AMTAS Meeting
Fall 2016

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Discussion

- AMTAS Fall 2016
- Method Development and Integration
- High Energy, Blunt Impact Treats

AMTAS 2016

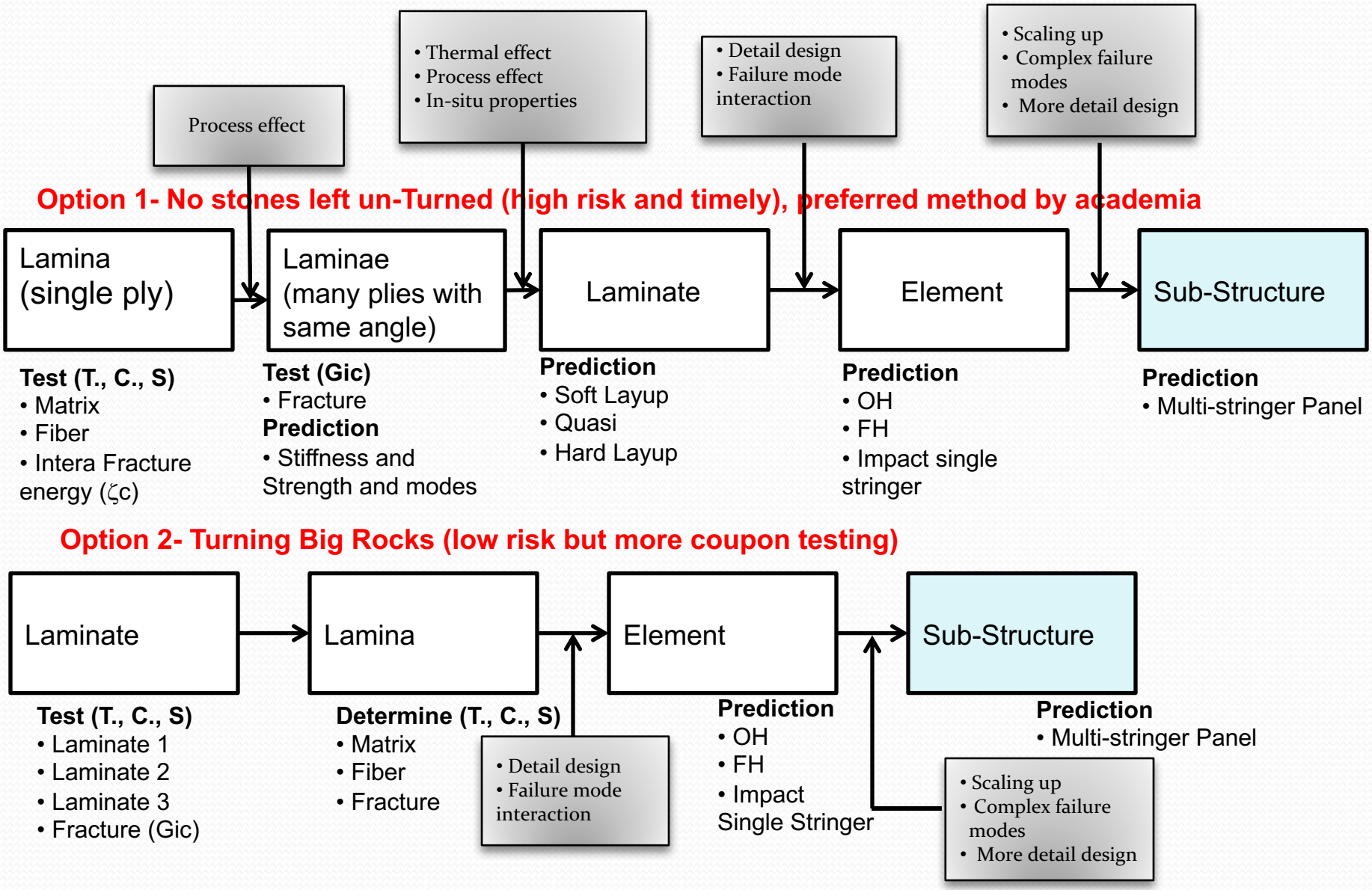
- Failure of Notched Laminates Under Out-of-Plane Bending
- Delamination/Disbond Arrest Features in Aircraft Composite Structures
- Safety and Certification of Discontiuous Fiber Composite Structures

Background

- More than 30 years of method and tool developments had limited effect to reduce cost of validation and certification of structures

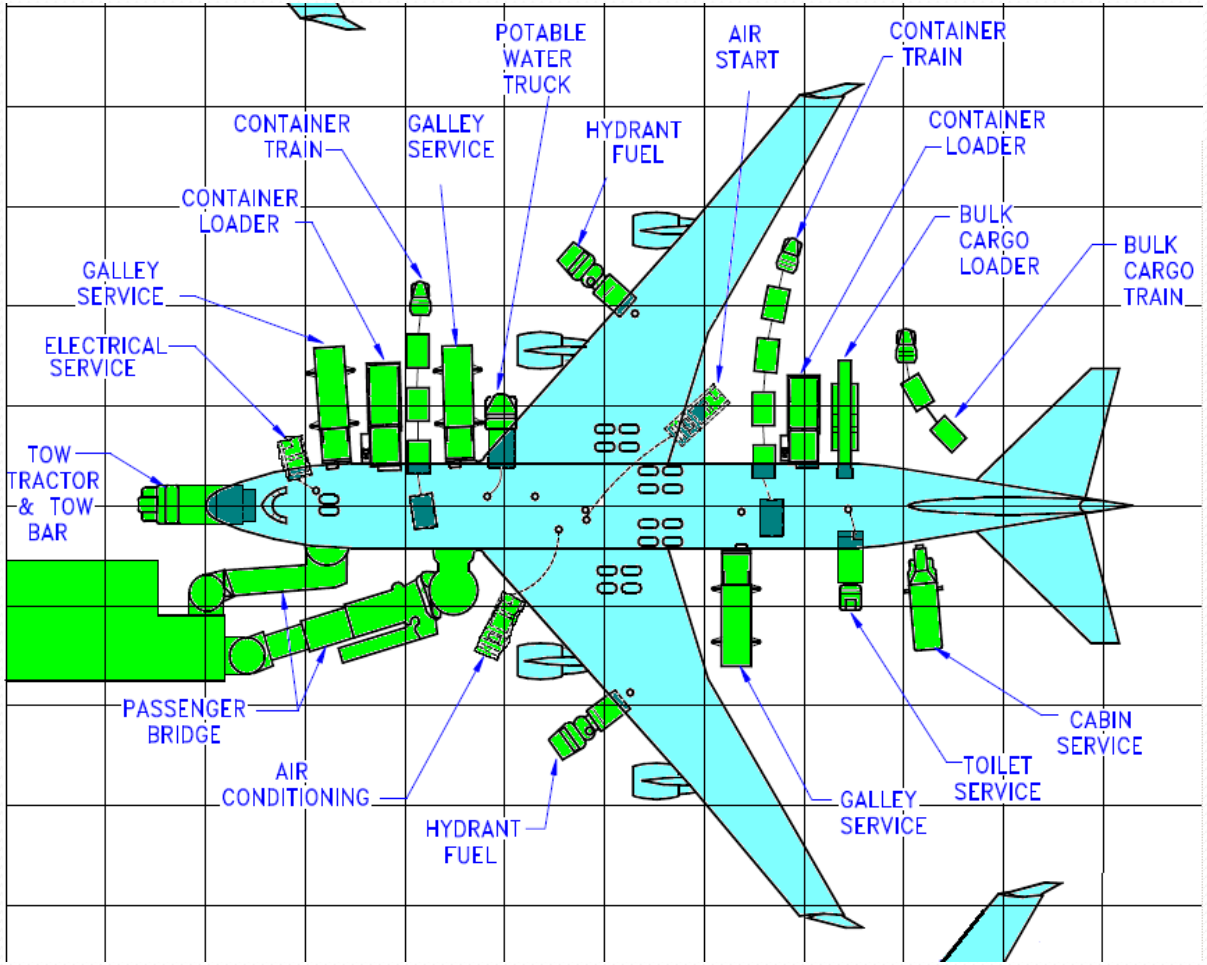
- WHY?
  - **Computing power**
  - **scaling up**
  - **Integration**

Methods and Tools Development Process



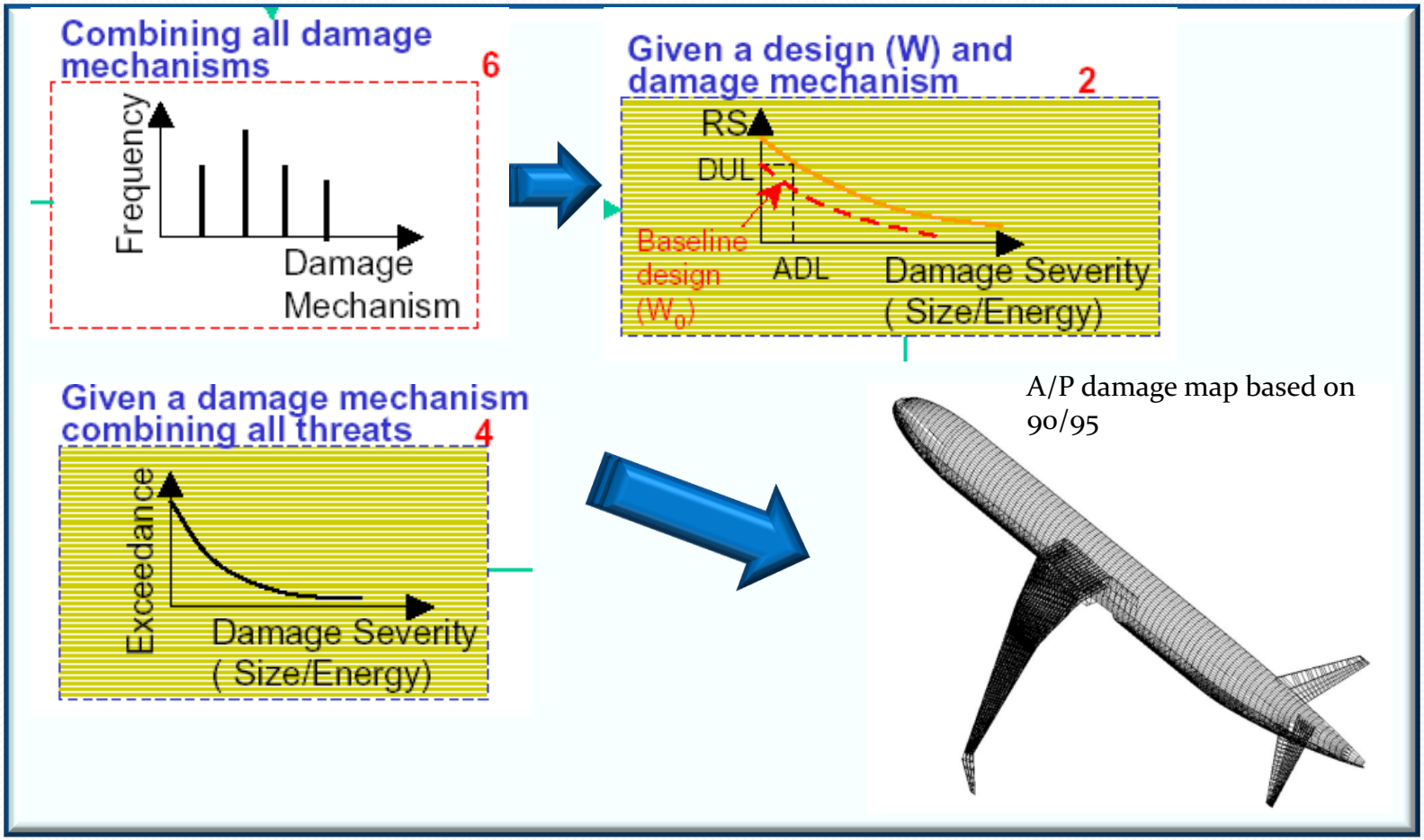
High Energy, Blunt Impact Damage

High-Energy, Wide-Area, Blunt Impacts(HEWARI)*



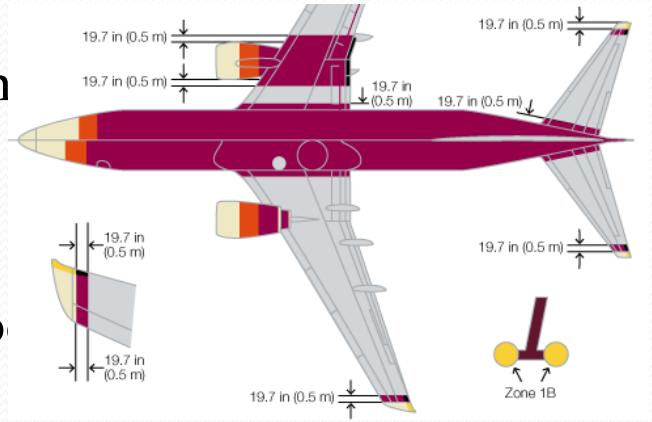
* AMTAS Fall 2015

Using Probabilistic Analysis



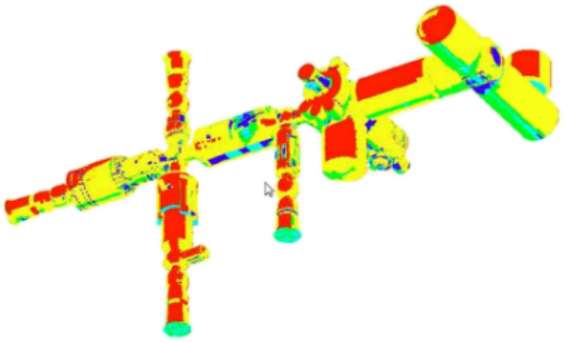
Probabilistic Design/Analysis

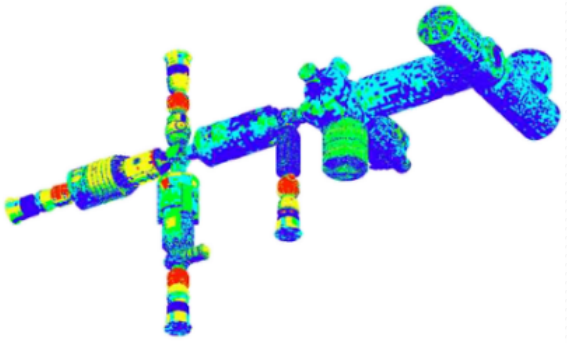
- Probabilistic design/analysis offers potential for structural optimization.
  Should be done in a structured way;
  Must maintain robustness of current design



- Design guidelines for lightning protection already use a probability-based zone metho

- International Space Station repair procedures were developed based on a probabilistic approach to impact damage energy mapping:





Data Mining and Analysis (2003-2005)*

Damage Event Count by Section

Fuselage 719 Damage Events	Horizontal Stabilizer 102 Damage Events
Wing 631 Damage Events	Landing Gear 77 Damage Events
Engine 242 Damage Events	Vertical Stabilizer 37 Damage Events

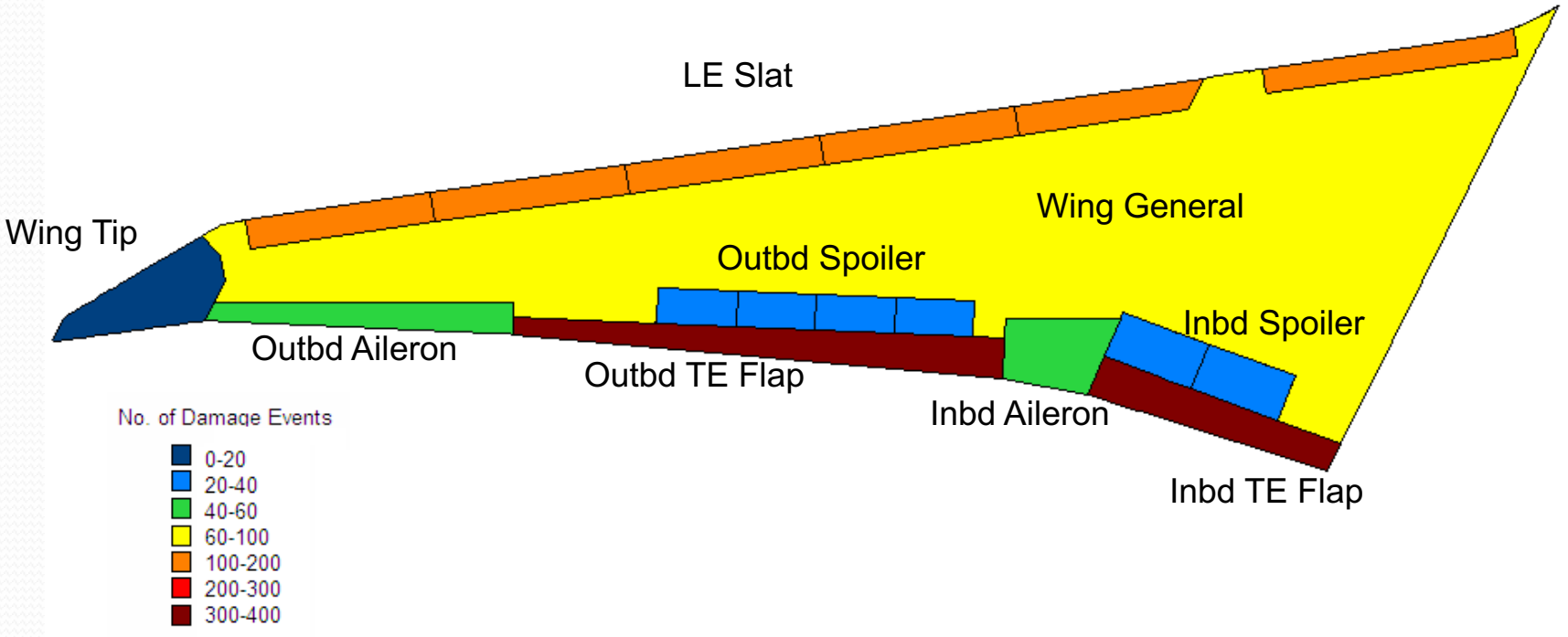
Total
1820 Damage Events

* SMA/SDT/UoW (2003-2005)

Damage Data Categorization

Material Type	Exterior Damage	Damage Type	Aircraft Location	Detection Method	Damage Cause
Metal	Yes	Crack	Fuselage	Visual Inspection	Bird Strike
Composite	No	Dent	Wing	Tap Hammer	Ground Collision
		Delamination	Horizontal Stabilizer	Mechanical Impedance	Departed Aircraft Component
		Hole	Vertical Stabilizer	Ultrasonic	Runway Debris
		Other	Engine	Other	Tire Tread Separation/Blowout
			Landing Gear		Ice/Sleet/Hail
					Lightning
					Unknown

Example of Damage Events in Wing

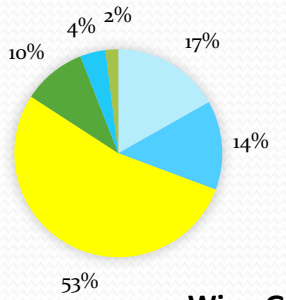


Damage frequency is highest in slats and outboard flaps

Data Mining (Wing Example)

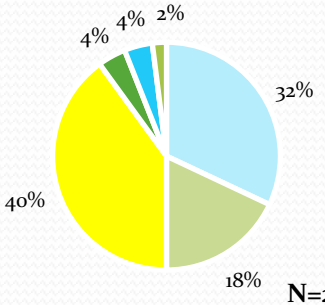
Flap, TE

N=337 damage events



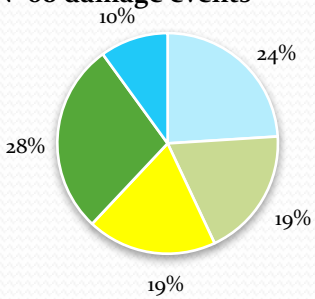
Slat, LE

N=163 damage events



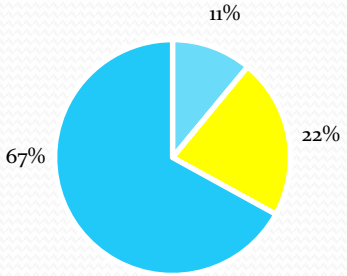
Wing General

N=60 damage events



Spoiler

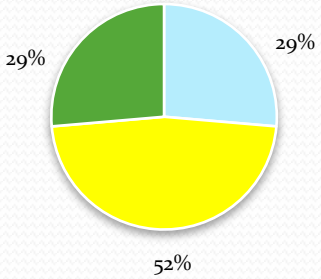
N=21 damage events



- Crack
- Delaminatio
- Dent
- Gouge
- Hole
- Others

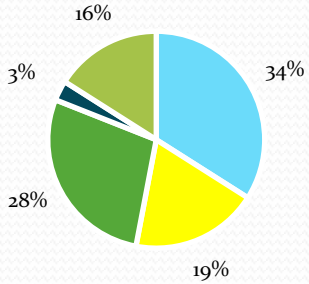
Wing Tip

N=7damage events



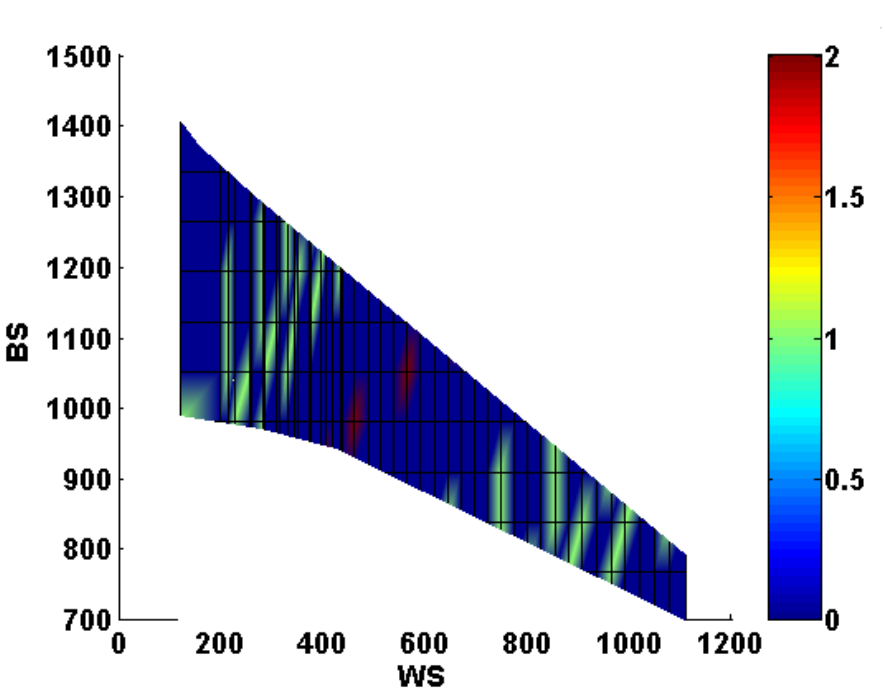
Aileron

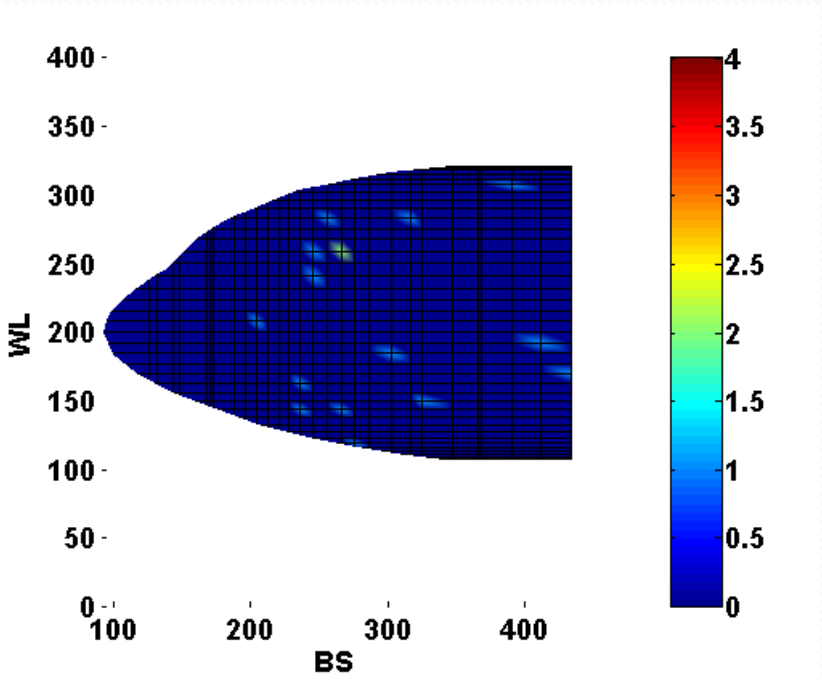
N=44 damage events



Most Damage occurs in Flaps / Trailing Edge

Example of Damage Mapping





Most damage is below 1.25 inches in size

Summary

- Progressive Failure:
  - Consider analysis methods with highest pay back
  - Consider effect of scaling up
  - Forming a working team from FAA, NASA, Industries and method developers to develop practical process for rapid integration method in to production

- Impact Probabilistic Analysis:

  Statistical analysis of existing in-service data to map impact energy will significantly improve manufacturers and airlines awareness to improve design and develop robust maintenance schedule