Use of probabilistic methods Sessions

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Transport Canada Transports Canada

Airbus Thoughts .

Probabilistic Approach: impact threat assessment

Pre-requisite for damage threat analysis

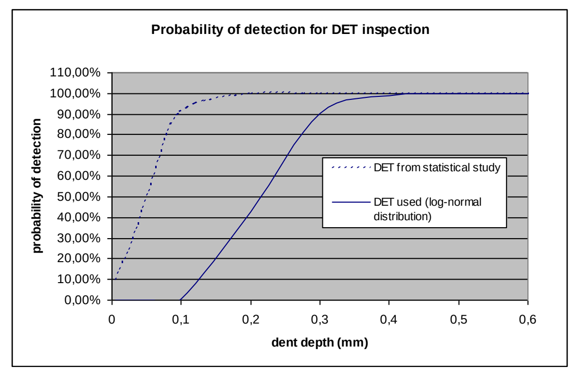
- **The source: Accidental damage assessment:**

Address all kind of threat/damages , hail, stone, lightning, Ground equipment…..calibrated for tests by low speed impactor

- **The inspection : Damage detectability**

Inspections procedures based Visual inspection means: BVID (barely visual Inspection damage), a dent metric with visibility/ PoD approach, (probability of detection of 90% with an interval of confidence of 95%), for both

  - DVI and GVI



Selection at 90% of PoD as criteria for BVID

Probabilistic Approach: impact threat assessment

The principle for damage threat analysis

- **Probabilistic approach& Energy threshold**

Principle is to address impact likelihood with the objective that at the DSG, (N Flight hour), most of the structure will not have been impacted by an energy above a realistic level (Eth)

>Pa, probability par flight hour to be impacted by an energy above E>Eth

>then (1-Pa) is the probability , either not to be damaged, either be impacted by a lower energy than Eth

>So: $P = 1-(1-Pa)^n$ **is the probability to be impacted at least with an energy E>Eth after n flight hour**

- **As a consequence, two values have to be addressed***

> the realistic one , probable range for the static ultimate level

> An higher one , representing the improbable occurrence for the damage tolerance evaluation

* Northrop / MCair (Rapport DOT/FAA/AR-96/111 ou NAWCADPAX-96-262-TR).

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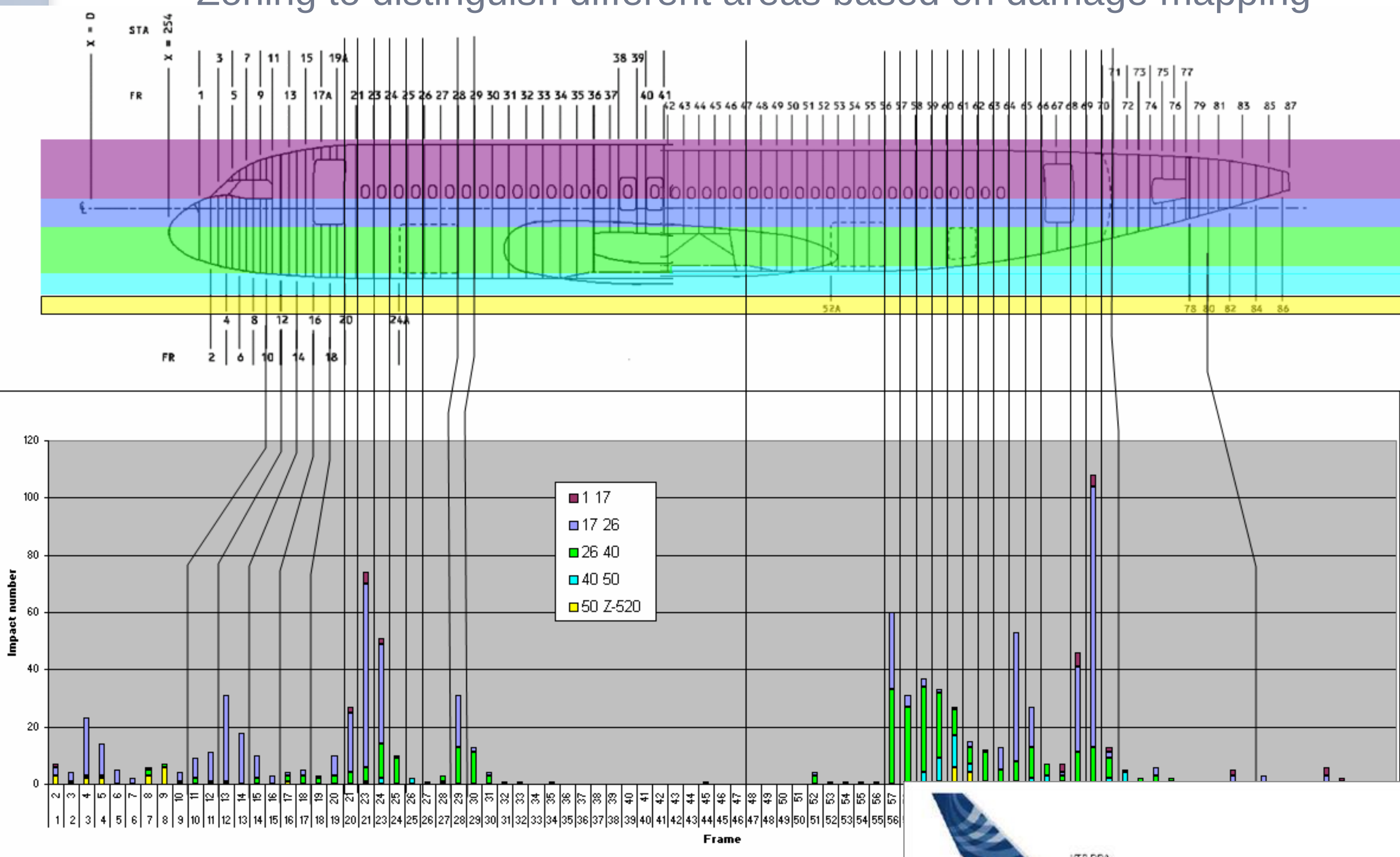
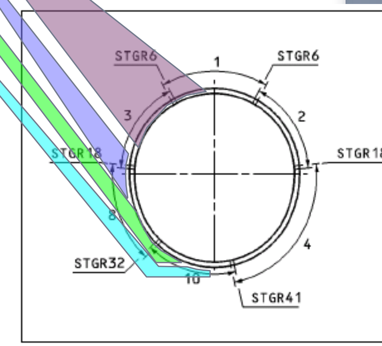
Probabilistic Approach: impact threat assessment: data analysis

Impact damages : impact threat definition based on in service experience and impact calibration (process overview)

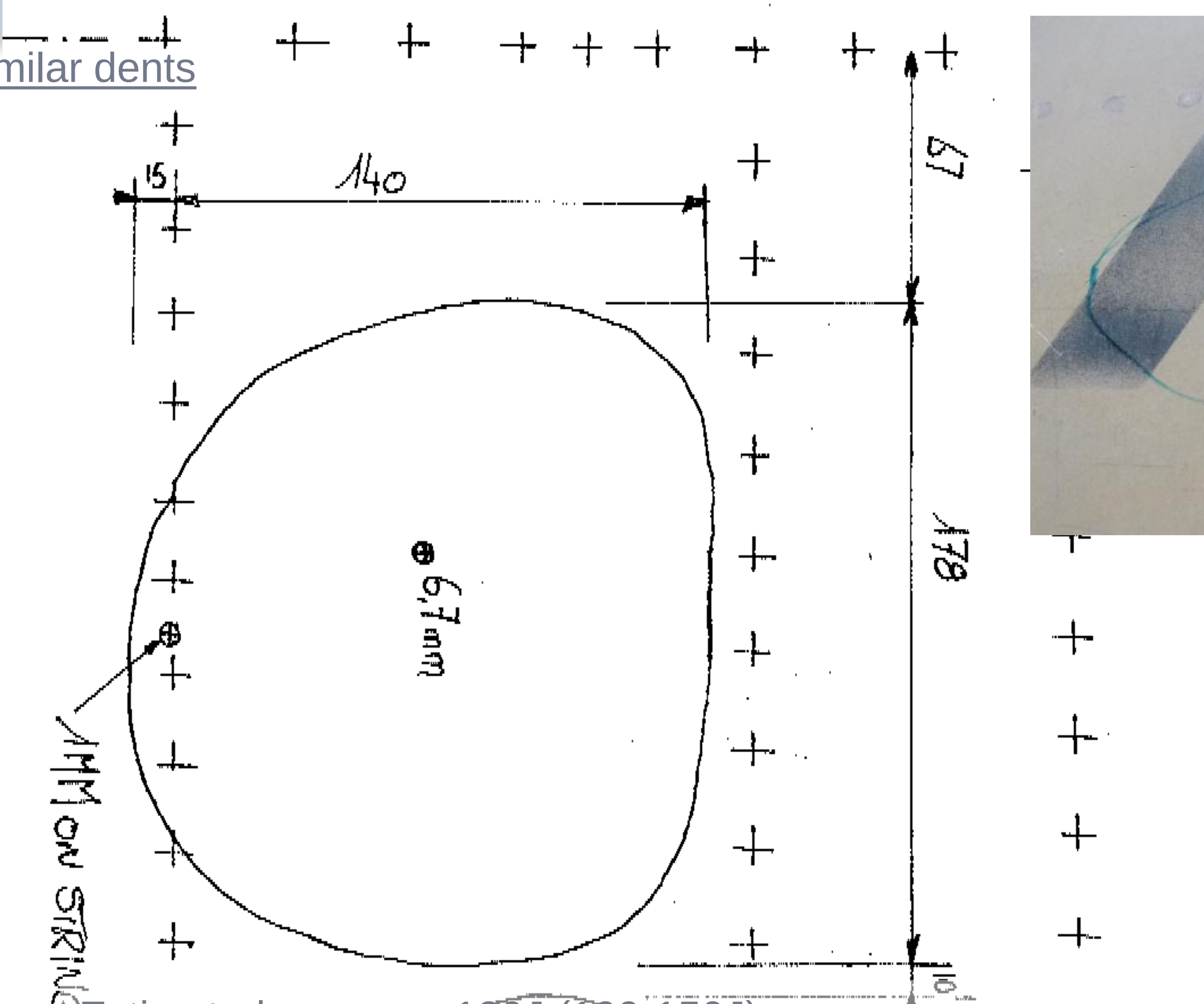
- Zoning to distinguish different areas based on damage mapping

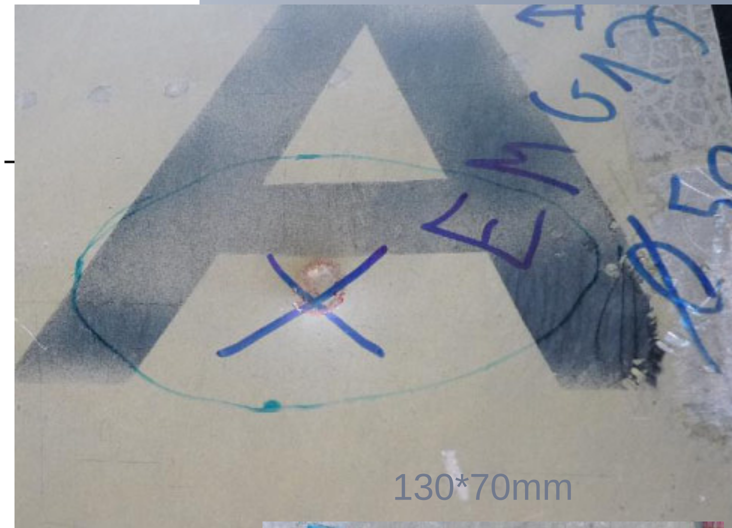


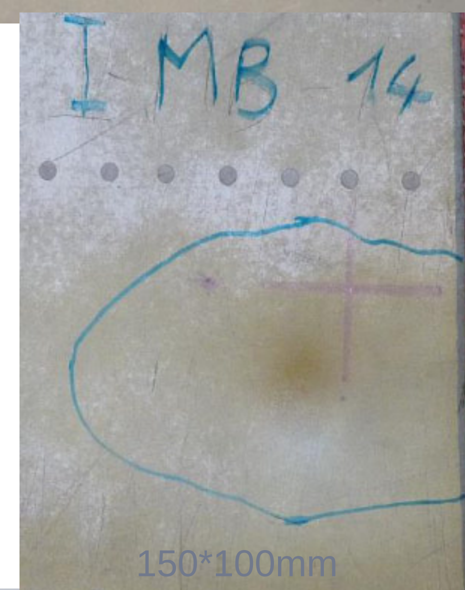


Impact threat assessment: data analysis
Example of damage: Pax door surround

2 similar dents




130*70mm



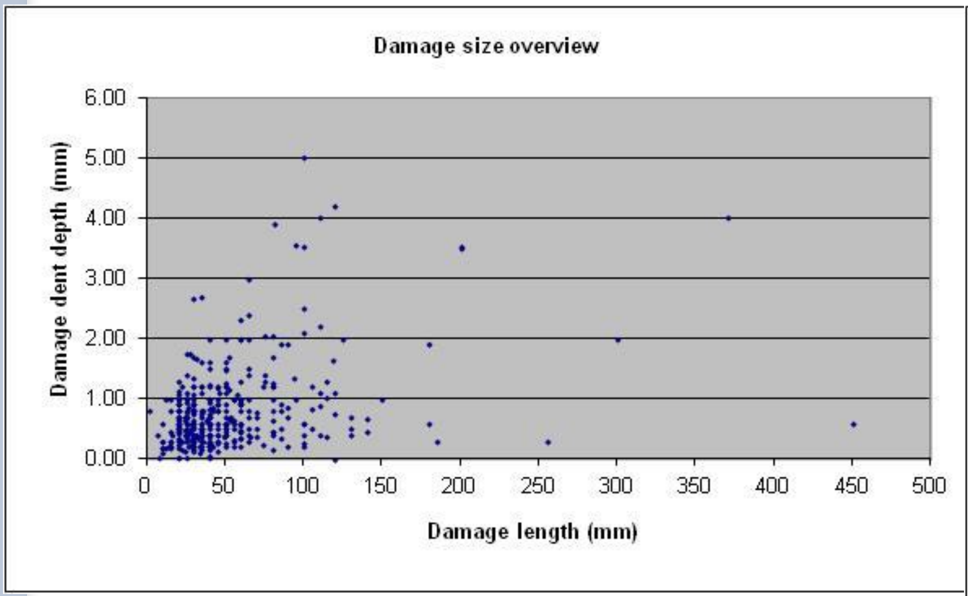
150*100mm

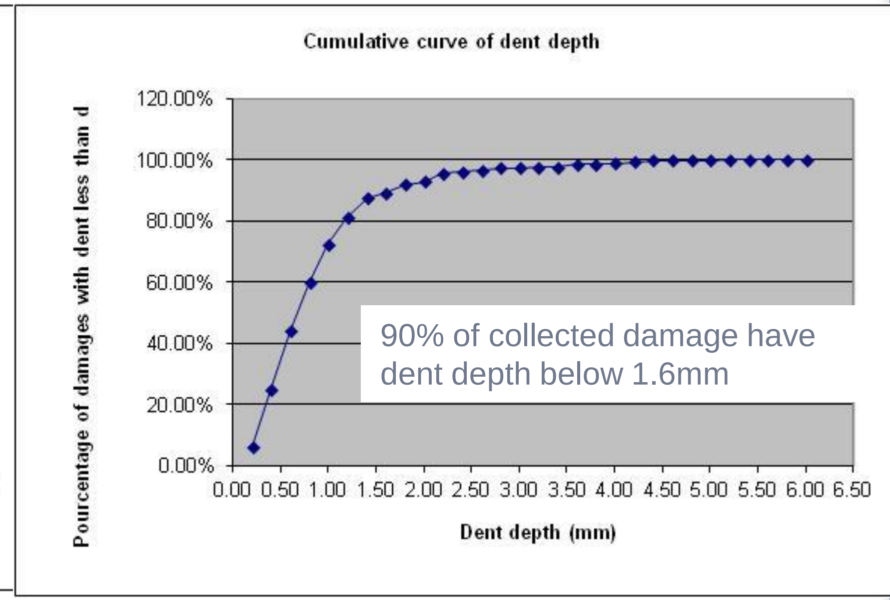
Estimated energy = 120J (100-150J)
(Mid bay, skin thickness=1.4mm, phi 70-100+)

Similar test points: depth=6.2mm, E=95J (MB, thickness=1.4mm, phi50)
depth=6.7mm, E=151J (MB, thickness=1.2mm, phi100)

Probabilistic Approach: impact threat assessment:

Example of damage characteristic from one survey (500000 FH, 73 aircraft over three years) used for impact threat assessment





Large dent depth and or large damage size accounted for in the DT analysis (static strength and residual strength substantiation)

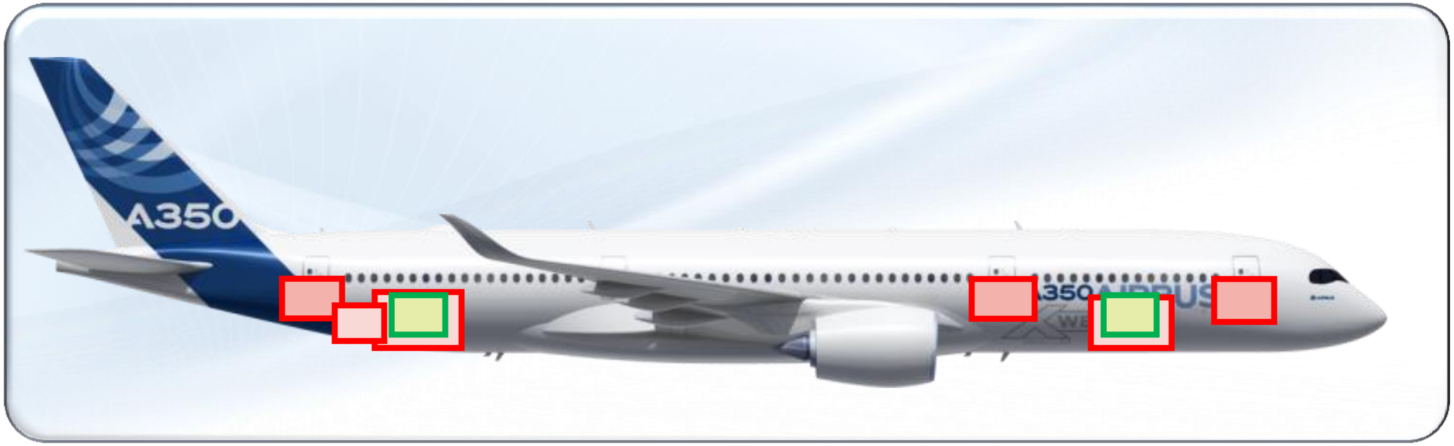
These damage range complies with CAT 1 & CAT 2 from AC 20 107B

Probabilistic Approach: impact threat assessment: E level

Threat level identified for example on fuselage

- Each zone sized to cope with in-service threat ➔ Minimize damage probability
  - **Typical** area Energy set at 35J
  - **Damage prone area :** (High threat /Medium threat)
    - on Fuselage: Energy up to 130J

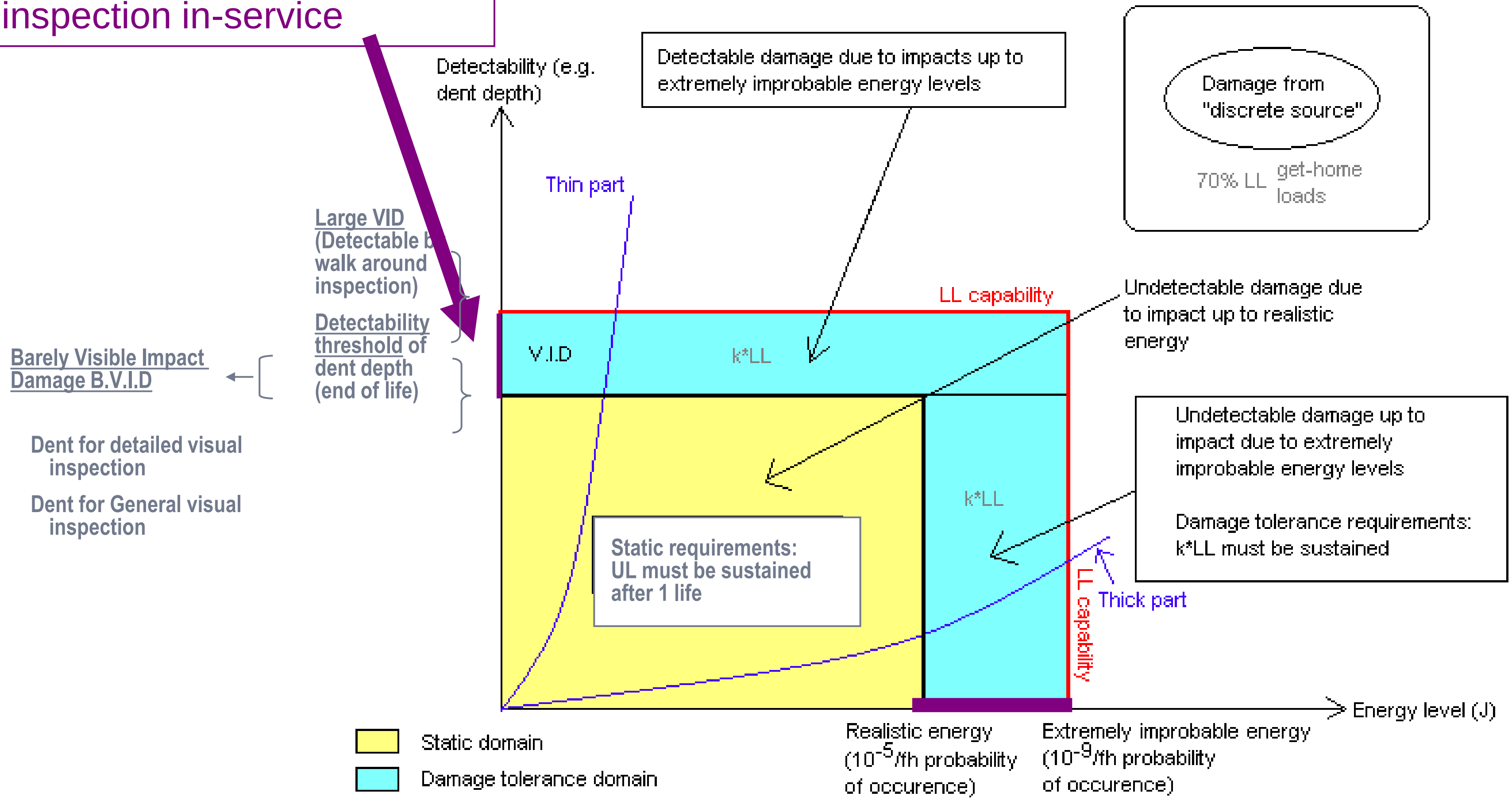
High threat Medium threat



- On Wing : Energy up to 60 Joules

Probabilistic Approach: impact threat assessment: the methodology

Linked to means of inspection in-service



Linked to in-service experience (data survey)

Probabilistic Approach: impact threat assessment: Bibliography studies;

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CMH 17 :rev 3G , § 12.9 'realistic impact energy threats to aircraft' : we can read that from different survey performed different level of upper impact energy:

- 48 J from report DTO/FAA/AR-96/111 or NAWCADPAX-96-262-TR April 97: Advanced certification Methodology for composite structure, based on 1644 records of impacts on a Military A/C
- 30 J from report DTO/FAA/AR-95/17 August 97: Development of a probabilistic design methodology for composite structures , based on 1484 records of impacts on civil A/C (2100 A/C and 19 operators)
- Airbus analysis preformed on more significant damages reports, where a specific focus on Short Range , with higher flight cycles per day compared to Long Range A/C have been considered to establish fuselage damage prone area:

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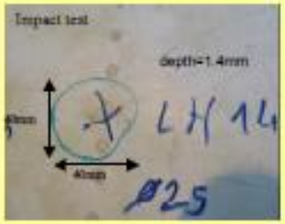
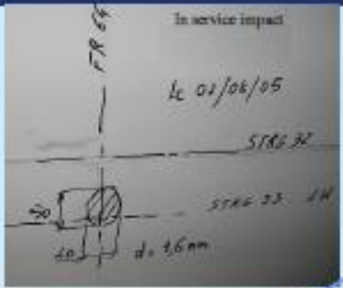
A350 XWB

Impact calibration Test procedure

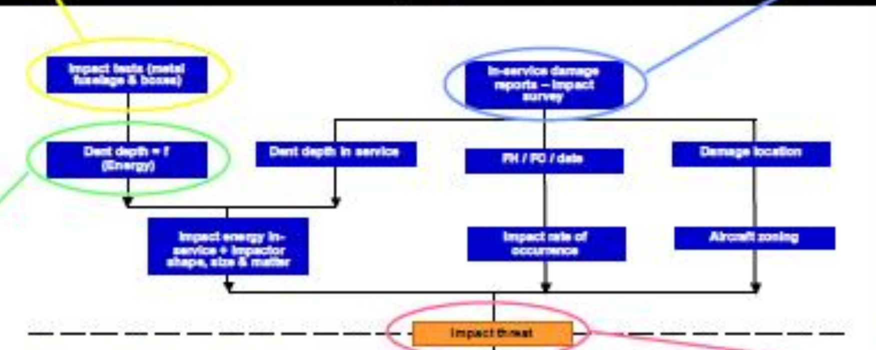
Reproduce damages in a laboratory on a fuselage representative of aircrafts in operation (full scale impact calibration test) with following investigated parameters:

- Energy range: 10J to 500J
- Impactor : steel hemispherical diameter 16mm, 25,4mm, 50mm, 70mm & 100mm and bumper representative of ground vehicule protection
- Impact type: Low velocity (1 to 14 m/s) and static impact (with jack)
- Impact location from outside: typical skin, near and on stiffened elements and at doors surround



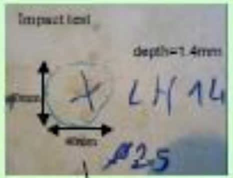


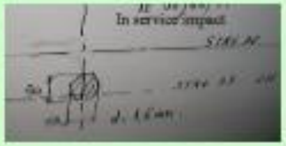
In-service damage report - impact survey

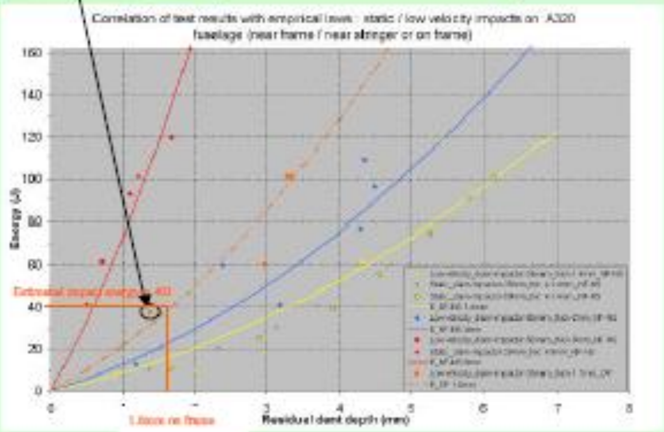


Impact threat evaluation objective: Have a better knowledge of in-service damages in order to size the fuselage (composite or metallic) damage tolerant: representative type/size of impactors and realistic level of energy for sizing.

Test analysis



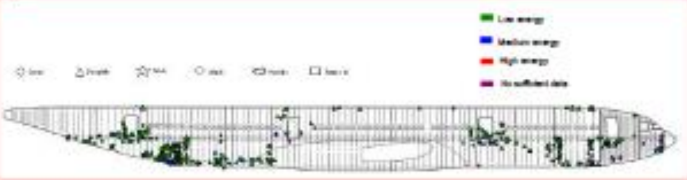


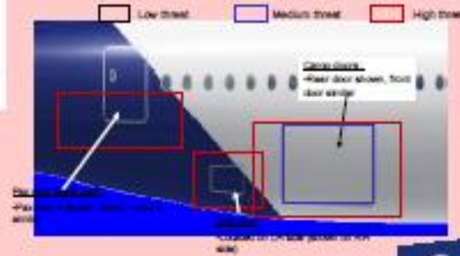


Statistical treatment of in-service data for impact threat definition

Step 1: Calculation of impact energy for each damage report

Step 2: Definition of aircraft zoning depending of damage density and severity





Step 3: Statistical treatment of impact energy on the period survey to derive realistic energy level to be used for aircraft sizing per zone

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