

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



June 21, 2018

MATERIALS LABORATORY FACTUAL REPORT

Report No. 18-029

1. ACCIDENT INFORMATION

Place : Arlington, Arizona
Date : June 27, 2017
Vehicle : Vans RV-7, N731RV
NTSB No. : WPR17FA134
Investigator : Maja Smith, AS-WPR

2. COMPONENTS EXAMINED

Multiple components from an empennage

3. DETAILS OF THE EXAMINATION

On June 27, 2017 about 0850 Mountain standard time, a Vans RV-7 was destroyed when it impacted mountainous terrain near Arlington, AZ. The pilot who was the registered owner of the airplane, and a pilot-rated passenger sustained fatal injuries. At 1810 the same day, the airplane wreckage was found by the sheriff's department in the Gila Mountains. There were no reported witnesses to the accident. The airplane was recovered and taken to a secure location for further examination. Several components from the empennage were sent to the NTSB Materials Laboratory for further examination—these include the vertical stabilizer and horizontal stabilizer assemblies.

Figure 1 shows the manufacturing label of the airplane on one of the received empennage parts. The label stated the model number was "RV-7", the engine was a Lycoming O-360-A1A, registration number "N731RV", the serial number was "70083", the gross weight was 1800 lbs., and was manufactured by John Jordan in June 2004. The components of the airplane tail section that were received had fractured in multiple locations, including stiffeners, spars, and attachments, as well as across skins and rivets.

Figure 2 through Figure 5 show the parts from the vertical stabilizer, as received. Figure 2 and Figure 4 show the vertical stabilizer with rudder from the left and right sides, respectively, arranged closely to represent where the parts of received wreckage were originally positioned. Figure 3 and Figure 5 show the same pieces but spread apart to emphasize the fracture surfaces and part deformation.

As seen from the figures of the vertical stabilizer and rudder, the skins had fractured in multiple locations. The forward vertical spar in the rudder had fractured just below the attachment point (shown in Figure 6). The fracture exhibited out of plane deformation and buckling, consistent with secondary fracture such as from ground impact.¹

The fisheye bearing at the rudder attachment point did not exhibit any signs of fracture, nor did the mating attachment flange bolt holes on the aft vertical stabilizer vertical spar. These bolt holes, however, were elongated oriented in the aft direction. These features were consistent with shear stresses on the bolt in this location. The bolt was not recovered or received by the NTSB Materials Laboratory.

Many of the horizontal stiffeners in the rudder had also fractured in multiple locations. Many of these fractures were collocated with tears and fractures of the skin in the rudder. Figure 7 and Figure 8 illustrate mating tear fractures in the rudder skins, consistent with the locations of horizontal stiffener fractures. Similar to the fracture of the rudder forward vertical spar, the fractured horizontal stiffeners exhibited out of plane deformation and buckling along multiple directions. The skin material adjacent to its skin fracture surfaces also exhibited buckling in multiple directions and out of plane deformation. The fractures of the skins were oriented in multiple directions. These features were consistent with secondary fractures, such as from ground impact, not consistent with a primary fracture (such as in-flight breakup).

The uppermost portion of the tail rudder is shown in Figure 9. This shows tearing fractures in the skin, accompanied by bending and twisting near the fractures of the horizontal and vertical stiffeners. The skin on the right side of Figure 9 exhibited a general sawtooth shape, consistent with the mating skin fracture surface shown on Figure 10. This sawtooth fracture pattern was consistent with fracture of the rudder skin about the rivets in the upper portion of the rudder. Again, buckling in multiple directions and out of plane deformation were prominent on all the fractured components in this region, consistent with secondary fractures. The sawtooth pattern and buckling in the upper rudder fractures were consistent with a general forward-to-aft shearing of the upper rudder.

Most of the vertical stabilizer assembly was intact, exhibiting some minor dents to the exterior of the skins. The two exceptions were the aft vertical spar (see Figure 11 through Figure 13), as well as a forward vertical spar fracture on the underside (see Figure 14 and Figure 15). A section of the aft vertical spar had separated from the rivets on the left and right sides. The upper portion of the liberated aft spar exhibited an angled fracture, and the bottom of the spar exhibited a fracture with an inward and outward facing portion of the wing skin, consistent with a twisting motion. These fracture surfaces exhibited a general slanted morphology, with a dull luster, consistent with overstress fracture.

¹ Primary fractures are those that occur initially in a fracture sequence, typically exhibiting features and deformation consistent with the loading direction at failure. Secondary fractures are those occurring after the primary fracture, typically exhibiting deformation patterns out of plane and inconsistent with the loading direction of failure.

The underside forward spar fracture of the vertical stabilizer (Figure 15) exhibited features consistent with overstress fracture. The material adjacent to the fracture surface had buckled in directions out of plane, consistent with secondary fracture.

The aft underside of the tail rudder is shown in Figure 16. The bottom of the rudder was made of a fiber-reinforced polymer composite, which had fractured towards the forward side. The erratic orientation of the fracture surface, along with the right side of the fracture bending outward while the left side bent inward, suggests fracture from impact.

The horizontal stabilizer assembly is shown in Figure 17, as received. The elevators were still connected to the center tailcone section. The upper side of the horizontal stabilizer skins exhibited sliding marks, buckling, and localized tearing, as typified by the right elevator in Figure 17. The witness marks were consistent with the top side of the horizontal stabilizer having contacted the ground or ground objects, and the sliding scrape marks (Figure 17 and Figure 18) were consistent with this portion of the airplane sliding from left to right.

The lower section of the aft vertical spar from the vertical stabilizer was still affixed to the horizontal stabilizer assembly, as shown in Figure 19 and Figure 20. This fracture surface was sectioned for further examination. Figure 21 and Figure 22 show the closer views of the lower fracture surface of the aft vertical spar from the vertical stabilizer. Both fractures exhibited a general slanted orientation, with a dull luster and rough surface texture. One of the sides of the fracture surface had bent aft ward. The opposite side, about a rivet hole, was flat.

Figure 23 shows a closer view of the fracture surface about the rivet hole. Close to the rivet hole, the vertical stabilizer section exhibited local necking and thinning. There were no indications of pre-existing cracks or fractures adjacent to the rivet hole. The fracture surface was examined using a scanning electron microscope (SEM). As typified in Figure 24, the fracture surface exhibited dimple rupture, consistent with tensile overstress. No indications of other features consistent with other fracture modes were found.

The chemical composition of the aft vertical spar was inspected using energy dispersive x-ray spectroscopy (EDS) and x-ray fluorescence (XRF). The chemical composition was consistent with an AA 2024 or 2014 aluminum alloy.

Figure 25 shows the right underside of the horizontal stabilizer assembly. Where the right stabilizer attached to the tailcone, there was a small dent or impression. This dent measured approximately 5 inches long, 4 inches across, and 2 inches deep (see Figure 26). With assistance of personnel from the Feather Identification Lab at the Smithsonian Institute National Museum of Natural History, several pieces of material suspected of being avian organic matter were extracted from the region. These pieces were found on the outside of the airplane skin, as well as underneath in crevices where the panels had been joined by rivets. Specimens were also extracted from portions of the tailcone, inboard of the dent (see Figure 27).

The extracted specimens were inspected at the Feather Identification Lab at the Smithsonian Institute National Museum of Natural History. The results were consistent with that of a rock pigeon or *Columba livia*, which were common in the area of the accident. These results were detailed in two reports, attached as Appendix A and Appendix B.

Erik M Mueller
Materials Research Engineer



Figure 1 – The manufacturing label on the airplane empennage.



Figure 2 – The components of the vertical stabilizer, view on the left, positioned close.



Figure 3 – The components of the vertical stabilizer, view on the left, positioned apart.



Figure 4 – The components of the vertical stabilizer, view on the right, positioned close.



Figure 5 – The components of the vertical stabilizer, view on the right, positioned apart.

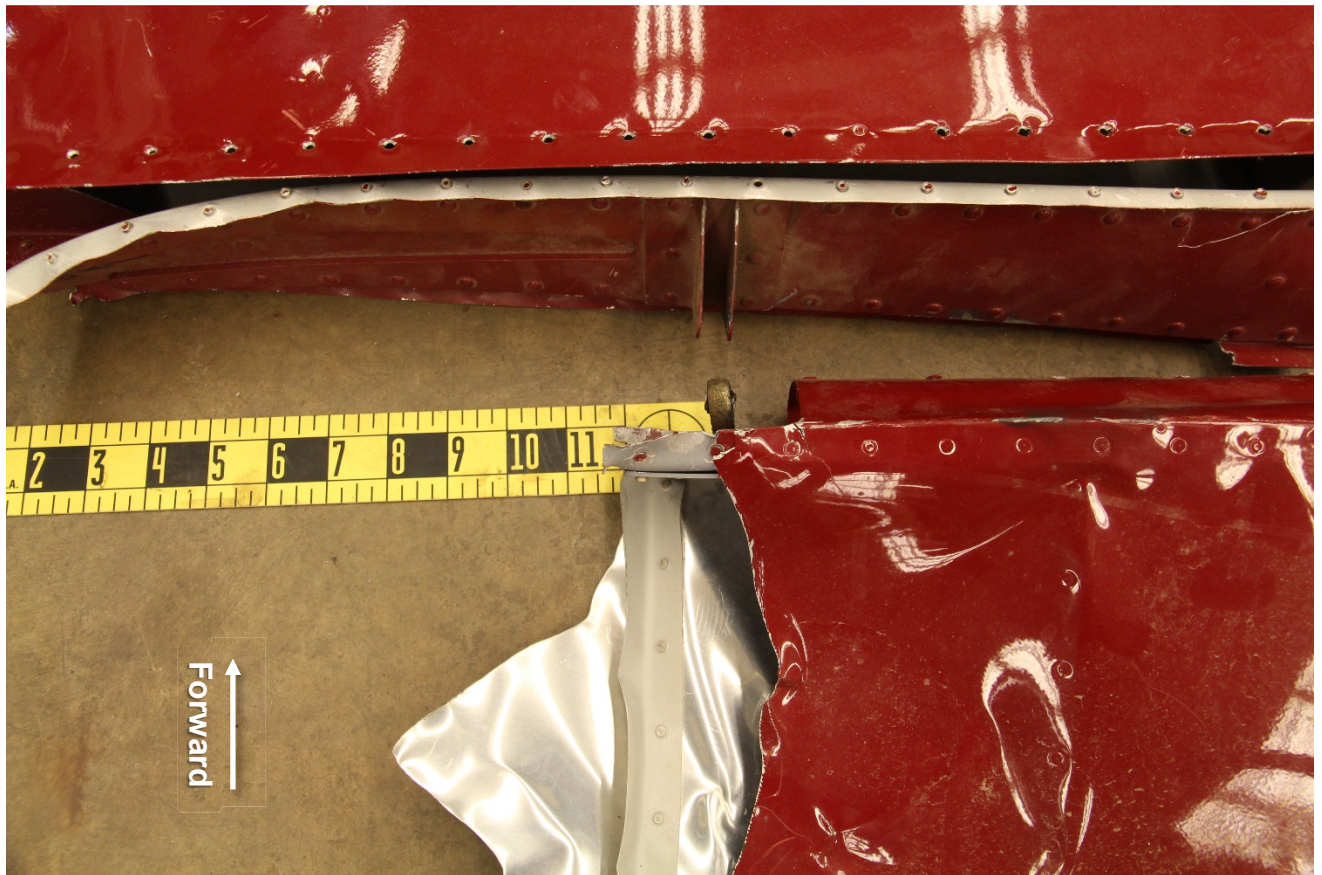


Figure 6 – The lower fisheye bearing attachment point, where the rudder assembly attached to the vertical stabilizer aft vertical spar (top of figure).



Figure 7 – Closer view of the fracture of the rudder skin on the left side.



Figure 8 – Torn and fractured portion of the skins on the upper portion of the right side of the rudder.

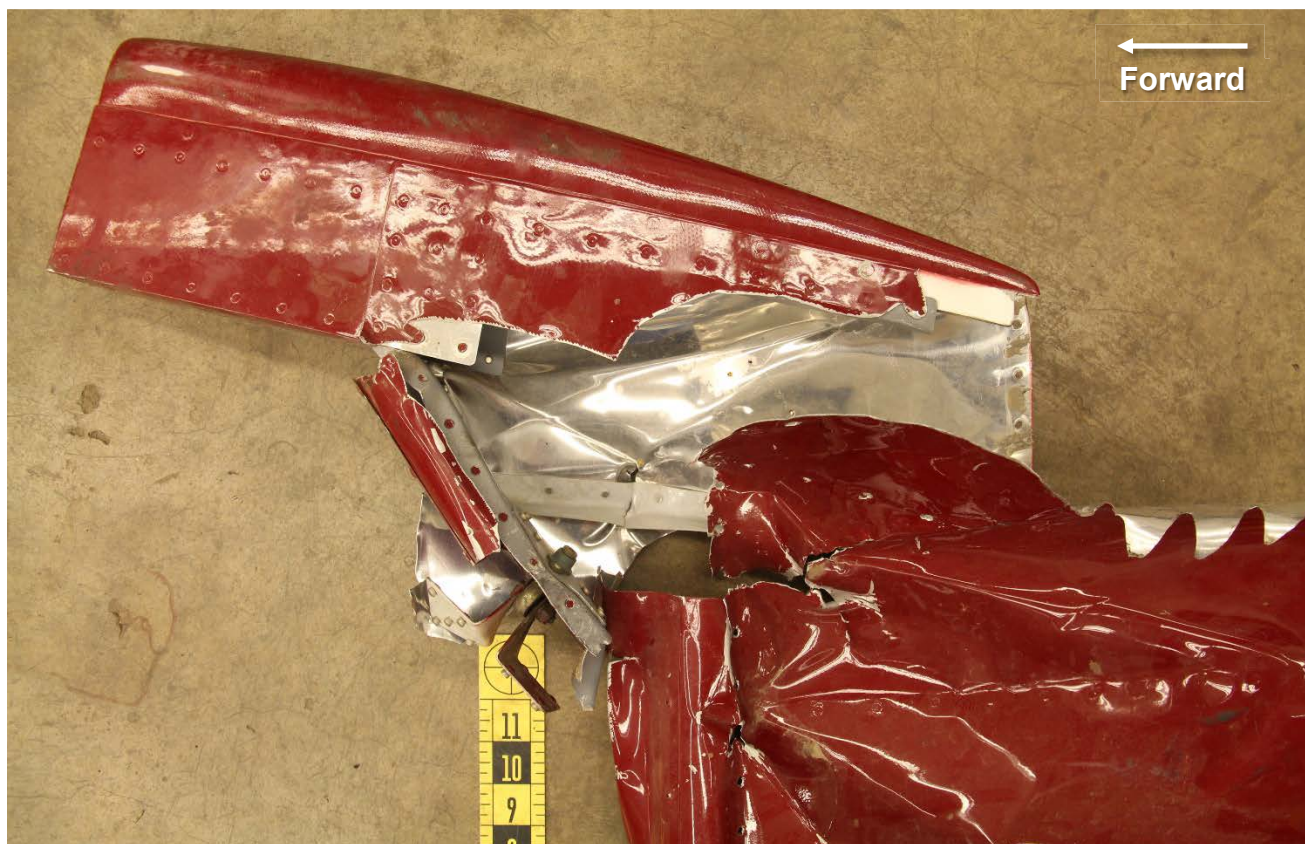


Figure 9 – The topmost portion of the rudder that fractured from the lower portion of the rudder on the left side. The sawtooth shape of the fracture on the right matched the skin fracture around rivets in Figure 10.

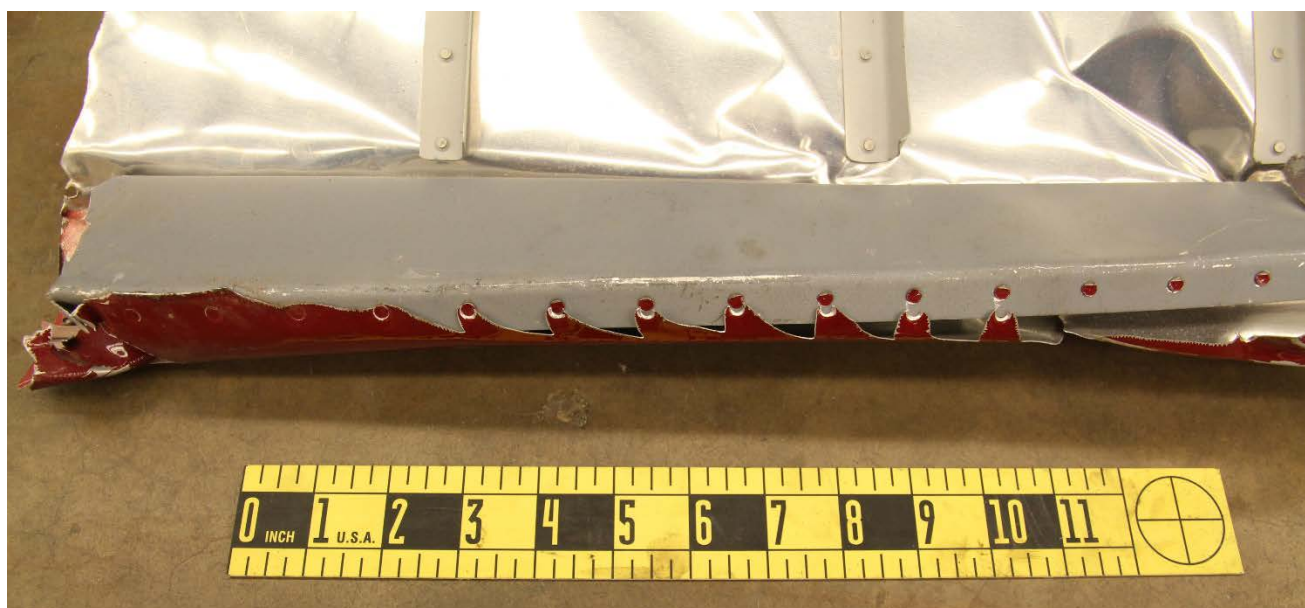


Figure 10 – Sawtooth shaped fractured of the wing skin on the rudder, exhibiting a fracture path around the rivets.

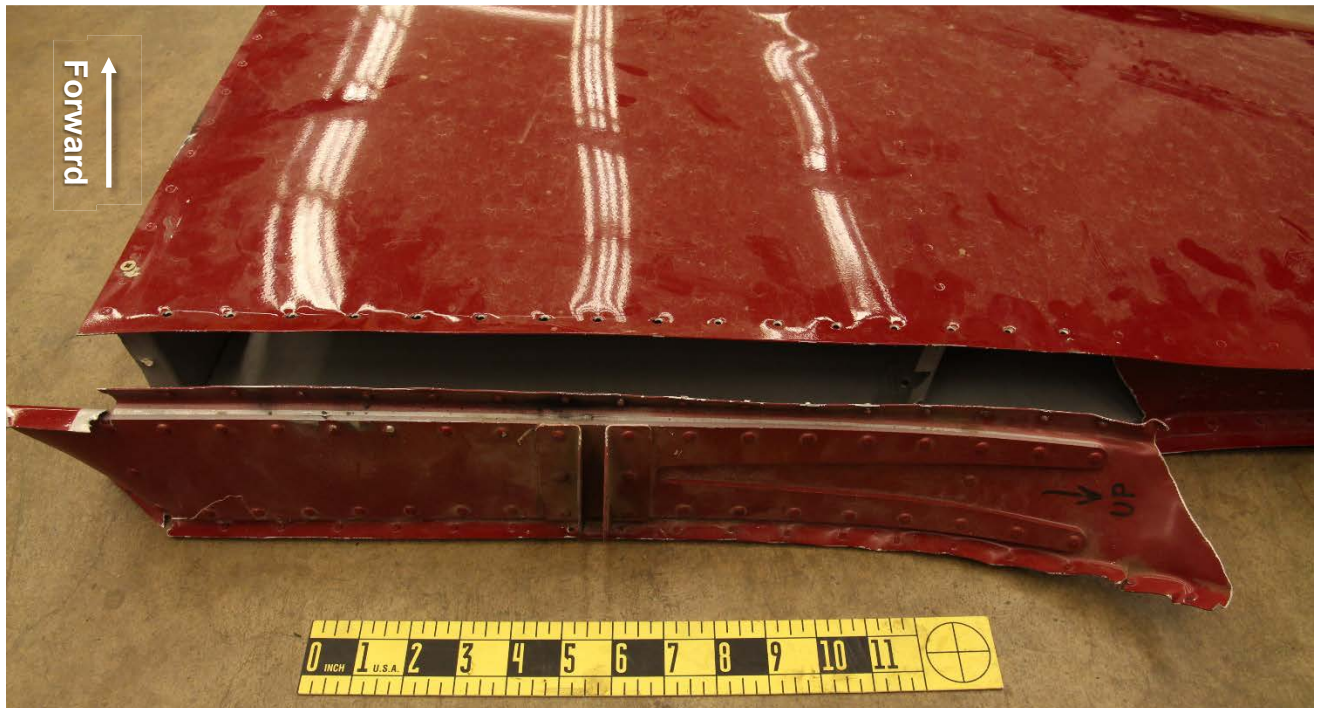


Figure 11 – Position of the lower portion aft vertical spar of the vertical stabilizer, which had fractured about the support rivets and torn away from the stabilizer (right side).



Figure 12 – Position of the upper portion face of the vertical stabilizer, showing rudder attachment flanges that had separated from the aft vertical spar.



Figure 13 – The separated section of the aft vertical spar from the vertical stabilizer, viewed aft looking forward.

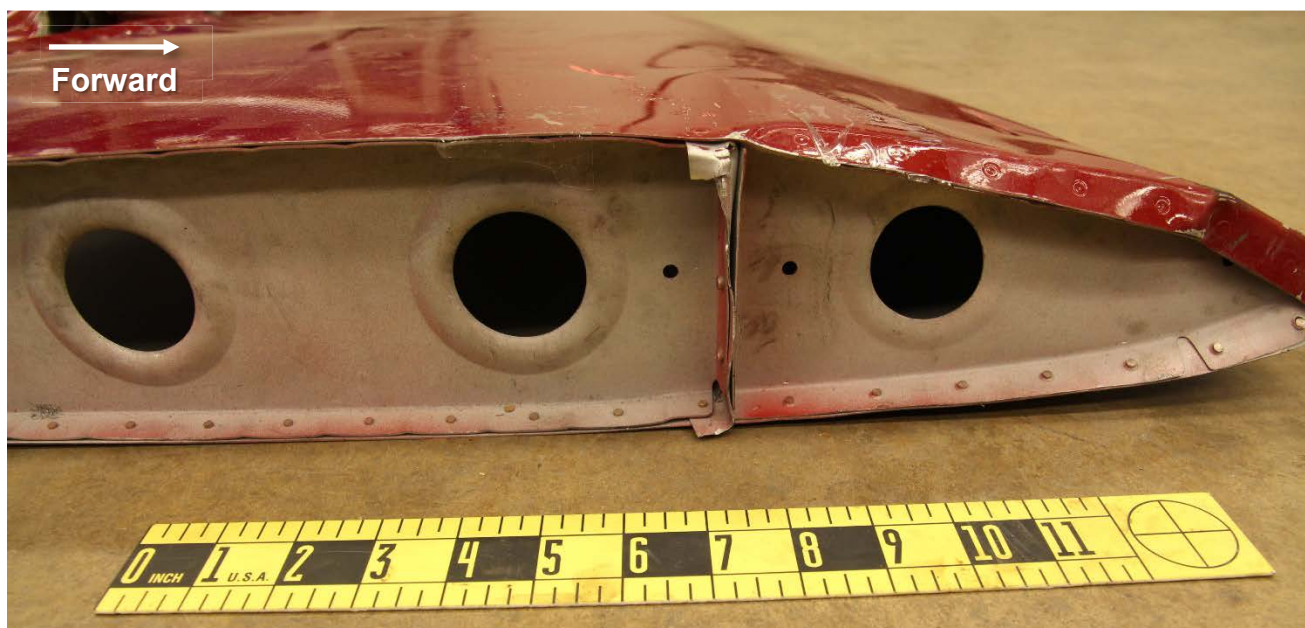


Figure 14 – Exposed area of the bottom face of the vertical stabilizer, showing the forward vertical spar fracture surface.



Figure 15 – Closer view of the fracture surface from the forward vertical spar from Figure 14.



Figure 16 – Closer view of underside of the tail rudder, showing fracture to the composite skin, bending and tearing of the support plate and the fracture surface of aft vertical spar.



Figure 17 – A view of the horizontal stabilizer assembly of the empennage, as received, viewed from the top.

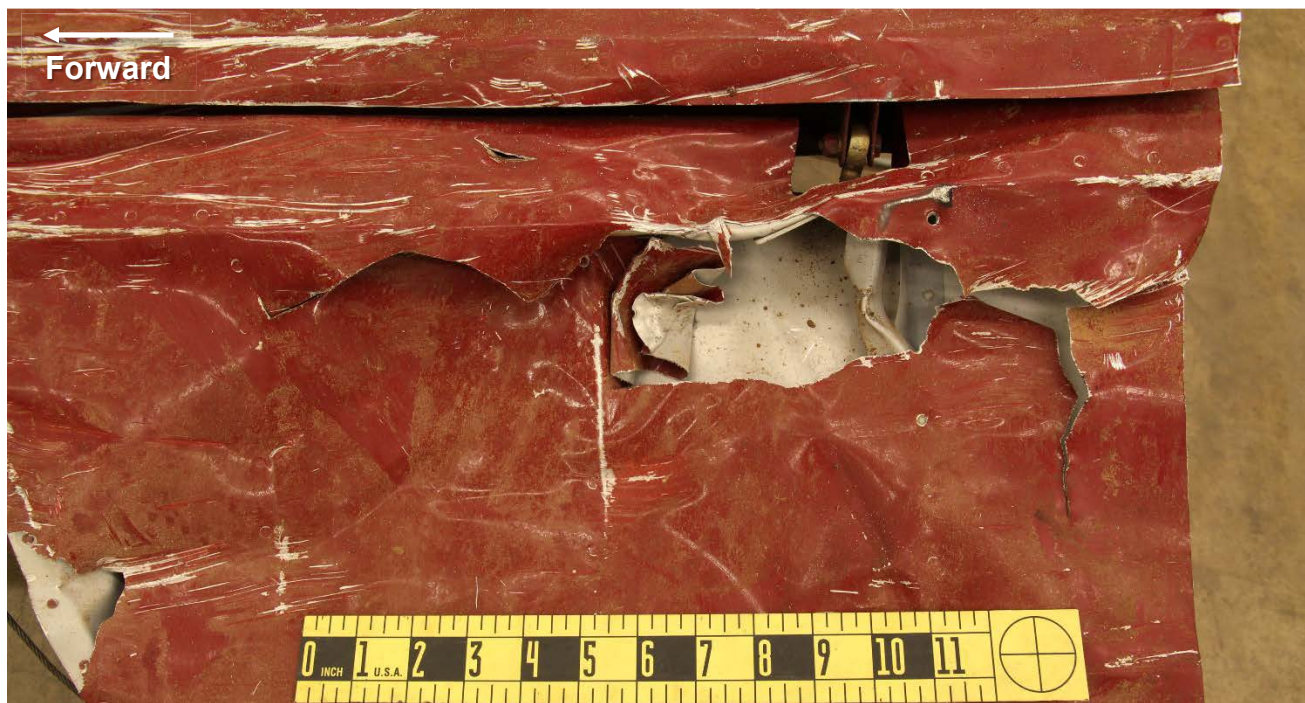


Figure 18 – The top side of the right elevator in Figure 17, showing sliding marks, buckling and tearing of the skin.



Figure 19 – Aft view (facing forward) of the center of the empennage horizontal stab assembly.



Figure 20 – The fracture surface of the lower section of the aft vertical spar from the vertical stabilizer, still affixed to the horizontal stabilizer assembly.

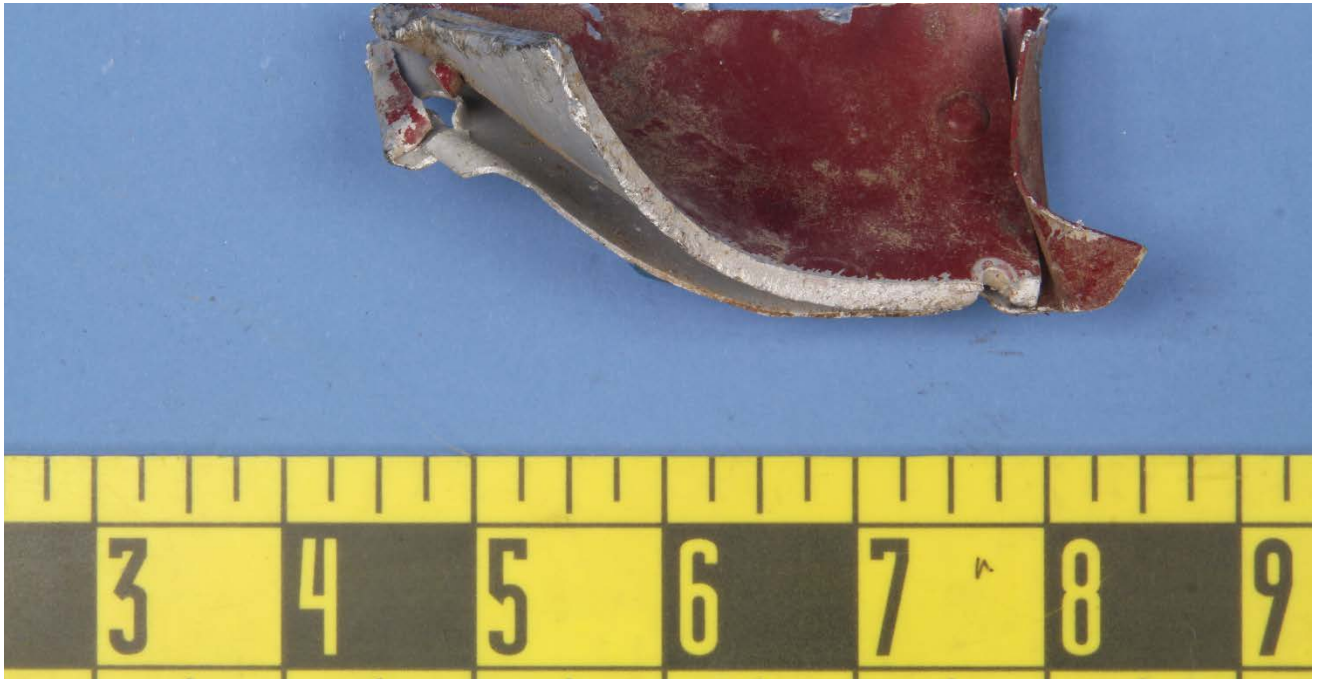


Figure 21 – The lower fracture surface from the aft vertical spar from the vertical stabilizer shown in Figure 20.



Figure 22 – The upper mating fracture surface of the separated section of the aft vertical spar from the vertical stabilizer, shown in Figure 16.



Figure 23 – Portion of the fracture about the rivet hole on the fracture surface in Figure 22.

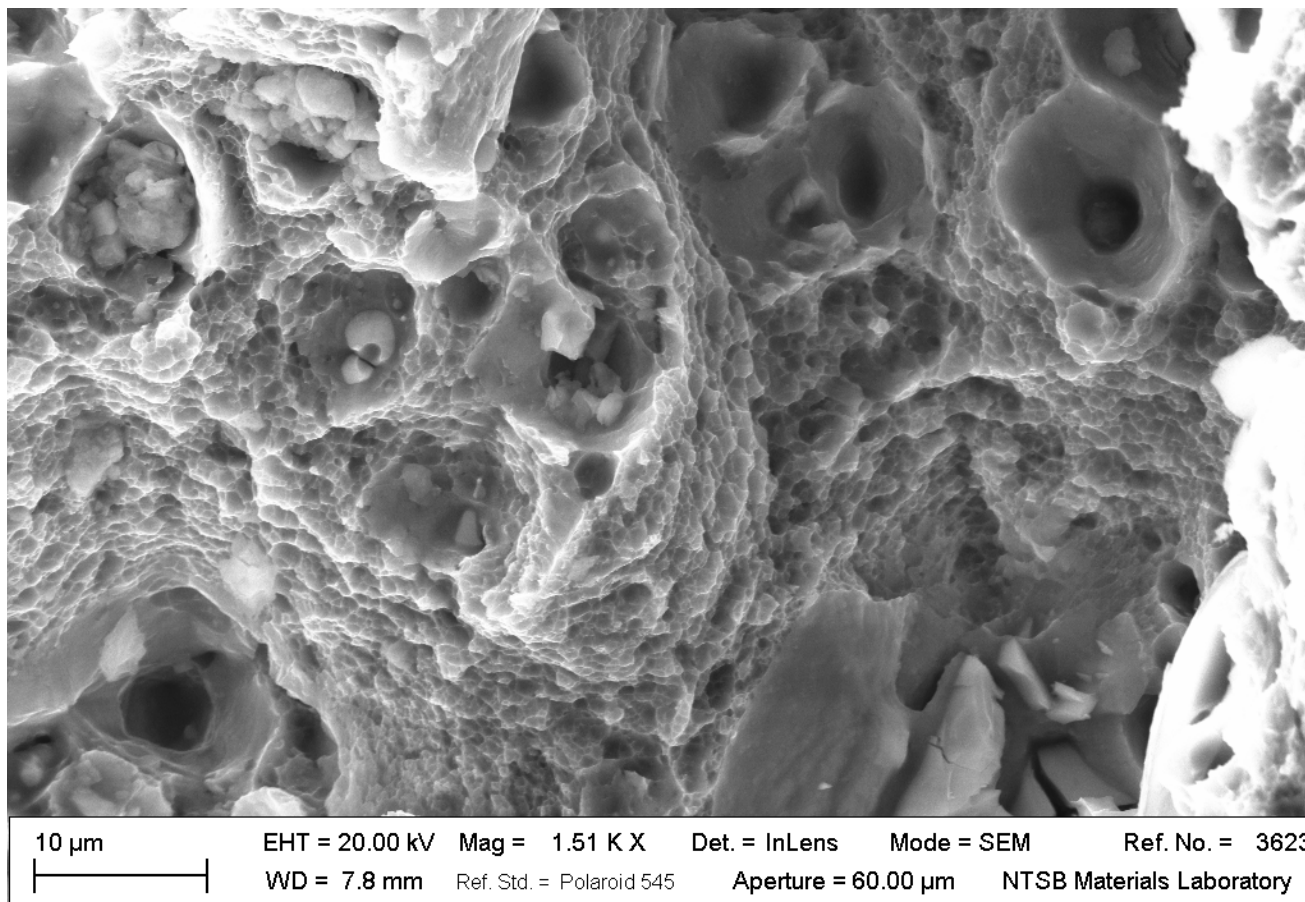


Figure 24 – Secondary electron (SE) micrograph of dimple rupture typical on the fracture surface on Figure 23.



Figure 25 – A view of the underside of the horizontal stabilizer assembly, showing a impressed or dented region in the structure. The boxed area is shown in Figure 26.



Figure 26 – Closer view of the dent in the underside of the horizontal stabilizer, showing the location where organic material was extracted.



Figure 27 – An example of organic material, consistent with avian material, extracted from the underside of the empennage tailcone.

APPENDIX A

FAA Wildlife Strike # 2017-10-30-094034; Smithsonian Feather Lab Case #25926
Final Report



Smithsonian Institution
National Museum of Natural History

Jack Vanover and Maja Smith
National Transportation Safety Board
General Aviation Accident Investigation Division, AS-20

09 November 2017

RE: FAA Wildlife Strike # 2017-10-30-094034; Smithsonian Feather Lab Case #25926

FINAL REPORT

Dear NTSB Investigators,

Your above referenced shipment containing five (5) separate samples from the RV7 crash investigation (27 June 2017) near Arlington, AZ was received on 31 October 2017. Each sample was submitted for DNA analysis and microscopic examination.

One of the bags contained 5 (five) whole feathers and some downy feather material. All of the whole feathers matched perfectly to a single museum specimen (USNM 274142) of Rock Pigeon (*Columba livia*; photos below). Additionally, microscopic examination of the feather samples was consistent with Rock Pigeon.

The remaining 4 bags were identified as *Homo sapiens* using DNA analysis. No feather evidence was found in microscopic examinations of these samples.

The average mass of the Rock Pigeon is 369g for males and 340g for females (Dunning 2008). The FAA National Wildlife Strike Database (1990-2015) includes 20 birdstrikes with Rock Pigeon at or above 2000 feet AGL; five of those strikes occurred between 4,000 and 6,000 feet AGL. Wild Rock Pigeons roost and nest in crevices, caves in rocky seaside cliffs or interior uplands, especially near open scrub vegetation or human agriculture. This species increasingly uses highway infrastructures (e.g., overpasses, bridges), facilitating its spread to more remote areas. Rock Pigeons may feed near the breeding territory, but also may fly up to 26 km to find feeding grounds.

I will return all of the samples to you today. Good luck with this investigation, let us know if you have any questions.

Sincerely,



Feather Identification Lab
Smithsonian Institution



References:

Dunning, Jr., J. B. 2008. CRC Handbook of Avian Body Masses, second edition. CRC Press, New York.

Lowther, Peter E. and Richard F. Johnston. 2014. Rock Pigeon (*Columba livia*), version 2.0. In The Birds of North America (P. G. Rodewald, editor). Cornell Lab of Ornithology, Ithaca, New York, USA. <https://doi.org/10.2173/bna.13>

Dolbeer, Richard (personal communication) USDA Science Advisor; FAA Wildlife Strike Database

Photos

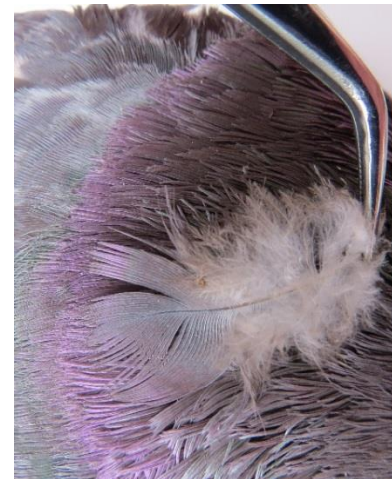


Photo left: Wing feather sample (at forceps) from wreckage compared with museum specimen of Rock Pigeon (USNM 274142). Photo right; Pink, iridescent upper back feather (at forceps) from wreckage compared to museum specimen of Rock Dove (USNM 274142).

APPENDIX B

FAA Wildlife Strike # 2017-10-30-094034; Smithsonian Feather Lab Case #25926 and
180323.54

Final Report - Addendum



Smithsonian Institution
National Museum of Natural History

Jack Vanover and Maja Smith
National Transportation Safety Board
General Aviation Accident Investigation Division, AS-20

Cc: Erik Mueller

30 March 2018

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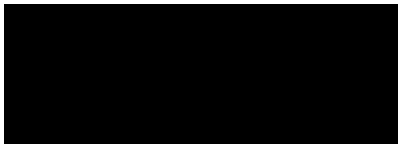
A report for these samples was completed and submitted to Mr. Vanover on 09 November 2017.

On 23 March 2018, I examined the empennage at the NTSB Headquarters in Washington, DC with Mr. Erik Mueller and collected additional samples. The samples consisted of several swipes from the tail section surfaces, and a small whole feather was found deep inside the bottom right side of the empennage. This feather was identified as Rock Pigeon (*Columba livia*) based on whole feather comparisons and microscopic analysis. The additional empennage samples were identified as the same species found in the initial material.

The average mass of the Rock Pigeon is 369g for males and 340g for females (Dunning 2008). The FAA National Wildlife Strike Database (1990-2015) includes 20 birdstrikes with Rock Pigeon at or above 2000 feet AGL; five of those strikes occurred between 4,000 and 6,000 feet AGL. Wild Rock Pigeons roost and nest in crevices, caves in rocky seaside cliffs or interior uplands, especially near open scrub vegetation or human agriculture. This species occurs in flocks and increasingly uses highway infrastructures (e.g., overpasses, bridges), facilitating its spread to more remote areas. Rock Pigeons may feed near the breeding territory, but also may fly up to 26 km to find feeding grounds.

Initial samples were returned to Mr. Vanover on 09 November 2017, samples collected on 23 March 2018 will be kept on file in the Feather Identification Lab. Good luck with this investigation, let us know if you have any questions.

Sincerely,



Feather Identification Lab
Smithsonian Institution



References:

Dunning, Jr., J. B. 2008. CRC Handbook of Avian Body Masses, second edition. CRC Press, New York.

Lowther, Peter E. and Richard F. Johnston. 2014. Rock Pigeon (*Columba livia*), version 2.0. In The Birds of North America (P. G. Rodewald, editor). Cornell Lab of Ornithology, Ithaca, New York, USA. <https://doi.org/10.2173/bna.13>

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Photos



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