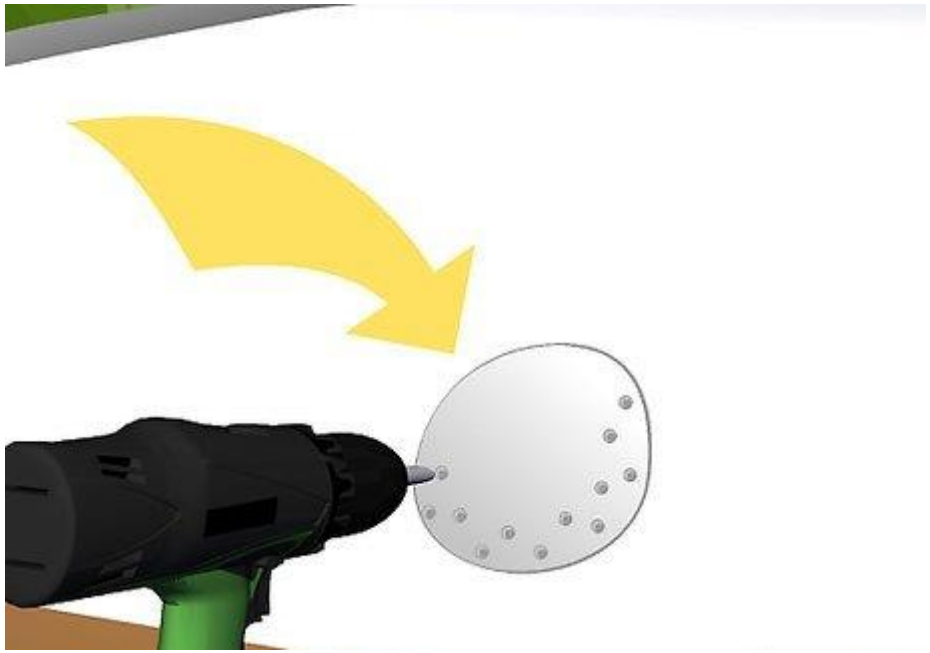
When you do the inspection on a surface which is painted, you will usually see corrosion as: **a scaly or blistered surface, a change of color and blisters in the paint**.

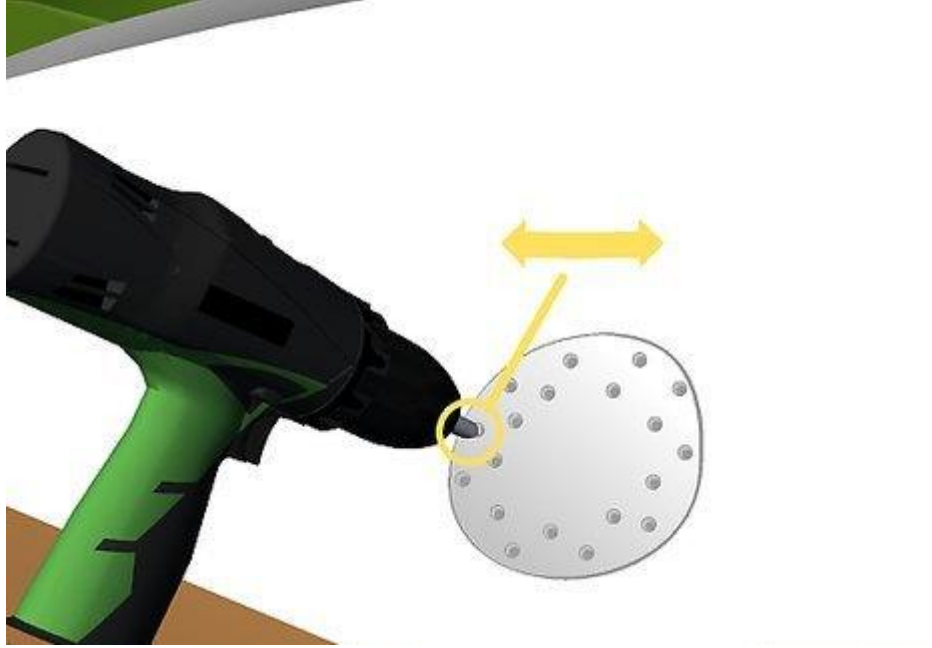
In corrosion on a metallic surface, you will usually see a **dulled or darkened area and a pitted surface**. Usually you will also see **white, grey or red dust or particles**.

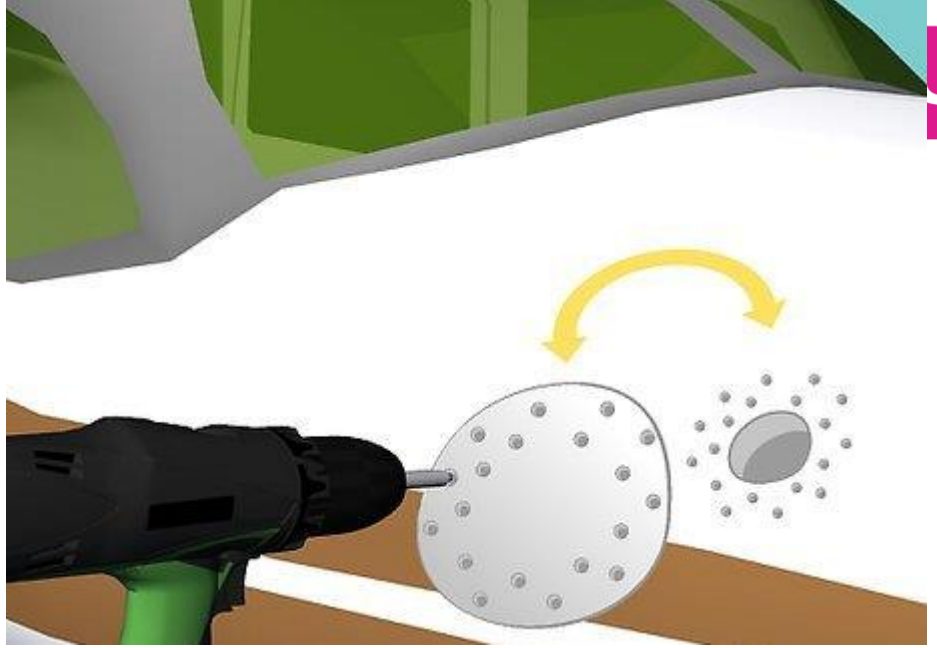


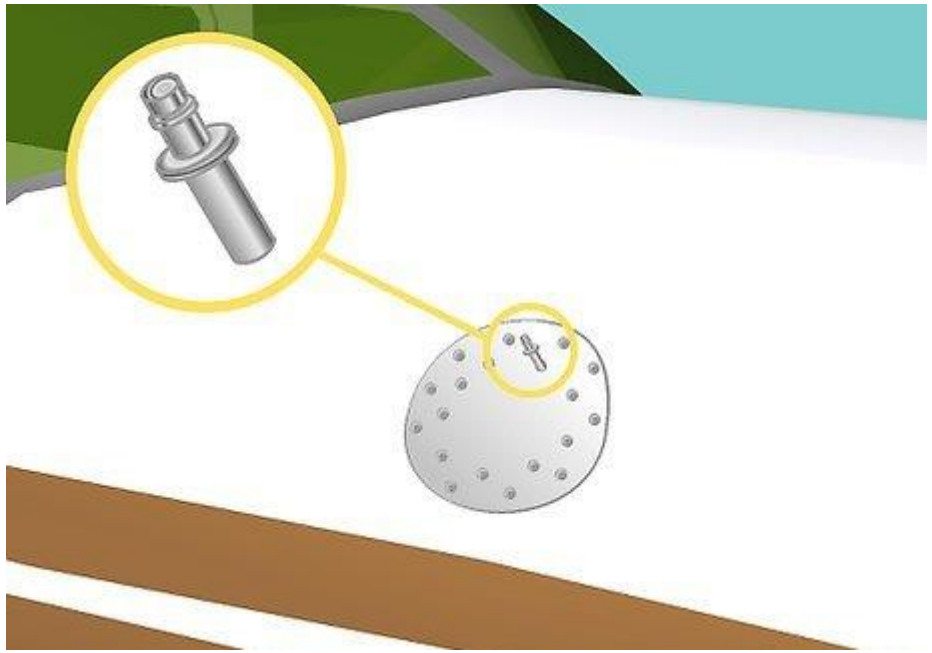












Allowable damage

Some types of damage or distortion are permitted with no flight restrictions if the damage condition can be corrected by a simple procedure. For example, damage that can be corrected when you smooth nicks or gouges is called “allowable damage”.

The allowable damage limits for the major assemblies and component parts are defined in the applicable chapter section subject of the SRM.

Make sure to refer to the applicable allowable damage chapter section subject in chapter 52 thru 57 of the SRM for the rework limits and the necessary shot peening data.

Allowable damage

It is recommended the use of an optical micrometer with a tripod base to find the depth of the damaged in the material

Hidden cracks can be included with other types of damage, such as dents, nicks, gouges, scratches, cracks, and punctures.

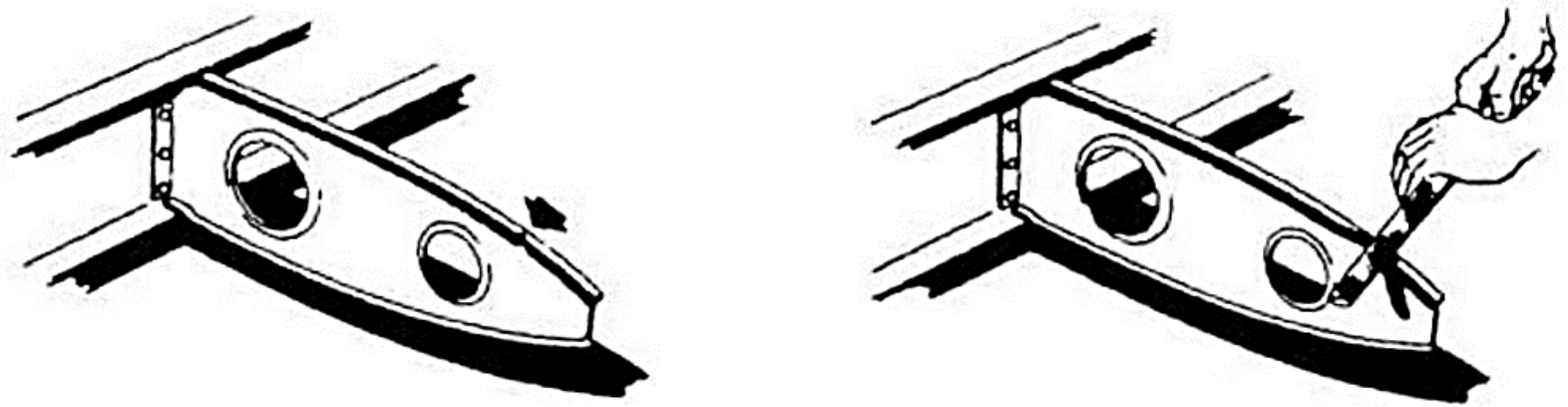
Evaluation of damage

To determine the damage category:

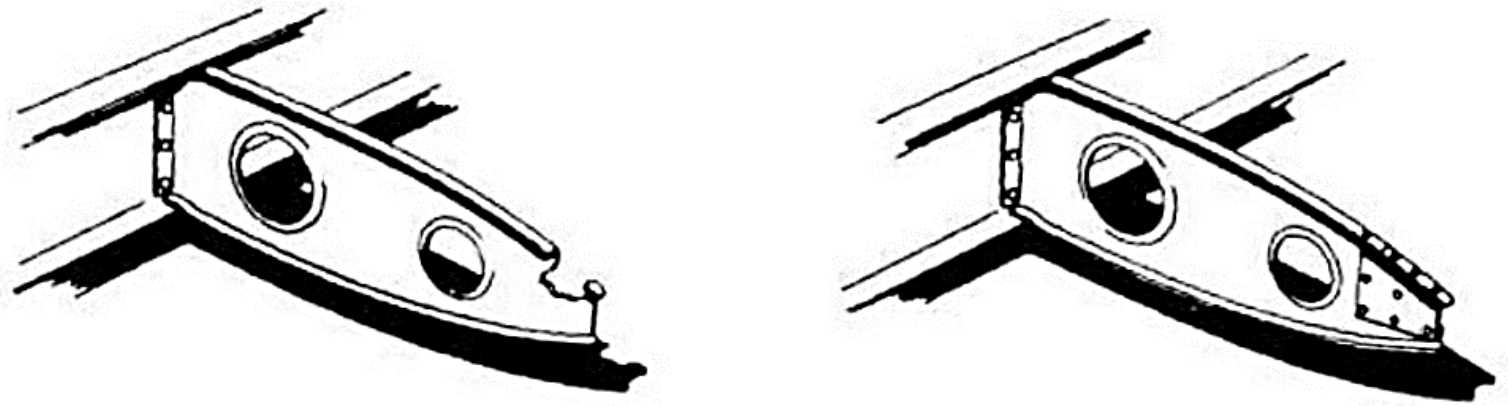
- Remove all unwanted material from the surface of the damaged component
- Cut out all broken, bent, heated or damaged areas of the component
- Remove all loose rivets

CAUTION: HIDDEN DAMAGE CAN LEAD TO FAILURE OF THE REPAIR OR THE SURROUNDING STRUCTURE

Evaluation of damage



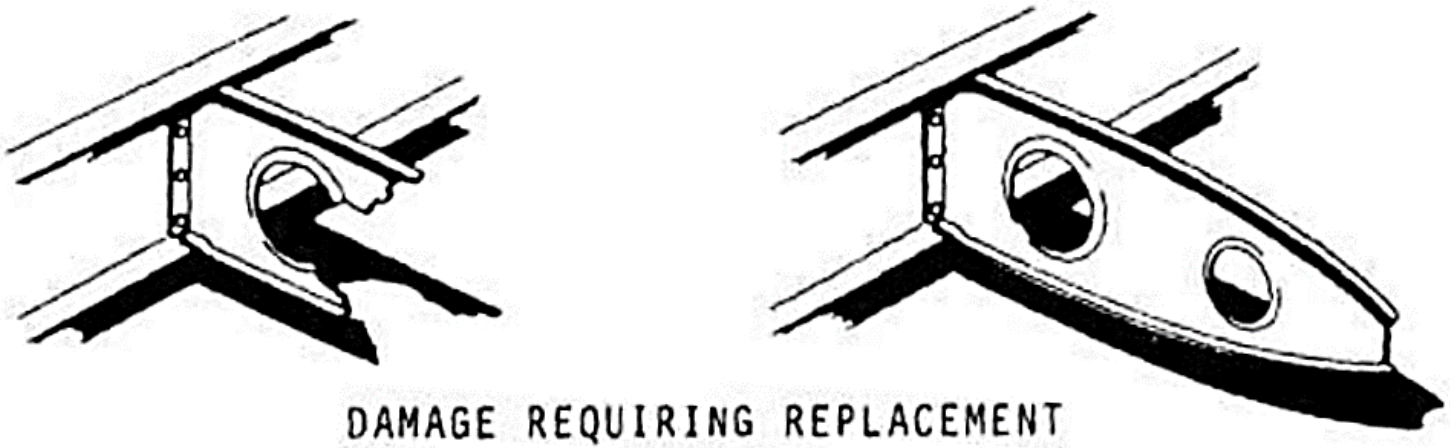
NEGLIGIBLE DAMAGE



DAMAGE REPAIRABLE BY PATCHING

Evaluation of damage

DAMAGE REPAIRABLE BY INSERTION

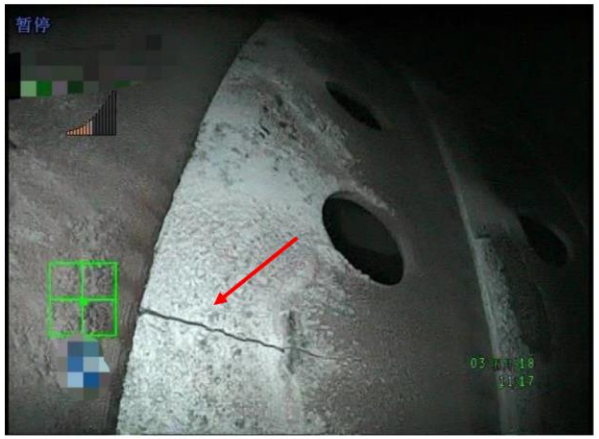


DAMAGE REQUIRING REPLACEMENT

Evaluation of damage

- In all forms of damage, particularly where shock has been sustained, **secondary damage is likely to exist**.
- Therefore, **a close examination of the structure surrounding the initial damage must be made**.
- If misalignment or twisting of the airplane structure is suspected, **alignment and/or leveling checks must be carried out.**

a. Crack in fuselage



b. Crack in engine

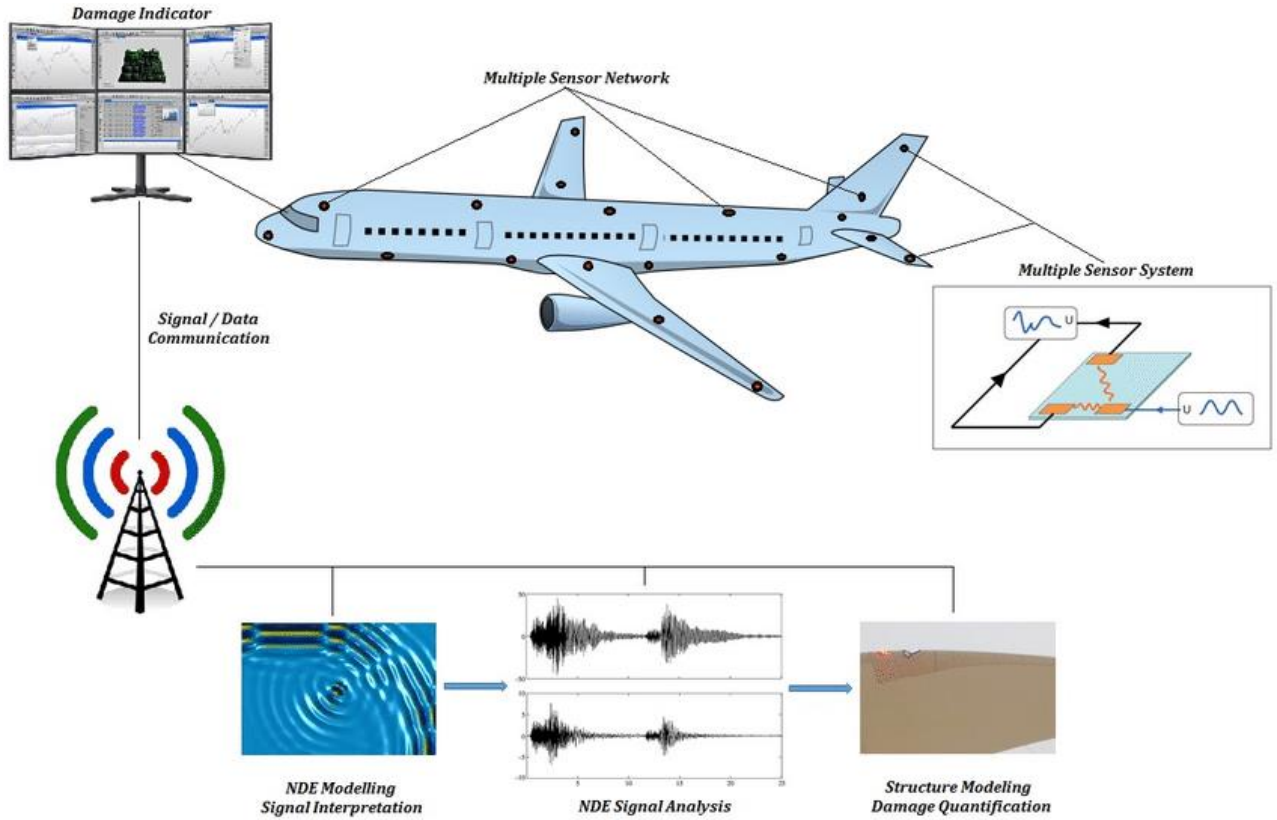
c. Pavement cracks

d. Concrete cracks

Evaluation of damage

Nondestructive testing (NDT)

Structural health monitoring (SHM)



Inspection methods

Inspections are an important part of the effort **to prevent structural failures**. Inspections are required on both new aircrafts and aircrafts that are in service.

Each of the inspection's methods presented have limitations regarding the size of the anomalies that can be detected and the materials on which the technique can be used.

Inspection methods

Typical NDT methods:

1. Visual inspections
2. Dye penetrant testing
3. Magnetic particles
4. Eddy current testing
5. Ultrasonic testing
6. Radiographic testing (x-ray, gamma ray)
7. Thermography
8. Acoustic emission
9. Tap testing

Inspection methods

Visual inspections

- Level 1: walkaround
- Level 2: general visual inspection
- Level 3: detailed visual inspection
- Level 4: special detailed visual inspection

NOTE

The inspections intervals for each of these methods vary depending on the capability of the method to detect damage.

Probability of detection

We cannot assume that the crack will be detected during a certain inspection. To make certain that the damage detection period will find cracks before they become critical, the probability of detection is included.

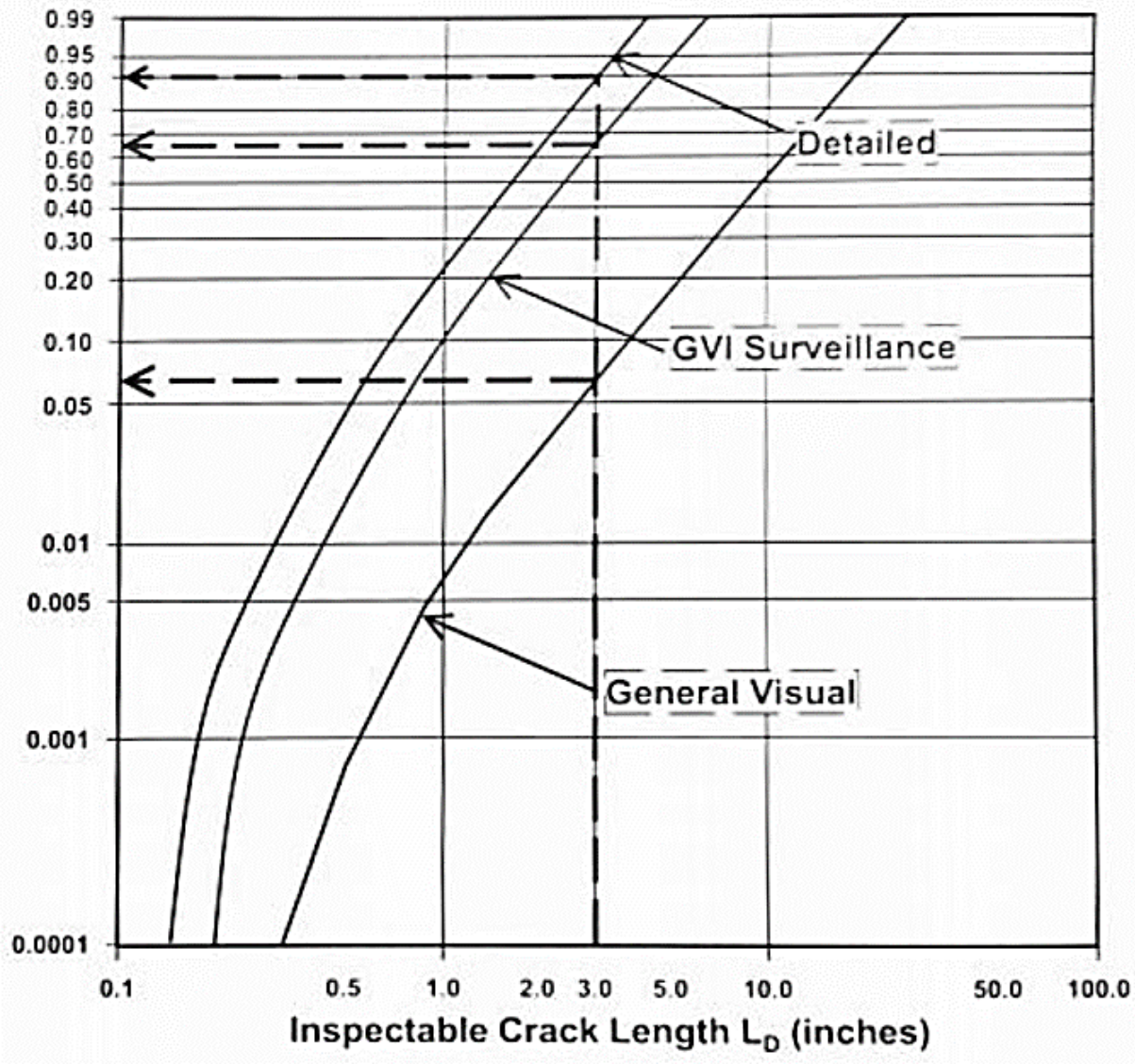
For example:

60 % of the inspectors found a 1-inch crack during a general visual inspection. At a detailed inspection level, 90 % of the inspectors found the same size crack.

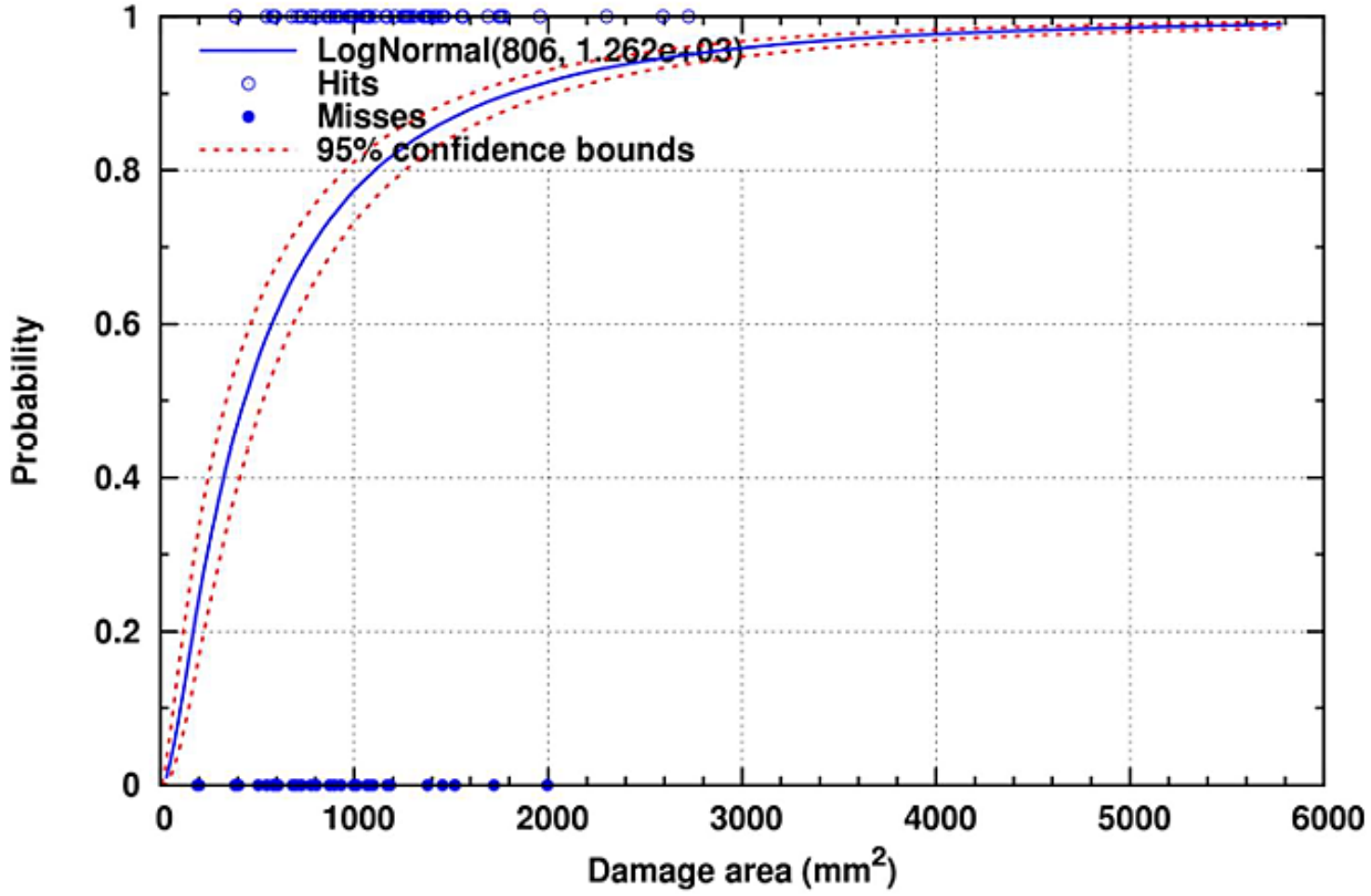
Probability of detection

Probability of detection can be used to:

- Aid establishment of acceptance requirements
- Set maintenance inspection intervals
- Choose appropriate NDI methods
- Select qualified operators



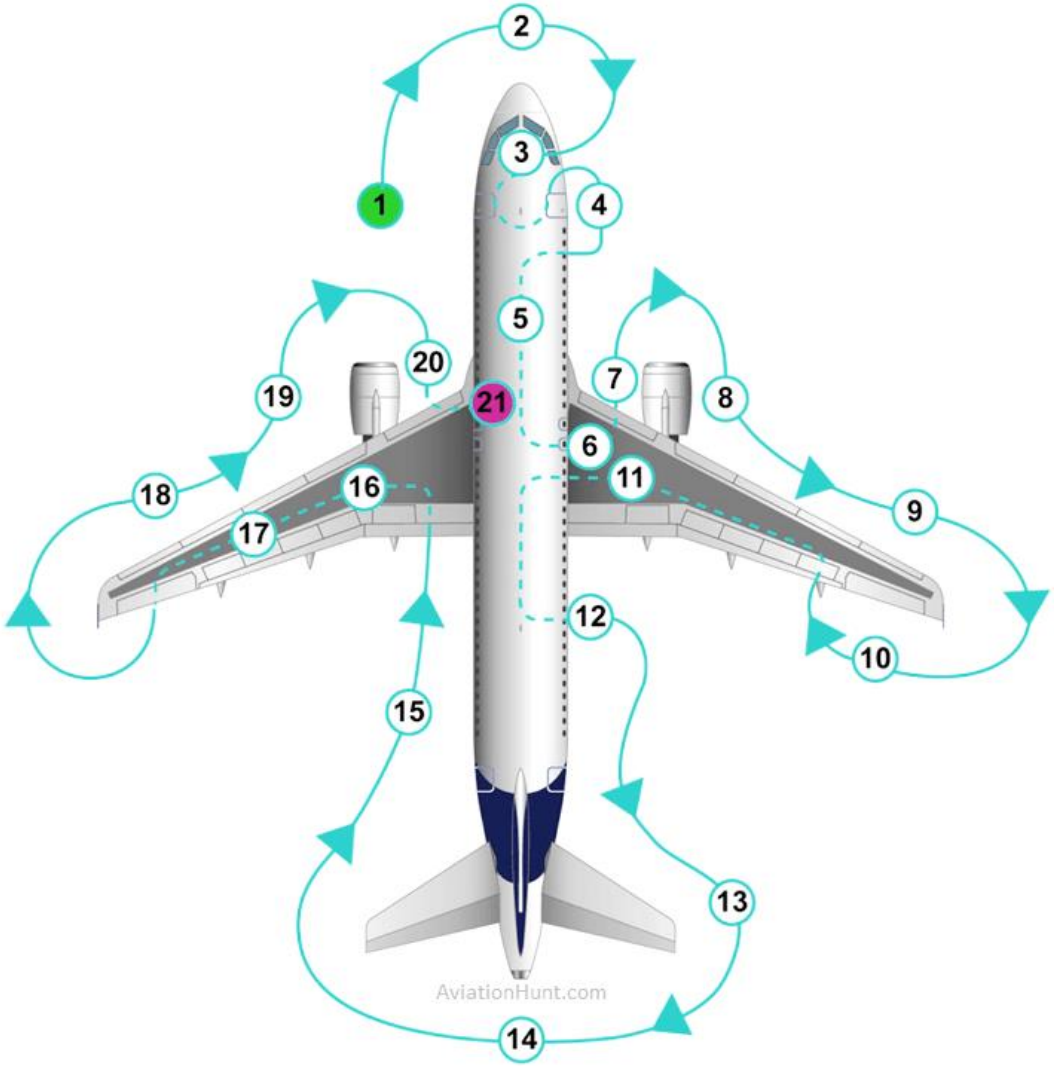
Probability of detection



Visual inspection

Level 1: walkaround

General visual inspection of the entire aircraft (skin, engines, control surfaces, nacelles, cowlings, antennas, tires, etc.) to look for damage and malfunction of aircraft components.



Visual inspection

Level 2: general visual inspection (GVI)

Also known as surveillance, is a visual examination of an interior or exterior area, installation or assembly to detect obvious damage, failure or irregularities.

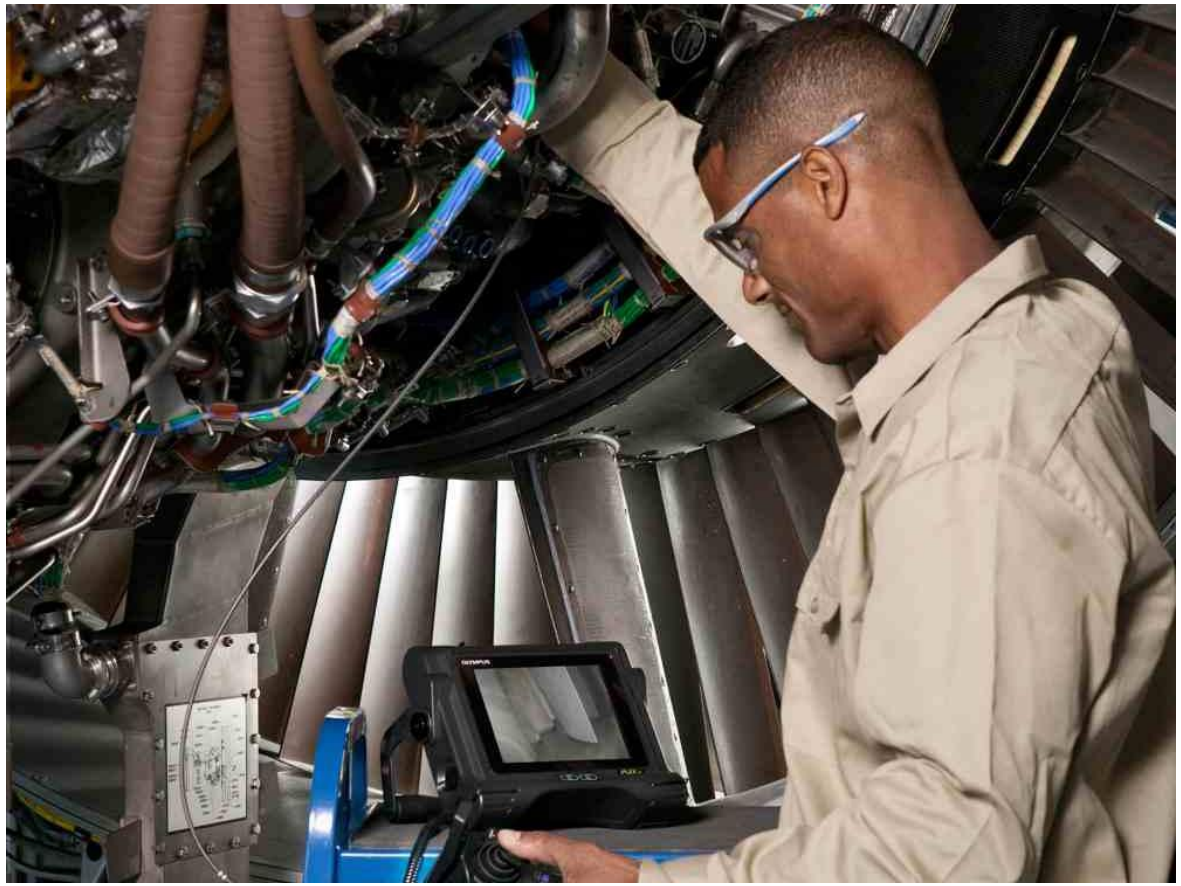
GVI use normally available light such as daylight, hangar light, flash-light, drop-light, and may require removal or opening of access panels or doors.

Visual inspection

Level 3 and 4: detailed and special detailed visual inspection

Extensive visual inspection testing that involves the use of advanced tools like borescopes or videoscopes for remotely damage detection.

Also another NDT techniques can be performed to assure reliable damage detection.



Visual inspection

Aids

- Mirrors
- Magnifying lens
- Borescopes or videoscopes
- Electronic imaging

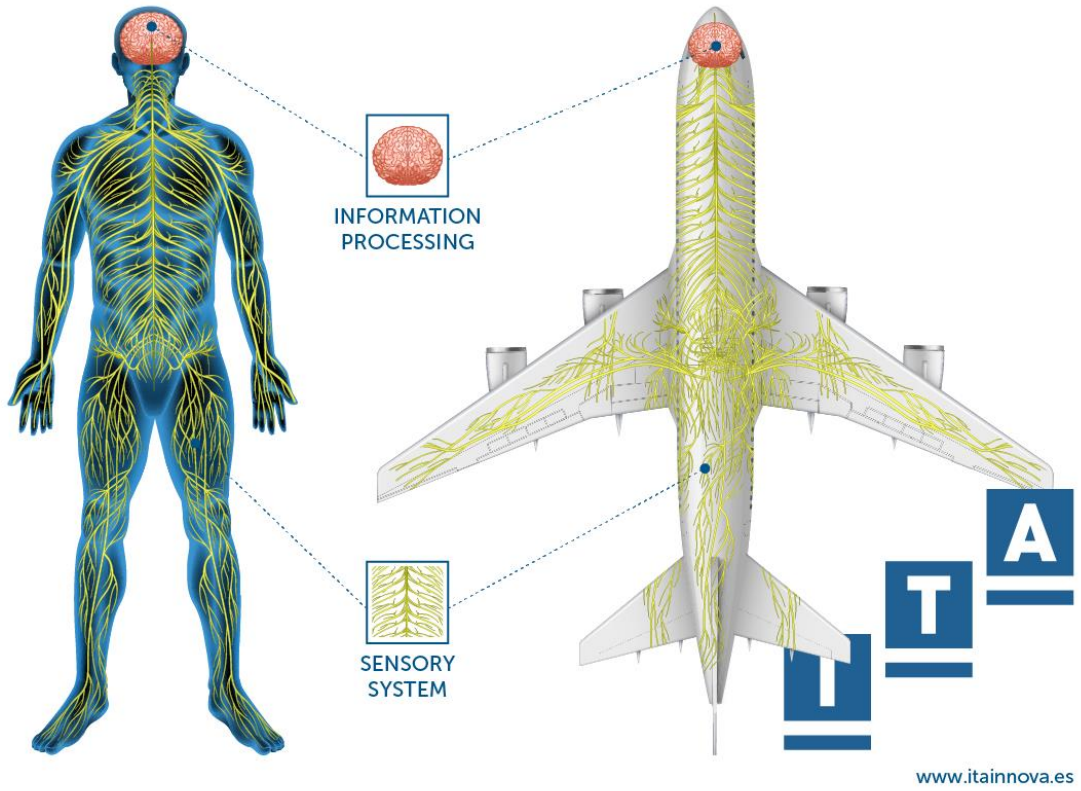
Advantages

- Low cost
- Minimal training,
- Quick results
- Flexibility

Structural health monitoring

Aircraft systems are designed to last under operation for long periods of time.

However, during these cycles, unexpected loads are presented in structures, for which an anomaly or a damage occurrence appear without a proper corrective action deriving often in serious incidents or accidents.



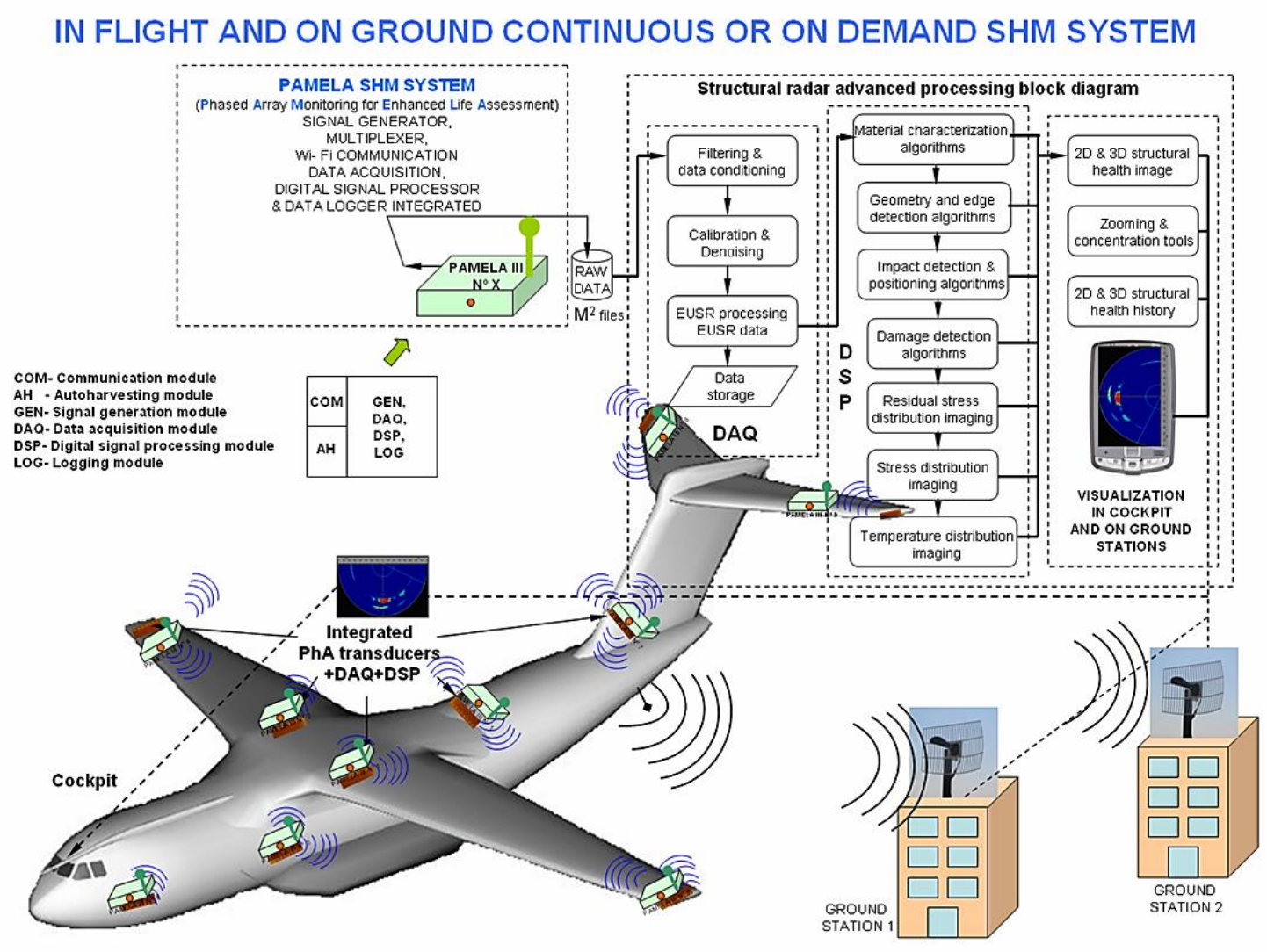
Structural health monitoring

SHM consists of implementation of a strategy for damage prognosis avoiding the human error factor by the automation of processes.

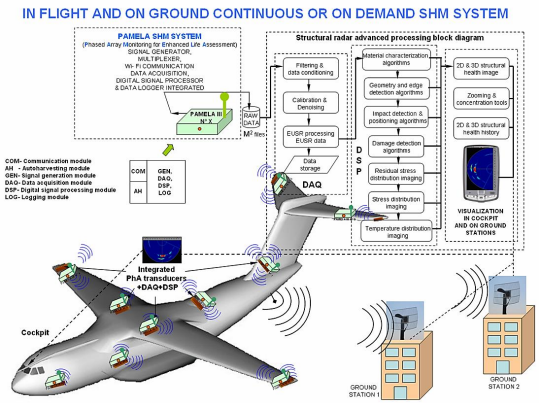
Nowadays, SHM is one of the most promising mechanisms of maintenance to prevent and forestall flaws dissemination in many kind of structures.

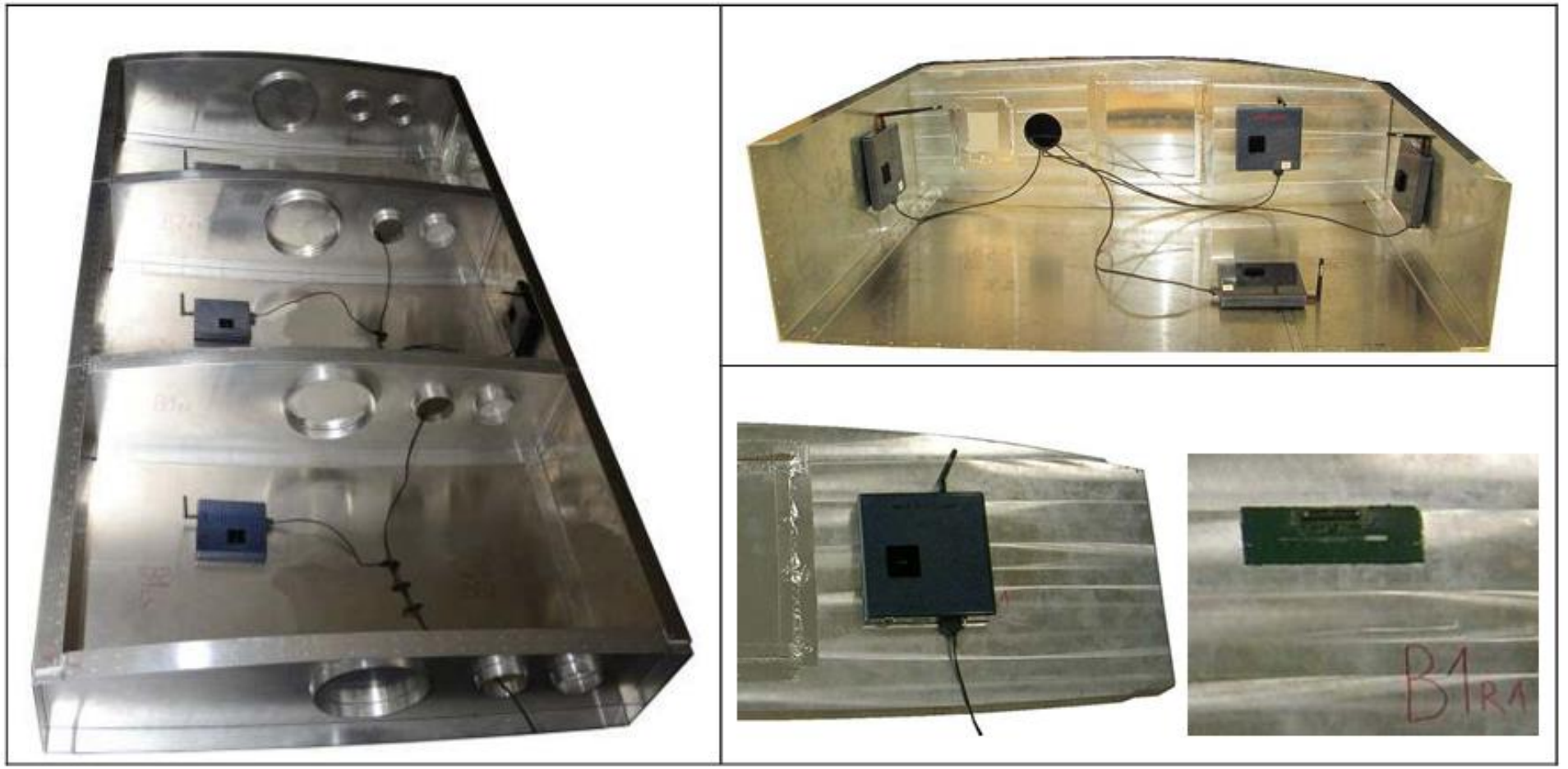
Structural health monitoring

A constant monitoring of aerospace structures is decisive for aircraft airworthiness. Such need of having global information about the structure's health can impact the way maintenance is performed today.



Structural health monitoring





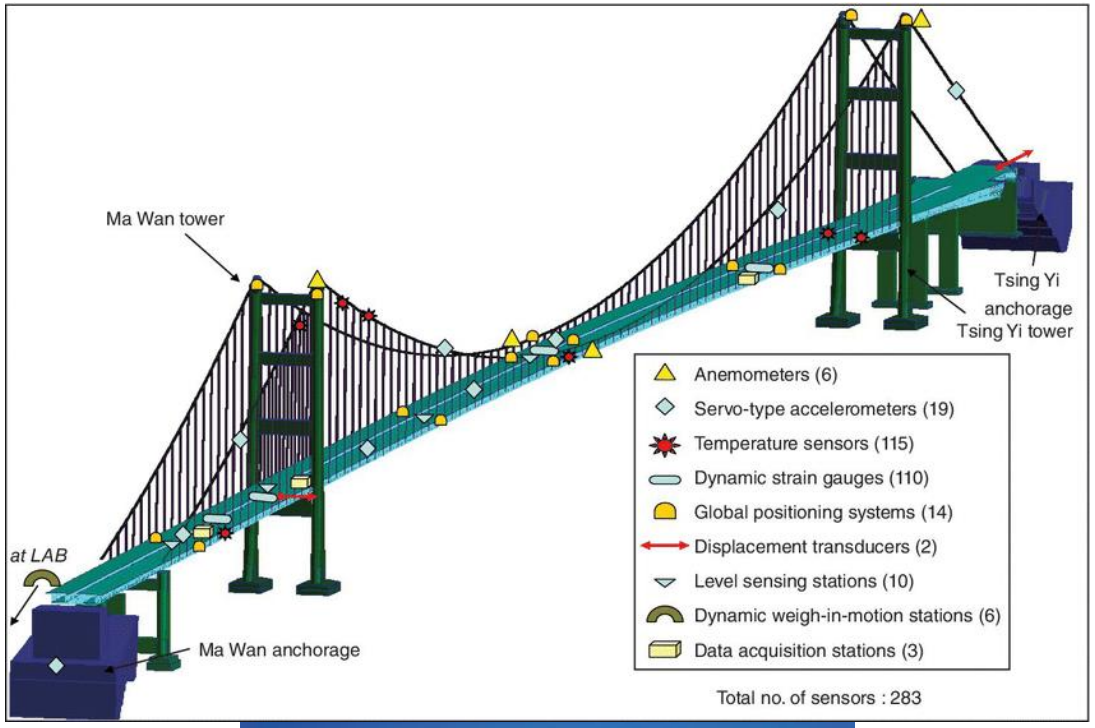
Structural health monitoring

6. SHM Cost – Tsing Ma Bridge

The Wind and Structural Health Monitoring System (WASHMS) at Tsing Ma Bridge has four different levels of operation: sensory systems, data acquisition systems, local centralised computer systems and global central computer system.

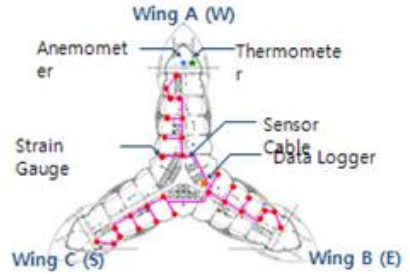
FACTS:

- ✓Origin: Hongkong
- ✓Year: 1997
- ✓Structure Cost: 929 Million
- ✓SHM Cost: USD 8 Million
- ✓350 Sensors
- ✓Cost per Sensor: USD 22,875
- ✓Technology: FOS, Wireless



Structural health monitoring

Photograph (2010)

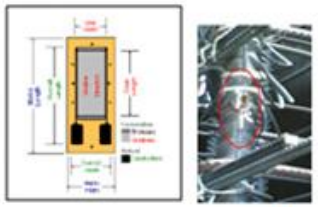


Measuring Instruments

Typical Layout for Strain Monitoring

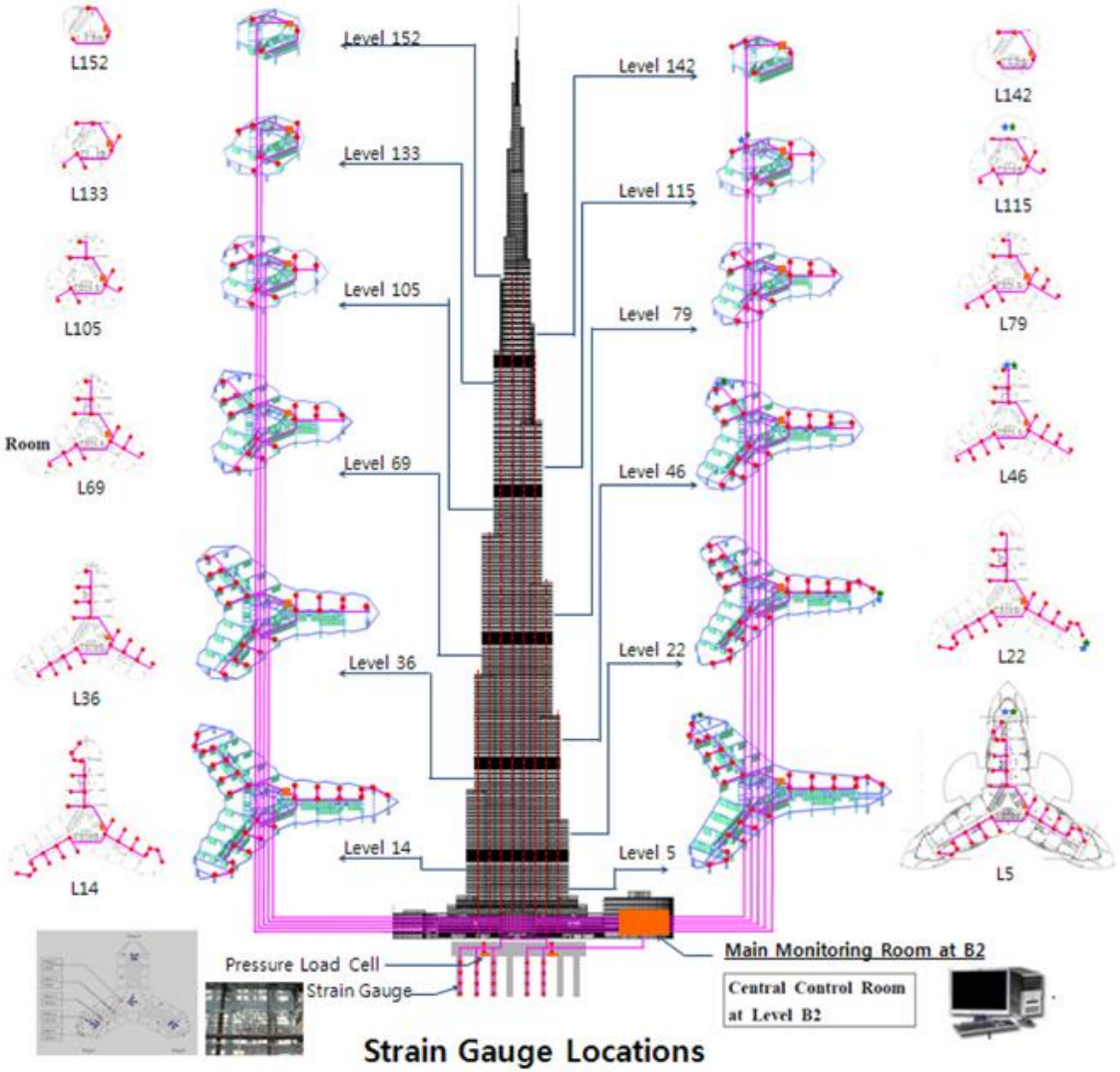
Concrete Embedment Strain Gage

Concrete embedment strain gage, VSM4200 by Geokon



Strain Gages – Electrical Resistance

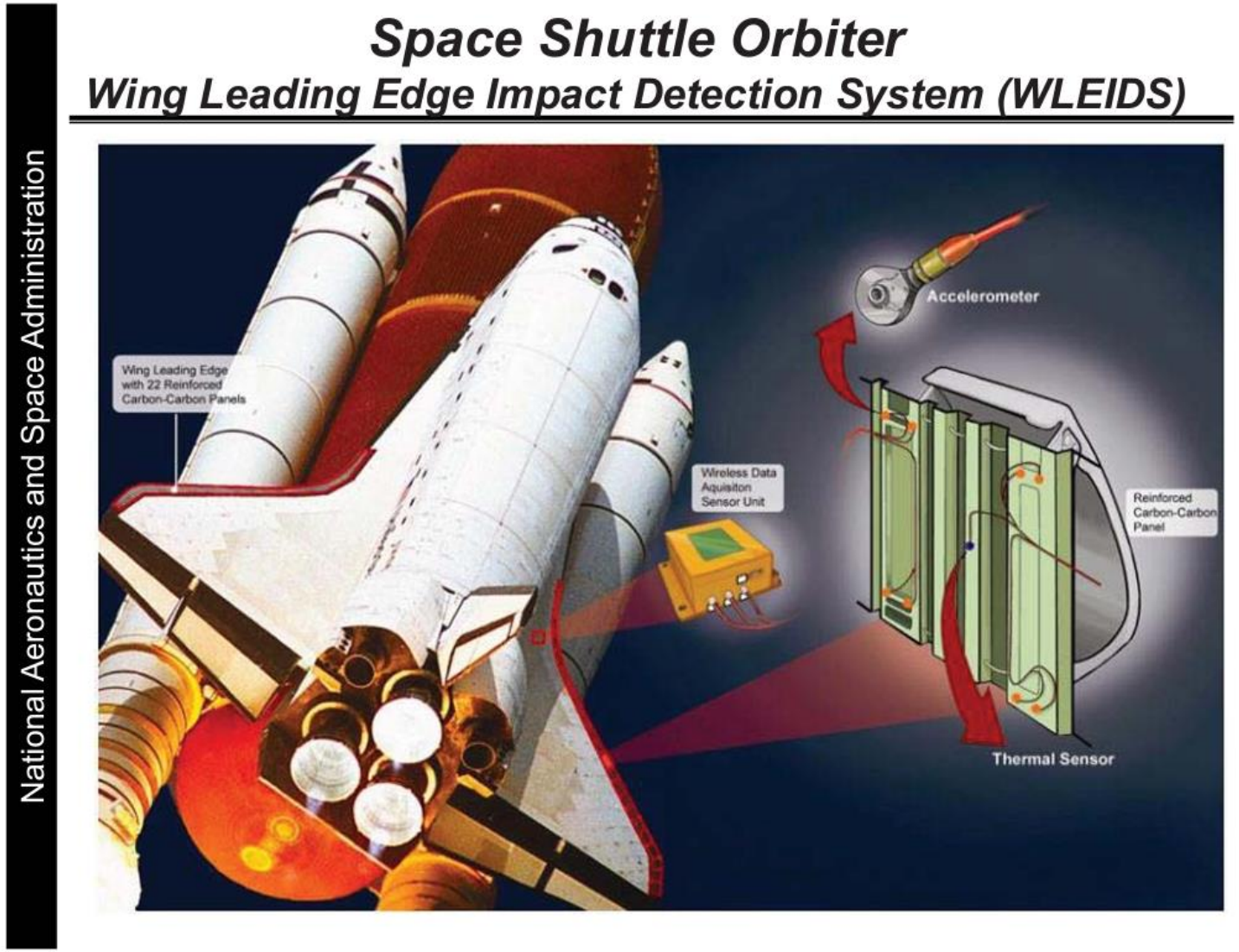
- CEA weldable series W250A by Micro Measurements UK



Strain Gauge Locations

https://global.ctbuh.org/resources/papers/download/1975-validating-the-structural-behavior-and-response-of-burj-khalifa.pdf

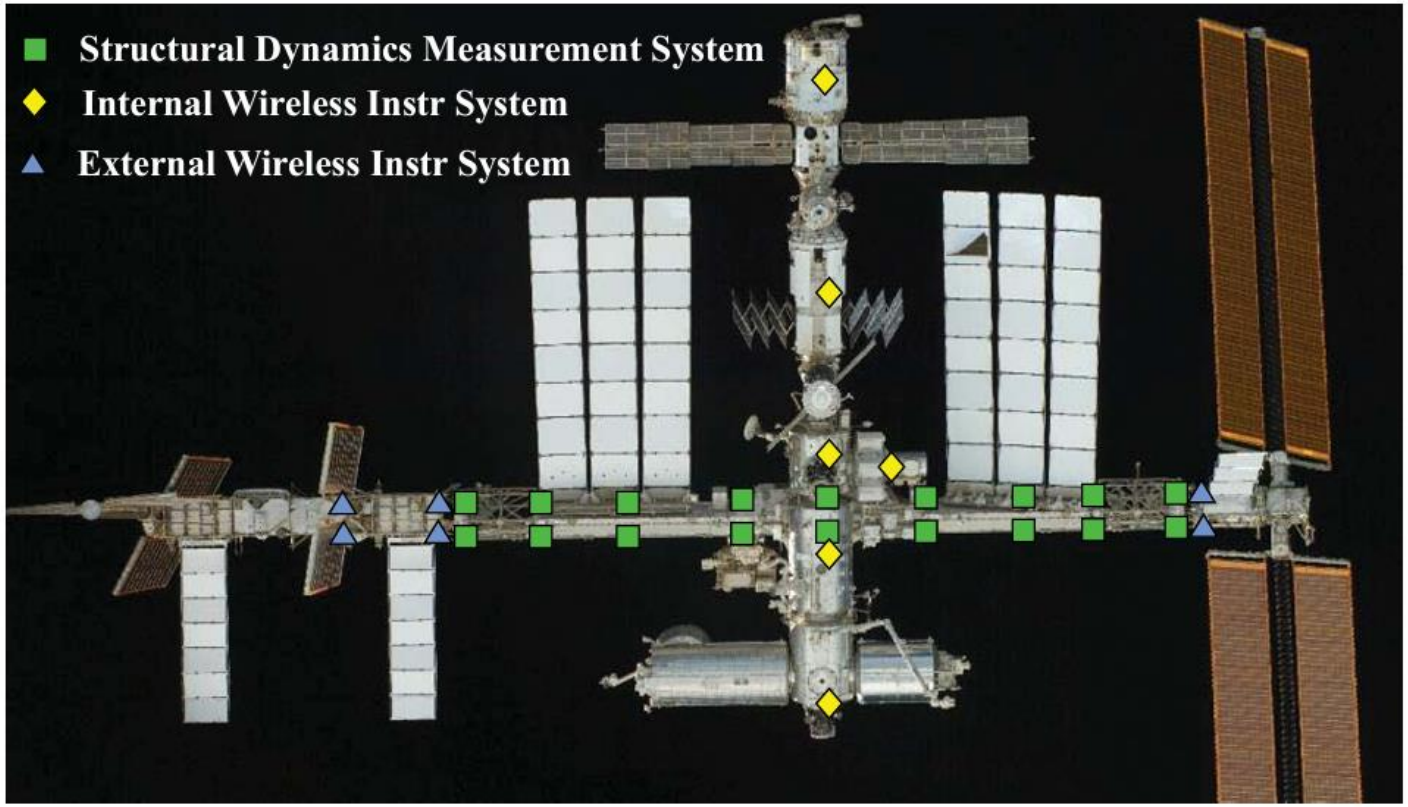
Structural health monitoring



Structural health monitoring

National Aeronautics and Space Administration

ISS Structural Dynamics Accelerometers

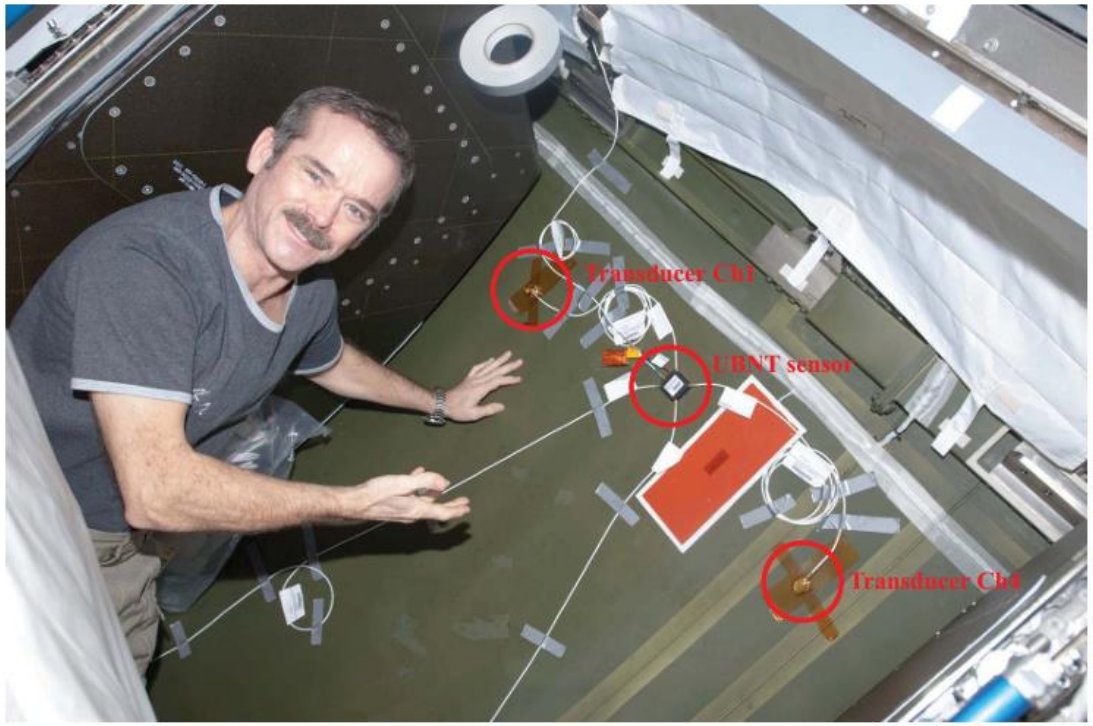


Current accelerometer count on ISS is 81
(SDMS: 33 EWIS: 30 IWIS: 18).

Structural health monitoring

National Aeronautics and Space Administration

Photo of Behind the Rack of USLab1O5 with UBNT Sensors Installed



Installed during Feb, 2013 by Chris Hadfield (shown)

Structural health monitoring

NDT	SHM
Inspection is done be external probes and equipment	Sensors are permanently attached at fixed locations in the structure
Off-line monitoring, parts need to be disassembled for inspection	On-Line monitoring, aircraft inspection may be done in flight or during overnight stops
Time based maintenance, checks must be regularly spaced	Condition based maintenance. Disassembly only when required for repair.
Labour intensive	Evaluation done without human intervention
Mature technologies are available	Still under development for real AC structures

Using the SRM

When you follow a procedure in the SRM **make sure that you do all the steps to the end of the procedure**.

Large blank spaces can occur at the bottom of pages which do not always indicate that you are at the end of the procedure.

If service history supports to have a chapter specific or typical repair, then more repairs are included in the SRM Nevertheless, structural modifications are not included in the SRM.

Using the SRM

If there is no a repair for your damage in the SRM, that means:

- A standard repair is not applicable
- An analysis with the manufacturer is necessary
- Replacement of part is more cost effective
- Service history has not shown a standard repair is needed

Exploring the manual

To identify the material of the damaged part, refer to the applicable material identification data in the SRM.

Refer to the Table of contents of

- the chapter
- E.g. crack in the horizontal stabilizer spar ATA 55

STRUCTURAL REPAIR
CHAPTER 55
STABILIZERS
TABLE OF CONTENTS

Exploring the manual

1. General

   A. This chapter provides structural identification, allowable damage and repairs to the horizontal stabilizer (metal stabilizer), elevators, vertical stabilizer and rudder. Structural identification is also provided for the graphite composite horizontal stabilizer; for inspection and repairs refer to documents D6-46035 and D6-46036.

   B. The terms "fin" and "vertical stabilizer" are used interchangeably in this section to denote the same item. In particular, fin stations and fin water lines are used to provide vertical stabilizer stations as shown in 55-00-1.

   C. The components covered by this chapter are basically similar for all models of the 737 and T-43A airplanes. Where detail differences between airplanes exist, they are denoted by notes.

2. Control Surface Balancing

   A. Refer to 51-80-0 for general information on control surface balancing.

   B. Refer to 51-80-4 for balance requirements and rebalancing instructions for the elevator.

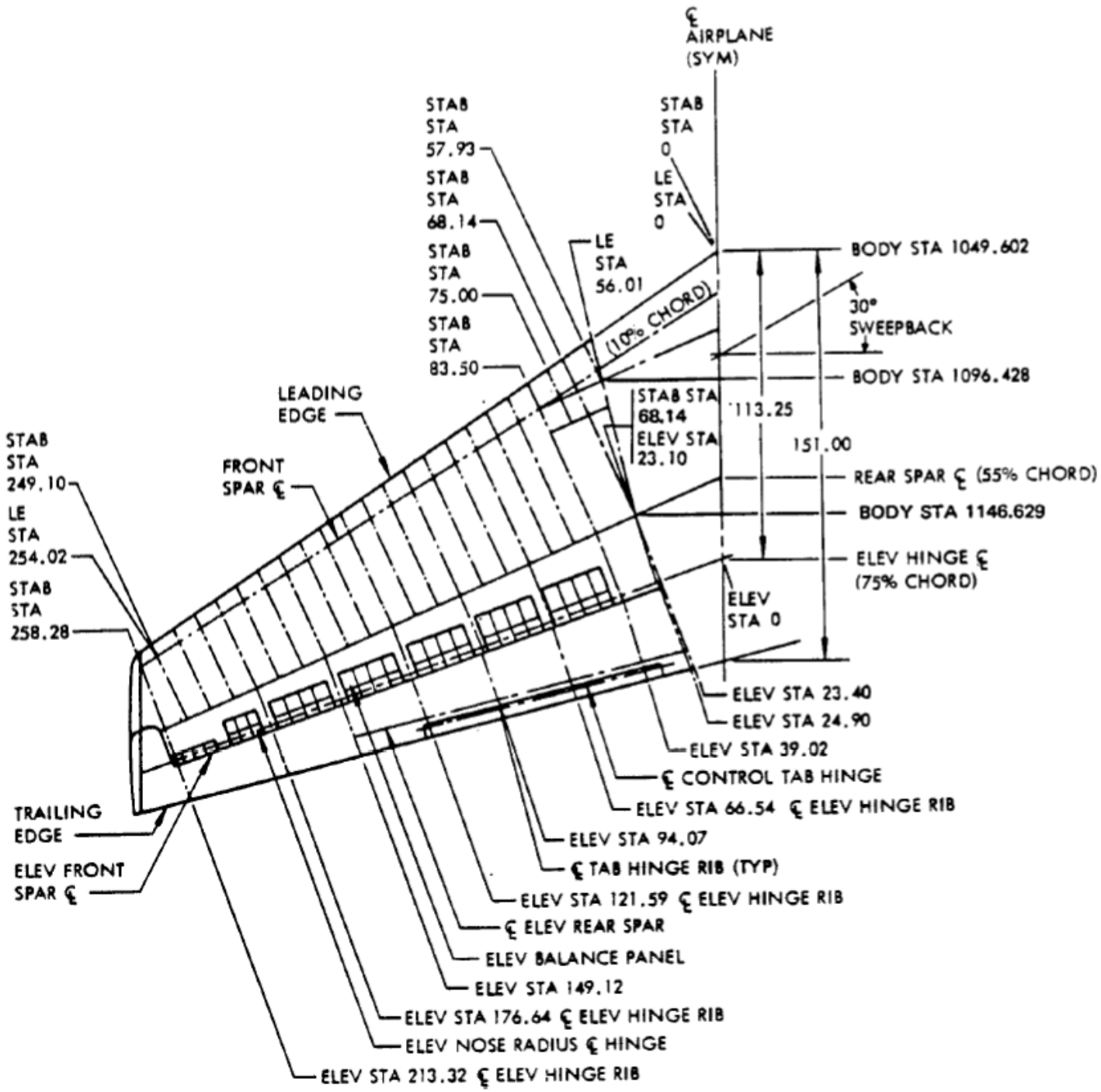
   C. Refer to 51-80-7 for balance requirements and rebalancing instructions for the rudder.

Exploring the manual

BOEING 737

STRUCTURAL REPAIR

CHAPTER 55
STABILIZERS
TABLE OF CONTENTS


℄ AIRPLANE (SYM)
STAB STA 57.93
STAB STA 68.14
STAB STA 75.00
STAB STA 83.50
STAB STA 0
LE STA 0
LE STA 56.01
(10% CHORD)
BODY STA 1049.602
30° SWEEPBACK
BODY STA 1096.428
STAB STA 68.14
ELEV STA 23.10
113.25
151.00
REAR SPAR ℄ (55% CHORD)
BODY STA 1146.629
ELEV HINGE ℄ (75% CHORD)
ELEV STA 0
LEADING EDGE
FRONT SPAR ℄
STAB STA 249.10
LE STA 254.02
STAB STA 258.28
TRAILING EDGE
ELEV FRONT SPAR ℄
ELEV STA 23.40
ELEV STA 24.90
ELEV STA 39.02
℄ CONTROL TAB HINGE
ELEV STA 66.54 ℄ ELEV HINGE RIB
ELEV STA 94.07
℄ TAB HINGE RIB (TYP)
ELEV STA 121.59 ℄ ELEV HINGE RIB
℄ ELEV REAR SPAR
ELEV BALANCE PANEL
ELEV STA 149.12
ELEV STA 176.64 ℄ ELEV HINGE RIB
ELEV NOSE RADIUS ℄ HINGE
ELEV STA 213.32 ℄ ELEV HINGE RIB

Exploring the manual

BOEING 737

STRUCTURAL REPAIR

CHAPTER 55

STABILIZERS

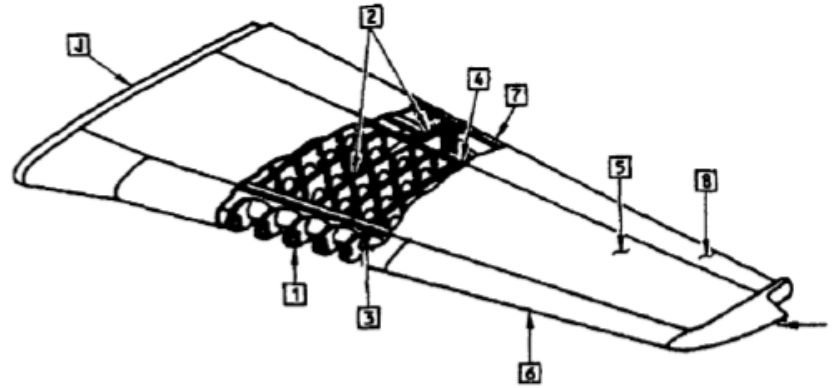
TABLE OF CONTENTS

Exploring the manual

BOEING 737

STRUCTURAL REPAIR

CHAPTER 55
STABILIZERS
TABLE OF CONTENTS



FOR GLASS FABRIC REINFORCED PLASTIC REPAIR, REFER TO SRM 51-40-9

NOTES

- DAMAGE, SUCH AS BLENDOUTS, TRIMOUTS OR DENTS:
  - THAT OCCUR TO A STRUCTURALLY SIGNIFICANT ITEM (SSI) GIVEN IN SRM 51-00-4, FIG. 3 AND,
  - THAT ARE WITHIN THE ALLOWABLE DAMAGE LIMITS OF THE BOEING SRM,

  DO NOT HAVE AN EFFECT ON THE DAMAGE TOLERANCE PROPERTIES OF THE SSI. THEREFORE, EXISTING SUPPLEMENTAL STRUCTURAL INSPECTION DOCUMENT (SSID) INSPECTION PROGRAMS REMAIN EFFECTIVE.
- D = THE LARGEST DAMAGE DIMENSION
- REFER TO SRM 51-10-1 FOR DAMAGE CLASSIFICATION.
- REFER TO SRM 51-10-2 FOR PROTECTIVE TREATMENT OF METAL REPAIR PARTS.
- REFER TO SRM 51-10-6 FOR CORROSION REMOVAL.
- REFER TO FIGURE 2 FOR ALLOWABLE CORROSION DAMAGE TO THE HORIZONTAL STABILIZER SKIN.
- REFER TO FIGURE 3 FOR ALLOWABLE CORROSION DAMAGE TO THE WEB AND THE CHORDS OF THE REPAIR AREA.
- REFER TO SRM 51-70 FOR AERODYNAMIC SMOOTHNESS.
- A REPAIR OR REPLACEMENT OF A STRUCTURAL MEMBER IS REQUIRED WHEN IT HAS BEEN SUBJECTED TO DAMAGE SUCH AS NICKS, SCRATCHES, GOUGES, DENTS AND HOLES THAT EXCEED THE ALLOWABLE DAMAGE.

[A] ON ANY REFERENCE LINE A-B DRAWN BETWEEN RIB OR SPAR CHORDS AS SHOWN IN DETAIL IV, THE MAXIMUM ALLOWABLE CROSS SECTIONAL AREA REMOVED FROM THE WEB INCLUDING ALL FASTENER HOLES, SCRATCHES AND GOUGES MUST NOT EXCEED 20% OF THE TOTAL CROSS SECTIONAL AREA BETWEEN A AND B.

ON ANY REFERENCE LINE M-N DRAWN THROUGH AN EXISTING LIGHTENING HOLE AS SHOWN IN DETAIL IV, THE MAXIMUM ALLOWABLE CROSS SECTIONAL AREA REMOVED FROM THE WEB INCLUDING ALL FASTENER HOLES, SCRATCHES AND GOUGES MUST NOT EXCEED 20% OF THE TOTAL CROSS SECTIONAL AREA BETWEEN M AND N.

[B] CLEAN UP CORROSION, GOUGES, NICKS AND SCRATCHES AS SHOWN IN DETAILS I, II, V, VI AND VII. THE MAXIMUM DEPTH (X) OF CORROSION, A GOUGE, A NICK OR A SCRATCH MUST NOT BE MORE THAN THESE LIMITS:

- 20% OF THE THICKNESS FOR THE SPAR WEB, THE LEADING EDGE RIBS AND THE TRAILING EDGE RIBS
- 25% OF THE THICKNESS OF THE SKINS
- 10% OF THE THICKNESS OR WIDTH OF THE FLANGE FOR THE SPAR CHORDS, THE RIB CHORDS AND THE TRAILING EDGE BEAM. [A] [G]

IGNORE ALL NICKS, GOUGES AND SCRATCHES THAT DO NOT GO THROUGH THE CLAD SURFACES. REFER TO SRM 51-10-1, PAR. 7.

Horizontal Stabilizer Allowable Damage
Figure 1 (Sheet 1)

NOTES (CONTINUED)

C DENTS ARE PERMITTED AS SHOWN IN DETAIL III. THE DAMAGE MUST NOT BE LESS THAN 4D (EDGE TO EDGE) FROM OTHER DAMAGE. REFER TO 51-7D FOR THE CRITICAL AERODYNAMIC AREAS.

D NO DENT DAMAGE IS ALLOWED ON RIB OR SPAR WEB STIFFENERS. REPLACE ALL STIFFENERS THAT SHOW DENT DAMAGE.

NO DENT DAMAGE IS ALLOWED ON RIB CHORD FLANGES. REPAIR OR REPLACE ALL RIB CHORDS THAT SHOW DENT DAMAGE.

NO DENT DAMAGE IS PERMITTED ON THE SPAR CHORD FLANGES OR THE TRAILING EDGE BEAM FLANGES. REPAIR OR REPLACE SPAR CHORDS AND TRAILING EDGE BEAMS THAT SHOW DENT DAMAGE.

E HOLE DAMAGE IN WEB STIFFENERS MUST NOT EXCEED THE LARGEST EXISTING RIVET OR BOLT FASTENER DIAMETER IN THE AREA OF THE DAMAGED PART OR TO EXCEED 20% OF THE FLANGE DIMENSION H. USE WHICHEVER VALUE IS SMALLER. FILL ALL HOLES WITH ALUMINUM RIVETS. SEE DETAIL IV.

F REPAIR ALL HOLES PER 51-40-6, FIG. 1, EXCEPT ORIGINAL REQUIRED DRAIN HOLES.

G ON ANY REF LINE A-B DRAWN BETWEEN THE REAR SPAR CHORDS, THE MAX ALLOWABLE CROSS SECTIONAL AREA REMOVED FROM THE WEB INCLUDING ALL FASTENER HOLES, SCRATCHES AND GOUGES MUST NOT EXCEED 10% OF THE TOTAL CROSS SECTIONAL AREA BETWEEN A AND B. THE 10% LIMIT IS APPLICABLE BETWEEN STAB STA 66.5 TO 120.3. NO HOLES ARE ALLOWED INBOARD OF STAB STA 66.5 FOR HOLES OUTSIDE THE ABOVE LIMITS. SEE A.

H ALL HOLES IN THE REAR SPAR WEB WHICH OCCUR IN THE BALANCE PANEL CAVITY MUST BE SEALED AGAINST AIR PRESSURE.

I ALL CRACKED PARTS MUST BE REPAIRED. REFER TO SRM 51-10.

CRACKS AT FLANGE EDGES MUST BE REWORKED AS SHOWN IN DETAILS I, II AND V.

THE TOTAL AREA THAT IS REMOVED MUST NOT DECREASE THE TOTAL CROSS SECTIONAL AREA MORE THAN 20%. THE AREA THAT IS REMOVED INCLUDES FASTENER HOLES, GOUGES, NICKS AND SCRATCHES.

J NO HOLES ARE ALLOWED OTHER THAN THE ORIGINAL HOLES REQUIRED BY THE MANUFACTURER.

K FOR ALLOWABLE DAMAGE ON GLASS FABRIC REINFORCED PANELS OR GLASS FABRIC REINFORCED HONEYCOMB PANELS SEE 51-40-6.

L REFER TO FIGURE 3.

M ON A REFERENCE LINE DRAWN BETWEEN FRONT AND REAR SPARS, PERPENDICULAR TO THE REAR SPAR, THE CROSS SECTIONAL AREA REMOVED INCLUDING ALL EXISTING HOLES SHALL NOT EXCEED 15% OF THE TOTAL CROSS SECTIONAL AREA OF THE SHEET, NOR SHALL THE CROSS SECTIONAL AREA OUT IN ANY LOCAL REGION EXCEED 15% OF THE LOCAL, CROSS SECTIONAL AREA. ANY HOLE WITHIN 30 DEGREES OF THE CLOSEST HOLE ON THE REFERENCE LINE SHALL BE INCLUDED IN THE TOTAL CROSS SECTIONAL AREA OUT. INCLUDE SCRATCHES AND GOUGES IN THE AREA OUT.

N MAXIMUM DIAMETER OF ANY HOLE SHALL BE 4 TIMES THE SKIN THICKNESS OR 0.25 WHICHEVER IS GREATER PROVIDED DAMAGE IS AT LEAST 1.00 INCH FROM ANY OTHER HOLE, PART EDGE, OR OTHER DAMAGE.

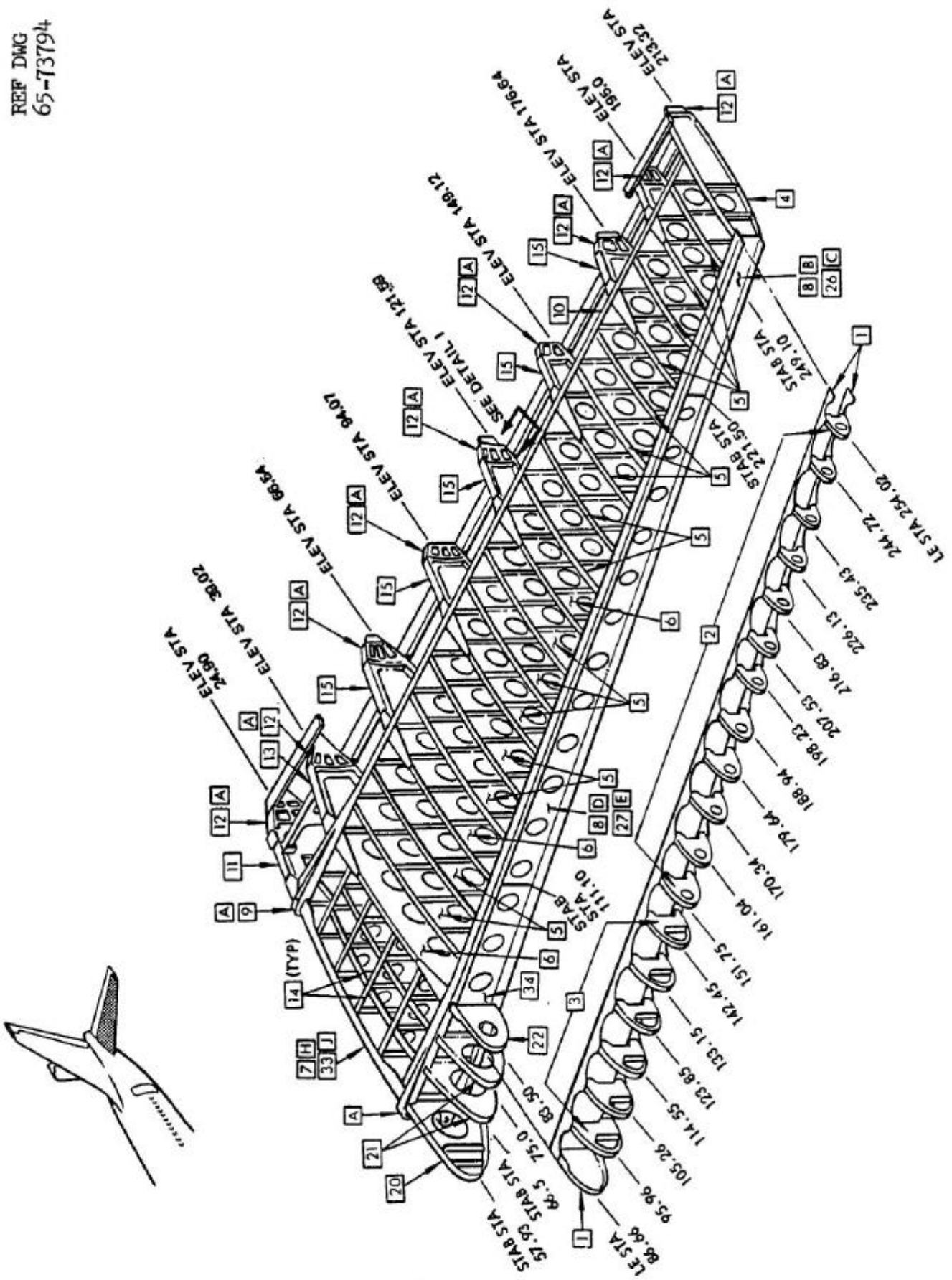
$$\frac{d1 + d2 + d3 - - + d15}{b1} = .15 \text{ MAX}$$

$$\frac{\frac{d7}{2} + d8 + d9 + \frac{d10}{2}}{b2} = .15 \text{ MAX}$$

Horizontal Stabilizer Allowable Damage
Figure 1 (Sheet 2)

Exploring the manual

REF DWG
65-73794



Horizontal Stabilizer Structure Identification
(Metal Stabilizer)
Figure 2 (Sheet 7)

ITEM	UPPER CHORD		WEB OR FORMED SECTION		LOWER CHORD	
	MATERIAL	REPAIR FIG. NO.	MATERIAL	REPAIR FIG. NO.	MATERIAL	REPAIR FIG. NO.
1			0.063 CLAD 2024-T3			
2			0.050 CLAD 2024-T42			
3	BAC1503-1430 2024-T42		0.010 + 0.010 CLAD 2024-T3		BAC1503-100235 2024-T4	
4	BAC1505-100583 7075-T6		0.032 CLAD 2024-T3		BAC1505-100583 7075-T6	
5	BAC1505-100556 7075-T6	55-10-4 FIG. 1, 2	0.010 + 0.010 CLAD 2024-T3 BONDED	55-10-3 FIG. 7, 8	BAC1505-100556 7075-T6	55-10-4 FIG. 1, 2
6	BAC1505-100557 7075-T6	55-20-4 FIG. 1, 2	0.016 + 0.016 CLAD 2024-T3	55-1-3 FIG. 8	BAC1505-100557 7075-T6	55-10-4 FIG. 1, 2
7	BAC1503-8893 7075-T6		0.025 + 0.025 CLAD 2024-T3 BONDED		BAC1503-8893 7075-T6	
8	BAC1506-1763 7075-T6511	55-10-5 FIG. 1	0.040 CLAD 7075-T6	55-10-5 FIG. 2	BAC1506-1764 7075-T6511	55-10-5 FIG. 1
9	BAC1506-1766 2024-T3511		0.180 CLAD 7075-T6		BAC1506-1767 7075-T6511	
10					BAC1506-1767 7075-T6511	55-10-5 FIG. 1
11	BAC1505-100593 7075-T6		0.020 CLAD 2024-T3		BAC1505-100593 7075-T6	
12			7075-T3 MACHINED FORGING			
13	BAC1505-100592 7075-T6		ALUM HONEYCOMB		BAC1505-100592 7075-T6	
14			BAC1505-18884 7075-T6511			

Horizontal Stabilizer Structure Identification
(Metal Stabilizer)
Figure 2 (Sheet 1)

BOEING 737
STRUCTURAL REPAIR

ITEM	UPPER CHORD		WEB OR FORMED SECTION		LOWER CHORD	
	MATERIAL	REPAIR FIG. NO.	MATERIAL	REPAIR FIG. NO.	MATERIAL	REPAIR FIG. NO.
15	BAC1505-100551 7075-T6		ALUM HONEYCOMB		BAC1505-100551 7075-T6	
16			MACHINED FROM 0.18 7075-T6			
17			0.016 + 0.016 CLAD 7075-T6	55-10-5 FIG. 3		
18			0.010 + 0.010 CLAD 7075-T6	55-10-5 FIG. 3		
19	BAC1506-1766 2024-T3511 (UPPER CHORD) BAC1520-1367 7075-T6511 (FAIL SAFE CHORD)	55-10-5 FIG. 1				
20	BAC1503-100195 2024-T42		0.050 CLAD 2024-T3		BAC1514-1720 2024-T42	
21	BAC1503-100242 2024-T42		0.010 + 0.010 CLAD 2024-T3		BAC1503-100242 2024-T42	
22	BAC1505-100578 2024-T42		0.010 + 0.010 CLAD 2024-T3		BAC1505-100578 2024-T42	
23	0.050 CLAD 2024-T4				0.050 CLAD 2024-T4	
24	0.040 CLAD 2024-T4				0.040 CLAD 2024-T4	
25	0.063 CLAD 2024-T42				0.063 CLAD 2024-T42	
26	BAC1506-1763 7075-T6511		0.012 + 0.012 BONDED 7075-T6 CLAD		BAC1506-1764 7075-T6511	
27	BAC1506-1763 7075-T6511		0.050 CLAD 7075-T6		BAC1506-1764 7075-T6511	

Horizontal Stabilizer Structure Identification
(Metal Stabilizer)
Figure 2 (Sheet 2)

Repair of a damaged part

BOEING 737

STRUCTURAL REPAIR

REPAIR INSTRUCTIONS

1. Remove leading edge skin assembly panels as required per the Maintenance Manual 55-10-1.
2. If access to the damage cannot be reached through the holes in the spar web remove inspar skin fasteners along the ribs and spar chords and lift skin up as required to gain access.
3. Stop crack with a 0.25 dia hole.
4. Drill out fasteners and remove stiffener rivets as required to install repair part.
5. Fabricate repair parts.
6. Drill holes in repair parts to match holes in spar web.
7. Bond and rivet part [1] to web as outlined in 51-40-5.
8. Replace web stiffener and chord rivets using size and type of fasteners as in original installation.
9. Replace removed skins and leading edge panels and all fasteners.
10. Restore interior and exterior finish.

NOTE

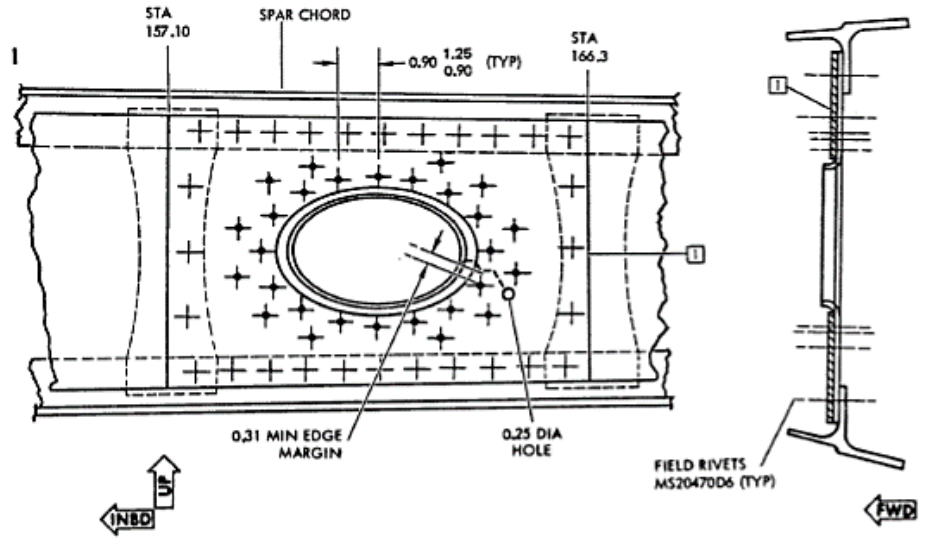
- THIS REPAIR IS APPLICABLE TO REPAIRS ON THE FRONT SPAR WEB BETWEEN STABILIZER STA 157.10 AND 221.50.
- REFER 51-10-2 FOR METAL PROTECTIVE TREATMENT.
- BREAK SHARP EDGES 0.03R ON ALL REPAIR PARTS AND TRIMMED ORIGINAL PARTS.
- REFER 51-30 FOR FASTENER CODES, REMOVAL AND INSTALLATION, HOLE SIZES AND EDGE MARGINS.
- REFER 51-21-0 OF THE MAINTENANCE MANUAL FOR FINISH REQUIREMENTS.

┼ ORIGINAL FASTENER LOCATIONS.

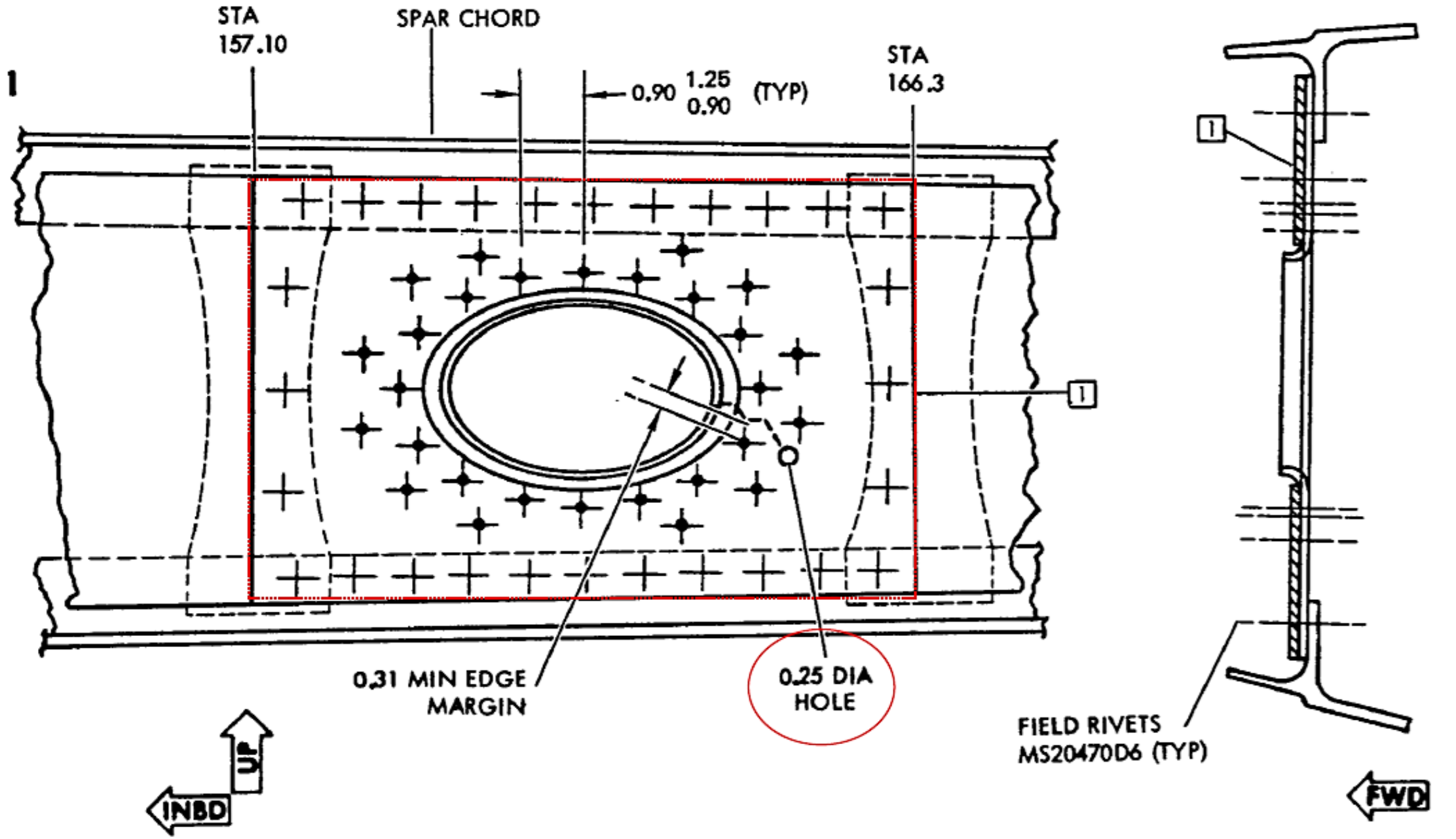
✚ REPAIR FASTENER LOCATIONS.

REPAIR MATERIAL			
PART		QTY	MATERIAL
[1]	PLATE	1	0.080 CLAD 7075-T6

Horizontal Stabilizer Front Spar Web Repair
Figure 2 (Sheet 1)



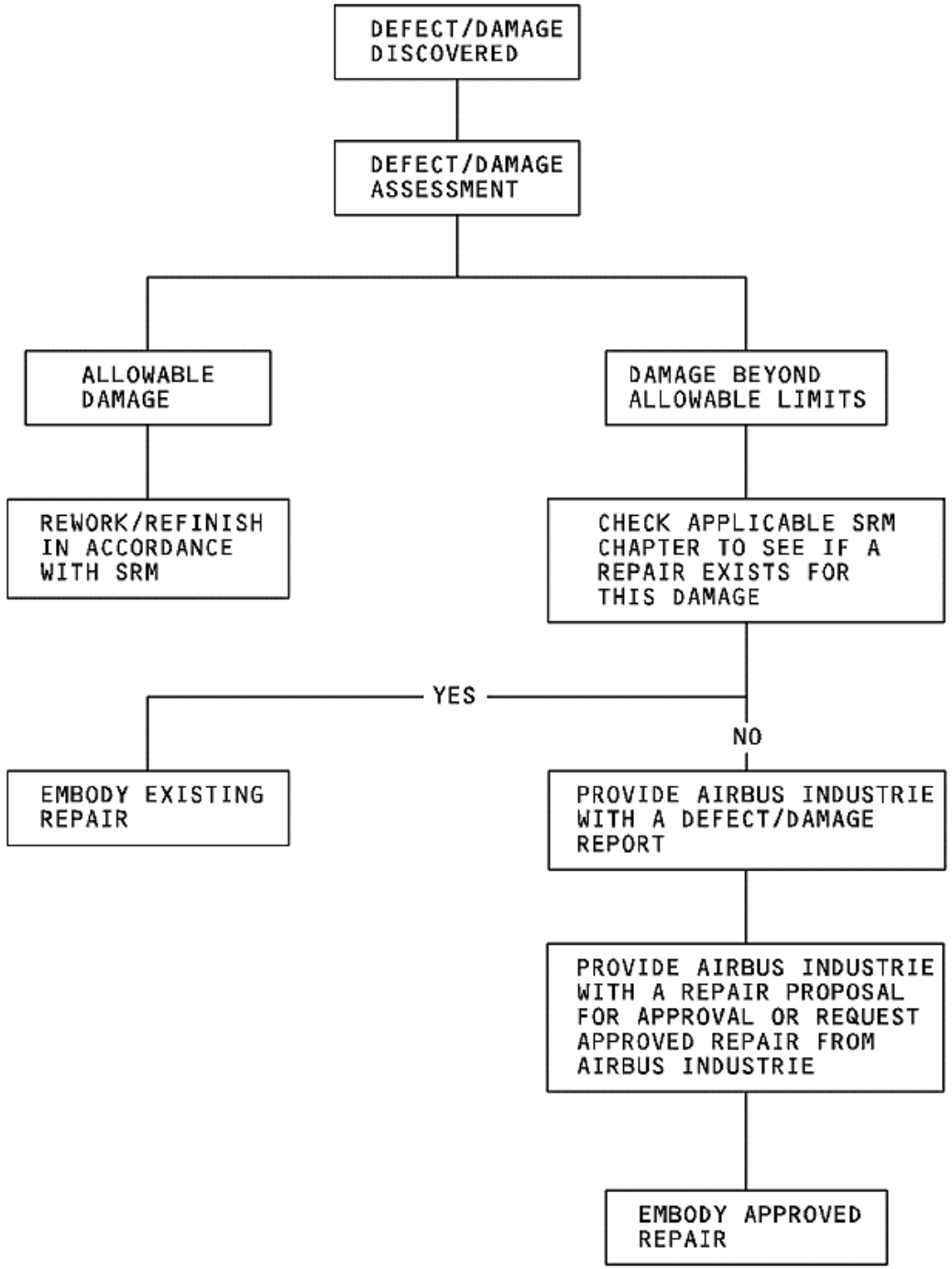
Horizontal Stabilizer Front Spar Web Repair
Figure 2 (Sheet 2)



FRONT VIEW

SECTION THROUGH DAMAGE

Source: Airbus A321 SRM



Other source of data

Many other source of structures related data are available Some of these documents and manual are referenced or linked to the SRM

- Maintenance performance toolbox
- Aircraft maintenance manual AMM
- NDT manuals
- Component maintenance manual CMM
- Standard Overhaul procedure manual SOPM
- Maintenance planning manual MPD
- Maintenance review board reports MRBR
- Supplemental structural inspection documents SSID
- Repair assessment guidelines RAG
- Service bulletins SB
- Airworthiness limitations
- Fatigue critical alteration structure list
- Fatigue critical baseline structure list
- In service activities report
- Structural item interim advisories
- Illustrated pats catalog IPC
- Manufacture part standard data
- Dispatch deviation guide DDG
- Master minimum equipment list MMEL
- Service letters (AOL, SL)

Other source of data

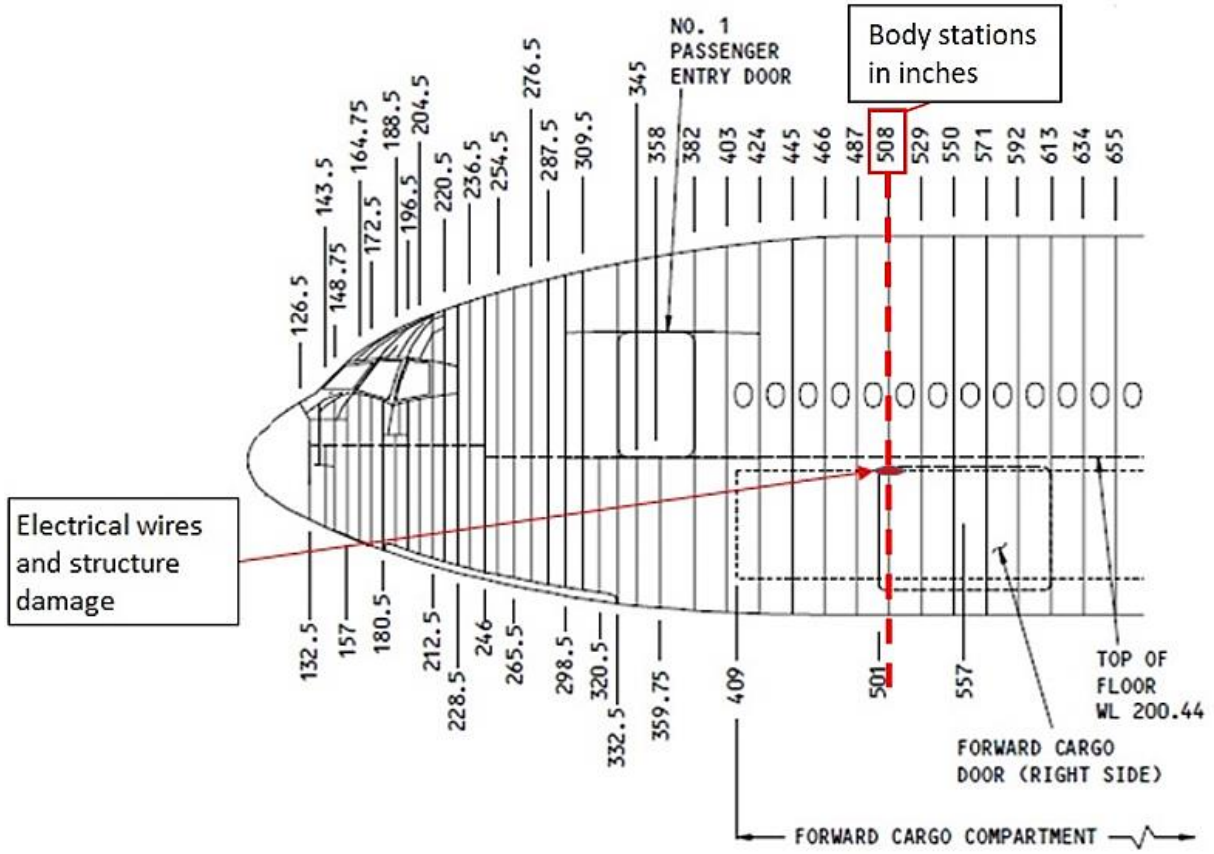
There are also other sources of structures or material data approved or endorsed by FAA such as:

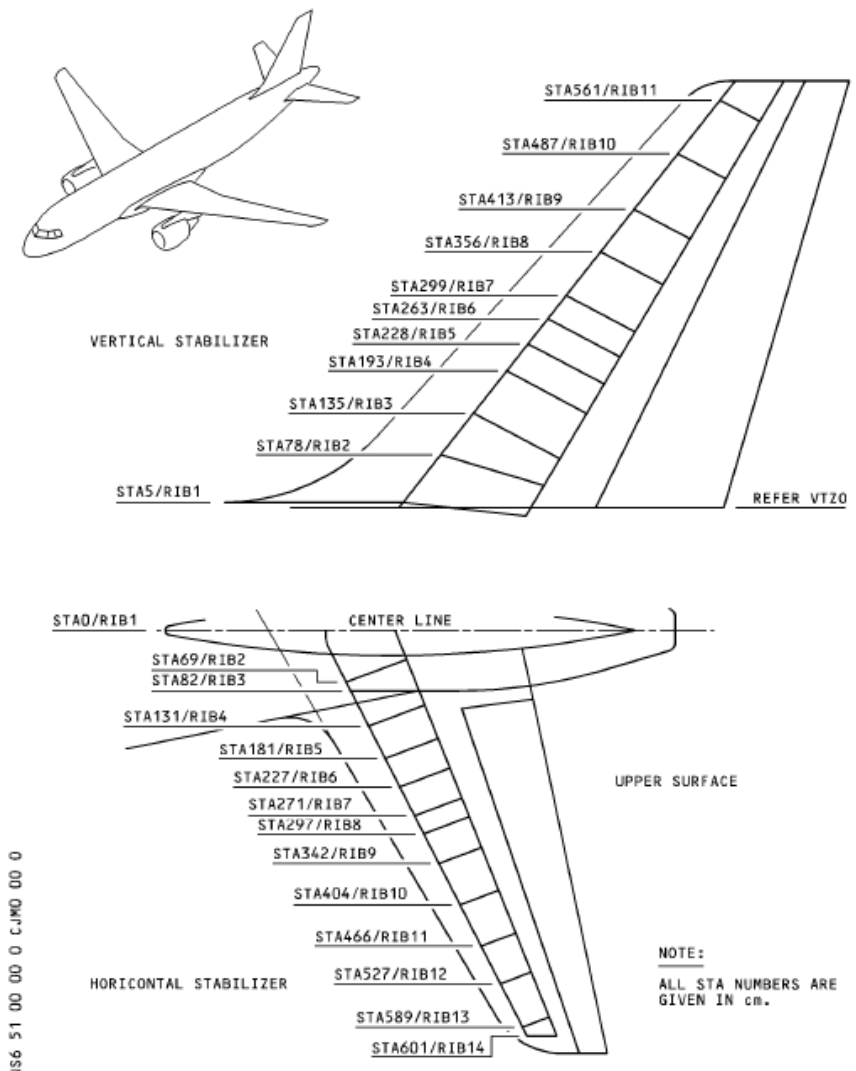
- FAR/RAC regulations
- Airworthiness directives (AD)
- Material safety data sheet (MSDS)
- Metallic material properties development and standardization (MMPDS) or MIL-HDBK-5
- Composite materials handbook MIL HDBK-17
- SAE composite materials repair procedures

SRM, general 51-00

Definitions of the fuselage (body) references plane

- B STA or BS: Body station, a vertical plane perpendicular to the fuselage centerline to the plane Its located by its distance aft of a plane forward of the nose radome
- BBL: Body buttock line, a vertical plane parallel to the fuselage centerline
- BWL: Body Waterline
- BRP: Body reference plane





Stabilizers - Stations and Ribs
Figure 9

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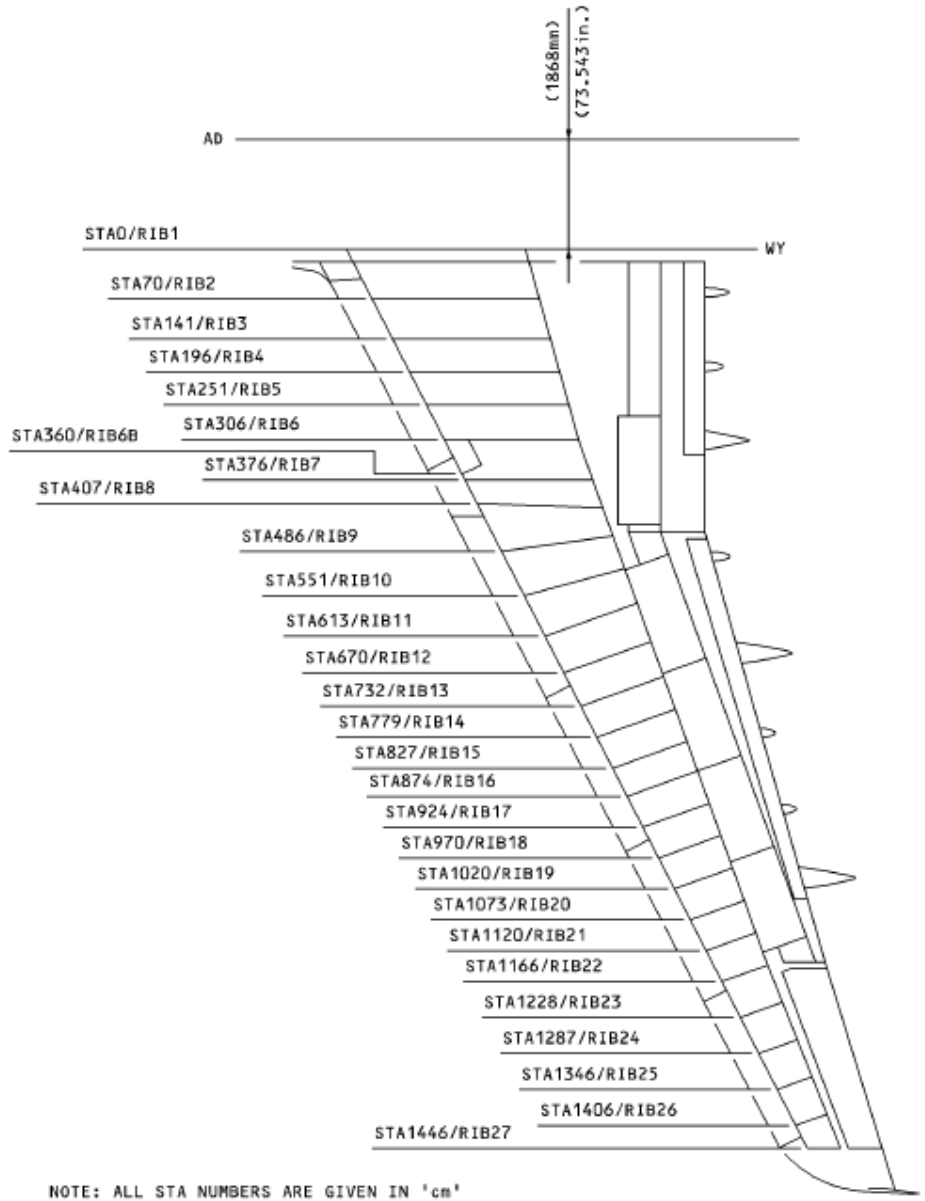
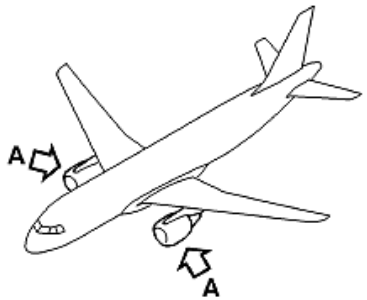
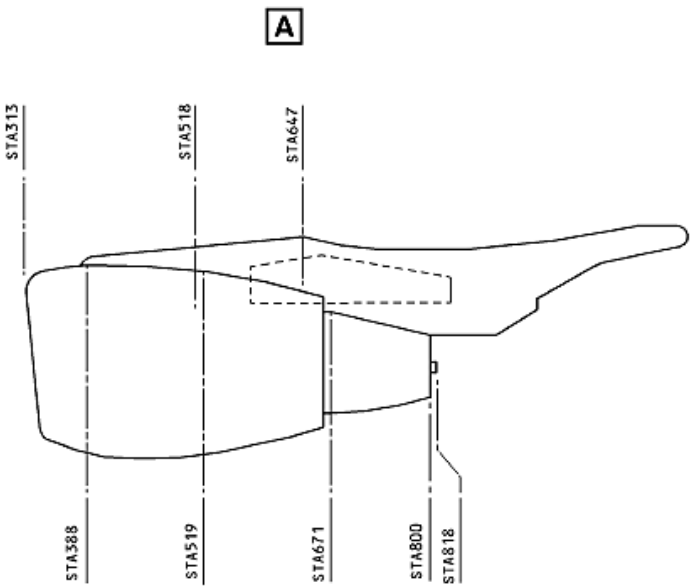


NS6 51 00 00 0 CNMO 00

NOTE: ALL STA NUMBERS ARE GIVEN IN 'cm'

Wing - Stations and Ribs
Figure 10

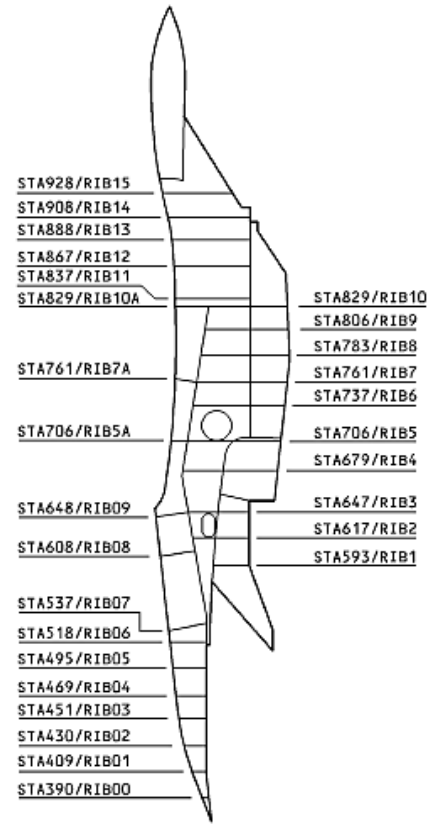




NOTE: ALL STA DIMENSIONS ARE GIVEN IN cm

NS6 51 00 00 0 CEMA 00 0

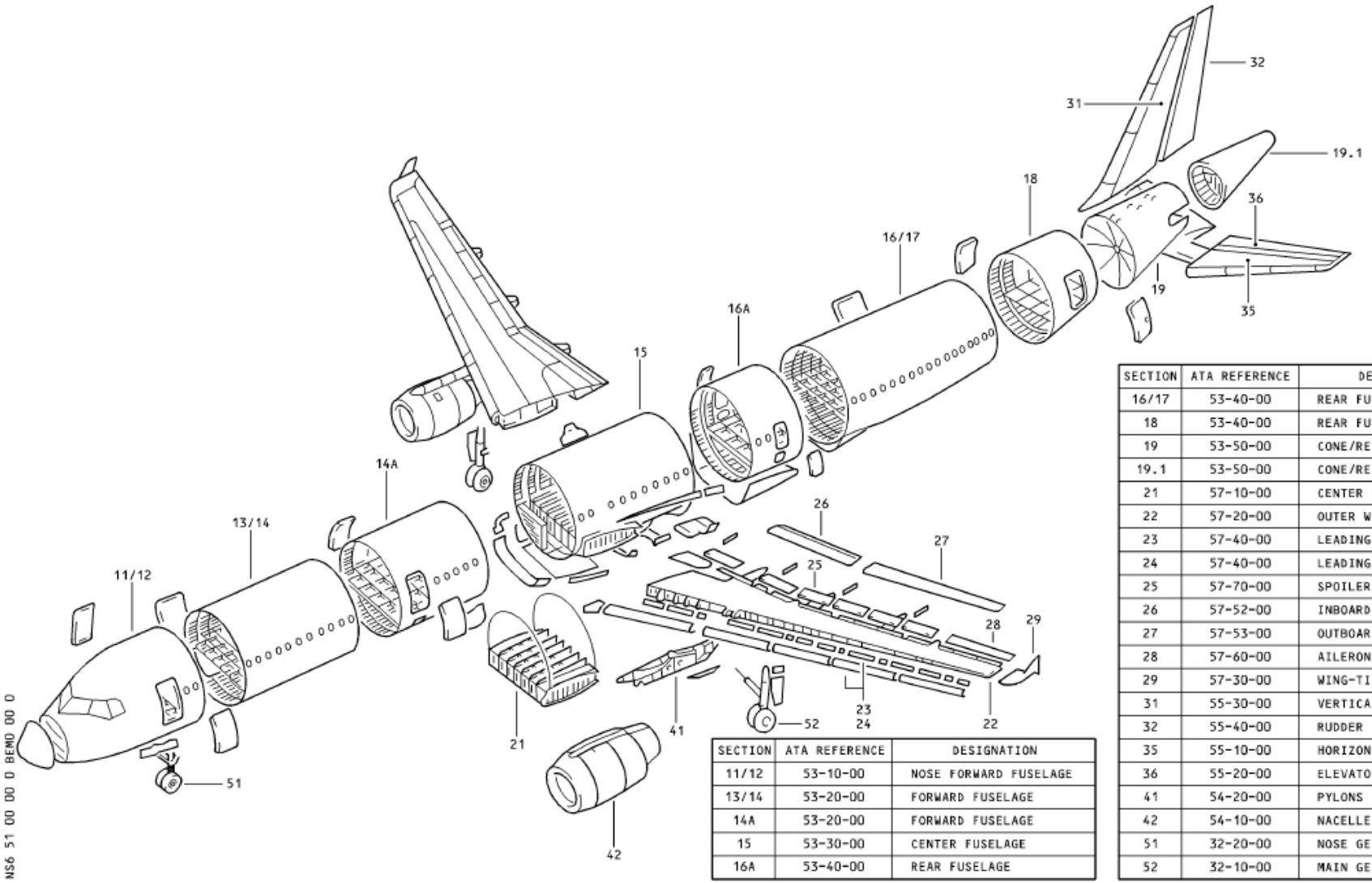
Nacelle and Pylon Stations
CFM56 Engine
Figure 7 (sheet 2)



NS6 51 00 00 0 CEMM 00 0

Nacelle and Pylon Stations
CFM56 Engine
Figure 7 (sheet 1)

Major assembly breakdown



SECTION	ATA REFERENCE	DESIGNATION
11/12	53-10-00	NOSE FORWARD FUSELAGE
13/14	53-20-00	FORWARD FUSELAGE
14A	53-20-00	FORWARD FUSELAGE
15	53-30-00	CENTER FUSELAGE
16A	53-40-00	REAR FUSELAGE

SECTION	ATA REFERENCE	DESIGNATION
16/17	53-40-00	REAR FUSELAGE
18	53-40-00	REAR FUSELAGE
19	53-50-00	CONE/REAR FUSELAGE
19.1	53-50-00	CONE/REAR FUSELAGE
21	57-10-00	CENTER WING
22	57-20-00	OUTER WING
23	57-40-00	LEADING EDGES
24	57-40-00	LEADING EDGES
25	57-70-00	SPOILERS
26	57-52-00	INBOARD FLAP
27	57-53-00	OUTBOARD FLAP
28	57-60-00	AILERON
29	57-30-00	WING-TIP
31	55-30-00	VERTICAL STABILIZER
32	55-40-00	RUDDER
35	55-10-00	HORIZONTAL STABILIZER
36	55-20-00	ELEVATOR
41	54-20-00	PYLONS
42	54-10-00	NACELLE SECTION
51	32-20-00	NOSE GEAR AND DOORS
52	32-10-00	MAIN GEAR AND DOORS

Aircraft Section Numbers
Figure 3

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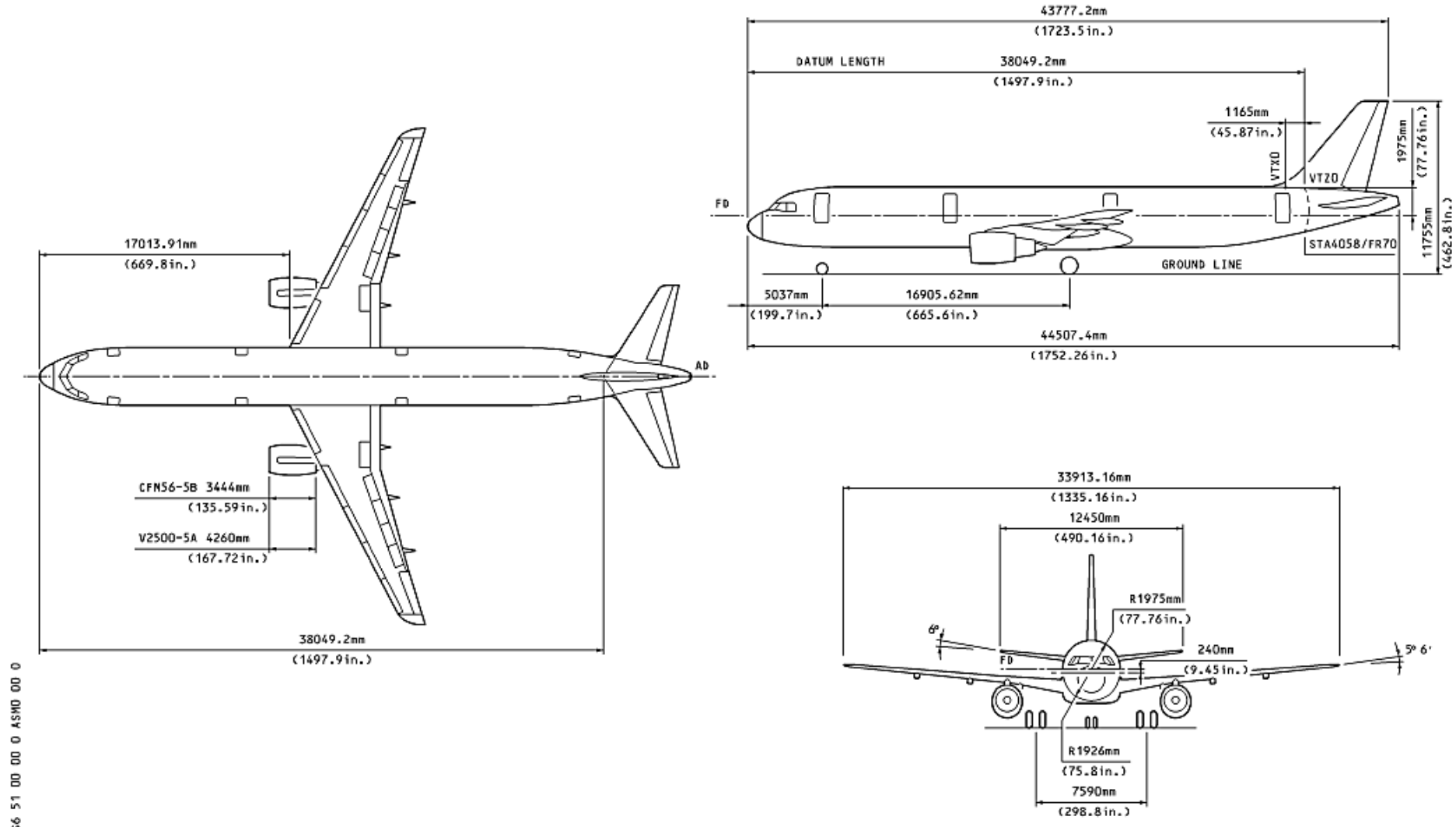
Principal dimensions



MS6 51 00 00 0 ASMO 00 0

Major Aircraft Dimensions
Figure 2

Printed in Germany

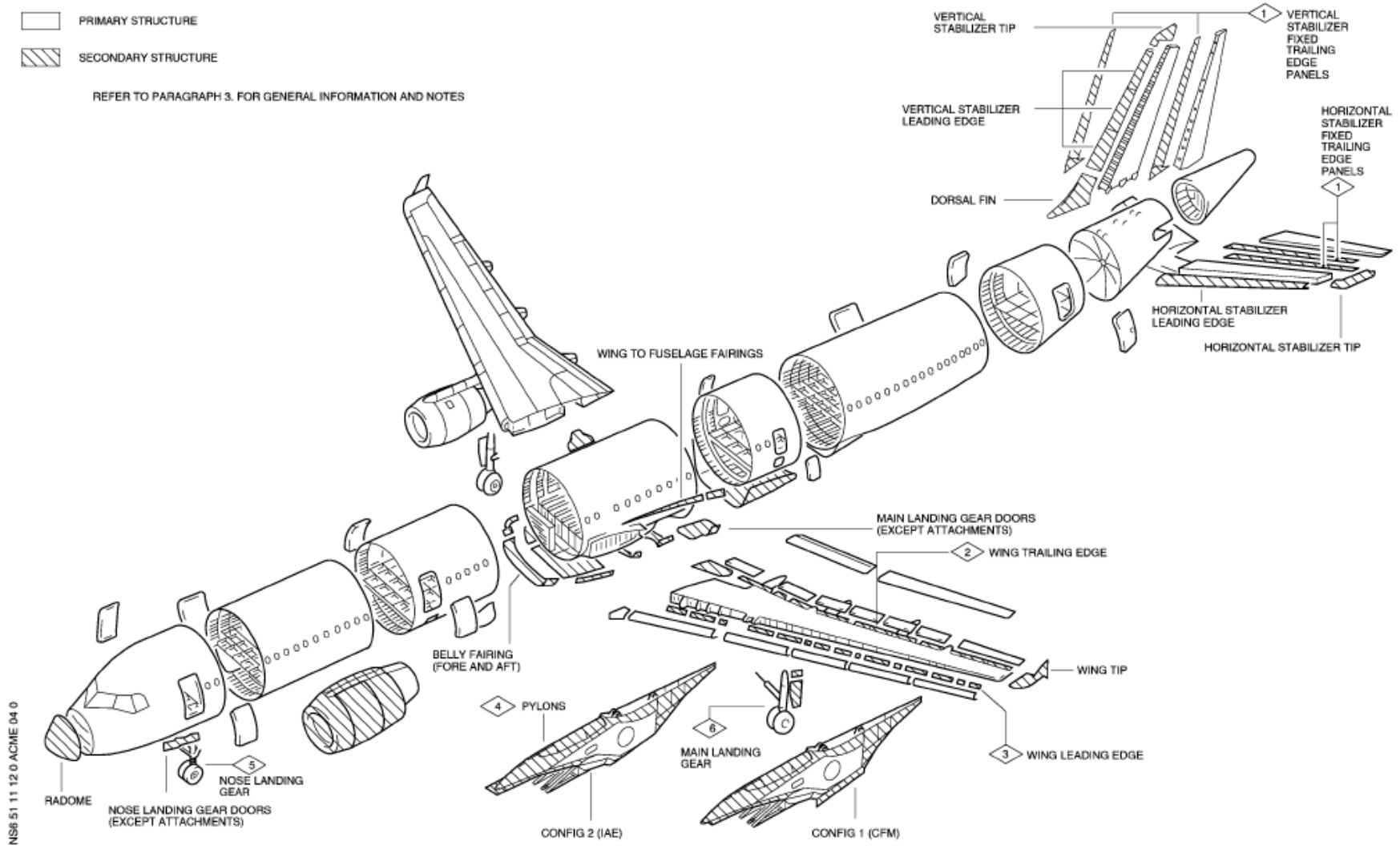
SRM, general 51

Structural Classification: this subject defines primary and secondary structure, principal structural elements PSE, structural significant items and fatigue critical baseline structure It also provides list lists of structural items for each of these

Structural classification diagram: the SRM includes a diagram that identifies primary ad secondary structure on the airplane

- **Primary structure**: includes all that carries **flight, ground or pressure loads**
- **Secondary structure**: carries only **air and inertial loads** generated on or within the secondary structure

Structure classification



Primary and Secondary Structure - General Details
Figure 2

SRM, general 51

Primary structure is classified into two categories:

- **Principal Structural Elements PSE**: Primary structure that contributes significantly to carrying flight, ground or pressurization loads. Their integrity is essential to maintain the overall structural integrity of the airplane
- Other structure: primary structure that is not a PSE

Repairs to PSE's are required to be evaluated for damage tolerance capability

Example of PSE
Airbus A321

FIGURE TITLE	FIGURE NUMBER
Passenger/Crew doors	Figure 3
Emergency Exit Doors	Figure 4
Cargo Compartment Doors	Figure 5 (sheet 1)
Bulk Cargo Compartment Door	Figure 5 (sheet 2)
Service and Access Doors, Entrance Stair Door and Main Landing Gear Doors FCBS	Figure 6
Forward Fuselage - Section 11 and 12	Figure 7
Forward Fuselage - Section 13 and 14	Figure 8
Forward Fuselage - Section 14A	Figure 9
Center Fuselage - Center Box - Sections 15/21	Figure 10
Aft Fuselage - Section 16A	Figure 11
Aft Fuselage - Section 16 and 17	Figure 12
Aft Fuselage - Section 18	Figure 13
Aft Fuselage - Tail Section 19	Figure 14
Pylon and Nacelle - CFM 56-5 Engine - Config 1	Figure 15
Pylon and Nacelle - V2500 Engine - Config 2	Figure 16
Horizontal Stabilizer	Figure 17
Elevator	Figure 18
Vertical Stabilizer	Figure 19
Rudder	Figure 20
Wings - Center Wing Box	Figure 21
Wings - Outer Wing Structure	Figure 22
Wings - Auxiliary Structure	Figure 23

Table 1

SRM General

Structural Significant Item: is defined as a structural detail, element or assembly which is judged significant because of the reduction in aircraft residual strength or loss of structural function which are consequences of its failure

SSI's must not be confused with Principal Structural Elements, PSE (FAR 25.571) however, all PSEs must be addressed by the SSIs

SRM General

Example: Carbon steel bushing (not SSI) corrodes and causes the fitting (SSI) to crack. Early detection of corrosion and replacement of the bushing would have prevented the lug from failing.

Advisory Circular 120-77A

Major Alteration: an alteration **not listed** in the aircraft, aircraft engine, or propeller specifications.

1. An alteration that **might appreciably affect** weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness
2. An alteration that is **not done according to accepted practices** or cannot be done by **elementary operations**

Advisory Circular 120-77A

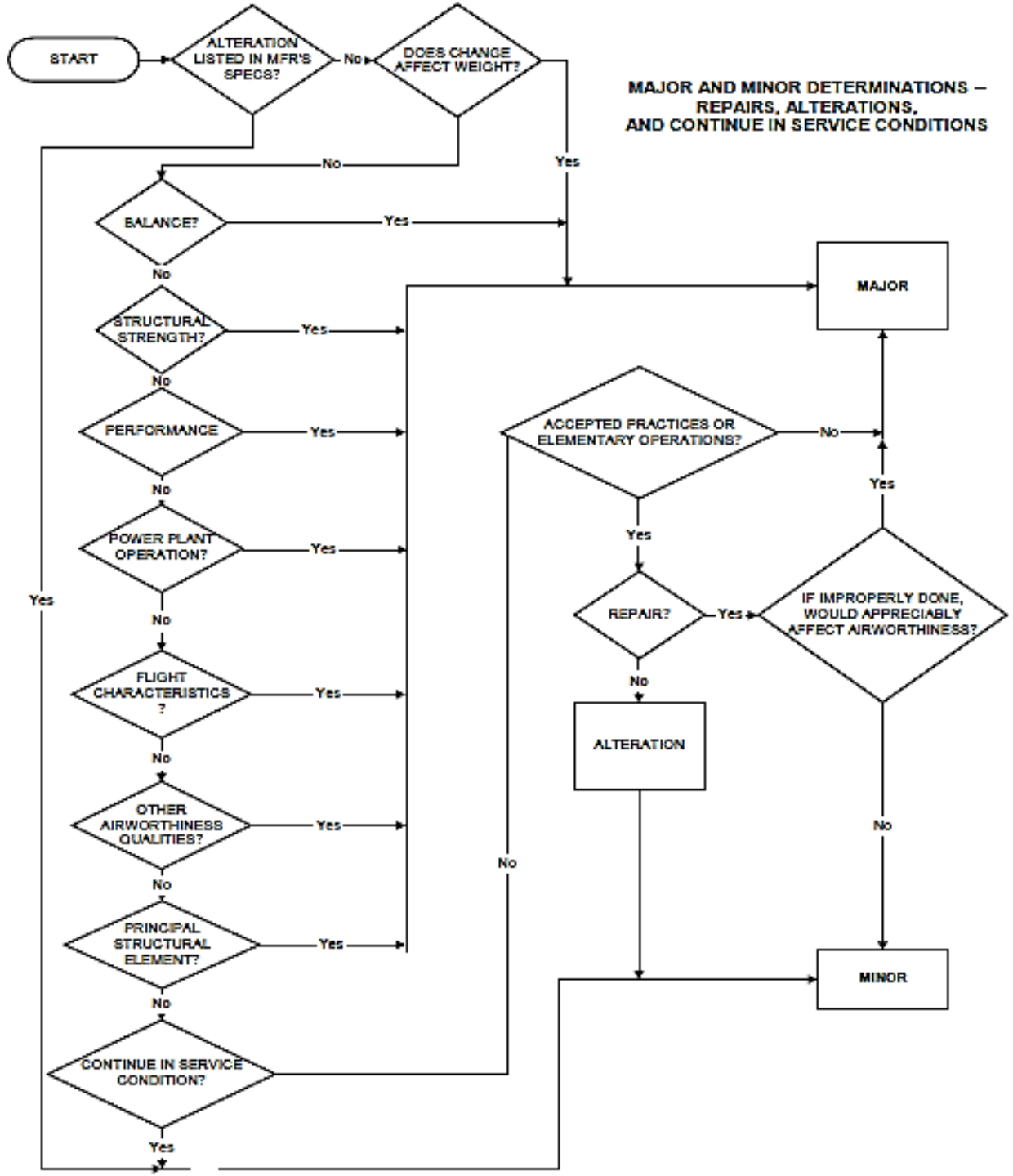
Major Repair

1. A repair that, if improperly done, **might appreciably affect** weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other qualities affecting airworthiness
2. A repair that **is not done according to accepted practices** or cannot be done by **elementary operations**.

Advisory Circular 120-77A

Minor Alteration: an alteration other than a major alteration

Minor Repair: a repair other than a major repair


MAJOR AND MINOR DETERMINATIONS –
REPAIRS, ALTERATIONS,
AND CONTINUE IN SERVICE CONDITIONS
START
ALTERATION LISTED IN MFR'S SPECS?
No
DOES CHANGE AFFECT WEIGHT?
Yes
No
BALANCE?
Yes
No
MAJOR
STRUCTURAL STRENGTH?
Yes
No
PERFORMANCE
Yes
No
POWER PLANT OPERATION?
Yes
No
FLIGHT CHARACTERISTICS ?
Yes
No
OTHER AIRWORTHINESS QUALITIES?
Yes
No
PRINCIPAL STRUCTURAL ELEMENT?
Yes
No
CONTINUE IN SERVICE CONDITION?
Yes
Yes
ACCEPTED PRACTICES OR ELEMENTARY OPERATIONS?
No
Yes
Yes
REPAIR?
Yes
IF IMPROPERLY DONE, WOULD APPRECIABLY AFFECT AIRWORTHINESS?
No
ALTERATION
No
MINOR

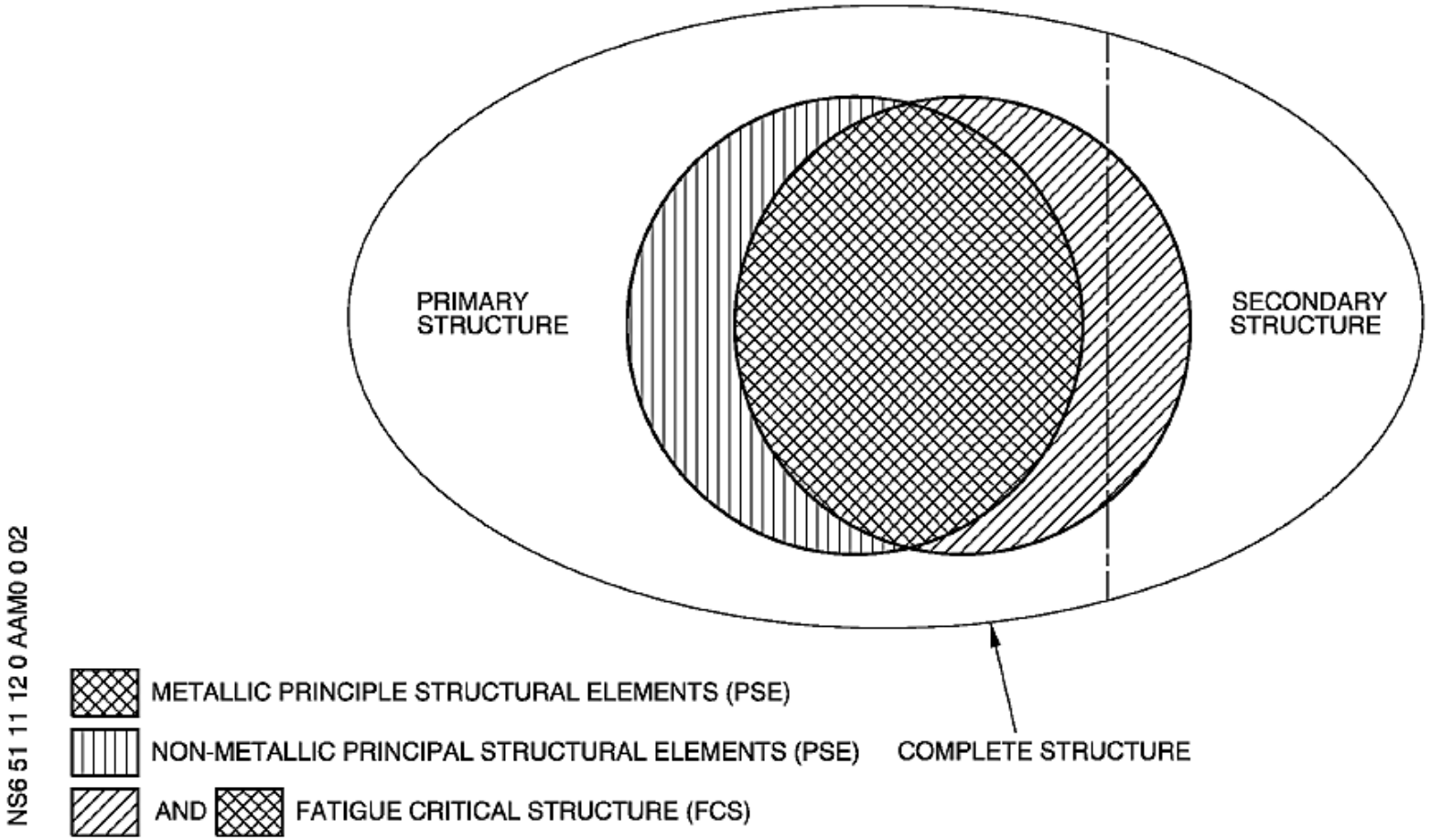
Fatigue critical structure

Fatigue critical baseline structure: airplane structure that is susceptible to fatigue cracking that could contribute to a catastrophic failure FCS includes structure, which, if repaired or altered, could be susceptible to fatigue cracking and contribute to a catastrophic failure Such structure may be part of:

- **The baseline structure**: structure that is designed under the original type certificate or amended type certificate for that plane model
- **Part of an alteration**: design change that is made to the structure to change functionality

Aging airplane safety rule: a damage tolerance based maintenance program is required for any new repair that affects the fatigue critical structure

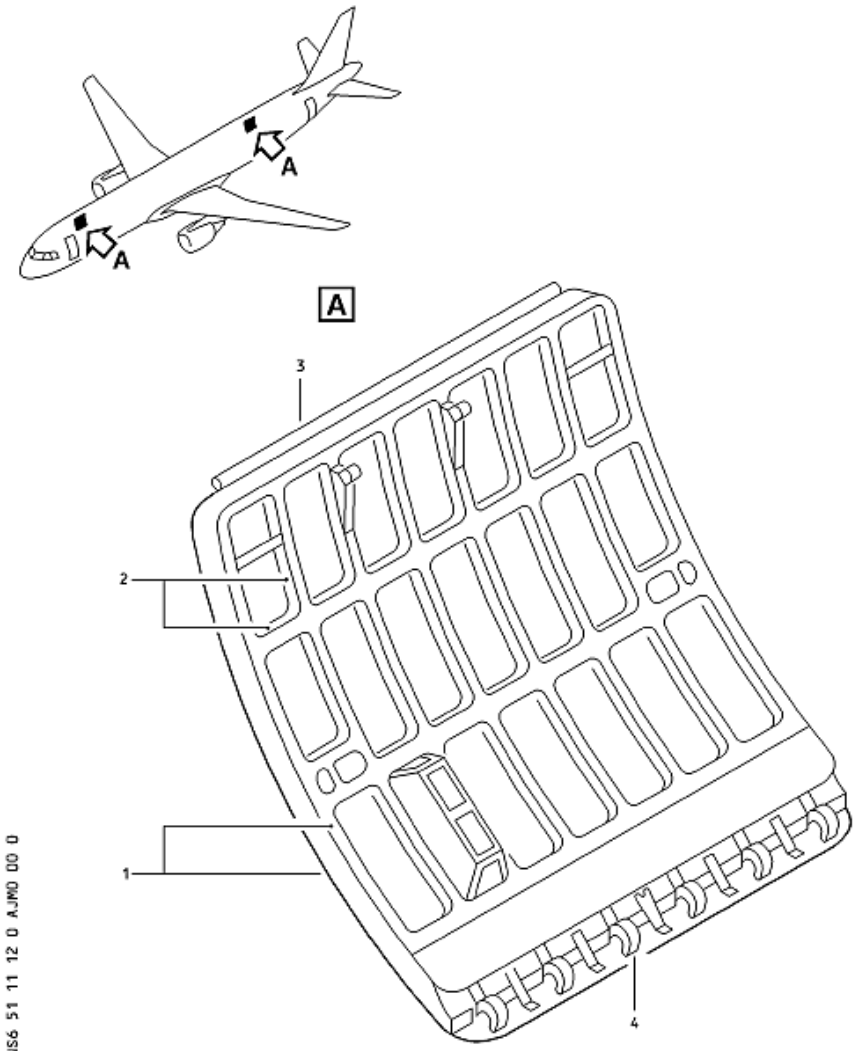
Fatigue critical structure



Structure Breakdown - Schematic
Figure 1

ITEM	PSE	FCS	SAFE LIFE	NOMENCLATURE
1	X	X		Outer and inner skin panel
2	X	X		Longerons and frame segments/beams and formers
3	X	X		All hinge fittings, piano hinge, hinge arms and hinge pins
4	X	X		All door stops, support fittings, locking latches and pivot pins

Key to Figure 5



NS6 51 11 12 0 AJMD 00 0

FCS / PSE Location - Cargo Compartment Doors
Figure 5 (sheet 1)

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Structural repair definitions

Damage tolerance: the ability of the structure to sustain anticipated loads in the presence of damage, such as fatigue cracks, until is detected through inspection or malfunction and repaired

Damage tolerant repair: a repair that meets the necessary damage tolerance conditions

Supplemental inspections: special inspections of the repaired structure which are done in addition to an operator's normal maintenance inspections

Structural repair definitions

There are two classifications of repairs in the SRM:

- Repairs that have been evaluated and analyzed for damage tolerance capability are classified as **category A, B, or C repairs**
- Repairs that are **not critical for damage tolerance** are classified as **permanent, interim, or time limited** based on the expected durability of the repair

NOTE: if a repair to a PSE or FCS does not identify the damage tolerance category, get instructions from the manufacturer for damage tolerance valuation

Structural repair definitions

Category A repair: a permanent repair for which the inspections given in the MPD, are sufficient and no other maintenance actions are necessary

Category B repair: a permanent repair for which supplemental inspections are necessary at the specified threshold and repeat intervals

Category C repair: a time limited repair that must be replaced or reworked within a specified time limit Also, supplemental inspections may be necessary at a specified threshold and repeat interval

Structural repair definitions

Category A:

- Permanent repair
- Standard inspection adequate

Category B:

- Permanent repair
- Supplemental inspections needed

Category C:

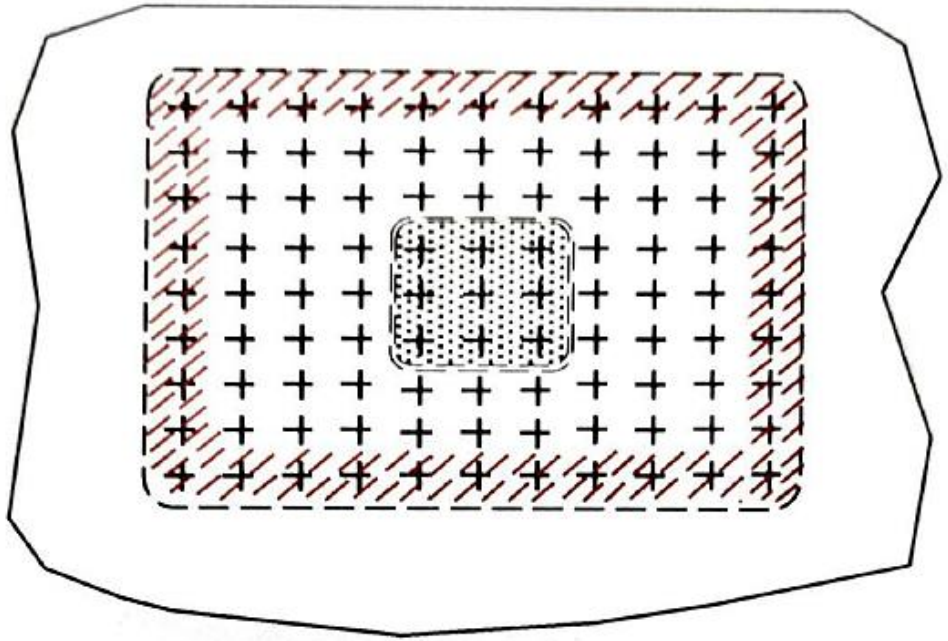
- Time limited repair
  - Supplemental inspections needed
  - Replace prior to the time limit due to low or uncertain fatigue life

Inspectability of critical details is the key difference

Structural repair definitions

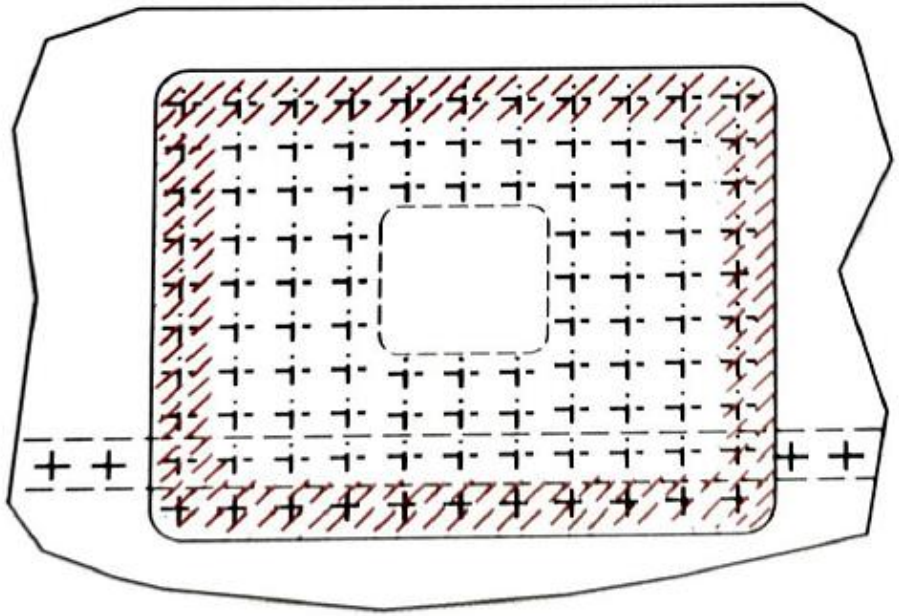
Category A

Critical detail (first row of fasteners in skin) easily inspectable from exterior

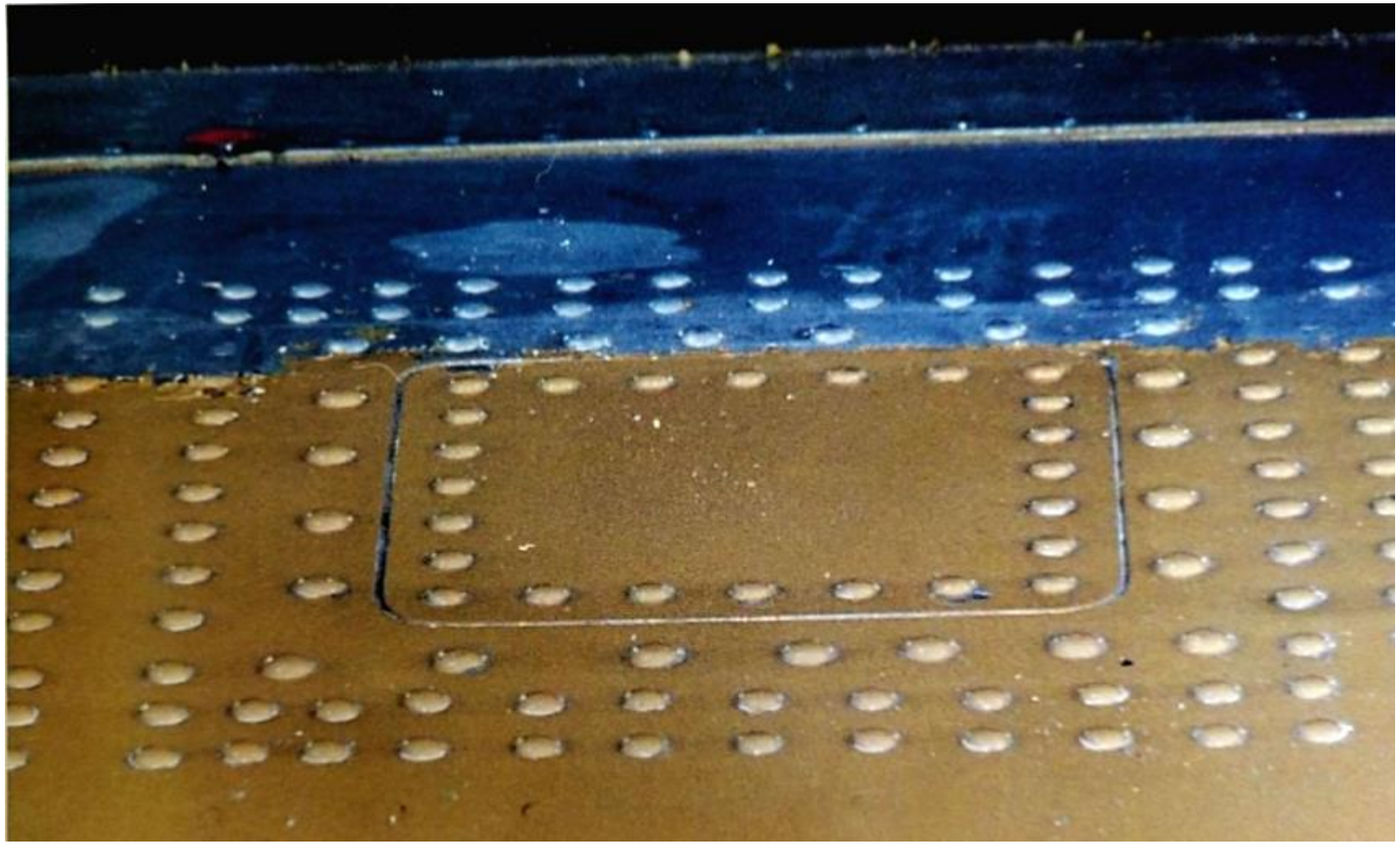


Category B

Critical detail (first row of fasteners in skin, under repair doubler) not easily inspectable from exterior

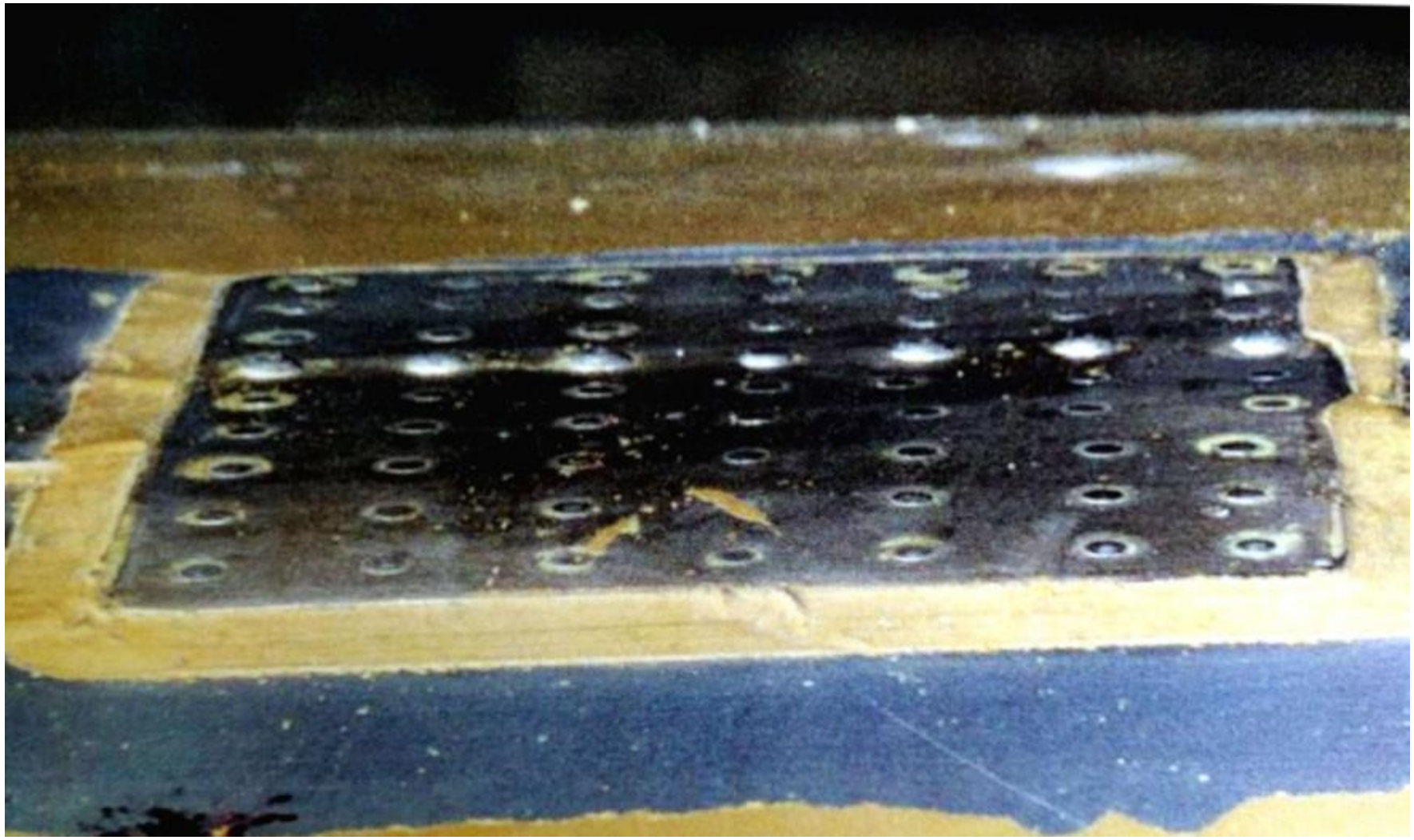


Category A, Flush repair



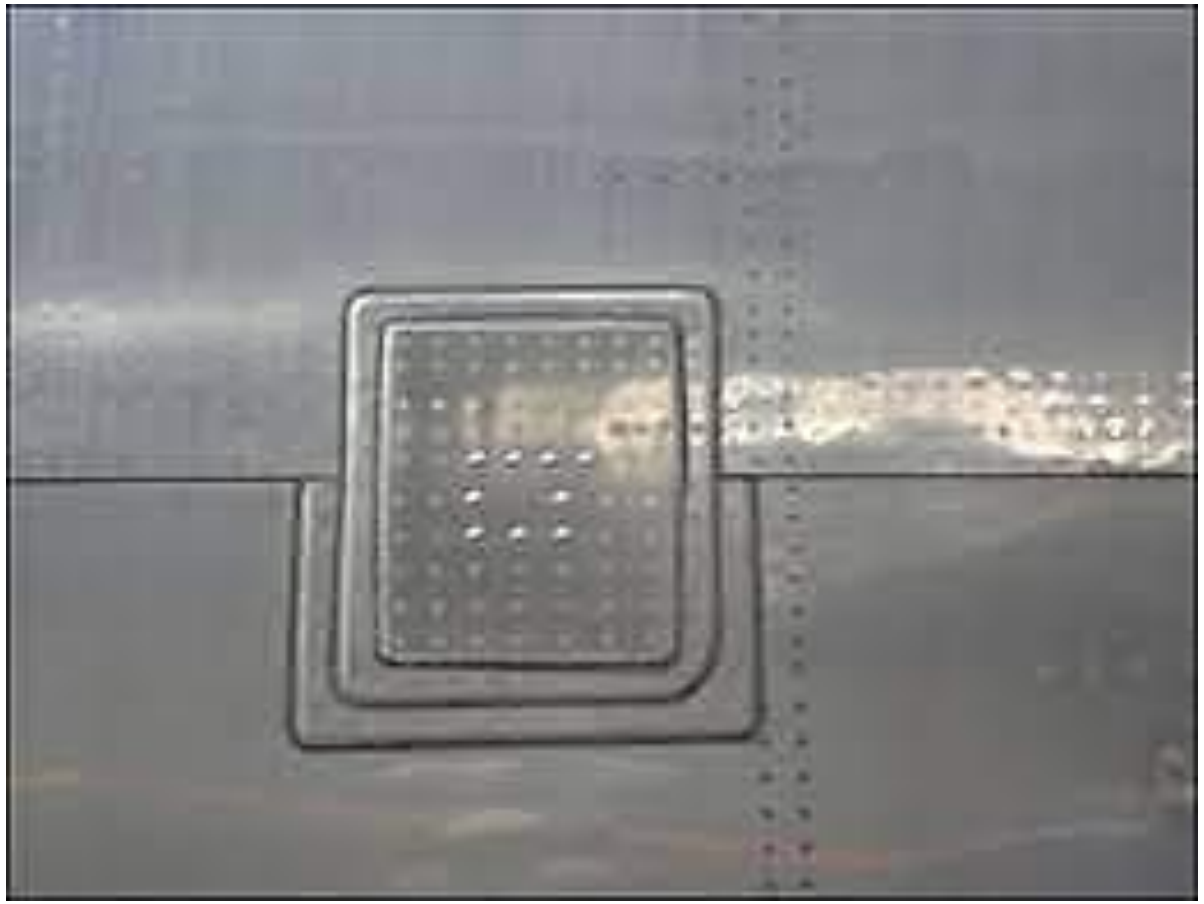
Category A, Flush repair

Category A External repair



Category B, Overlapping repair

Category B, Overlapping repair



CATEGORY B REPAIR INSPECTION REQUIREMENTS FOR DETAIL III					
TYPE OF STRUCTURE	INSPECTION THRESHOLD	ALTERNATIVE	REPEAT INSPECTION ALTERNATIVES		
			METHOD	INTERVAL	REFERENCES
AFT ENTRY AND GALLEY DOOR CUTOUTS	[X]	I	MFEC	24,000 FLIGHT CYCLES	737 NDT, PART 6, 53-30-00, FIGURE 6
			GENERAL VISUAL (SURVEILLANCE)		
		II	LFEC	4,000 FLIGHT CYCLES	737 NDT, PART 6, 53-30-00, FIGURE 5
FWD AND AFT CARGO DOOR CUTOUTS	[X]	III	MFEC	15,000 FLIGHT CYCLES	737 NDT, PART 6, 53-30-00, FIGURE 6
			GENERAL VISUAL (SURVEILLANCE)		
		IV	DETAILED VISUAL INSPECTION	8,000 FLIGHT CYCLES	
			GENERAL VISUAL (SURVEILLANCE)		
		V	LFEC	3,800 FLIGHT CYCLES	737 NDT, PART 6, 53-30-00, FIGURE 5
NOTE: ALTERNATIVE I AND III: REFER TO DETAIL XIII FOR INSPECTION AREAS. ALTERNATIVE II AND V: REFER TO DETAIL XIV FOR INSPECTION AREAS. ALTERNATIVE IV: REFER TO DETAIL XV FOR INSPECTION AREAS.					

TABLE VIII

[X] IF THE CRITICAL FASTENER ROWS HAVE THREE OR LESS INITIAL FASTENER HOLES, IN A SEQUENCE, THE INSPECTION THRESHOLD IS THE LATER OF:

- THE INITIAL SCHEDULED INSPECTION AS GIVEN IN THE OPERATOR'S REPAIR ASSESSMENT PROGRAM (RAP)
- 60,000 FLIGHT CYCLES AFTER THE REPAIR WAS INSTALLED.

IF ONE OR MORE OF THE CRITICAL FASTENER ROWS HAS MORE THAN THREE INITIAL FASTENER HOLES, IN A SEQUENCE, THE INSPECTION THRESHOLD IS THE LATER OF:

- THE INITIAL SCHEDULED INSPECTION AS GIVEN IN THE OPERATOR'S REPAIR ASSESSMENT PROGRAM (RAP)
- 60,000 FLIGHT CYCLES AFTER THE REPAIR WAS INSTALLED, IF THE INITIAL FASTENER HOLES HAVE BEEN ZERO-TIMED.
- 4,000 FLIGHT CYCLES AFTER THE REPAIR WAS INSTALLED, IF THE INITIAL FASTENER HOLES HAVE NOT BEEN ZERO-TIMED.

Table 3 Inspection Requirements for Category B Titanium Skin Repair

INSPECTION THRESHOLD*[1]	REPEAT INSPECTION ALTERNATIVES		
	METHOD	INTERVAL	REFERENCE
44,000 flight cycles (Short Mission)	External HFEC inspections of the doubler along the circumferential and longitudinal directions	24,000 flight cycles	NDT Part 6, 51-00-05 for titanium parts
16,000 flight cycles (Medium Mission)	External HFEC inspections of the doubler plate along the circumferential and longitudinal directions	10,000 flight cycles	NDT Part 6, 51-00-05 for titanium parts
44,000 flight cycles (Short Mission)	Internal HFEC inspection of the stringers	24,000 flight cycles	NDT Part 6, 51-00-05 for titanium parts
16,000 flight cycles (Medium Mission)	Internal HFEC inspection of the stringers	10,000 flight cycles	NDT Part 6, 51-00-05 for titanium parts

*[1] Use the Short Mission value if the average flight length is less than 2.5 hours. If the average flight length is 2.5 hours or more use the Medium Mission value.

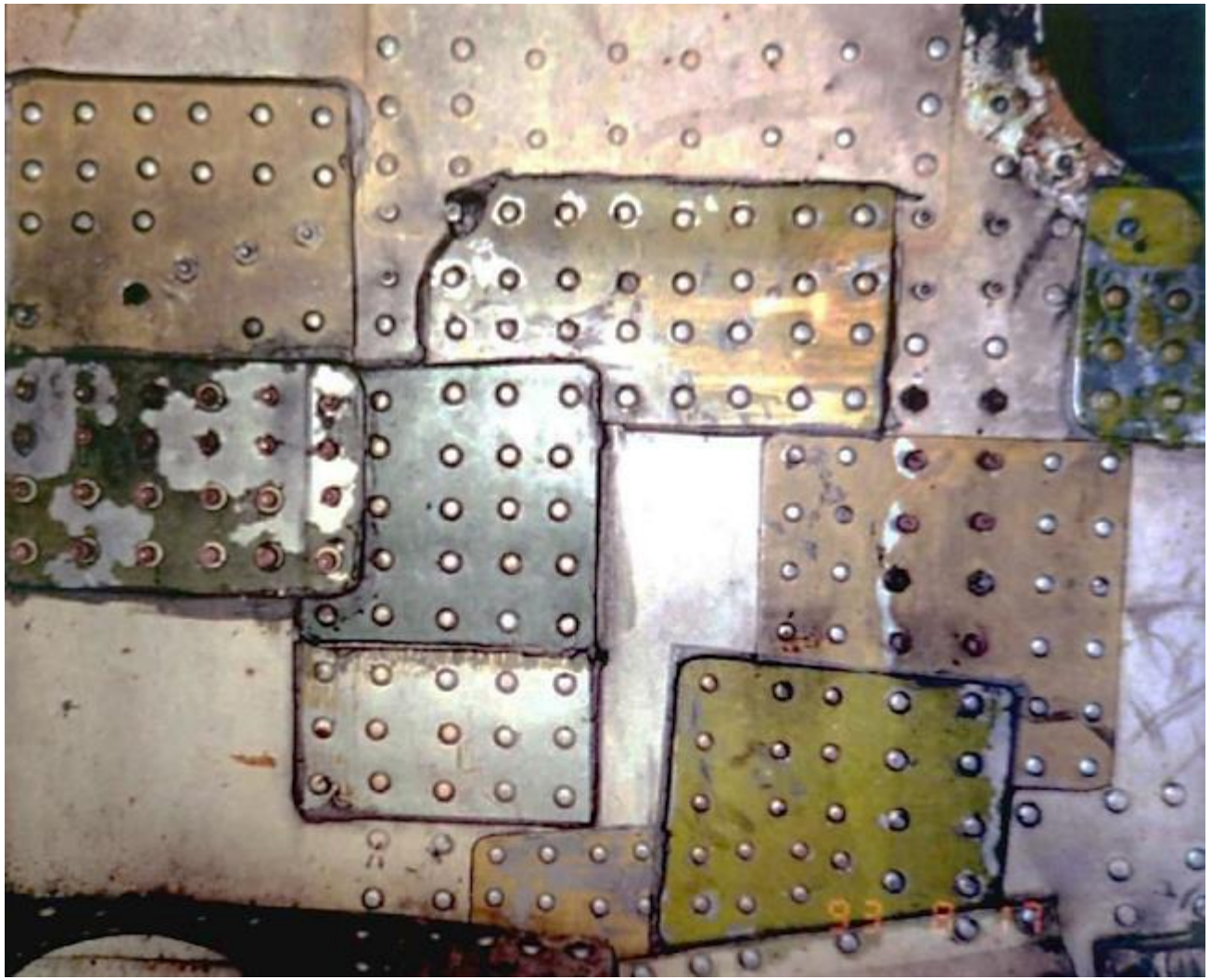
Category C, Blind rivets

Table 3 Equal Thickness Material Replacement (Replacement Factor = 1.00)

TYPE	INITIAL MATERIAL	ALTERNATIVE MATERIAL STOCK THICKNESS LESS THAN 0.250 INCH (EXCEPT AS NOTED)
SHEET 0.016 TO 0.125 (EXCEPT AS NOTED)	2024–T3	2524-T3 *[1] *[2] *[3] *[4] 7075-T6 *[1] *[2] *[3] *[4] Clad 7075-T6 *[1] *[2] *[3] *[5] *[6]
	Clad 2024–T3	2024–T3 *[7] 7075–T6 *[1] *[2] *[3] *[4] *[7] Clad 7075–T6 *[1] *[2] *[3] *[5] *[6]
	2024–T4	7075–T6 *[1] *[2] *[3] *[4] Clad 7075–T6 *[1] *[2] *[3] *[5] *[6]
	Clad 2024-T4	2024–T4 *[7] 7075–T6 *[1] *[2] *[3] *[4] *[7] Clad 7075–T6 *[1] *[2] *[3] *[5] *[6]
	2024–T42	7075–T6 *[1] *[2] *[3] *[4] Clad 7075–T6 *[1] *[2] *[3] *[5] *[6]
	Clad 2024–T42	2024-T4 *[7] 2024-T42 *[7] 7075-T6 *[1] *[2] *[3] *[4] *[7] Clad 7075-T6 *[1] *[2] *[3] *[5] *[6]
	2024–T351 (Stock Thickness 0.250 to 0.499 inch)	7075-T7351 *[1] *[2] *[3] 7050-T7451 *[1] *[2] *[3] Clad 7075–T6 *[1] *[2] *[3] *[5] *[6]
	Clad 7075-T6	7075-T6 *[4] *[7]
FORMED SECTION	2024-T42	7075-T6 *[1] *[3] *[4] *[8]

*[3] The use of these alloys as a replacement material for primary structure repairs is a Category C Repair. Refer to SRM B787-A-51-00-06-00A-030A-A Technical Data for the definitions of the repair categories. It is time-limited to 18 months or 1,600 flight cycles (that which occurs first). This is because Boeing has not done a damage tolerance analysis of the repair developed by the operator with the replacement material. Category C restrictions do not apply if: The alternative replacement material is already defined in the specific SRM repair section, and the SRM repair specifies the repair as Category A or B or specifies different time-limits and/or inspection intervals for a Category C repair.

Multiple overlapping repair



Structural repair definitions

Repairs which are not critical for damage tolerance are classified as:

- **Permanent repair**: a repair where no action is necessary except the operator's normal maintenance. A repair not defined as interim or time limited.
- **Interim repair**: a repair that has the necessary structural strength and could stay on the aircraft indefinitely. The repair must be inspected at specified intervals and replaced if deterioration is detected or damage is found.
- **Time limited repair**: a repair that has necessary structural strength but does not have sufficient durability. The repair must be replaced after specified time, usually given as a number of flight cycles, flight hours or calendar time.

BOEING 737

STRUCTURAL REPAIR

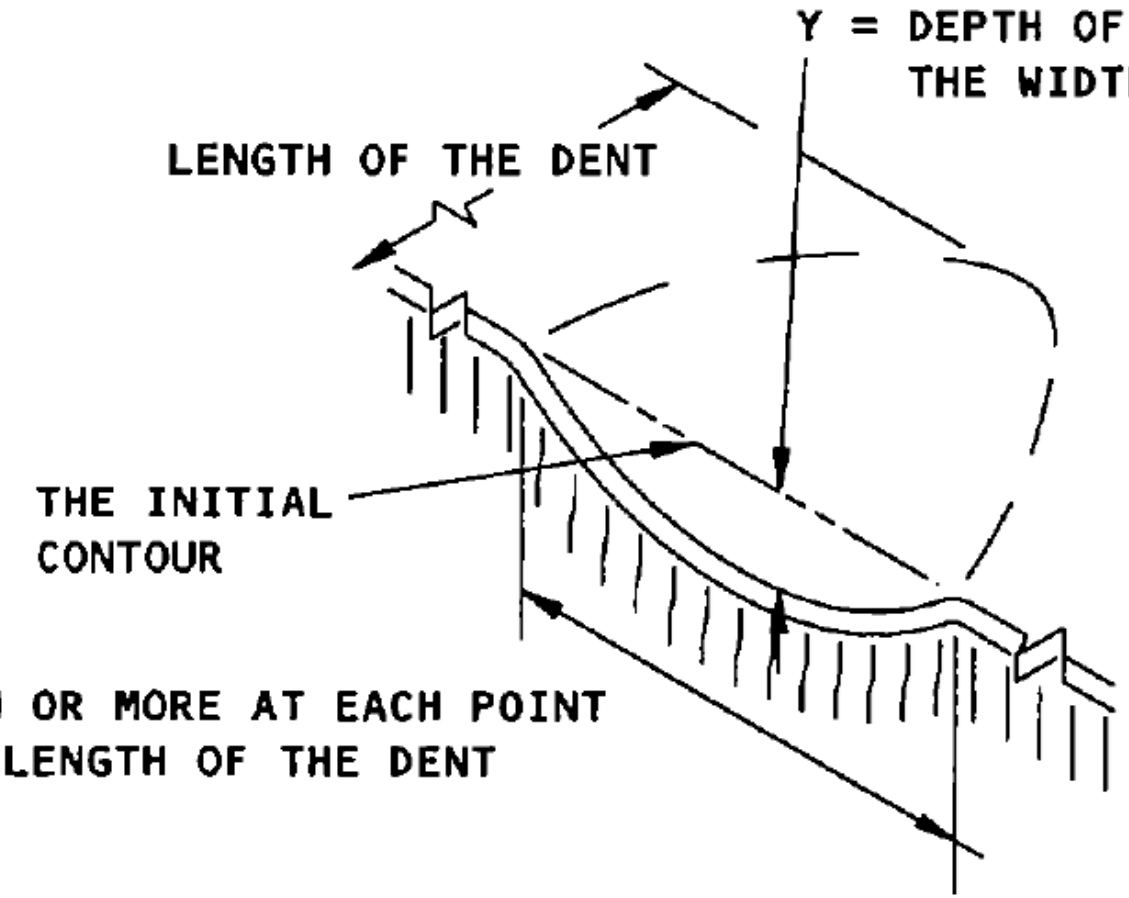
REPAIRS TO SMALL DAMAGE

1. Applicability

A. This procedure has typical repairs that are applicable to dents, nicks, creases, gouges, cracks and small holes on one side of an aluminum honeycomb sandwich structure. Refer to 51-10-1 for the damage definitions.

NOTE: These repairs are limited to damage that is 2.0 inches (50 mm) or less in length and diameter. These repairs are interim when paste adhesive is used. Inspect past adhesive repairs each 24 months or less, or each 3500 flight cycles or less (no later than the interval that occurs first). Refer to Fig. 1 for other repair options.

B. Refer to 51-40-24 for all damage that is larger than 2.0 inches (50 mm) in length and diameter.

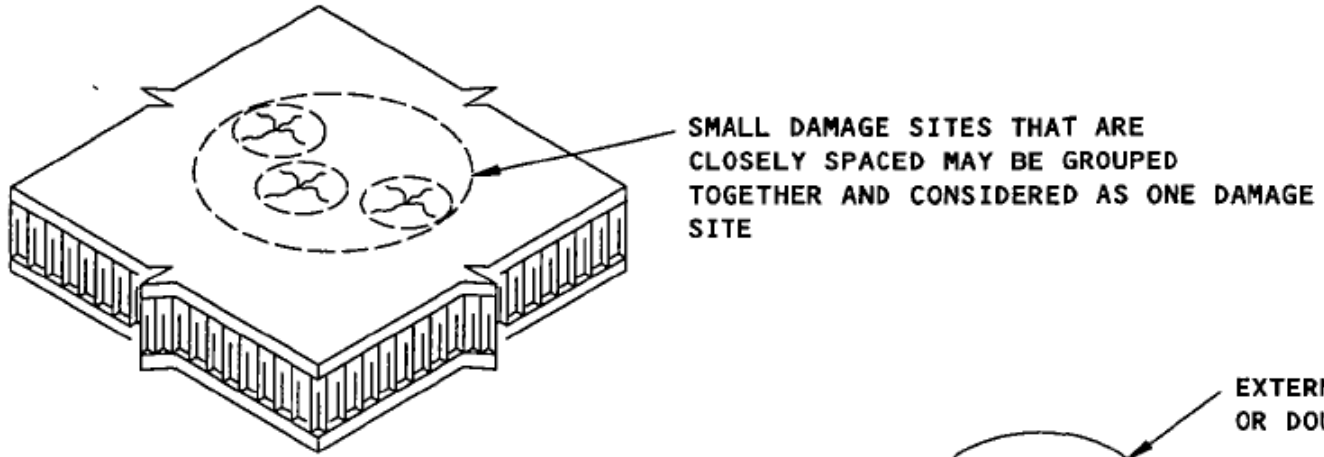


$\frac{W}{Y}$ MUST BE 20 OR MORE AT EACH POINT ALONG THE LENGTH OF THE DENT

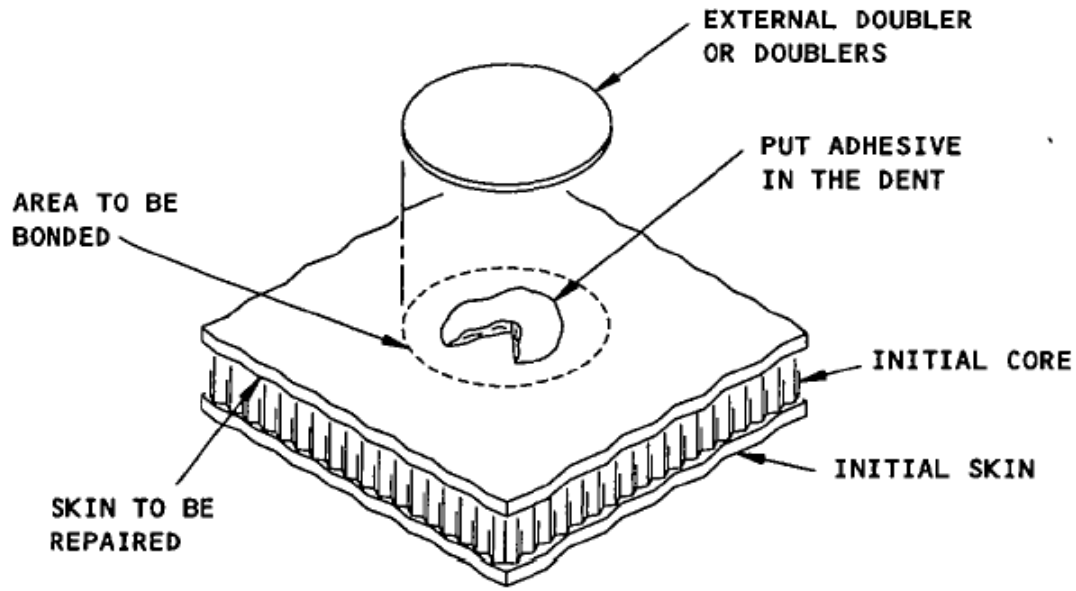
W = WIDTH OF THE MINOR AXIS OR DIAMETER OF DENT

DENT THAT IS PERMITTED IN METAL HONEYCOMB STRUCTURE

DETAIL I



DETAIL II



LAYOUT OF THE REPAIR PARTS

DETAIL III

External Doubler Repair of a Dent
Figure 1

Structural repair definitions

Threshold: the periods in **flight cycles, flight hours or calendar time** from the time design service goal DSG an airplane is delivered or repair is made, until the first supplemental inspection is necessary

For Category B repairs, the threshold starts from the time the repair was installed if the repair fasteners in the critical rows have been installed in new fasteners holes or existing fasteners holes that have been zero timed.

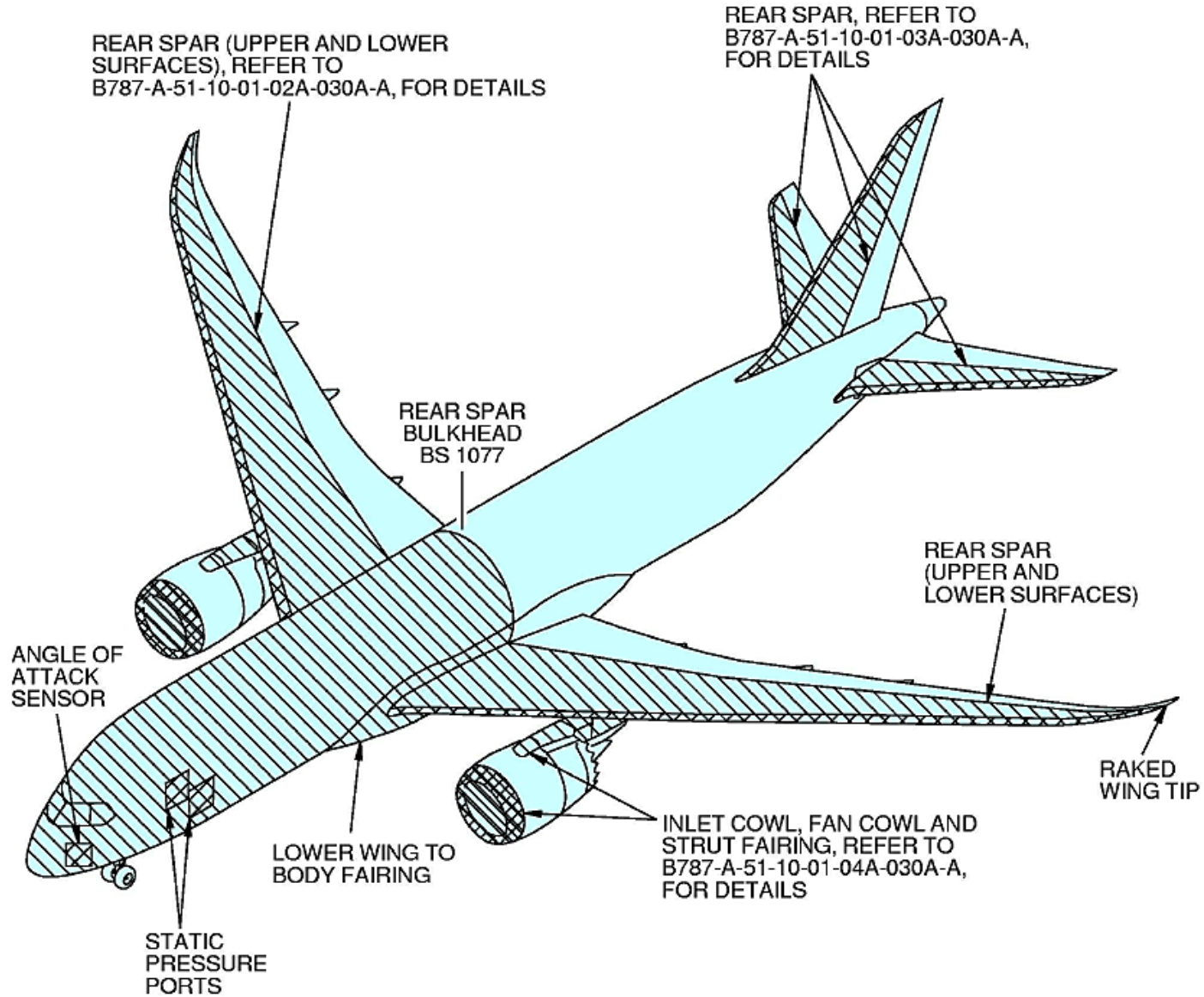
If the repair fasteners are installed in existing fastener holes that have not been zero timed, the inspection threshold will start from the time the airplane was delivered.

Aerodynamic smoothness

In some aircrafts, this subject complains with the requirements for RVSM (Reduced Vertical Separation Minimum).

The airplane must have an aerodynamically clean shape and a smooth exterior surface to give high performance. Damage that is not repaired, dents that are not filled or repairs that change the shape of the surface **will cause a reduction in the airplane's performance**.

You should try to keep the initial contour and smoothness of the airplane's surface. **For a repair that uses an external patch, make the patch with chamfered edges**.



EXTRA CRITICAL AREA (EXTRA HIGH LEVEL OF AERODYNAMIC SMOOTHNESS IS NECESSARY)

CRITICAL AREA (A HIGH LEVEL OF SMOOTHNESS IS NECESSARY). INCLUDES INTERNAL NACELLE FLOW SURFACES AND THE LEADING EDGE (FIRST 20 PERCENT OF THE CHORD) OF ALL HIGH LIFT DEVICES AND CONTROL SURFACES.

NON-CRITICAL AREA

Aerodynamic smoothness

There are three categories for aerodynamic shape:

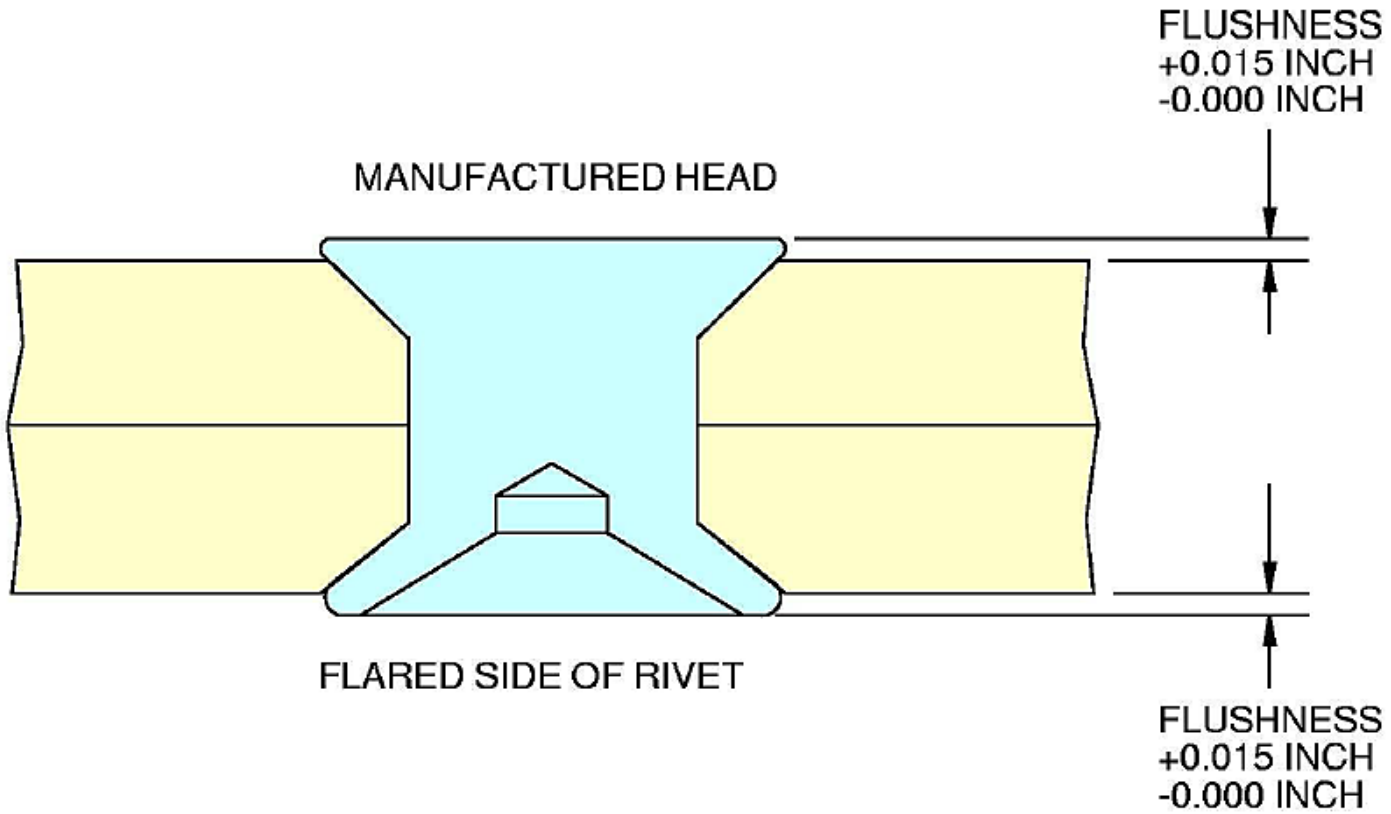
Extra critical aerodynamic surfaces are those near static pressure ports and AOA sensors. These surfaces needs the higher level of aerodynamic smoothness.

Aerodynamic smoothness

For joints and fasteners in extra critical areas:

- Joints, except for the fuselage longitudinal lap splices, **must be flush** to within the limits specified for the applicable extra critical area
- Fasteners must be flush to within the limit specified
- **Protruding head fasteners are not permitted**
- Skin gaps and permanently installed bolts and screws must be filled and faired with an aerodynamic smoother to be flush with the initial skin contour

Aerodynamic smoothness



INSTALLATION REQUIREMENTS FOR HOLLOW ENDED RIVETS

Aerodynamic smoothness

Critical aerodynamic surface are those surfaces that must have high level of aerodynamic smoothness.

For best airplane performance, replace an external patch with flush repair as soon as possible in aerodynamically critical areas

Aerodynamic smoothness

Non-critical aerodynamic surfaces have less effect on aerodynamic smoothness than critical areas, but a rough surface will reduce performance somewhat

Aerodynamic smoothness

Michroshaving of aluminum alloy rivets: a micro shaver is used to shave aluminum rivets to meet the surface flushness requirements.

- The micro shaver is a pistol grip air motor with an adjustable micro stop
- The cutter shaves the rivet head to within 0.002 inch (0.051 mm) of the surface

NOTE: Do not shave steel fasteners, titanium fasteners, BACR 15 CE, BACR 15 GF or BACR 15 FV rivets

Inspection and removal of damage

This section gives general procedures about the investigation and removal of any type of damage to the airplane skin and structure

The procedures cover removal of nicks, scratches, gouges, and corrosion damage on aluminum, titanium magnesium alloy materials a well as damage to non-metallic structures

Inspection and removal of damage

Burnish:

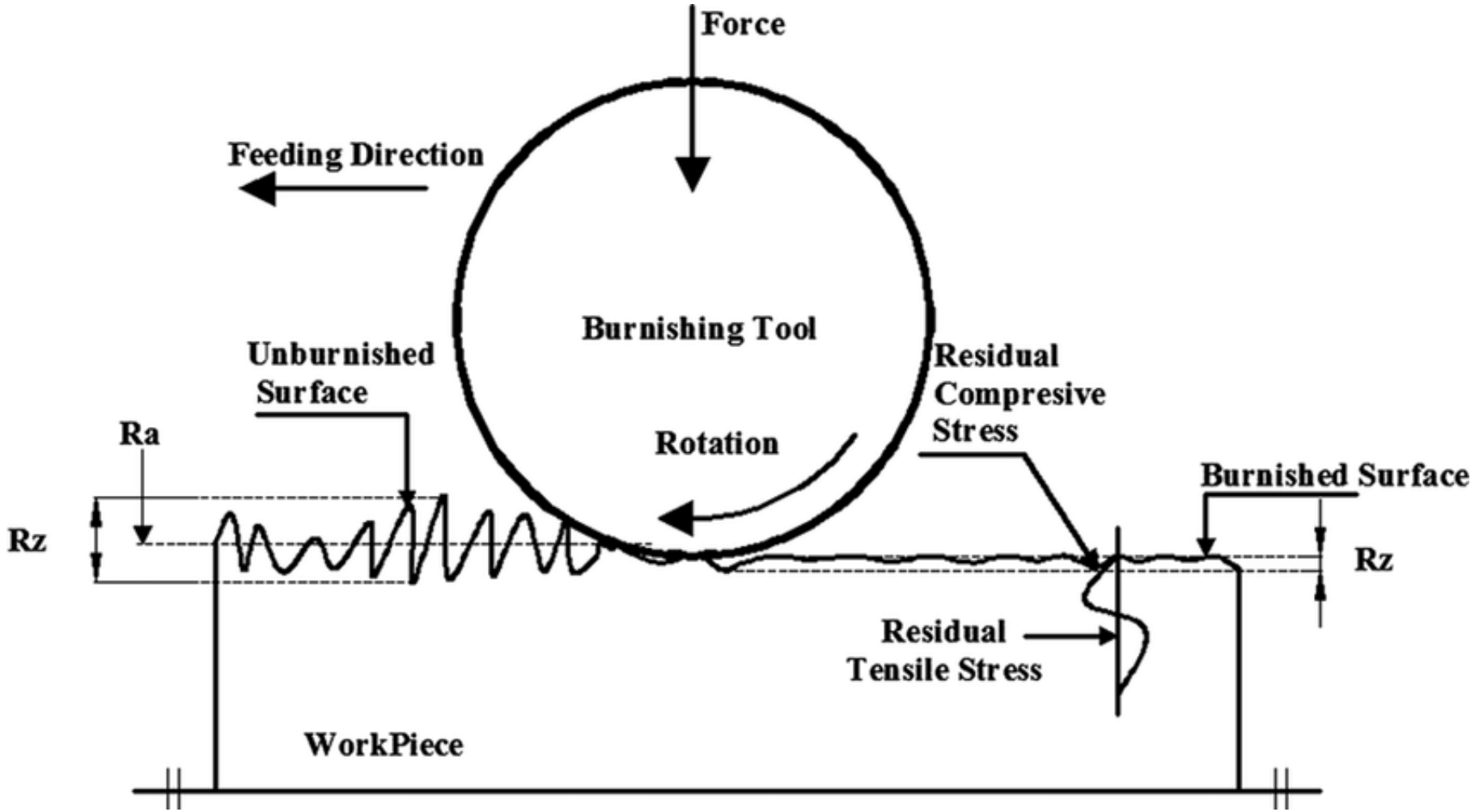
To smooth the surface of metal that has been damaged by a deep scratch or gouge. The metal piled up at the edge of the damage is pushed back into the damage with a smooth, hard steel burnishing tool.

Burnishing:

- It is possible to burnish a damage area that does not go all way through the clad aluminum surfaces of secondary structure It is not necessary to do supplemental inspections or to record the location of the damage.
- You can burnish clad aluminum surface of primary structure if the damage agrees with the conditions specified in the chapter.

Inspection and removal of damage

Inspection and removal of damage



ABRASIVES FOR DAMAGE REMOVAL, FAIRING OR FINISHING

MATERIAL	USE	ABRASIVE PAPER OR CLOTH			ABRASIVE FABRIC OR PAD	METAL WOOL		PUMICE (350 MESH OR FINER	ABRASIVE WHEELS		RESTRICTIONS
		Aluminum Oxide	Silicon Carbide	Garnet		Aluminum	Stainless Steel		Removal of Discoloration	Scratch Removal	
FERROUS ALLOYS (220 KSI AND ABOVE)	Corrosion removal or fairing	150 or finer	150 or finer	------	Fine to ultrafine	X	X	X			Do not use acid base rust removers. Do not use hand-held power tools. Grinding is not permitted.
	Finishing	400				X	X	X			
FERROUS, NICKEL, COBALT & TUNGSTEN ALLOYS	Corrosion removal or fairing	150 or finer	180 or finer		Fine to ultrafine	X	X	X	3S medium	5A or 7S medium	Only applies to steels heat treated to below 220 KSI
	Finishing	400				X	X	X		7S fine	
ALUMINUM ALLOYS EXCEPT CLAD	Corrosion removal or fairing	60 or finer		240 (7/0 or finer)	Very fine and ultrafine	X		X		5A medium	Do not use silicon carbide abrasives
	Finishing	400				X		X			
CLAD ALUMINUM	Corrosion removal or fairing	240 or finer		240 (7/0 or finer)	Very fine and ultrafine			X			Sanding limited to the removal of minor scratches
	Finishing	400						X			
MAGNESIUM ALLOYS	Corrosion removal or fairing				Very fine and ultrafine	X		X			Do not use carbon steel brushes, silicon carbide abrasives.
	Finishing	400				X		X			
TITANIUM	Sanding, Scouring	80 or finer	80 or finer				X	X	3S medium	5A or 7S medium	
	Finishing	150 or finer	180 or finer				X	X		7S fine	

Inspection and removal of damage

Removal of small cracks and fatigue damage material from an existing hole or zero-timing:

- Zero-timing **improves the durability of the repair** by eliminating the possibility of existing cracks in the fastener holes

Zero-timing **must only be used where specially permitted in an SRM** chapter section repair. Also, zero-timing must not reduce:

- Edge margins.
- Fastener spacing
- Countersink depths below the minimum allowed in the SRM.

Inspection and removal of damage

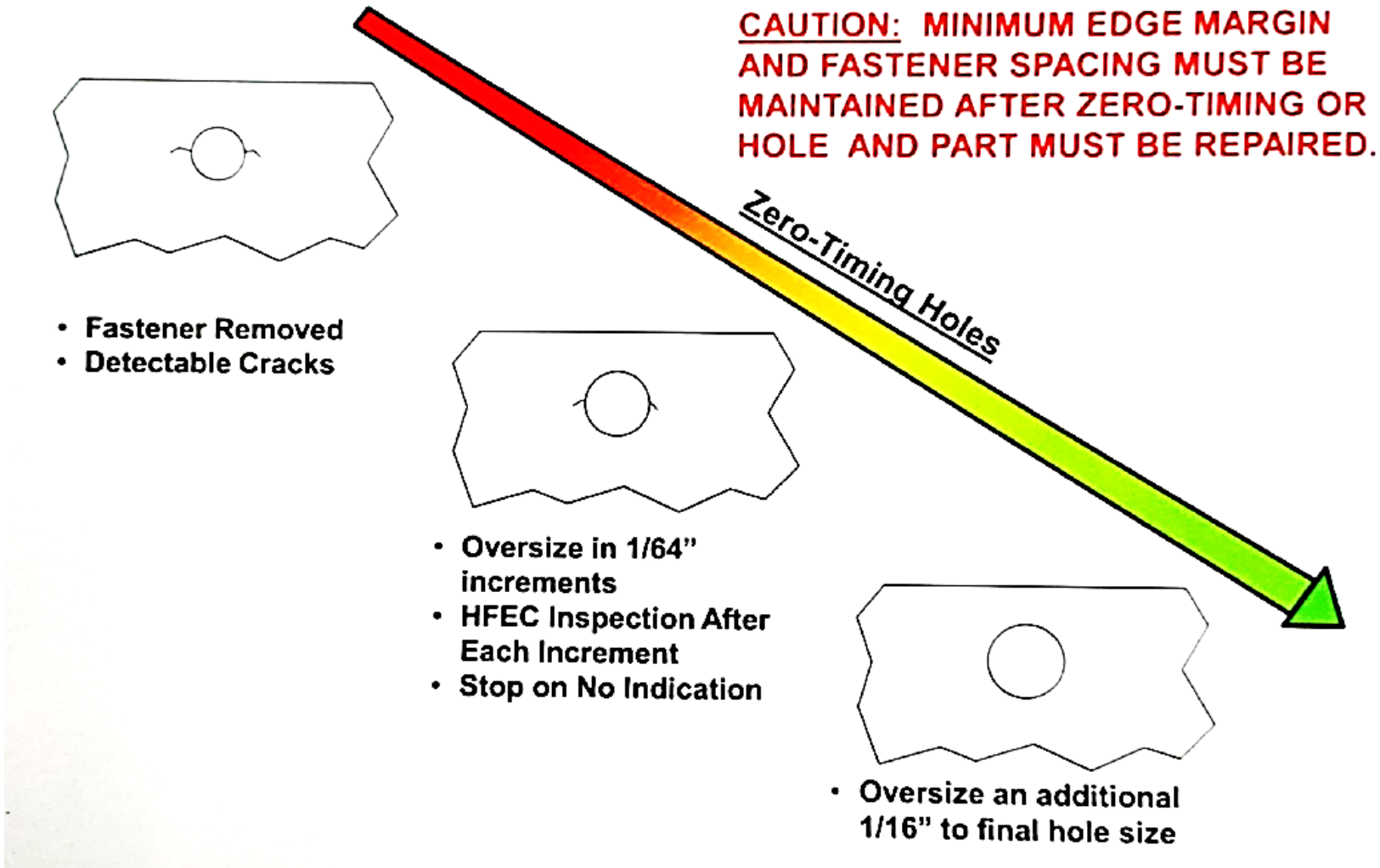
Zero-Timing: The process used to improve the repair durability in order to make the inspection threshold start from the time the repair is installed. This involves the removal of small cracks and fatigue damaged material by oversizing the existing fastener holes before the repair is installed as given in Inspection and Removal of Damage - Metal Structure - Inspection, SRM B787-A-51-11-02-01A-280A-A. Zero-timing must only be used where specifically permitted in an SRM chapter-section-repair. Also zero-timing must not cause short edge margins, or short fastener spacing, or knife-edging of the fastened material at the location of the repair fasteners.

Inspection and removal of damage

- If no cracks are found, make the hole diameter 1/16 inch (1.59 mm) oversize to remove any fatigue damaged material
- If cracks are found, make the hole diameter larger by 1/64 inch (0.4 mm) increments until (High Frequency Eddy Current), shows no more cracks

The limit to make the hole larger is different for each situation and depends on the load pattern and the stress levels in the rework area. Sometimes is necessary to install a plug with the same size of the initial fastener

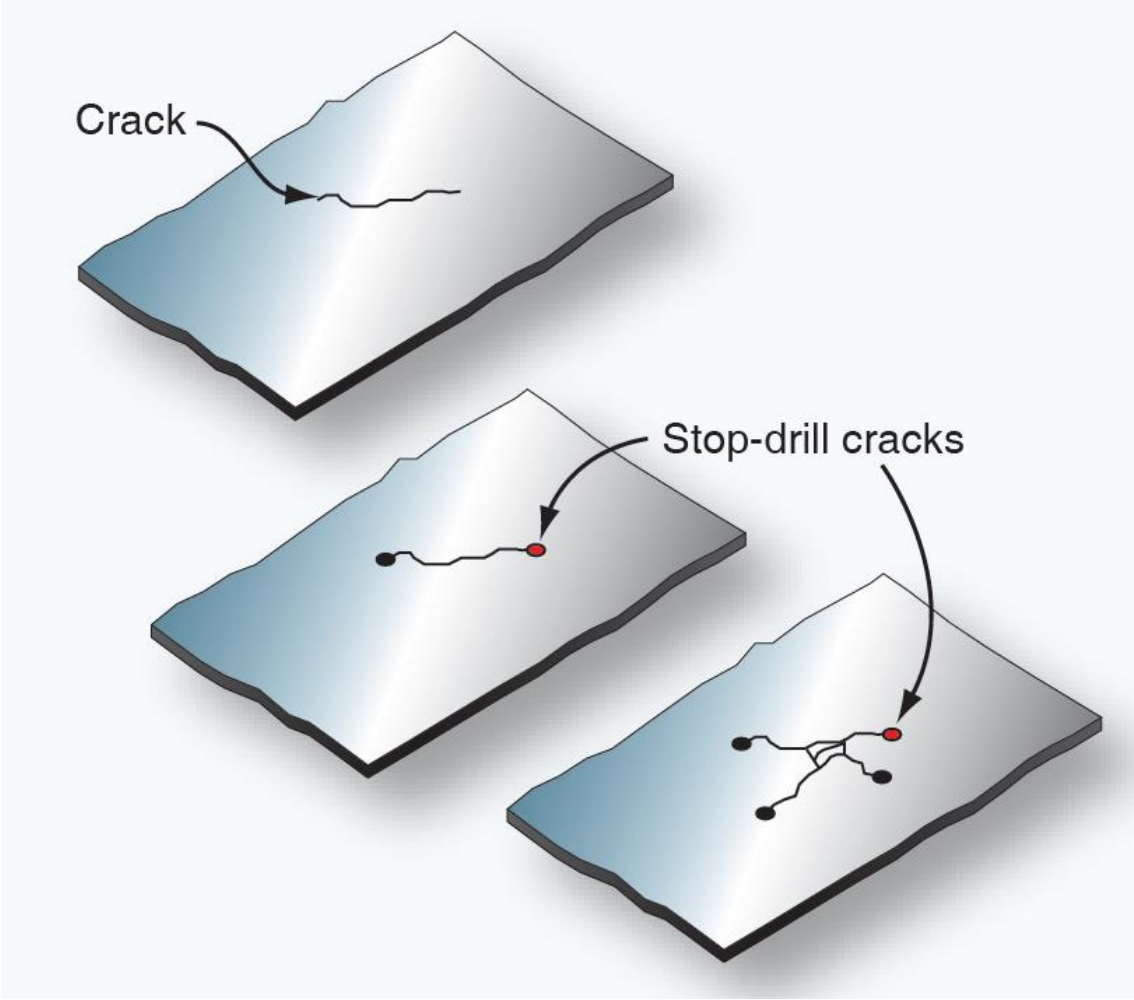
Inspection and removal of damage



Inspection and removal of damage

Stop drilling a crack temporally prevents its growth

The procedure for stop drilling a crack may be used **only if it is referred to in the applicable allowable damage** or repair chapter section subject of the SRM or in the specific approved repair

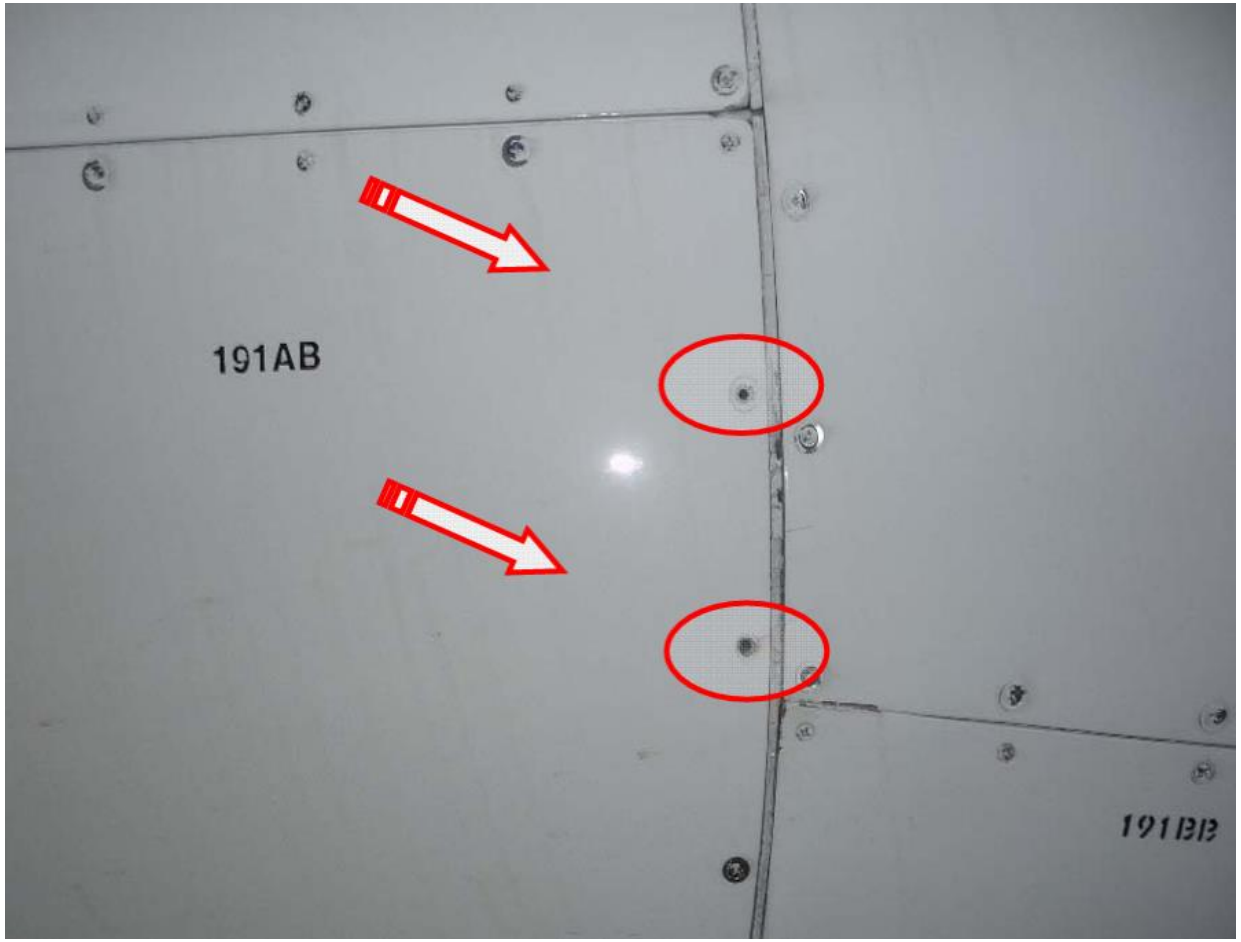


Missing fasteners

This subject gives procedures to find if it is possible to operate an airplane with missing fasteners in **secondary structure**.

The structures that follow are examples of secondary structure that are permitted to have missing fasteners:

- Fairings
- Trailing edge panels
- Access panels



Protective treatment of metallic materials

When you do a repair or rework **procedure that breaks the surface of an initial structure** you must **apply protective treatment**.

The treatment makes a **base for the paint** and **inhibits corrosion** when you apply it before the installation of the repair parts.

Protective treatment of metallic materials

Protective treatment of metallic materials

Aluminum alloys in initial structure need a subsequent chemical conversion coating when the repair procedures remove the initial coatings. The product that follows is approved for use to make a chemical film on aluminum alloys

Alodine is a registered trade name for Parker-Amchem, Henkel Corp.

Protective treatment of metallic materials

In Alodine® coatings, also known as chromate conversion coating, the outer portion of the metal surface is chemically transformed into a protective layer.

The coating of Alodine® is what leaves a base on the surface finish for organic coatings, provides aluminum corrosion protection, and can also protect against the loss of electrical conductivity.

ALODINE® 1000™

Light Metals Conversion Coating.

SPECS:BAC 5719.

ALODINE® 1132™

Touch-N-Prep ® Coating Applicator Pen.

SPECS: MIL-DTL-81706B

ALODINE® 1500™

Liquid Chemical to Protect Aluminum or Aluminum Alloys.

SPECS:MIL-DTL-81706B.

ALODINE® 1201™

Ready-to-use Chromate Conversion Chemical.

SPECS:MIL-QPD-81706.

ALODINE® 600™

Powdered Chemical used to produce a Chromate Conversion Coating.

SPECS: MIL-C-81706.

ALODINE® 1200S™

Aero Chromate Coating.

SPECS:MIL-DTL-81706A

ALODINE® 1200

Two Component Brush-On Process

SPECS:MIL-DTL-81706, DTL5541

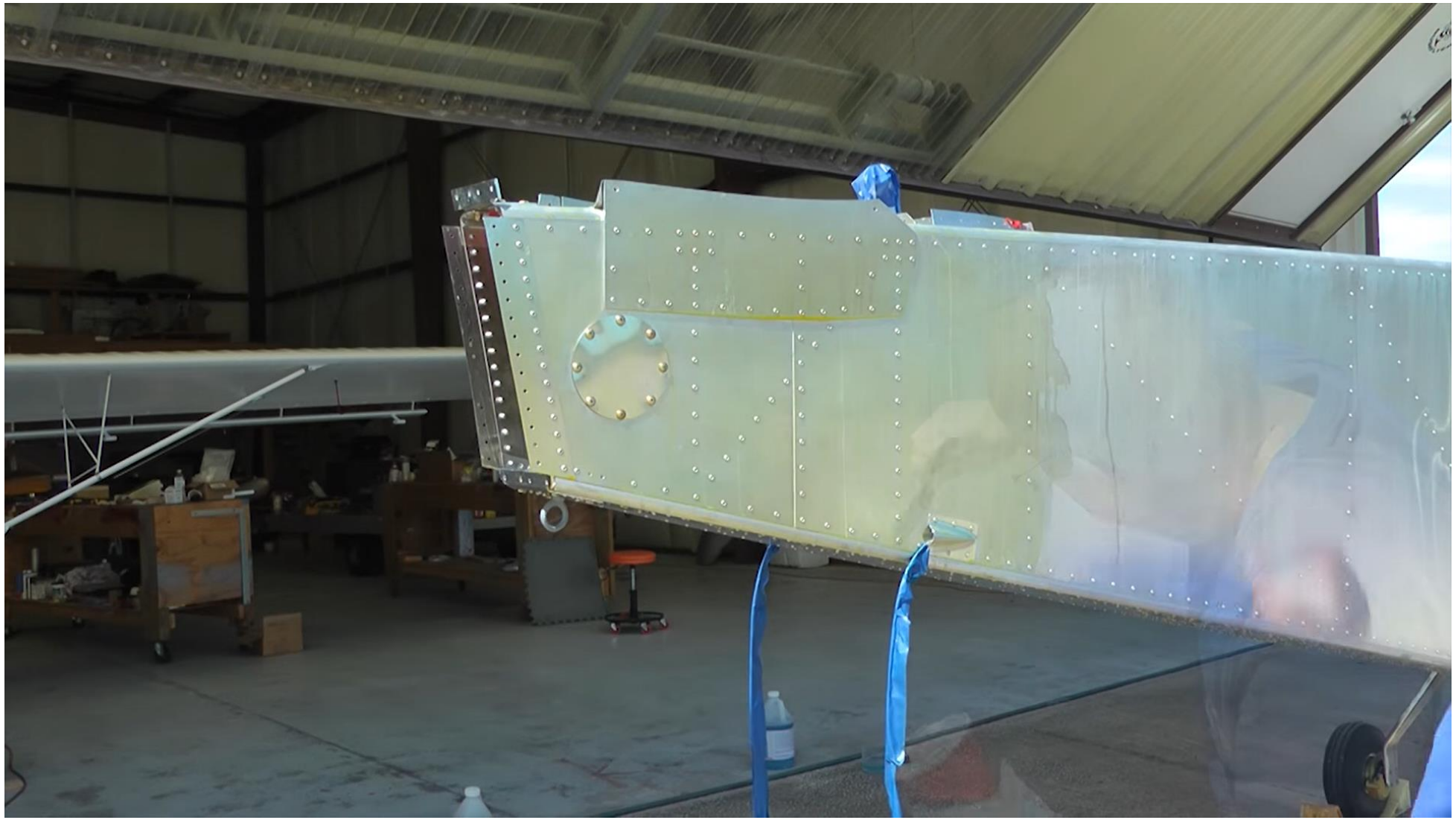
Protective treatment of metallic materials

Epoxy primer **is used to coat steel, aluminum, and composite surfaces** before painting.

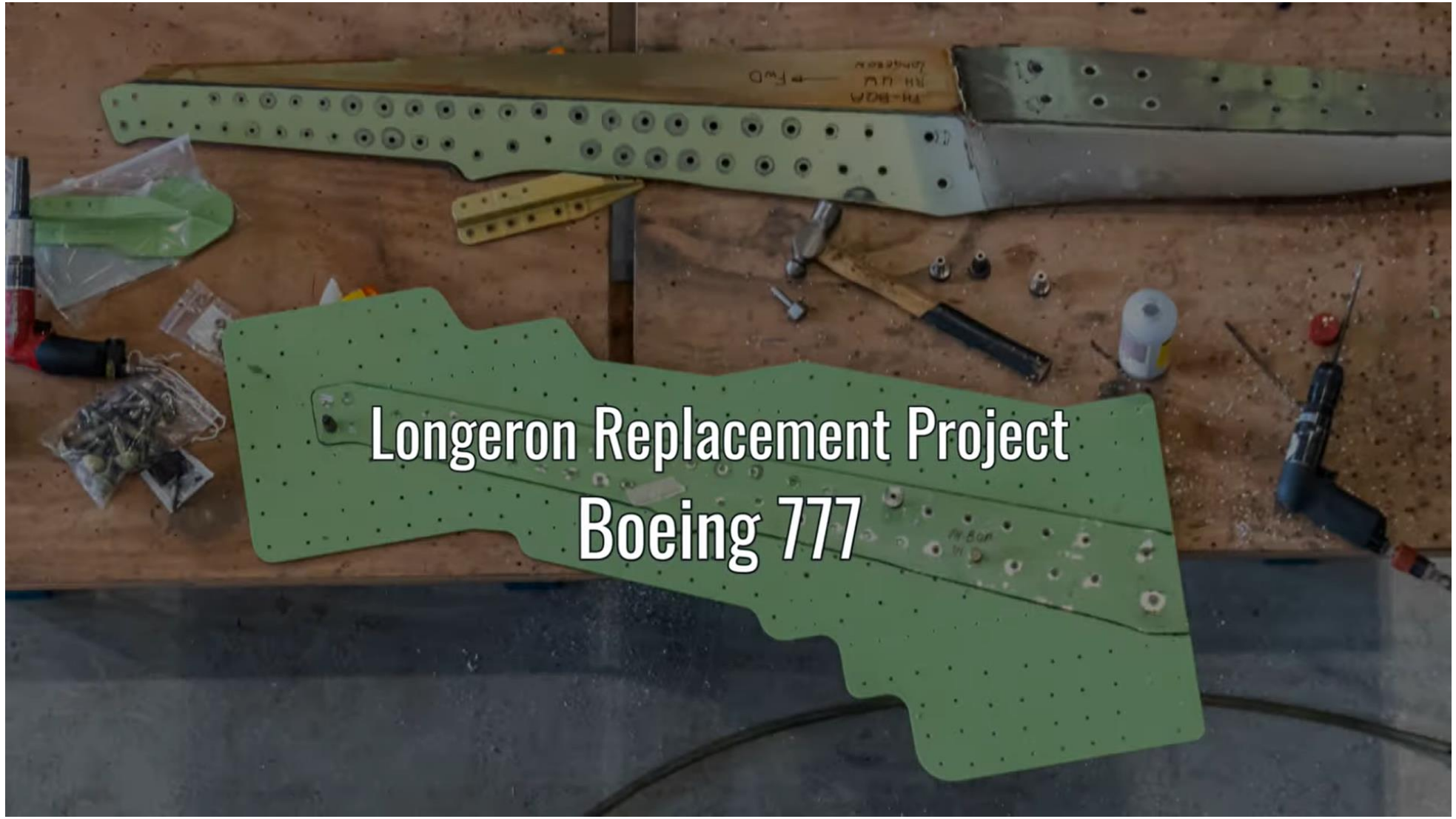
It has superior anticorrosive properties that exceed one part zinc chromate primers in all levels of performance.

Protective treatment of metallic materials

Alumiprep is a non-flammable phosphoric acid based cleaner, brightener and prepaint conditioner for aluminum



https://www.youtube.com/watch?v=SHePtG9LtIU&t=211s&ab_channel=HomebuiltHELP



https://www.youtube.com/watch?v=9UCq6ThCIfQ&ab_channel=TheGreenharm