Towards the last seconds of the MH370

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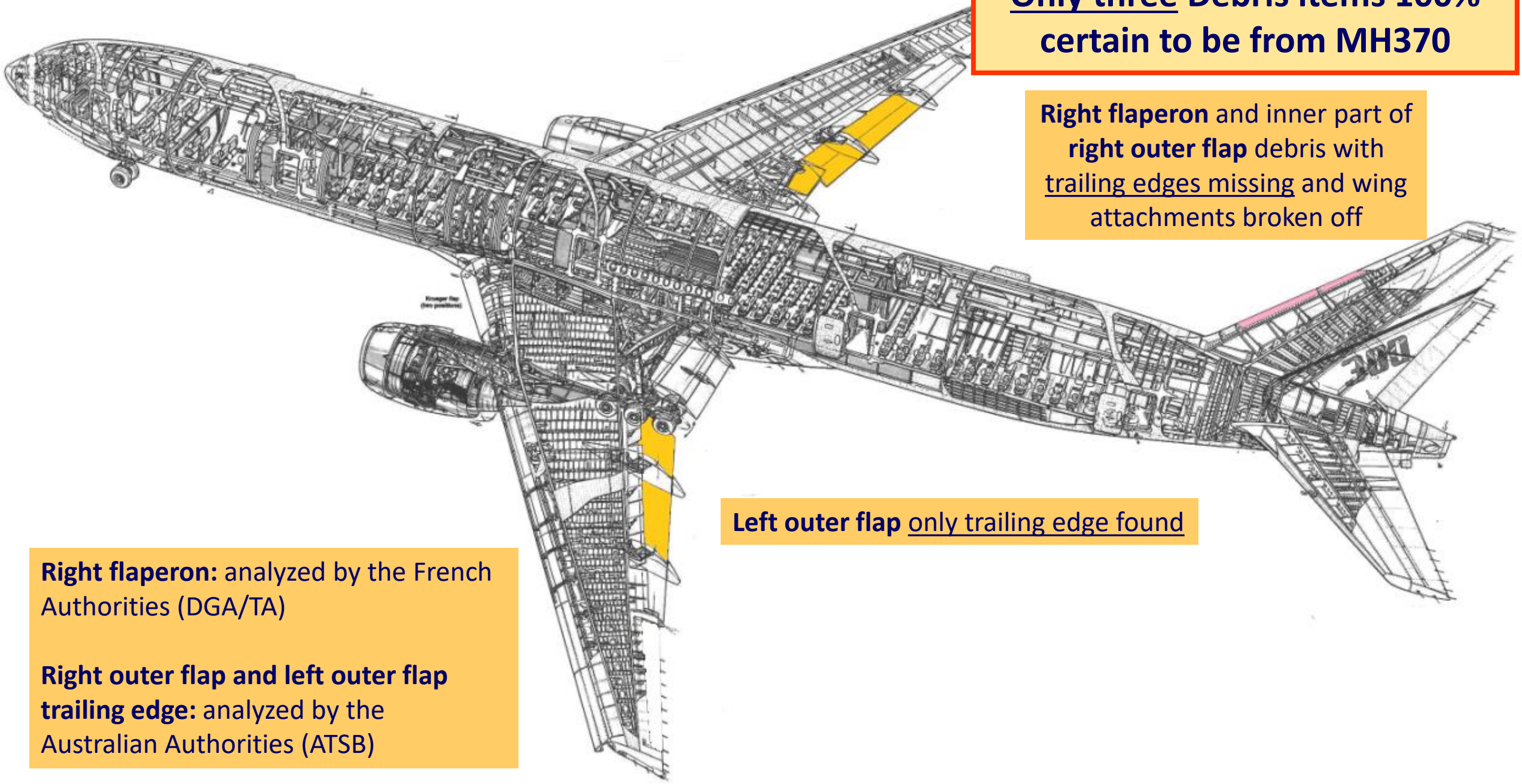
Only three Debris items 100% certain to be from MH370



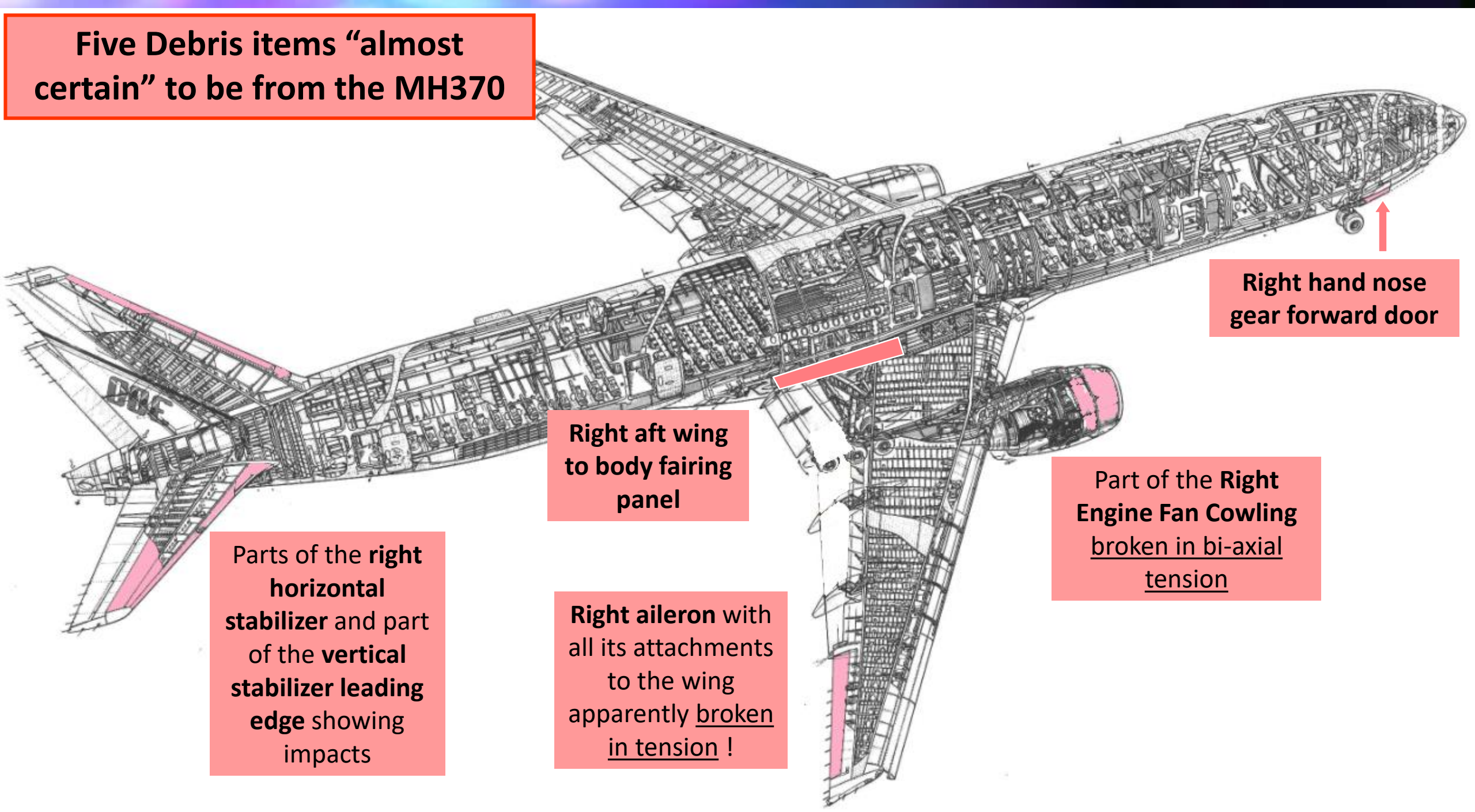
Right flaperon and inner part of **right outer flap** debris with trailing edges missing and wing attachments broken off

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)

Five Debris items “almost certain” to be from the MH370



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 !

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.
    - 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.

Facts about the loadings upon the debris

- The **right wing** flaperon examined by the French authorities appears to have its attachments to the wing **broken, mainly from lateral or torsional loads,** not just direct hydrodynamic loads.
  - **COMMENT from Aeronautical design:** Aeronautical attachments are optimal for the support they are supposed to give and are made to break when loaded in other ways that would result in aircraft structural damage if they do not break.
- The **right wing** aileron was completely ripped off from its attachments by **pure tension.**
  - This item is one of the five debris items considered by the examining authorities as being "almost certainly" from the MH370.

Important point

- The Australian report dealing with the flap debris suggests that it is possible that the flaps were NOT extended during a presumed ditching.

- This implies that it might not be just hydrodynamic loads that released them from the wing. However, hydrodynamic loads could break the trailing edges off.
- **Large lateral attachment loads** might had been eventually present, like with the flaperon, in addition to the hydrodynamic loads.

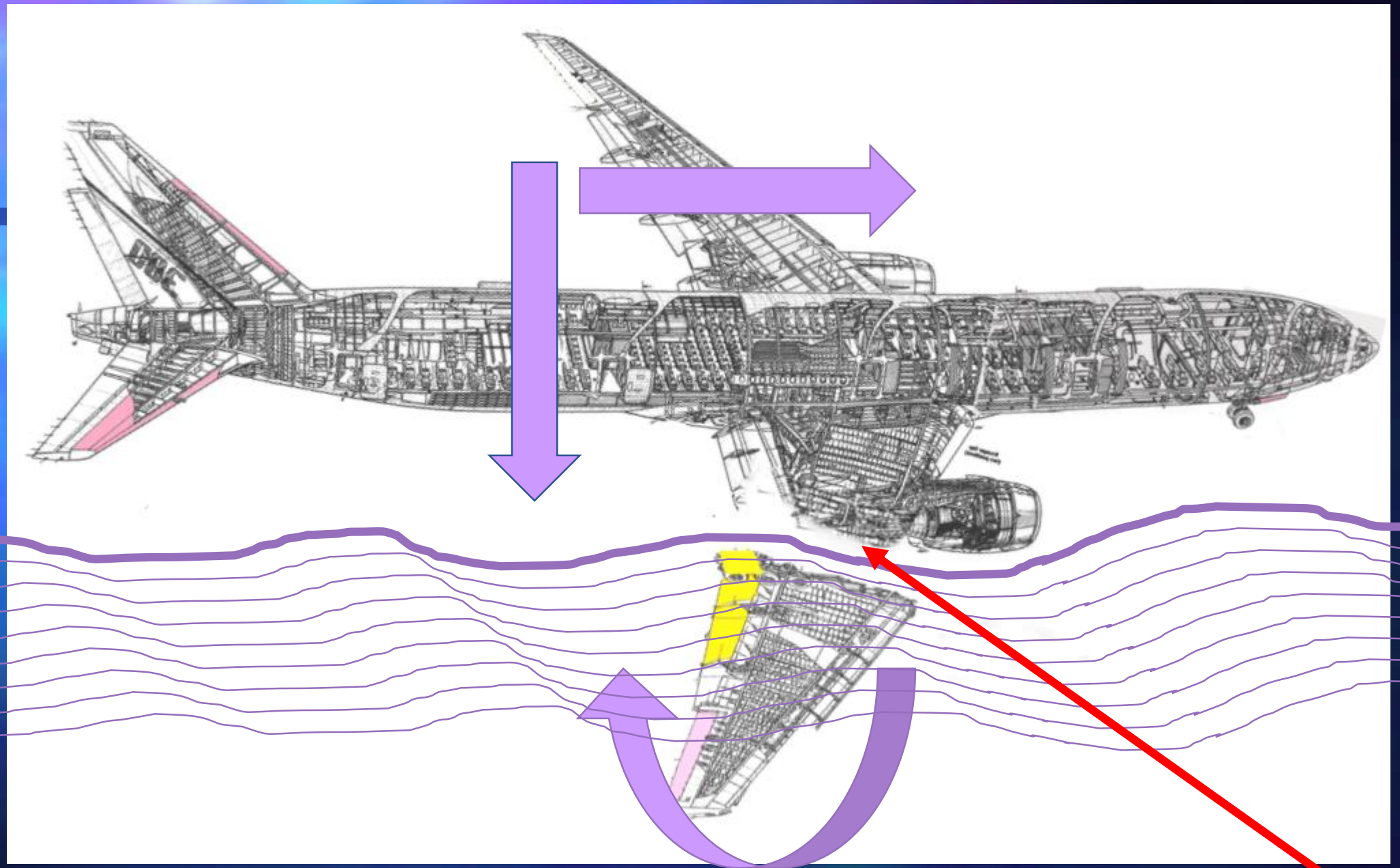
The case for a violent right wing first impact

- Right wing flaperon and inner flap attachments to fail in this catastrophic way can be due to combined loads resulting from 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 significant vertical 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 that break the flap attachments and lead to possible failure of the wing near the flaperon section, hence releasing flaperon and flap.

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 of the flaperon and right engine support pylon, close to were the inner part of the outer flap begins.

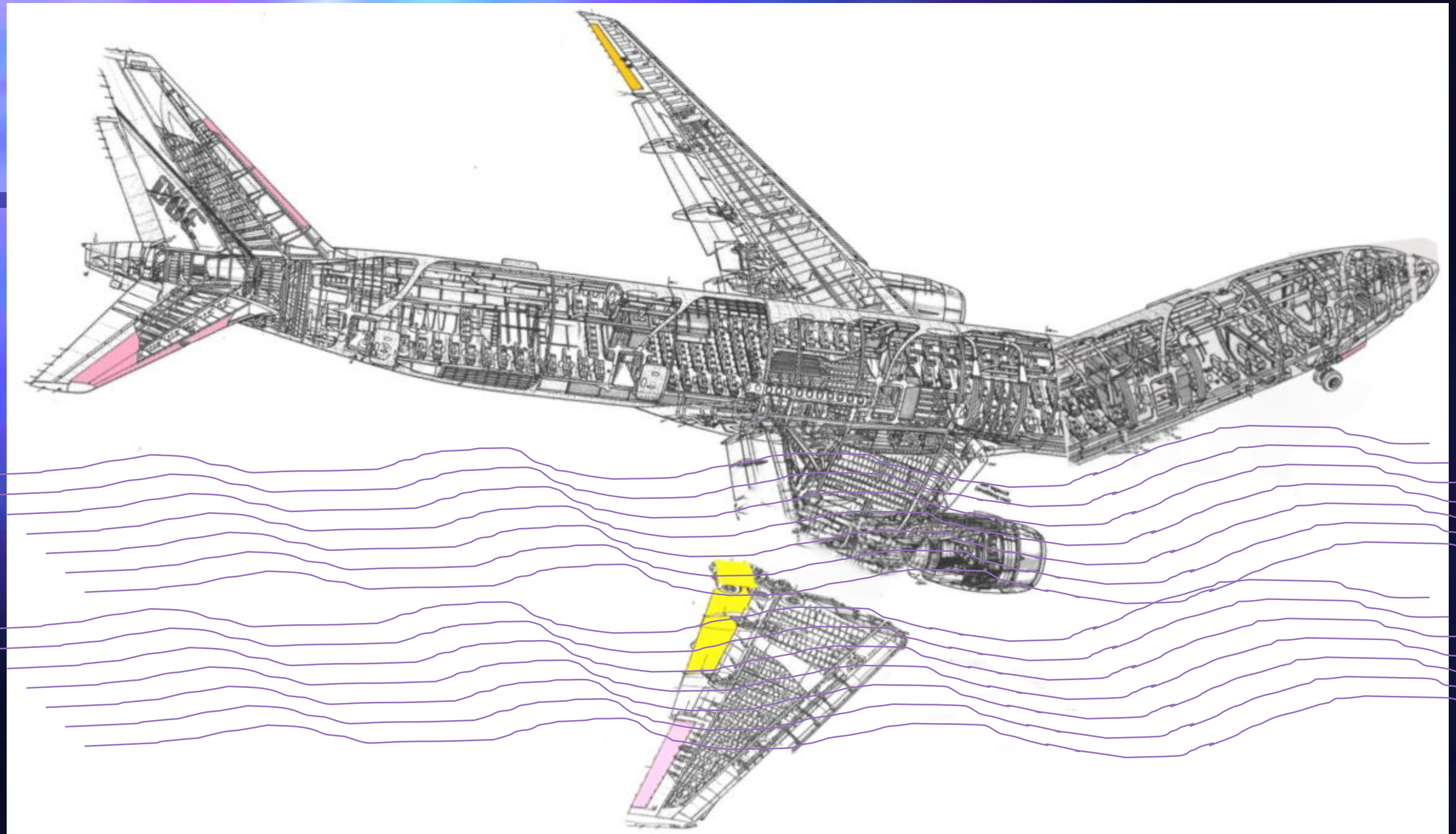


Violent wing first-impact with extreme upward bending leading to failure in Rib 25 area

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 .

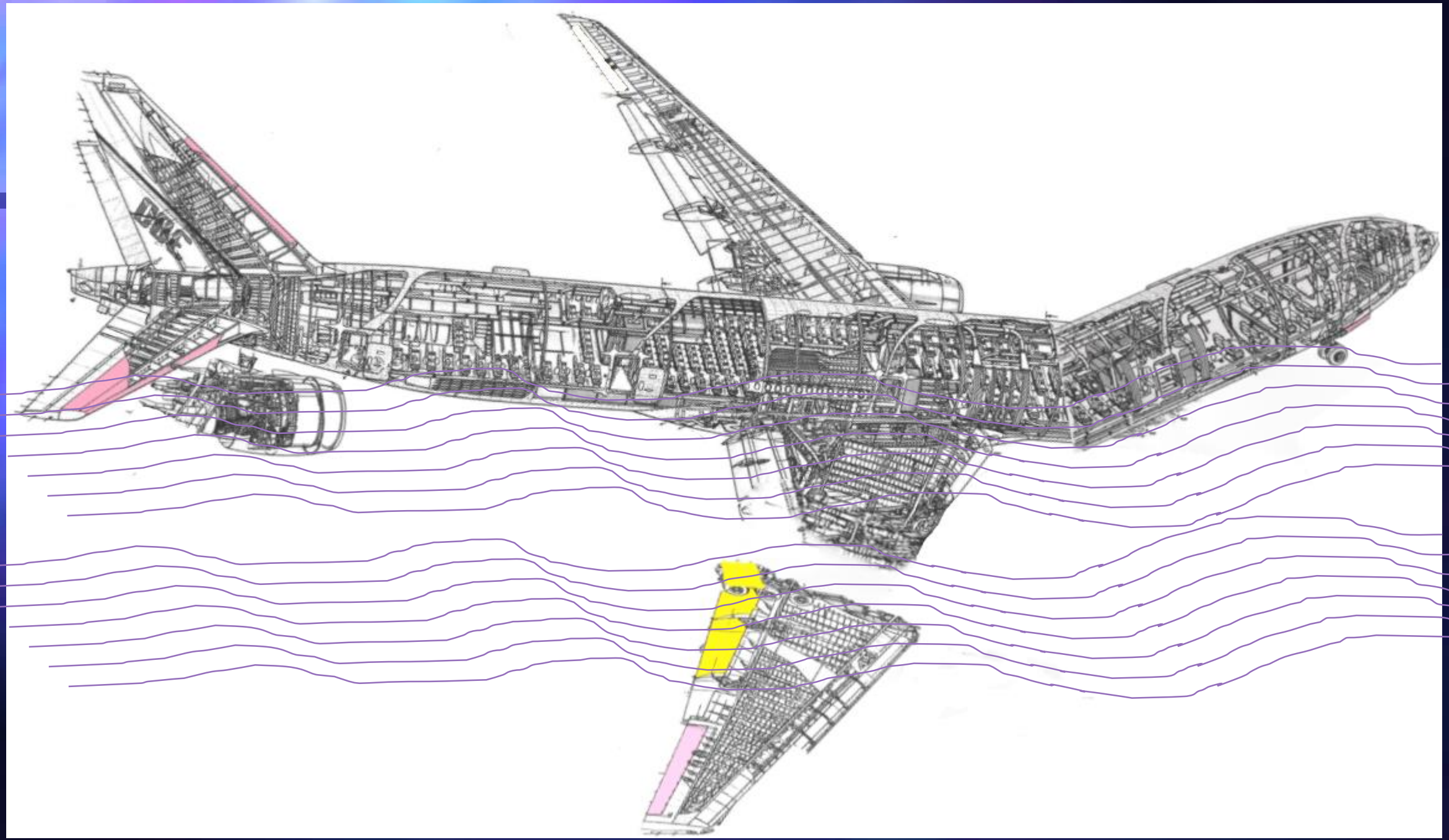
- damage of the frontal part of the fuselage/cabin that might lead to rupture at the level of the attachment to the “central wingbox” (junction between wing and fuselage).



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.

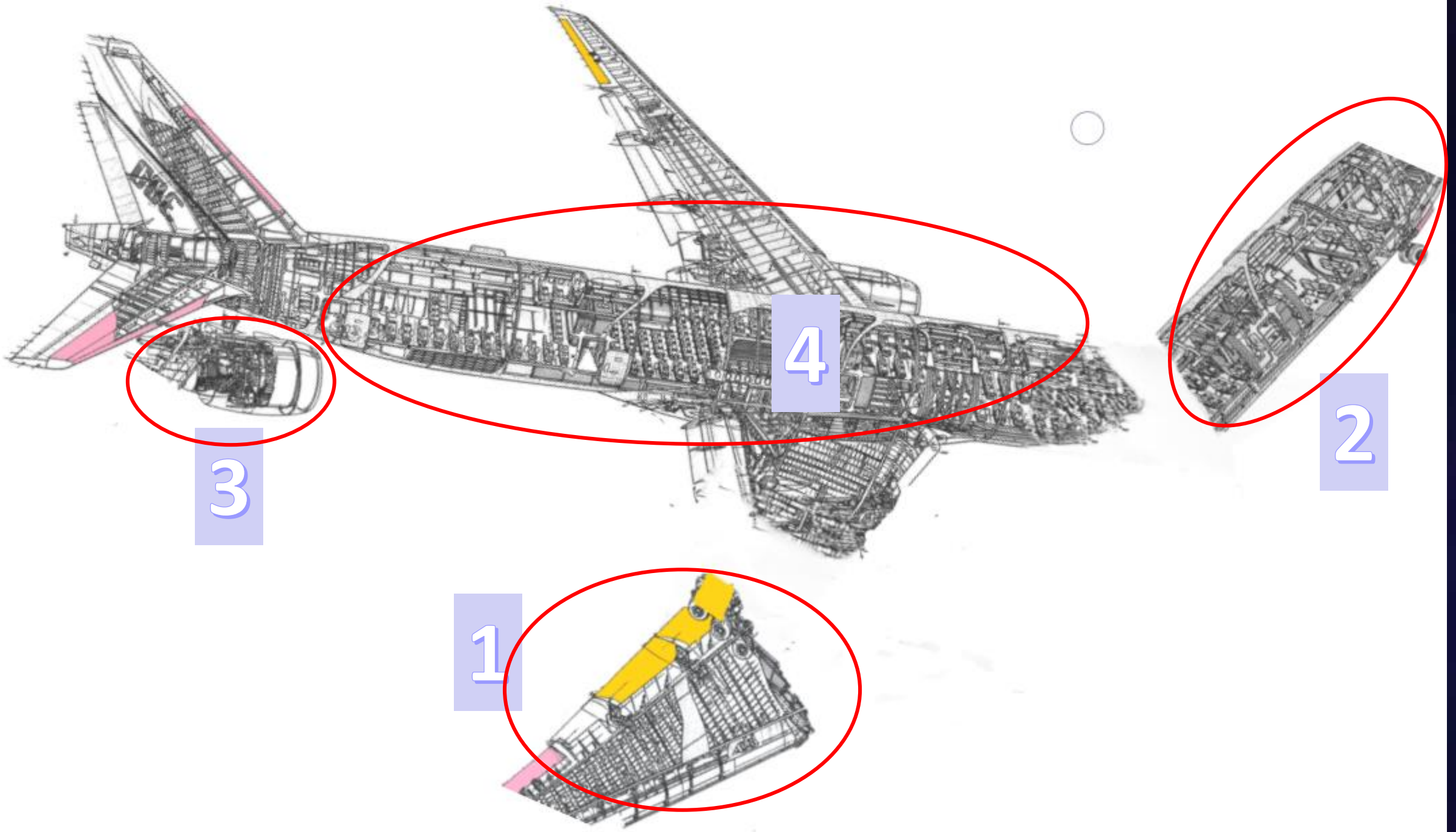
- *Damage or eventual rupture of the rear part of the fuselage/cabin at the level behind the junction with the wing.*



Aftermath …

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

1. The right wing part from 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.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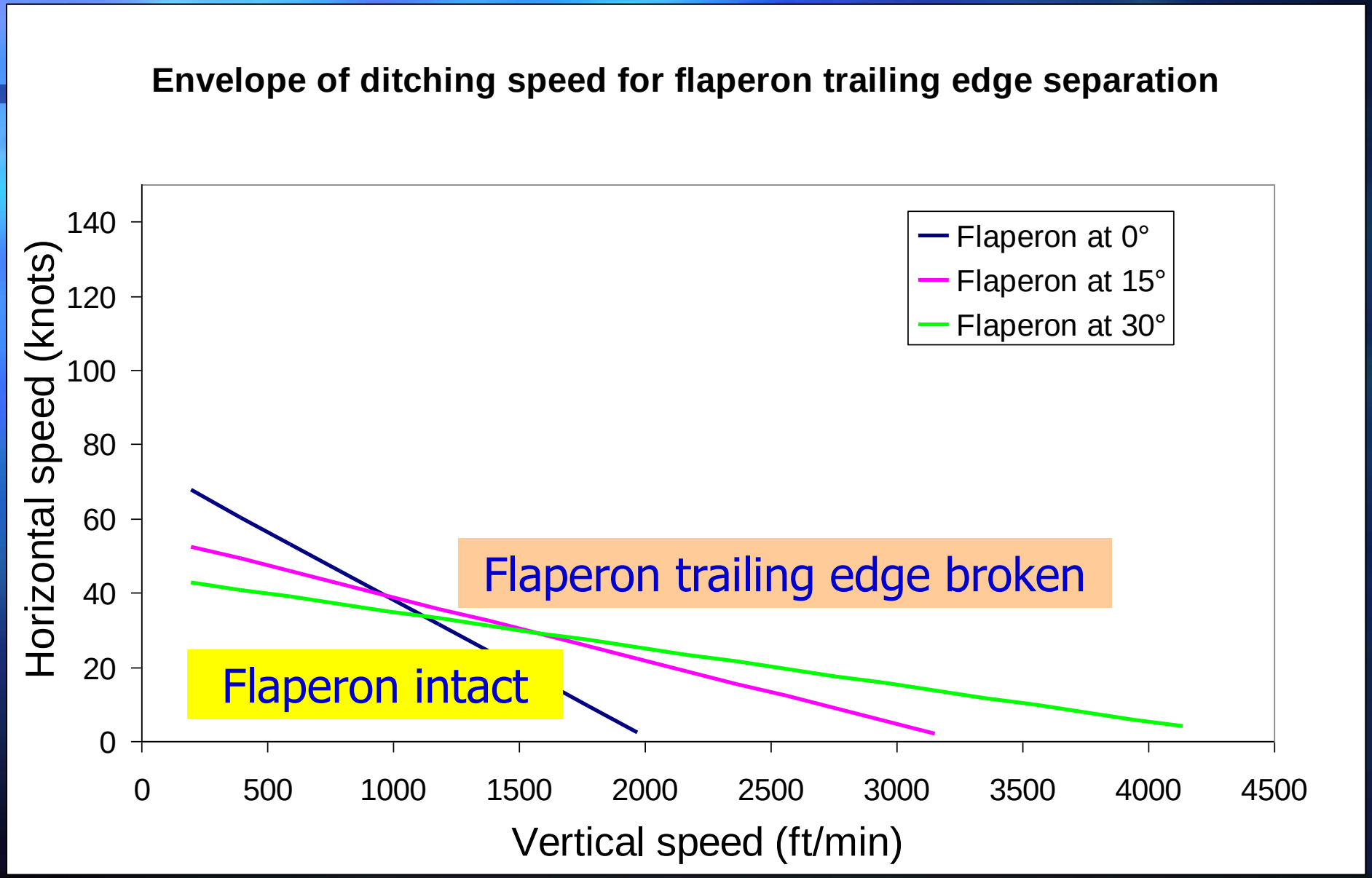
Ratifying the water impact conditions

- It can be shown analytically that there is a range of specific combinations of horizontal and vertical speeds that can break off the trailing edges of parts like the flaperon under ditching conditions.
  - See publications below:
  - “Aspects of analysis and simulation of a flaperon ditching scenario”, Argiris Kamoulakos, CAPTIO Team, 2020 AIAA AVIATION Forum, 15–19 June 2020.
  - “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-captio.net/

Taking the wing into consideration

- Similar analytical methods can be used to assess a wing under ditching.
  - “Aspects of analysis and simulation of a wing ditching scenario”, Argiris Kamoulakos, CAPTIO Team, accepted to be presented at 2021 AIAA AVIATION Forum, 2–6 August 2021.
- Combining them with the flaperon assessment, we can investigate the range of admissible impact conditions that can lead initially to flaperon trailing edge removal and eventual wing fracture.
- In this presentation, extreme asymmetric impact is assumed where the right wing hits the ocean before other parts of the fuselage do.

Wing at 0-15° pitch asymmetric first impact



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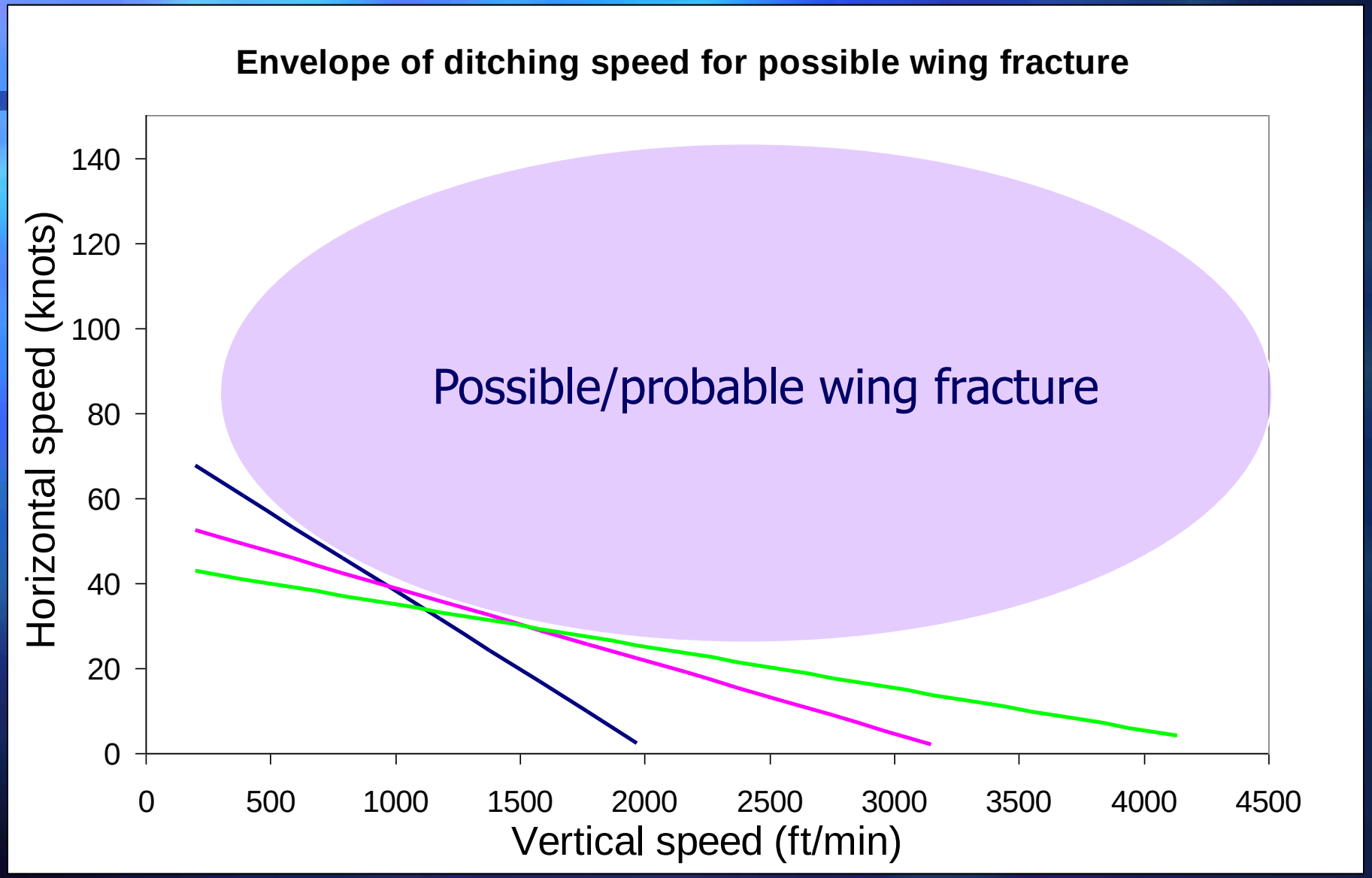
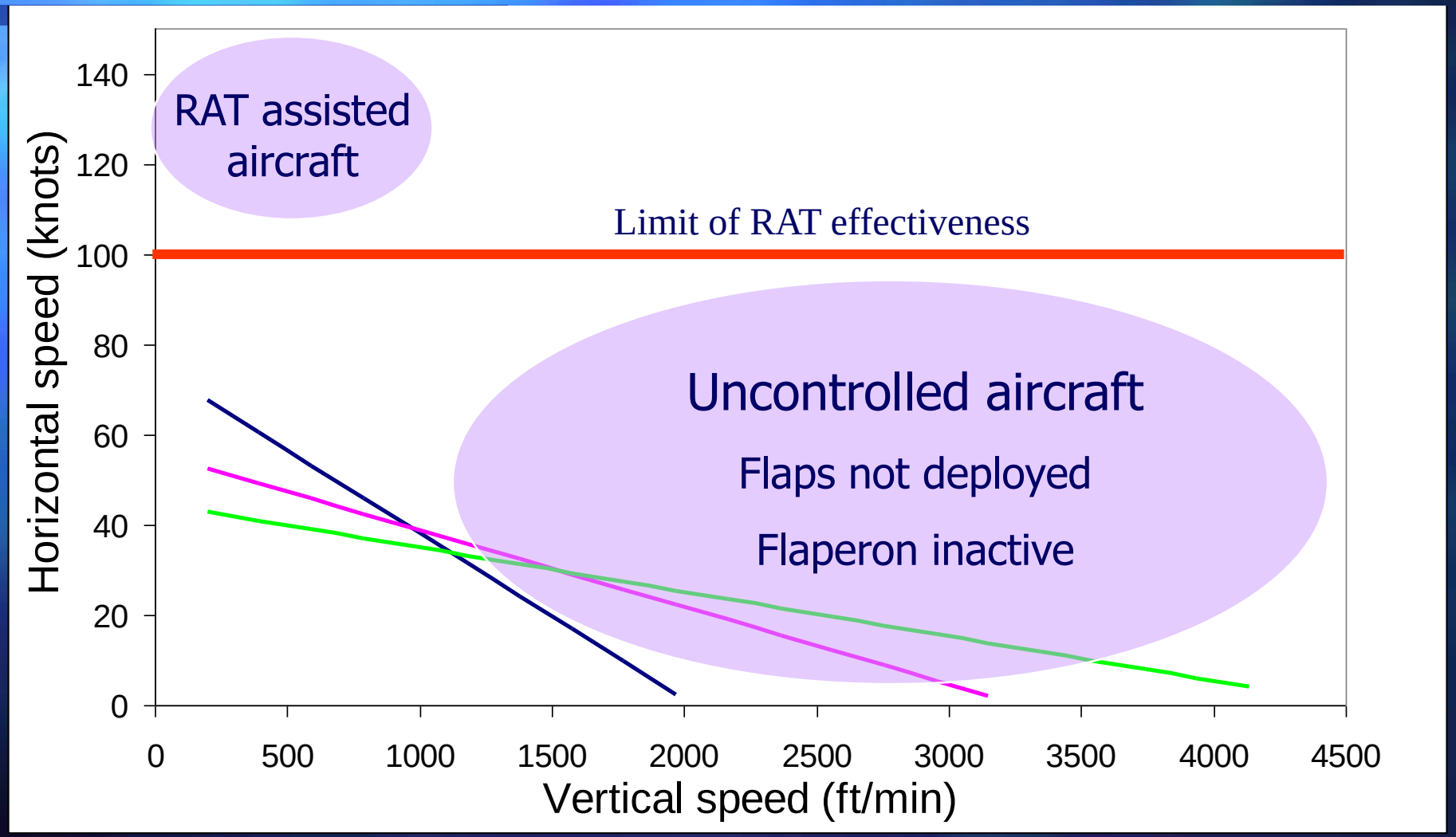


Further on …

- The Inmarsat data analysed 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 CAPTIO website for more). However, it is well accepted today that the aircraft was professionally piloted, probably to the end.
- No floating mass of debris has been detected anywhere in the ocean following the disappearance of MH370 and this leads us to exclude a possible suicide vertical dive or a deep stall water impact similar to the AirFrance Rio-Paris A330 accident (vertical speed of about 11000 ft/min).

Previleging a "missed" ditching event
(asymmetric first impact)



Looking to the future

- These results are indicative and will be refined further in time.
- We shall be assessing analytically the fuselage damage/failure potential in similar ways.
- However, this is only “first impact” analysis. Ditching involves very complex “subsequent impacts” trajectories that cannot be done analytically, but only by computer-assisted simulations.
- Important aspects might never be resolved:
  - Did MH370 ditch along the swell ? Inclined to the wind ? Against the swell ?
- What are any other “first impact” credible scenarios ?

To be continued …

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