NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

October 12, 2012

MATERIALS LABORATORY FACTUAL REPORT Report No. 12-118

A. ACCIDENT INFORMATION

Place	:	Borrego Springs, California
Date	:	September 8, 2012
Vehicle	:	Moore MXS Experimental, N21MX
NTSB No.	:	WPR12LA407
Investigator	:	Patrick Jones, AS-WPR

B. COMPONENTS EXAMINED

Flight control torque tube, forward and aft torque tube bearing assemblies, and forward bearing support panel assembly.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 1. The flight control torque tube was separated from the forward and aft bearings. The forward bearing was retained in its housing, which was attached to the forward bearing support panel. The aft bearing inner race, outer race, and cage were separated from each other and from the housing. The rolling elements for the aft bearing were not included in the submitted components.

As designed, the flight control torque tube is an integral part of the flight controls for roll and pitch. The torque tube has thrust bearings attached to each end of the tube that allow the tube to rotate about its axis, and that rotation is linked to the aileron movement for roll control. A rod for pitch control is located at the axis of the torque tube. The pitch control rod moves axially forward and aft, and pitch control forces are reacted through the torque tube which remains fixed in the axial direction (forward and aft). The thrust bearings at the forward and aft ends of the torque tube provide the resistance for the torque tube forward and aft thrust forces associated with pitch control. The forward bearing resists torque tube thrust in the forward direction, and the aft bearing resists torque tube thrust in the aft direction.

A view of the submitted aft bearing components is shown in figure 2. The inner and outer races of the aft bearing were fractured. Fracture features of both fractures showed uniform matte-gray rough surfaces consistent with overstress fracture. The cage was deformed but intact.

The outer race was marked with the bearing thrust direction as shown in figure 3. An arrow marked on the outer race indicated the direction of thrust applied to the outer bearing race when installed correctly. For a properly installed bearing, the arrow should point toward the torque tube in both the forward and aft bearing positions. Thus the arrow on the aft bearing should point forward, and the arrow on the forward bearing should point to the aft.

The thrust bearings were asymmetrical mirrored across the middle circumferential plane. The raceway groove on the outer race had a higher shoulder on one side to accommodate thrust loads on the ball bearings. The parallel faces on each side of the outer race were also different. The face on the side with the higher shoulder was wider than the face at the opposite side of the bearing as shown in the upper and middle images in figure 4. The faces are designated in this report as the thrust face and the non-thrust face as indicated in figure 3. The thrust face is the wider face which is designed to take the thrust load by contacting the shoulder of the bearing housing, and the non-thrust face is the thinner face that is designed to free from contact.

The aft bearing housing showed multiple indications of contact damage on its forward face around the perimeter of the bearing opening as indicated in figure 2. A magnified view of damage on the lower side of the bearing housing is shown in the lower image in figure 4. The indicated damage was an impression that matched the flat face and adjacent bevels of the non-thrust face of the outer race shown in the middle image in figure 4. The impression did not match the shape of the thrust face of the outer race shown in the upper image in figure 4, and similarly the impression did not match either face of the inner race. The impression is consistent with the bearing having been installed incorrectly with the design non-thrust side of the bearing facing the aft direction against the shoulder of the bearing housing. (The shoulder of the bearing housing is indicated in figure 4.) This orientation with the design non-thrust face of the aft bearing facing the aft direction is the orientation shown in figure 3.

Views of damage at the upper side of the aft bearing housing is shown in the upper image in figure 5. Deformation from the damage extended inward into the opening for the thrust bearing outer race. Corresponding contact damage was present on the aft face of the control stick attachment structure in the areas indicated in figure 5.

A close view of the forward bearing in the bearing housing is shown in figure 6. The inner race of the bearing was tilted off-axis relative to the outer race with the lower right portion of the inner race displaced forward relative to the outer race. The inner race was lodged within the outer race and could not be rotated by hand.

The forward thrust bearing was installed incorrectly. The thrust face of the outer race (wider face) is visible in figure 6. Thus, the non-thrust face of the outer race (thinner face) was facing forward toward the shoulder of the bearing housing, which is an incorrect installation for the thrust bearing.

A view of the forward side of the bearing support panel is shown in figure 7. The middle of the panel was bent forward relative to the edges. A piece of the panel around the lower right quadrant of the center hole was fractured and missing (right as viewed looking forward). The area of the fracture corresponded to the area where the inner race of the forward bearing was displaced forward past the shoulder of the bearing housing.

Aluminum alloy flanges were observed at the edges of the bearing support panel attaching the panel to the sidewalls. The flanges were bent and cracked. The flange faces attached to the sidewalls were bent inward such that the corner of the flange was displaced away from the sidewall. Attachment bolts at the lower end of the flanges were pulled out of the flange holes consistent with the attachment bolts displacing inward and downward relative to the flanges. The upper ends of the flanges showed buckling deformation near the upper attach points, also consistent with a downward displacement.

According to representatives of MX Aircraft, the aluminum flanges were inconsistent with the MXS airplane design. Photographs of an exemplar airplane with a reportedly proper installation of the bearing support panel showed flanges located on the aft side of the forward bearing support panel, and the flanges were made of composite material.

The forward face of the flight control torque tube is shown in figure 8. A number of sliding contact marks were observed on the forward face as indicated in figure 8, and the sides of the face were bent to the aft in the areas of contact. The location and shape of the contact marks were consistent with sliding contact with the aileron control stop assembly on the forward bearing support panel (see figure 8). The aft faces of the aileron control stop assembly also showed missing paint and evidence of contact damage.

Matthew R. Fox
Senior Materials Engineer

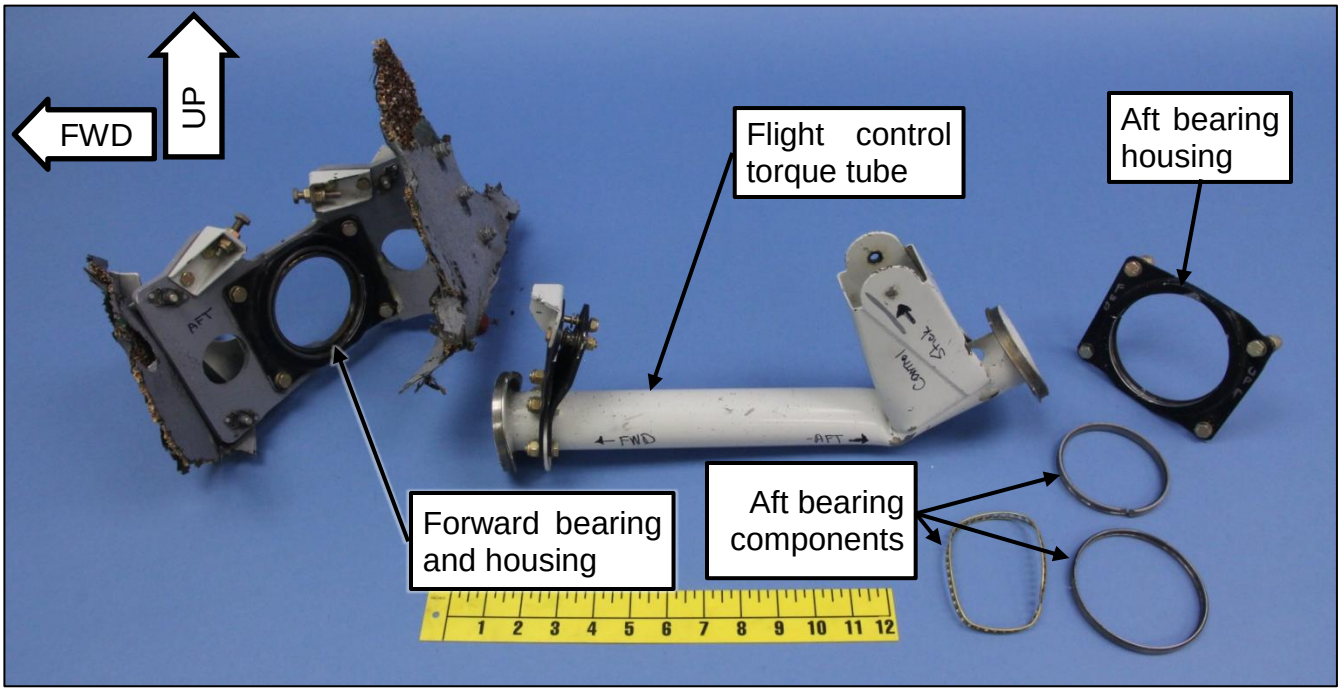

Figure 1. Overall view of the submitted components.

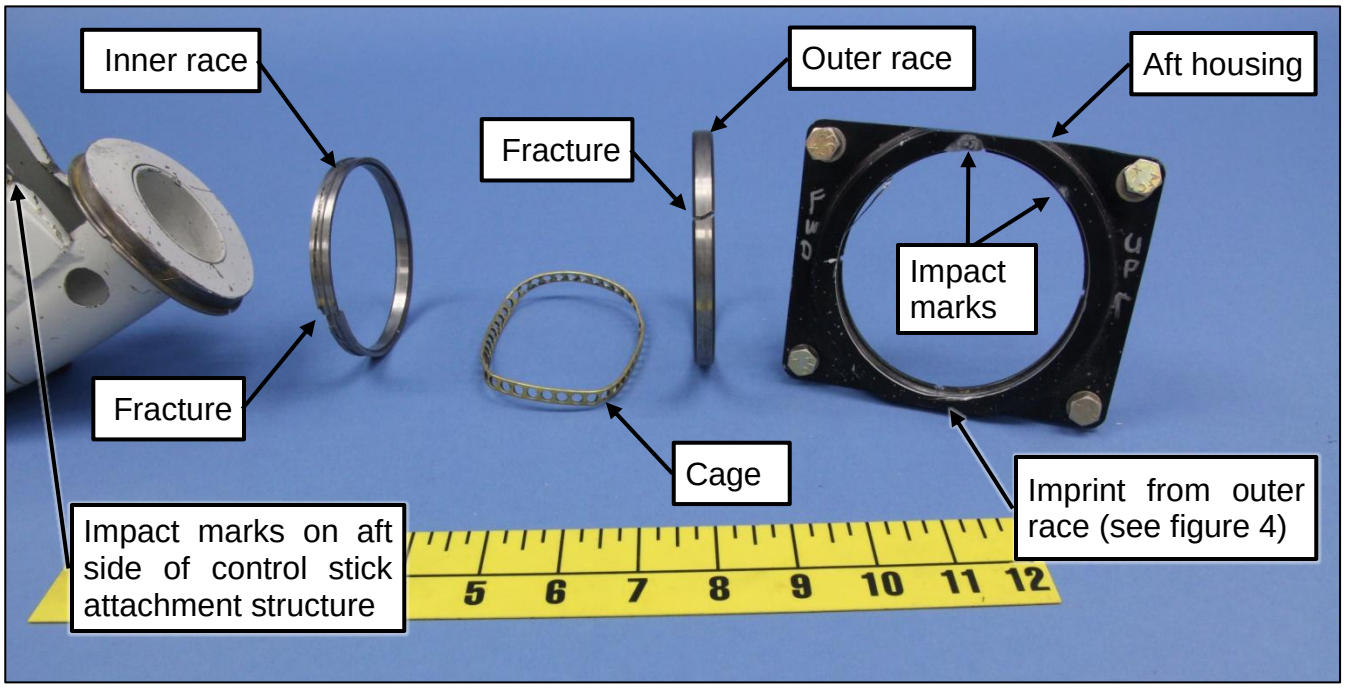

Figure 2. View of the aft control tube bearing components. Fractures in the inner and outer race are indicated.

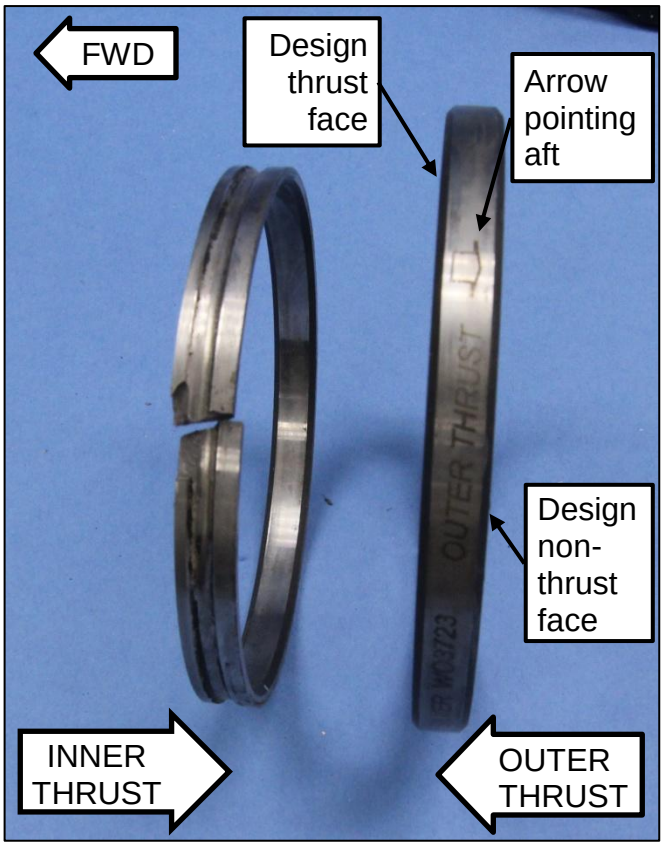

Figure 3. Close view of the inner and outer race of the aft bearing. The forward direction indicated is based on witness marks on the aft bearing housing (see figure 4). The arrow pointing aft on the outer face of the outer bearing points in the direction of applied thrust on the outer race when the bearing is correctly installed. The thrust and non-thrust faces of a correctly installed bearing are also indicated. The direction of outer thrust is opposite that of the thrust from the flight control tube (inner thrust). Arrows at the bottom of the figure point to directions of applied thrust as installed on the airplane.

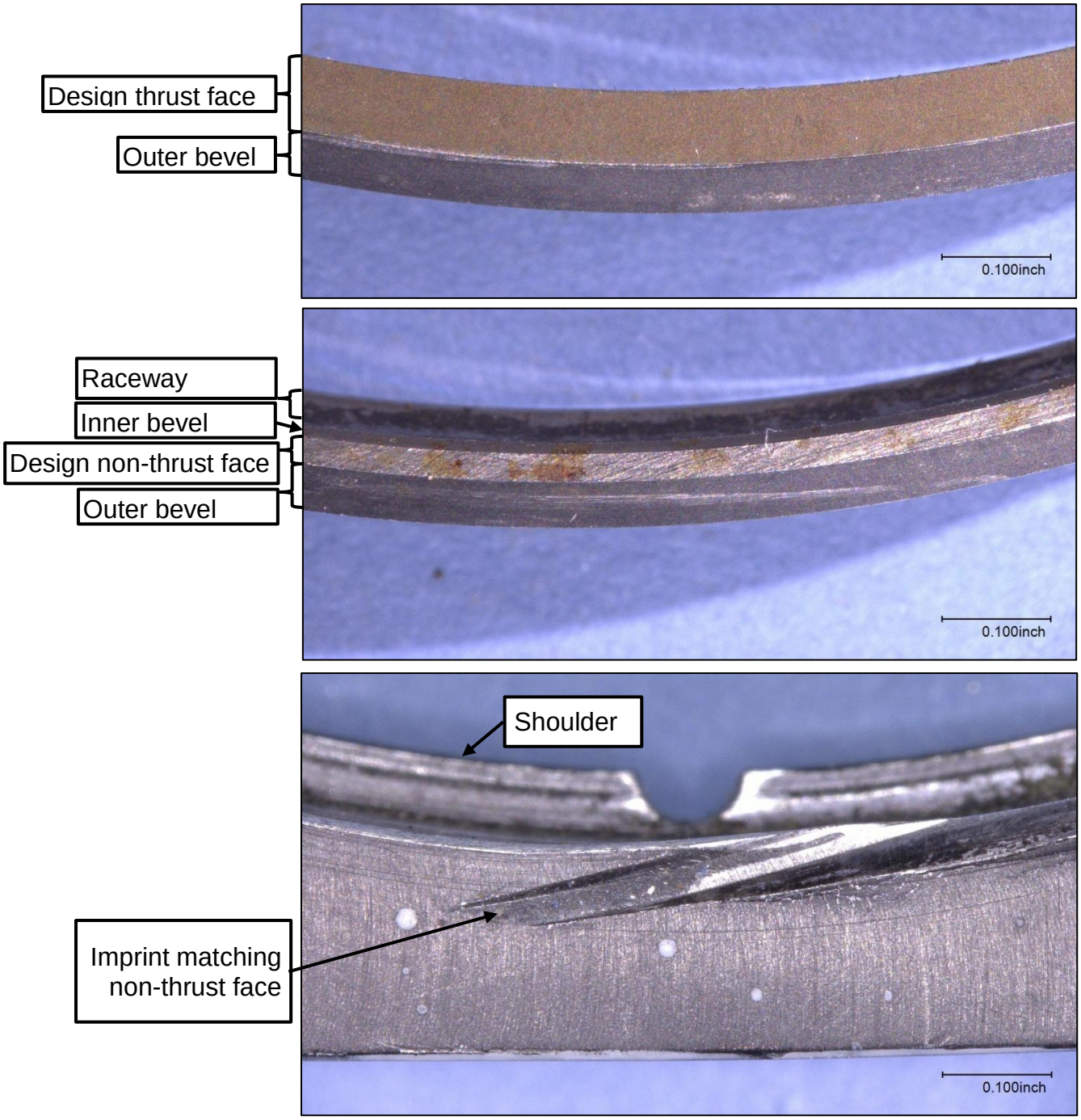

Figure 4. Views of the thrust face (upper image) and non-thrust face (middle image) of the aft bearing outer race. The imprint mark on the forward face of the aft housing (lower image) shown at the same magnification as the upper and middle images corresponded to contact with the thinner non-thrust face and not the wider surfaces of the thrust face of the outer race or either face of the inner race.

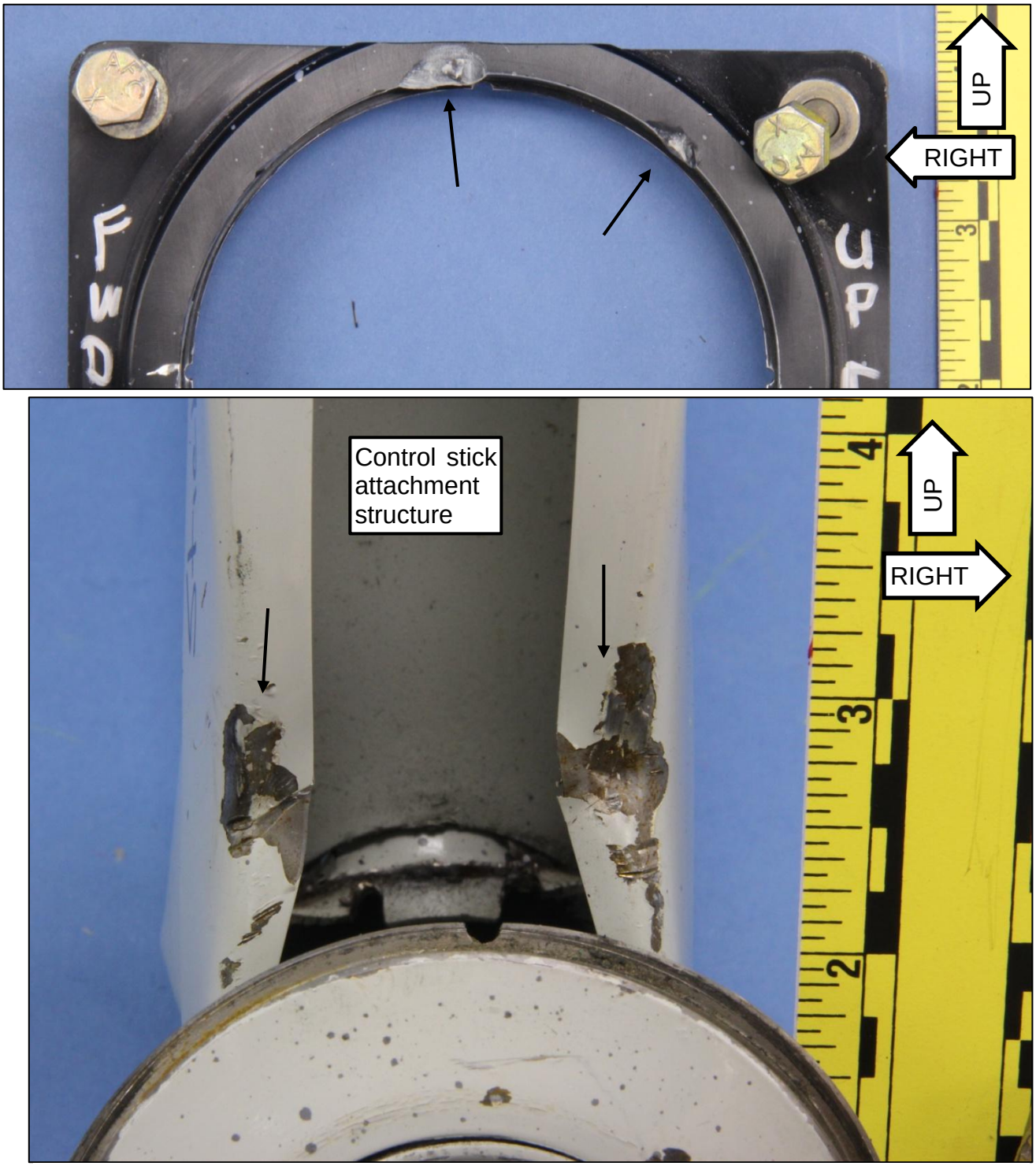

Figure 5. Close views of the forward face of the aft bearing housing (upper image) and the aft face of the control stick attachment structure (lower image). Unlabeled arrows in both images indicate corresponding contact damage on the two components.

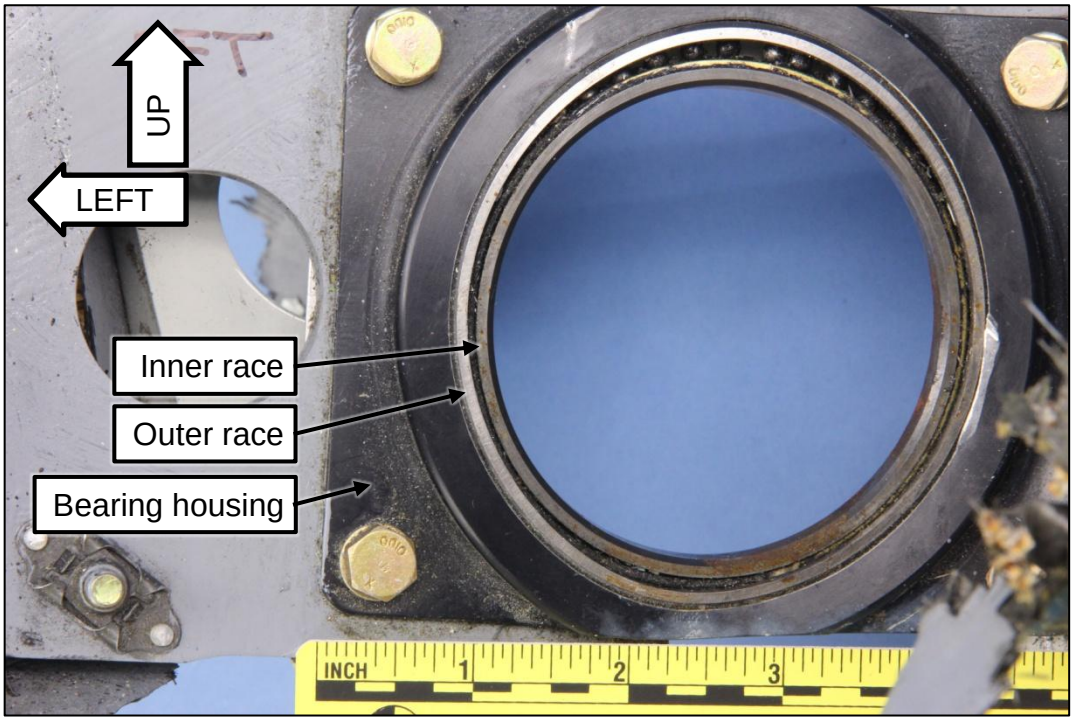

Figure 6. View of the aft face of the forward bearing. The design thrust face of the outer race is visible. When correctly installed in the housing, the thrust face of the outer race should face forward on the forward bearing.

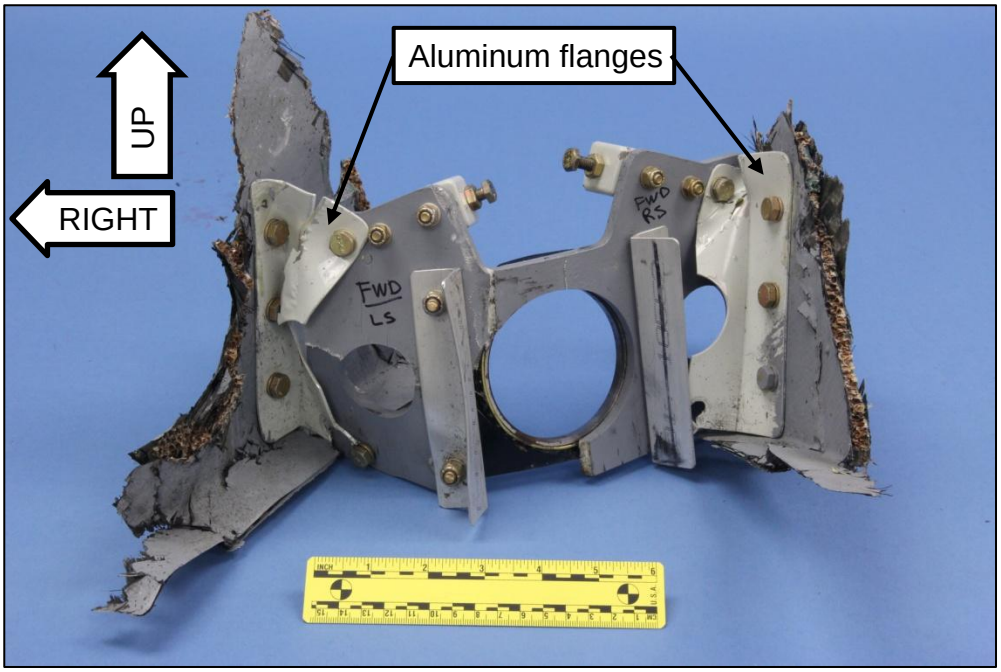

Figure 7. View of the forward side of the forward bearing support panel. Aluminum flanges attaching the bearing support panel to the sidewalls are indicated.

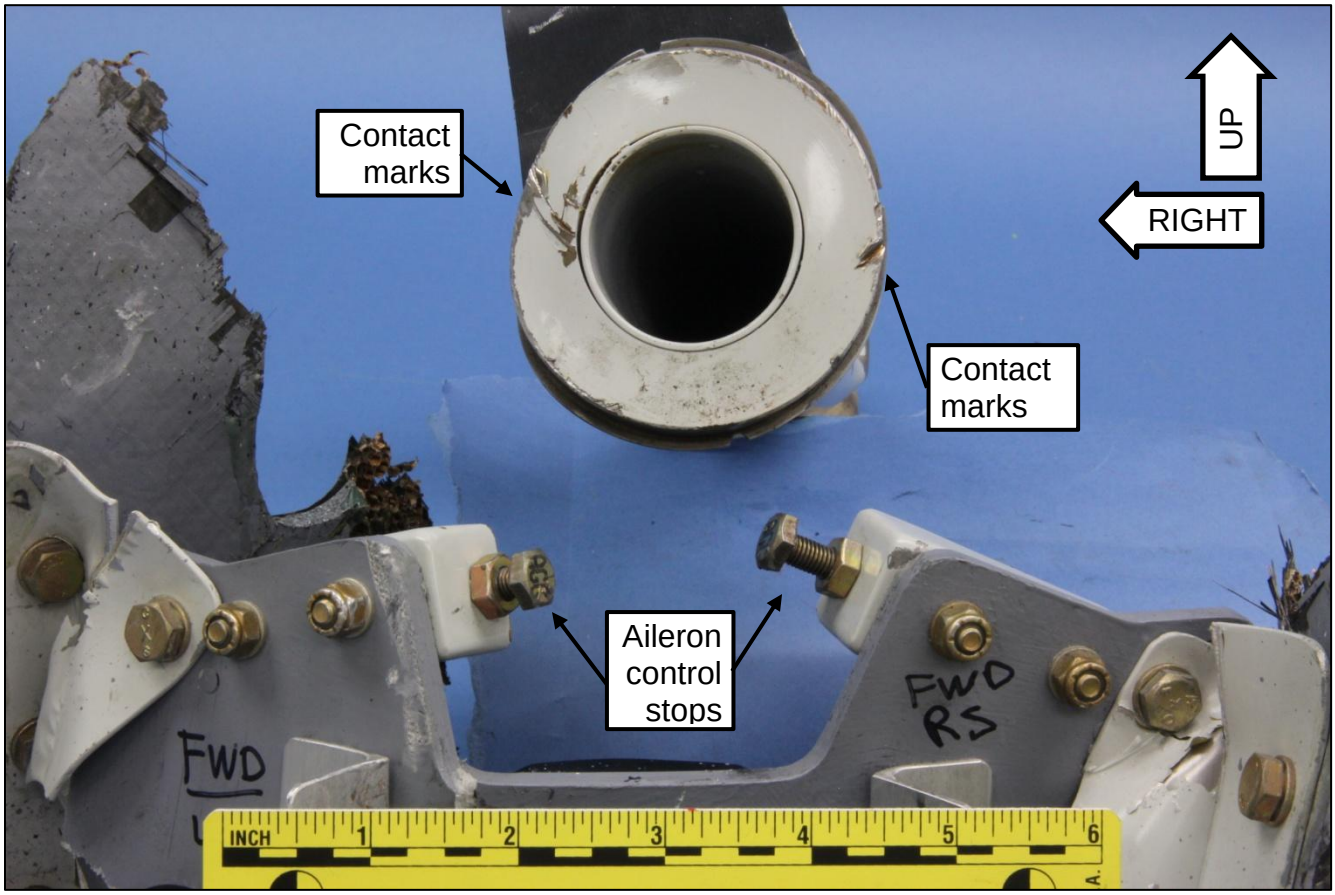

Figure 8. View of the forward face of the flight control tube showing sliding contact marks.