10 Year Anniversary

# An assessment of the last seconds of the MH370

Argiris Kamoulakos

COMPutational ASsessment Suite (comp-as-s.com/mh370)

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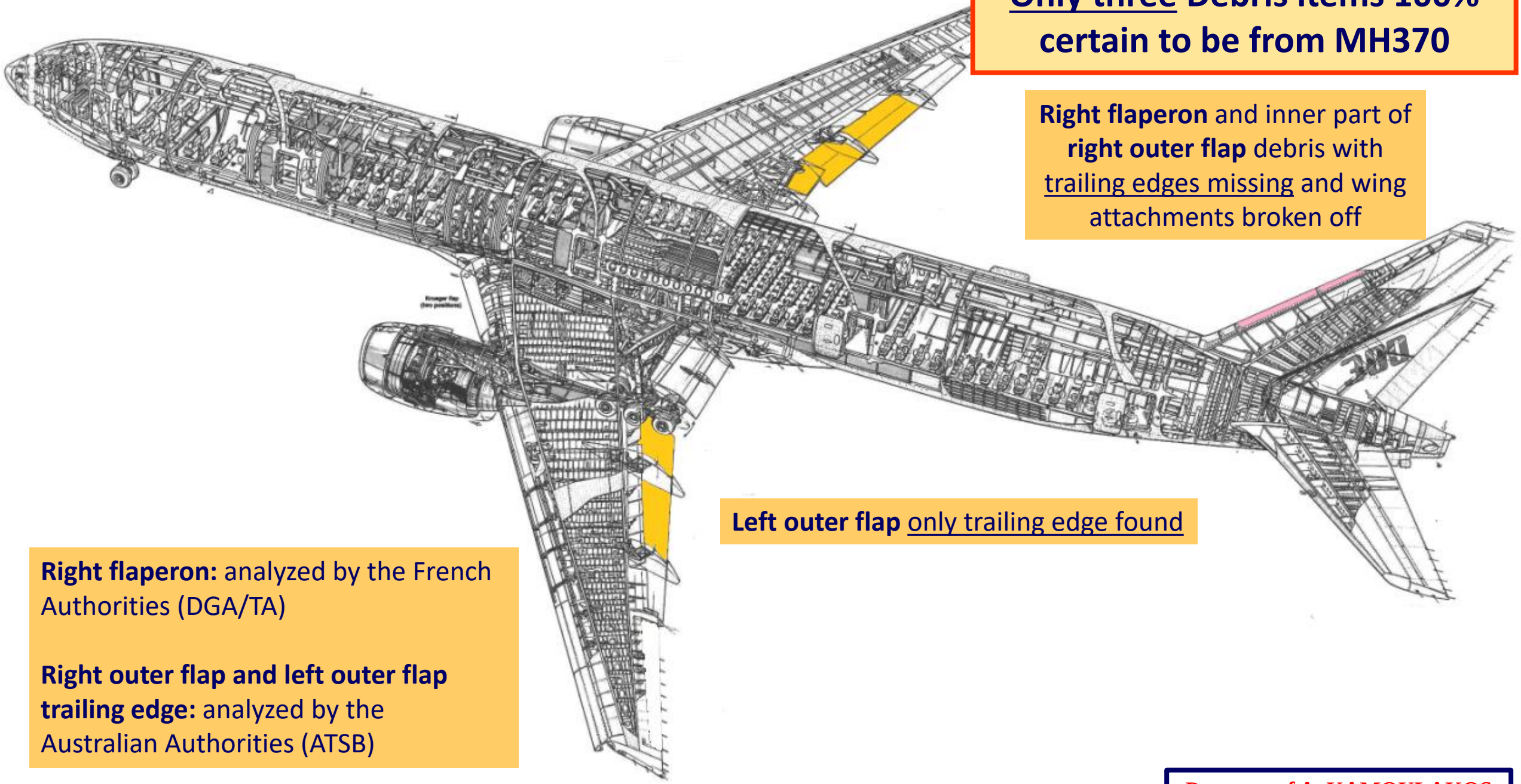
COMPutational ASsessment Suite

CAPTIO(N) Team Member

# Only three Debris items 100% certain to be from MH370

**Right flaperon** and inner part of **right outer flap** debris with trailing edges missing and wing attachments broken off



**Left outer flap** only trailing edge found

**Right flaperon:** analyzed by the French Authorities (DGA/TA)

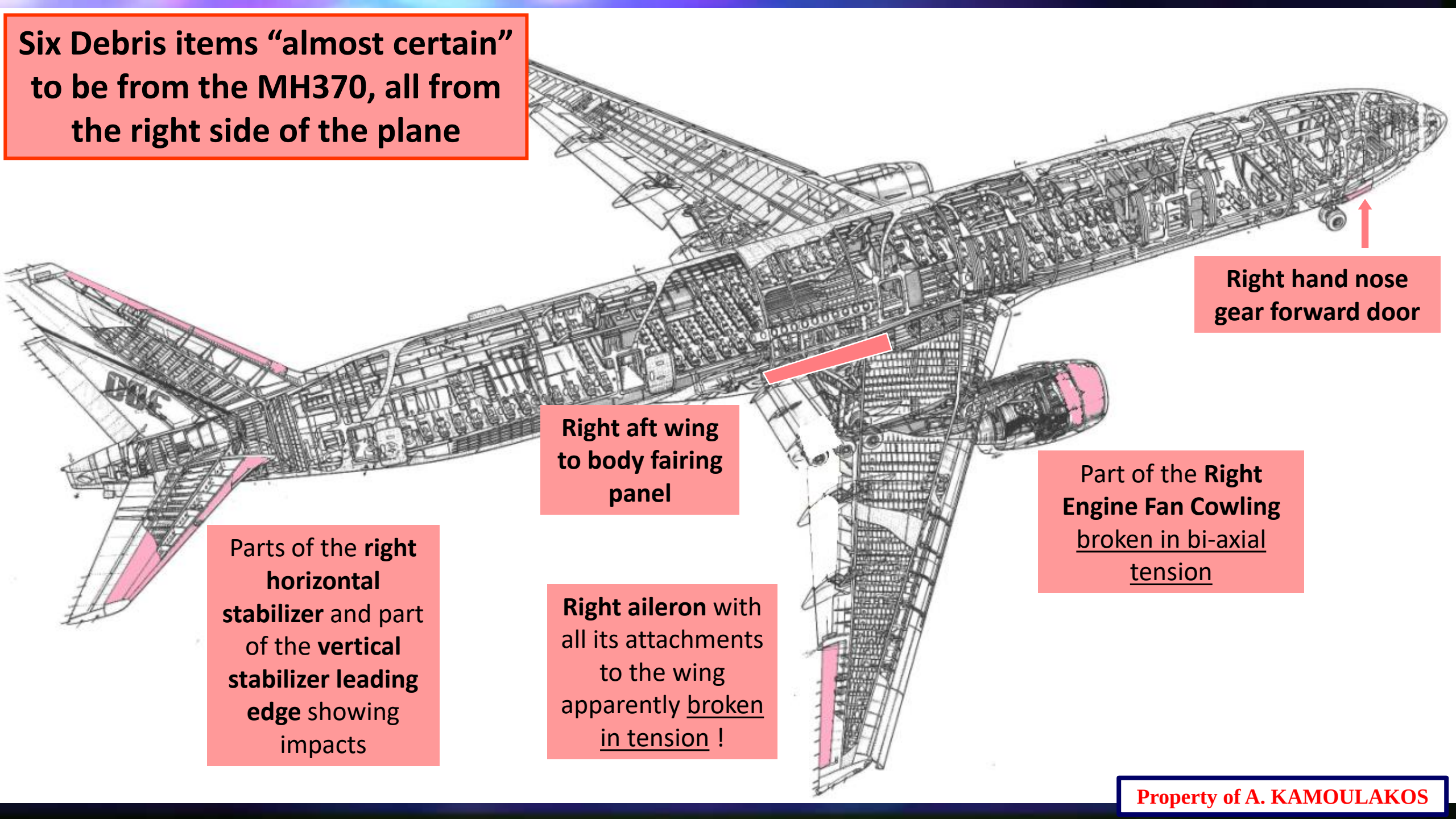
**Right outer flap and left outer flap trailing edge:** analyzed by the Australian Authorities (ATSB)

# Facts regarding the certified debris

- Only three debris items are 100% certified to be from MH370.
  - 100% means that part serial numbers were fully identified upon them.
- These three debris items have in common the trailing edges (rear edges) been broken off.
  - **Right wing flaperon:** trailing edge missing.
  - **Inner part of right wing outer flap:** trailing edge missing: rupture shape similitude with flaperon (see next page).
    - OBSERVATION**:** the similitude can imply that they experienced similar event; if we assume water impact, then they were together when they hit the water.
  - **Left wing outer flap:** only trailing edge recovered.

# Combined location of Flaperon and Flap Debris

# Six Debris items “almost certain” to be from the MH370, all from the right side of the plane



**Right hand nose gear forward door**

**Right aft wing to body fairing panel**

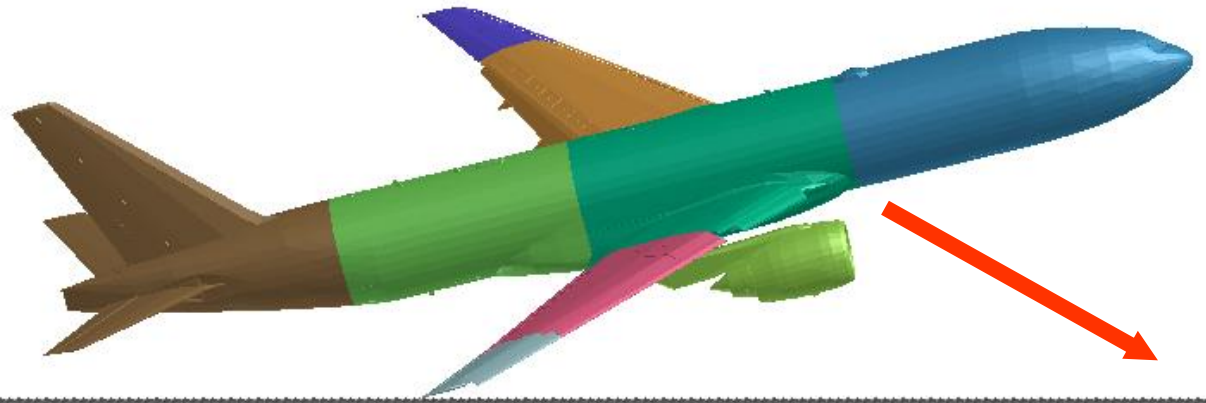
Part of the **Right Engine Fan Cowling** broken in bi-axial tension

Parts of the **right horizontal stabilizer** and part of the **vertical stabilizer leading edge** showing impacts

**Right aileron** with all its attachments to the wing apparently broken in tension !

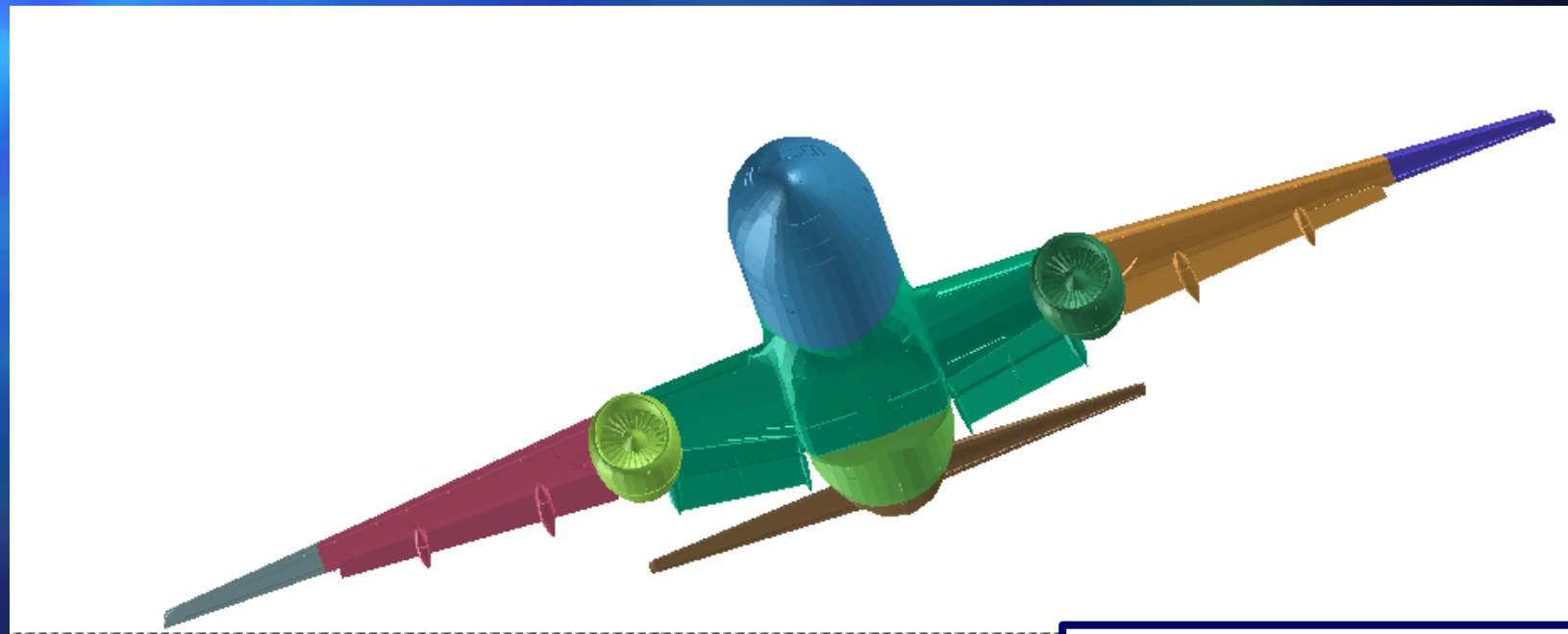
# The case for a violent right wing first impact

- Right wing flaperon and inner flap attachments to fail in this catastrophic way can be due to combined loads resulting from hydrodynamic loads and large wing deformations and/or fracture of the wing.
- This can imply an impact of the aircraft with the sea at a large roll rotation and appropriate speed, leading to:
  - impact of the **right wing** tip with the sea resulting in the ripping off of the right aileron,
  - then violent impact of the **rest of the right wing** suffering large deformations from the hydrodynamic forces that break the flap attachments and lead to possible failure of the wing near the flaperon section, hence releasing flaperon and flap.



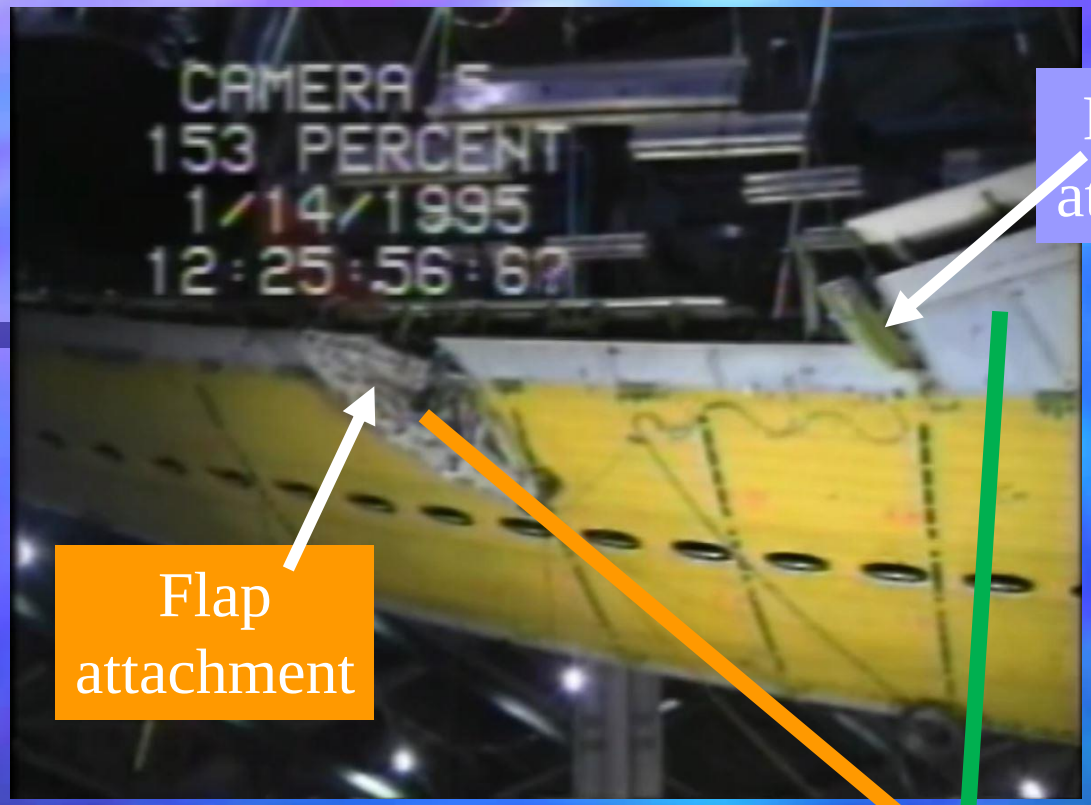
# The case for a violent right wing first impact

## Problematic ditching



# Extract from the Boeing B777 certification test

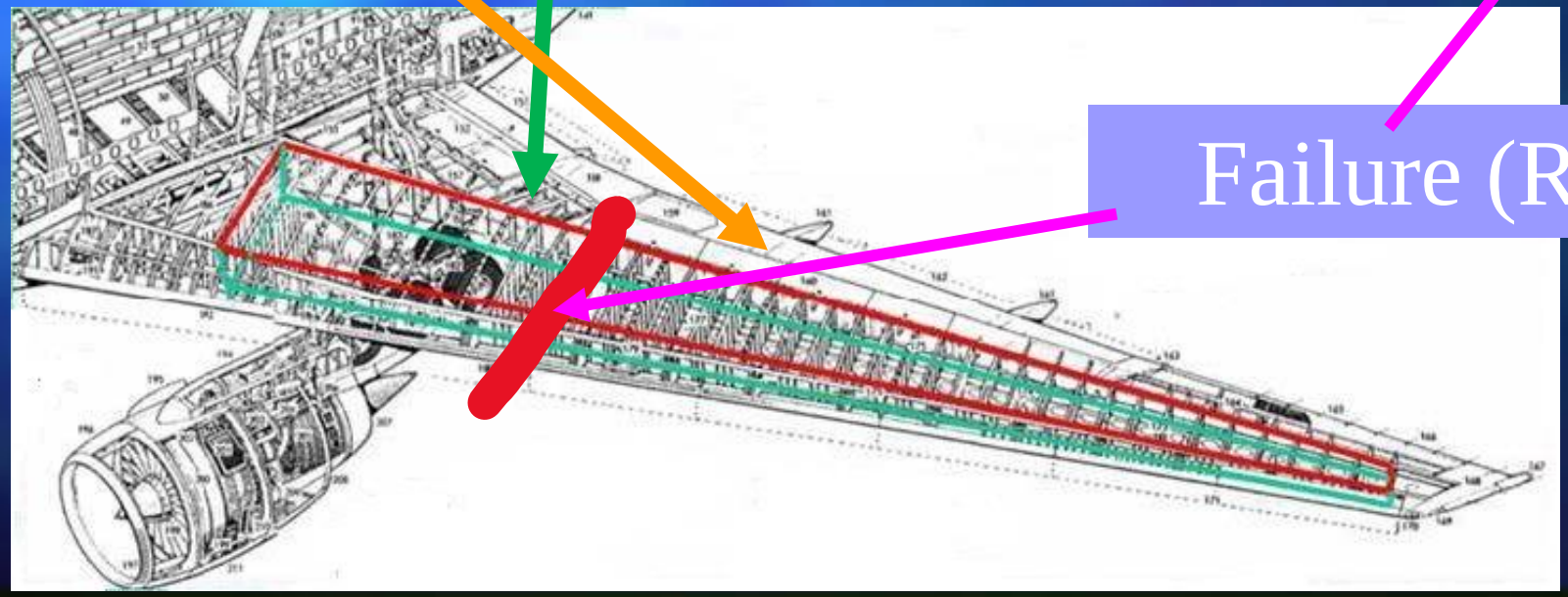
- *"… Wing failure occurred at 154.4% from our initial readings. Failure occurred in both wings, so again analyzing data afterwards we determined that they failed 20 milliseconds apart; right wing going first. Additional analysis after that showed that* ***the right wing failed beginning in the area of rib 25*** *…"*
- *"… This test, at destruction, we failed at approximately 24 feet tip deflection of the wing …"*
  - This is about 7.3 meters tip deflection.
- To our understanding, Rib 25 area appears to be in the vicinity between the inner part of the outer flap and the right engine support pylon, close to the flaperon. Look image from the certification test in next page.




Flaperon attachment

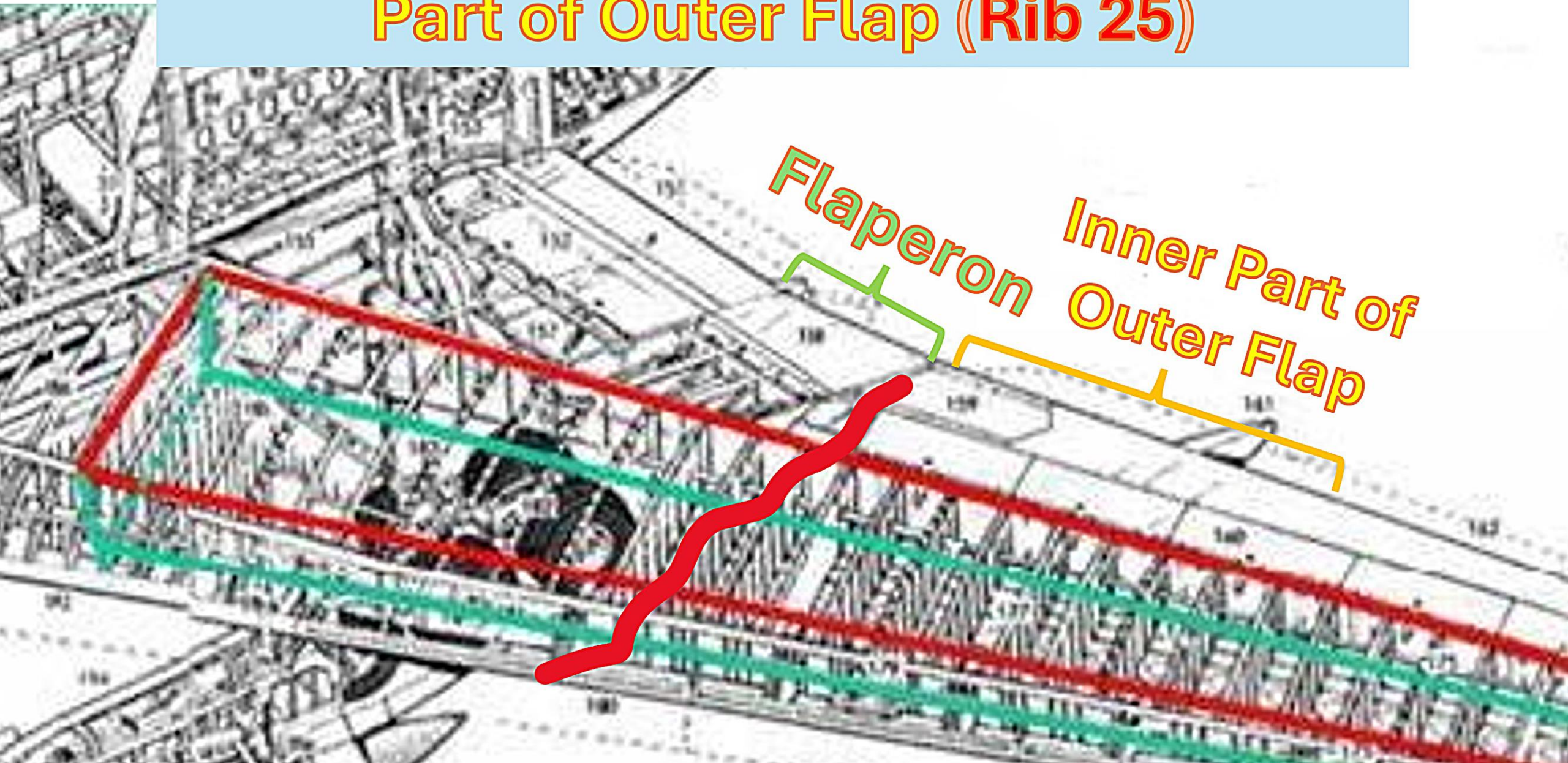
Flap attachment

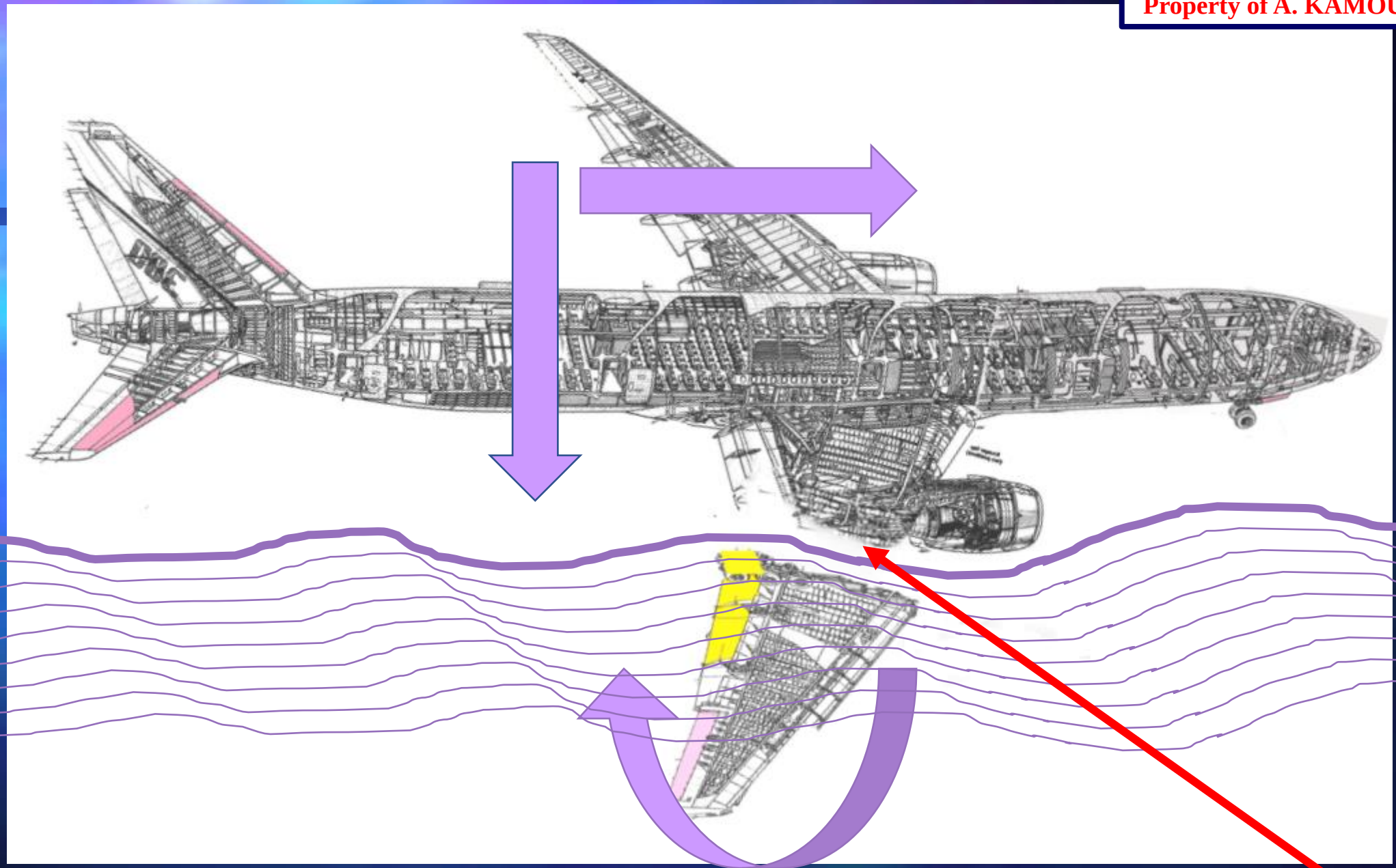

**Boeing B777 certification test**



Failure (Rib 25)

# Failure between Flaperon and Inner Part of Outer Flap (Rib 25)



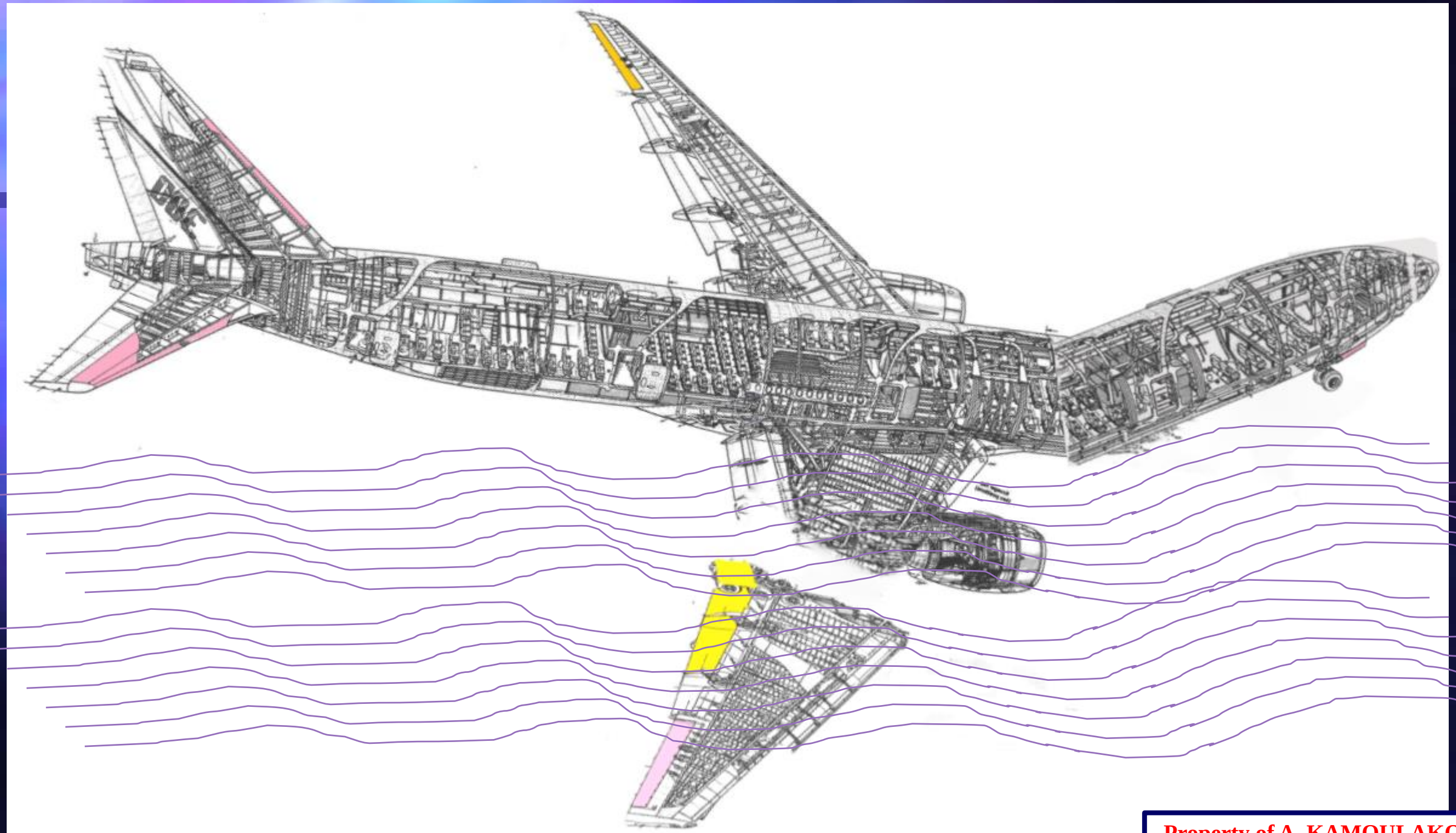


Violent wing first-impact with extreme upward bending leading to failure in Rib 25 area

# Yaw rotation and impact of the aircraft “nose”

- It follows a large aircraft yaw to the right (pivoting around the deforming right wing) and impact of the aircraft frontal fuselage underbelly releasing **(at least)** the right-hand nose gear forward door .

- damage of the frontal part of the fuselage/cabin that might lead to rupture at the level of the attachment to the “central wingbox” (junction between wing and fuselage).



# Release of the right engine

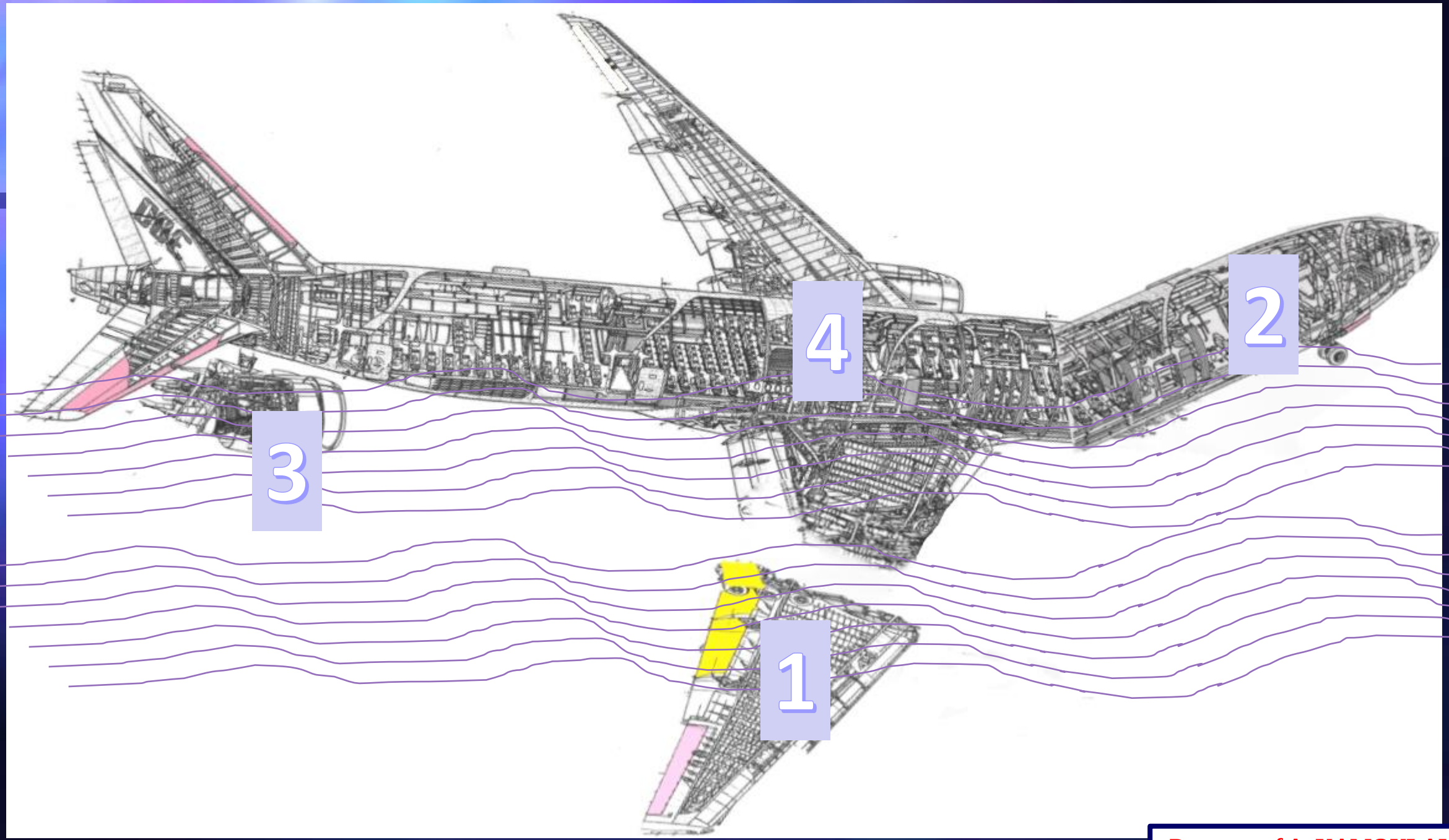
- Release of the right engine from its supports due to the large vertical and axial hydrodynamic loads.
  - Evidence from the cowling debris failure mode (bi-axial tension) that suggests internal hydrodynamic overpressure.
- Released engine and associated debris possibly moving backwards over the right wing and impacting the right horizontal stabilizer and the vertical tail fin.

- *Damage or eventual rupture of the rear part of the fuselage/cabin at the level behind the junction with the wing, but difficult to quantify.*

# Aftermath …

- Finally the **main aircraft wreckage** could consist of four parts:

1. The right wing part after the engine pylon (Rib 25 area) outwards.
2. The front part of the fuselage heavily damaged or detached.
3. The right engine.
4. The central fuselage with the root of the right wing and the entire left wing plus maybe the left engine and maybe the rear fuselage with the tailfin and right stabilizer heavily damaged, all as one piece.



# Detailed technical analysis sources

- See the publications below:
  - "La fin du vol MH370: un amerrissage forcé, étude du flaperon heurtant la surface de la mer" par Argiris Kamoulakos, Jean-Luc Marchand, Philippe Gasser, Michel Delarche, Jean-Marc Garot, membres de l'équipe CAPTIO, LETTRE 3AF, NUMÉRO 41, JANVIER - FÉVRIER 2020
    - English version available in the CAPTIO website http://mh370-caption.net/
  - "**Aspects of analysis and simulation of a flaperon ditching scenario**", Argiris Kamoulakos, CAPTIO Team, 2020 AIAA AVIATION Forum, 15–19 June 2020.
  - "**Aspects of analysis and simulation of a wing ditching scenario**", Argiris Kamoulakos, CAPTIO Team, 2021 AIAA AVIATION Forum, 2–6 August 2021.

# Further on …

- The Inmarsat data analyzed by Boeing suggest that MH370 run out of fuel before plunging into the ocean.
  - ie. both engines inoperative
- The associated trajectory is a subject of debate that will not be touched in this presentation (see CAPTION website for more, in particular the latest report by **Jean-Luc Marchand** and **Captain Patrick Blelly**). However, it is well accepted today that the aircraft was professionally piloted (to our opinion, to the very end).
- No floating mass of debris has been reported anywhere in the Indian ocean following the disappearance of MH370. This leads us to exclude a possible uncontrolled dive or water impact similar to the AirFrance Rio-Paris A330 accident (which figured vertical speed of about 11000 ft/min).

# Conclusion

**My appreciation of the debris evidence is that the MH370 has been somehow piloted to the very end, leading to a missed ditching attempt.**

# Looking to the future

- These results are indicative and will be refined further in 2024.
- We shall be assessing analytically the fuselage damage/failure potential in similar ways as the wing and flaperon.

- However, this is only "first impact" analysis. Ditching involves very complex "subsequent impacts" trajectories that cannot be done analytically. We expect to go beyond the "first impact" stage in 2024 using computer-assisted simulations.
  - Including variants of impact setup scenario including, variants of the sea state etc.

# Where to find technical details of this work

- https://comp-as-s.com/mh370/

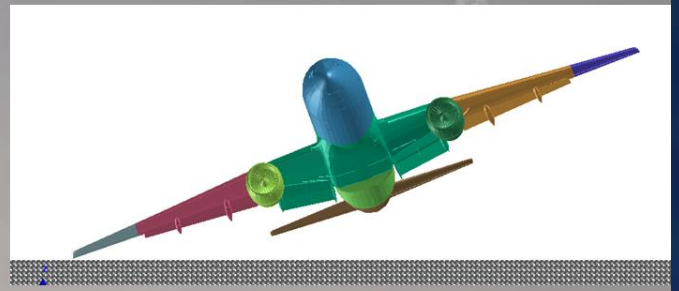
- Also at the following sites:
  - https://www.mh370-caption.net/
  - https://www.researchgate.net/profile/Argiris-Kamoulakos/publications
  - Argiris Kamoulakos in ORCID
    - https://orcid.org/0000-0001-6834-4289

# Appendices

- Landing under Extreme Gusts
- Transair Flight 810 Boeing 737-200 Cargo ditching
- Flaperon "first impact" analysis

# Comparison to different but similar real cases

The case for a violent right wing first impact



"Delicate" Landing under Extreme Gusts

# Comparison to different but similar real cases

Transair Flight 810 Boeing 737-200 Cargo crashed to the sea shortly after takeoff in the early morning of July 2, 2021.



Air-ground communications indicate that the aircraft was suffering engine failure, and unable to hold altitude as the crew attempted to return to Honolulu.

Both pilots were injured but survived the accident. The aircraft was badly damaged and sank, although a "small amount" of floating debris has been retrieved.

# Aircraft broken in 3 parts

WASHINGTON (Reuters) - Investigators have located a Boeing 737-200 cargo jet that made an emergency water landing off the Hawaiian island of Oahu in the Pacific Ocean on July 2, the National Transportation Safety Board said on Friday.

Transair Flight 810 was found approximately 2 miles offshore from Ewa Beach. The major components of the airplane -- the aft fuselage including both wings and tail along with both engines, and forward fuselage -- were located on the sea floor at depths between 360 and 420 feet, the NTSB said in a statement.

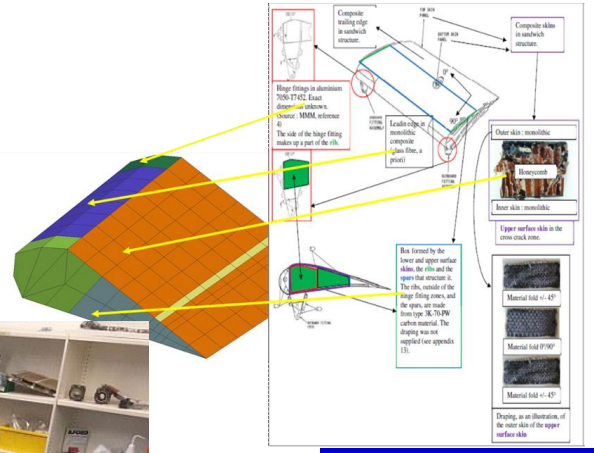


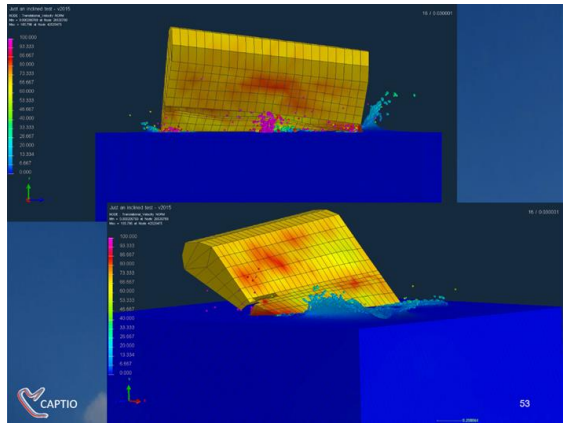
# Flaperon "first impact" analysis

## Preliminary results for trailing edge rupture

## Combined location of Flaperon and Flap Debris

## FE analysis of the 3D elastic flaperon



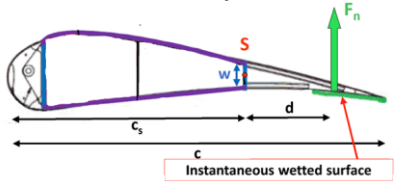






## Deriving skin equilibrium maximal stresses

- For a typical section of the 3D flaperon, at the intersection of the skin with the spar S




$$Bending\ Moment = F_n d = F_m w$$

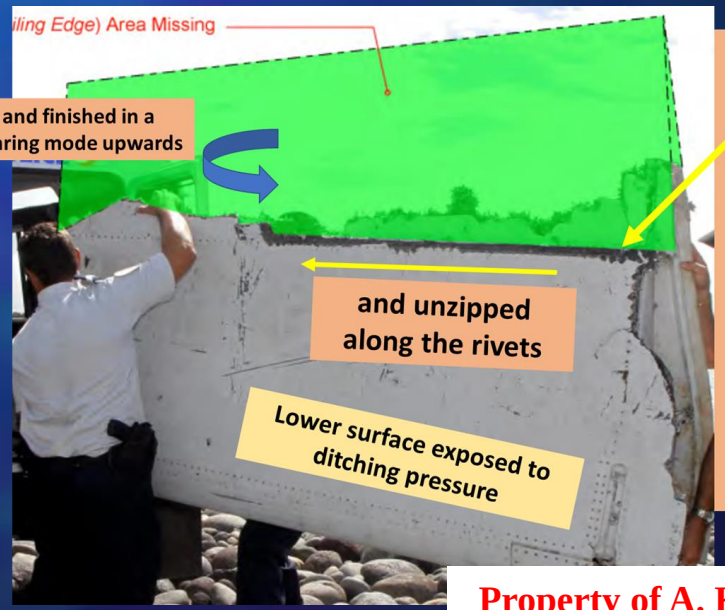
$$F_m = \sigma_{av} l n_{ply} t_{ply}$$

(order of magnitude)

$$\sigma_{max} = C_\alpha C_{3D} C_\sigma \left(\frac{\pi}{2}\right)^2 \left[\frac{(V_{x0}+V_{yo}\cot\alpha)^2 \rho y d}{n_{ply} t_{ply} w \cos\alpha}\right]$$

$$2 < C_\sigma < 3$$



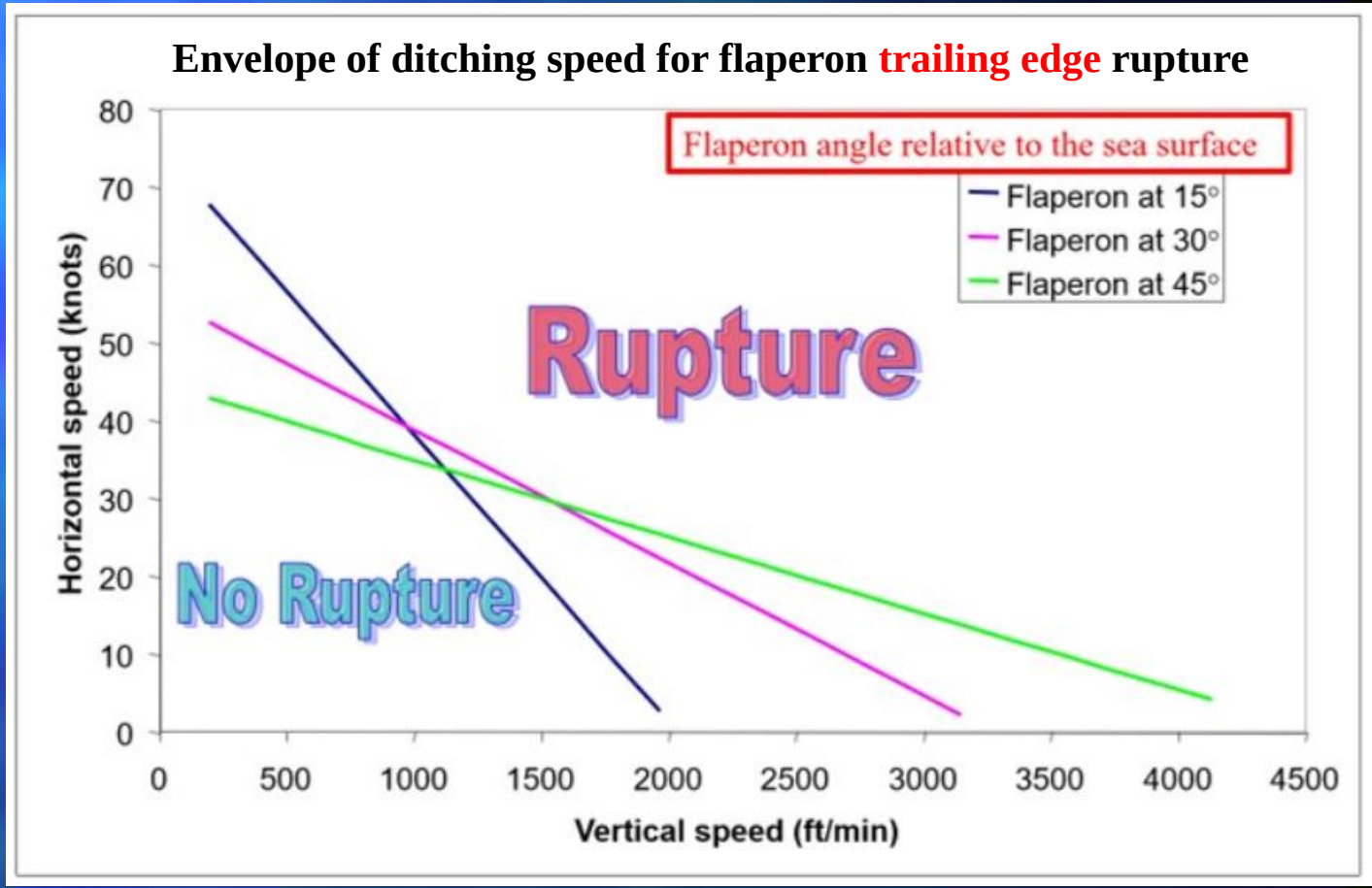



**Possible fracture initiation**

**Around the riveted corner of the Outboard lower surface due to bending-induced tensile stress around the rivets**

- Each of these curves corresponds to a particular flaperon inclination to the sea surface, which might mean many different configurations. For instance flaperon at 30 degrees might mean:

- sea-surface calm, wing horizontal, flaperon extended at 30 degrees
- sea-surface calm, wing at 15 degrees, flaperon extended at 15 degrees
- sea-surface disturbed with ascending wave crest of 15 degrees, wing at 15 degrees and flaperon extended at 30 degrees, etc.



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# To be continued …

argiris@comp-as-s.com

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