MH370 Flaperon Inboard Hinge - Finite Element Analysis (FEA)

by Tom Kenyon

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1.0 Introduction

The purpose of this analysis is to provide FEA results for two (2) key Flaperon Hinge failure scenarios for the MH370 right-side Flaperon recovered at Reunion Island on July 29, 2015.

2.0 Study Approach

a. Develop 2D drawings of the Boeing 777 Flaperon composite body and hinge systems. Using 2D drawings develop a 3D model of the Flaperon hinge and body system.

b. Extract the inboard alloy hinge sub-assembly from the composite 3D model of the right-side Flaperon.

c. Develop a Dassault Systèmes SOLIDWORKS® 3D model (*Version 2017 x64 SP 2.0*) from the alloy hinge sub-assembly 3D Model.

d. Inputs chosen for the alloy hinge FEA analysis include the following:

- Data for the study is largely based on careful analysis of publicly available photographs and a few public references to dimensions related to the Flaperon and its sub-assemblies.
- The alloy material selected for the SOLIDWORKS 3D model is T73651 metallurgical grade (*European standard*). This is equivalent to metallurgical grade 7050 T7451 (*American standard*). Other alloy choices are available but this was chosen for the initial feasibility grade study.
- 7050 T7451 Tensile Yield = 68 ksi
- The temperature of the hinge alloy used in the FEA is set at -50 ^{o}C (-58 ^{o}F).

e. Perform Finite Element Analysis using SOLIDWORKS Simulation Professional on the inboard Hinge System:

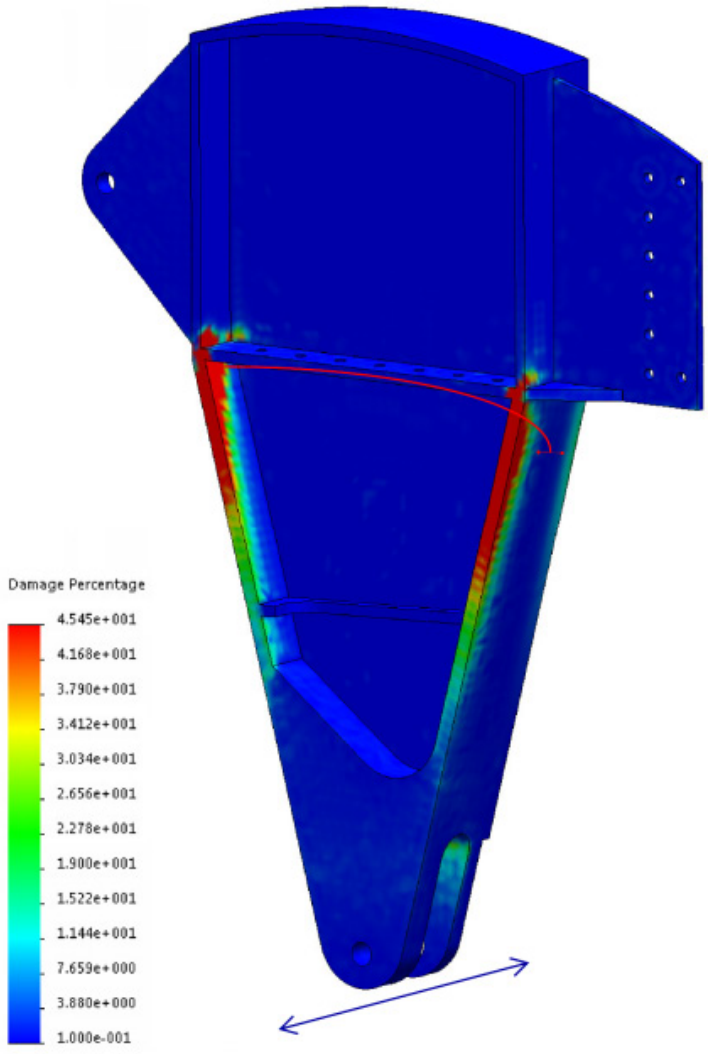
Case 1: Cyclical, lateral (*inboard - outboard*), movement of the Flaperon hinges.

- Upper Flaperon Hinge section fixed (*Portion integral with the Flaperon main body*.)
- Bottom Flaperon Hinge (pin-pivot) laterally loaded force *(inboard – outboard*) with fully-reversing loads (*to simulate a Torsional Flutter scenario*)

A simplified sketch of the torsional flutter movement was created to help convey the torsional concept and is provided at this link: Concept Sketch

Case 2: Upward rotation of the Flaperon trailing soft-body edge *(to simulate Surface Contact scenario*)

3.0 Torsional Flutter Scenario (CASE 1)

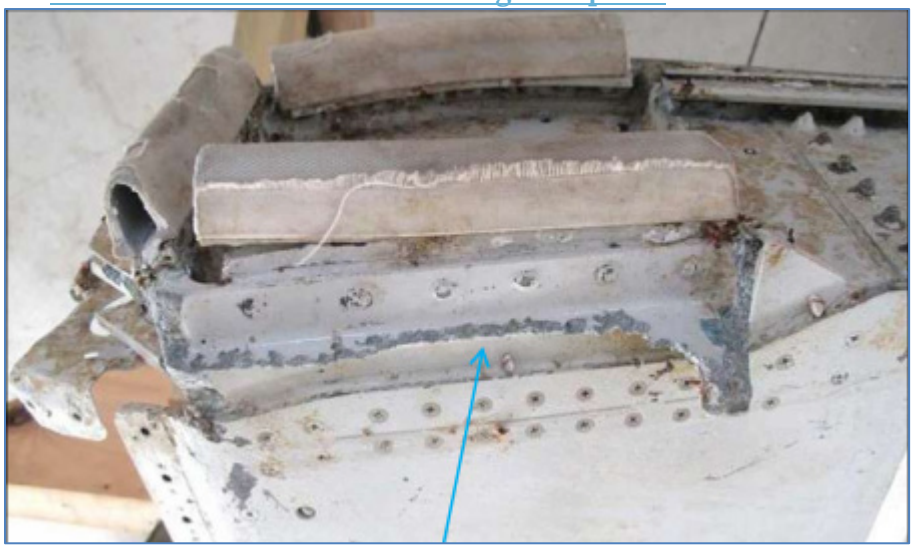


a. The percent alloy damage, calculated by the SOLIDWORKS torsional flutter simulation, indicates failure of the Inboard hinge's forward and aft flanges near the hinge connection point at the Flaperon's bottom exterior skin. This result is highly consistent with the MH370 photographs of the recovered right Flaperon (*see Exhibit 1*)

b. An additional detail is observed that further mimics MH370's Flaperon inboard hinge. The aft flange fails at a point lower in elevation compared to the forward flange. The failure points of each flange is identified by the narrowest strip of low damaged flange. The projected high damage areas match the flange and web failures observed on both of MH370's inboard and outboard Flaperon hinges. (*see Exhibit 1*)

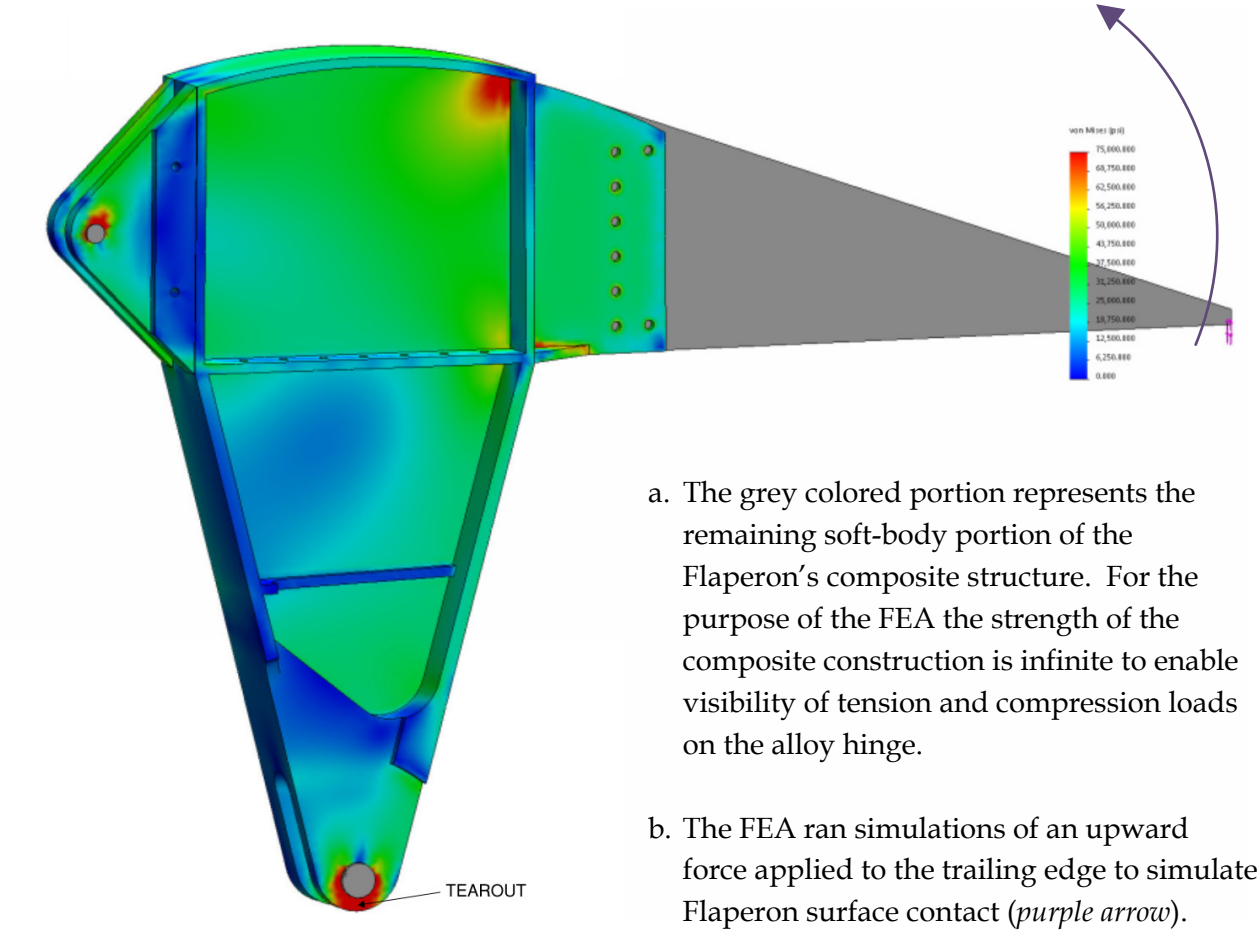
c. Note once the flanges reach a point of fatigue failure, the interstitial web simply fails along a path between the flange's failures. (*depicted by red line*)

Lower Inboard Side of MH370 Right Flaperon EXHIBIT 1



(*Photo inverted for orientation clarity, ignore blue arrow from DGA report*)

4.0 Surface Impact Scenario (CASE 2)



a. The grey colored portion represents the remaining soft-body portion of the Flaperon's composite structure. For the purpose of the FEA the strength of the composite construction is infinite to enable visibility of tension and compression loads on the alloy hinge.

b. The FEA ran simulations of an upward force applied to the trailing edge to simulate Flaperon surface contact (*purple arrow*).

c. Several FEA runs were made between 10 kips and 15 kips with similar results.

d. The top of the hinge system exhibits significant compression load in the aft position and a tension load where the aft portion of the hinge meets with the bottom of the Flaperon composite surface.

e. The bottom hinge connection shows a local tension failure (Tearout) and the PCU attachment exhibits compression damage.

5.0 Summary

The FEA analysis performed for the two scenarios results in two (2) distinct and opposing hinge failure modes.

- The FEA hinge failure results for the Torsional Flutter scenario align with the photographic evidence available from the recovered right-side Flaperon of MH370.

- Hinge damage characteristics anticipated from the Surface Impact scenario were not observed in the photographs of the recovered right-side Flaperon.

Further FEA analysis can be performed on the PCU attachment area (*shown below*) to provide further insight. However, general observation of the PCU area damage in the photographs of the recovered right-side Flaperon indicate an additional FEA study would likely support the Torsional Flutter scenario.

Annotated View of Inboard Side of MH370 Right Flaperon EXHIBIT 2

6.0 References

All websites/pages active as of November 24, 2020 unless otherwise noted. If photographer is inadvertently improperly credited, please comment to allow for correction.

Exhibits:

EXHIBIT 1 DGA Techniques Aéronautiques. SAFETY INVESTIGATION REPORT MH370 (9M-MRO)APPENDIX 1.12A-2 - DEBRIS EXAMINATION ITEM 1 – FLAPERON Page 66 http://mh370.mot.gov.my/Appendix-1.12A-2-Item1Flaperon(Main).pdf (Unknown Photographer, Photoshop by author.)

EXHIBIT 2 http://www.digital-resource.com/wp-content/plugins/wcache/images/DR%20NEWS-Urandir-c2be-19511621-h38522454-wide-4c437e1a6f6f82c6efcf4b97f7d0b216a1be2865-s1100-c15.jpg
(Photographer believed to be Raymond Wae Tion, Photoshop by author.)

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