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***Biomedical, Materials Science and Mechanical Engineering Analysis 1-800-MSA-MSA1***

July 23, 2014

**Forensic Evaluation of Video Footage from the TIGHAR 2010 Nikumaroro Expedition – Supplemental Report 3**

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**Introduction:**

This is a supplement to my prior supplemental report, which was dated June 4, 2014. At timestamp 13:43:48:24 in the 2010 HD video titled "ROV OPS_0010134 0012XO.mov", an object of potentially unnatural origin was observed (Figure 1). A series of repeating, staggered features on a rectangular object sits adjacent, and perpendicular to a second rectangular object. This second rectangular object contains parallel features on both long edges of the object. Approximately halfway down this second object, one of the long sides exhibits repeating, staggered features similar to the top, horizontal object. These features bear a resemblance to the window slide rail in the cockpit of the Lockheed Electra 10E aircraft (Figure 2 and Figure 4), prompting further analysis.

**Analysis:**

In order to take more accurate measurements from a photograph of the window slide rail, a perspective transformation of the angled, side-view photograph of the window was performed using MATLAB in order to view the window head-on (Figure 5). The yard stick, having known length, width, and shape was used as a reference to perform the transformation, with the assumption that the outer faces of the window slide rail and yard stick were parallel. This transformed view is orthographic for all features contained in the same plane as the ruler, such as the rivets highlighted in Figure 2. Therefore, the ruler in the transformed image can appropriately be used to measure objects contained in the same plane.

A 3D CAD model of the window rail was created using measurements taken from the transformed image and another photograph of the window slide rail (Figure 4). From the rover image, the estimated centers of the repeated, staggered shapes were drawn. The CAD model was overlaid in perspective view over the rover image in order to perform a numerical comparison between the CAD model and the object seen in the rover video.

The 3D CAD model was visually fit to objects in the rover image, while maintaining the CAD model on approximately the same plane during each fit. After fitting, the rover image was replaced with an identical image, but with the centers of the staggered, repeating features of the horizontal object highlighted, and the parallel edge features of the vertical object highlighted.

In order to provide a quantitative measurement of the misalignment error of individual features, the distance between each rivet and the corresponding center of each staggered shape was measured within Solidworks. The average error was 1.32 mm with a standard deviation of 1.09 mm. As a measure of the overall scaling error, a worst-case measurement was taken, which used the farthest-spaced rivets and the farthest-spaced staggered shapes as references. The distance between the centers of the farthest-spaced staggered shapes measured 53.28 mm. The distance between the centers of the corresponding, farthest-spaced rivets measured 52.59 mm. The difference between these measurements gives an overall scaling error of 0.69 mm.

To put these errors in context, you can define the fit as follows:

*Center of the staggered shapes perfectly align with the centers of the rivets = Perfect fit*
*Center of the staggered shapes aligns with the radius of the rivets = Limit of fitting*
*Center of the staggered shapes is outside the radius of the rivets = Not a fit*

Numerically,

$$Fit = 100\% - 100 * \frac{\sum_n Distance\ from\ center\ point_n}{\sum_n Radius\ of\ rivet_n}$$

With the radius of the rivet used as as the reference, the fit numerically becomes:

*Perfect fit = 100%*
*Limit of fitting = 0%*
*Not a fit < 0%*

Therefore, there is a fit if the value is between 0-100%, and there is not a fit if the value is negative.

Every measured point on the rover image is within the radius of the rivets, and using the collected data, there is an 84% perfect fit between the rivets and the centers of the staggered objects seen in the 2010 HD video.

Furthermore, using the equation for percentage error, and applied to the worst-case scenario of using the farthest-spaced rivets to measure the error between the rover image and the CAD model, the error is 1.3%, or conversely, has a fit of 98.7%:

$$Percentage\ Error = \frac{Rover\ Image\ Distance - CAD\ model\ distance}{CAD\ model\ distance} * 100$$

In addition, for the vertical object, the long edges of the rail aligned with the edges of the vertical object in the rover image to within 3.18 mm, establishing a second correspondence between the CAD model and the objects on the sea floor. Furthermore, there are additional repeating, staggered features toward the bottom of this vertical object, but the vertical object appears non-uniformly bent. Therefore, an overlay of the CAD model on this section of the object was unfeasible to perform.

## Conclusion

The size and shape of both the rail and the rivets of the Lockheed Electra 10E side cockpit window are consistent with the objects seen in the 2010 HD video, supported by measurements of two features seen in the rover image.

- The rivets of the CAD model of the Lockheed Electra 10E side window slide rail aligned with objects seen in the rover image with an 84% fit.
- A worst-case measurement comparing the distance between the farthest-spaced rivets had a fit of 98%.
- The parallel edges in the rover image aligned within the width of the rails of the CAD model.

Sincerely,
Materials Science Associates, LLC

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**Figure 1: Screenshot at timestamp 13:43:48:24 in the 2010 HD video titled "ROV OPS_0010134 0012XO.mov".**

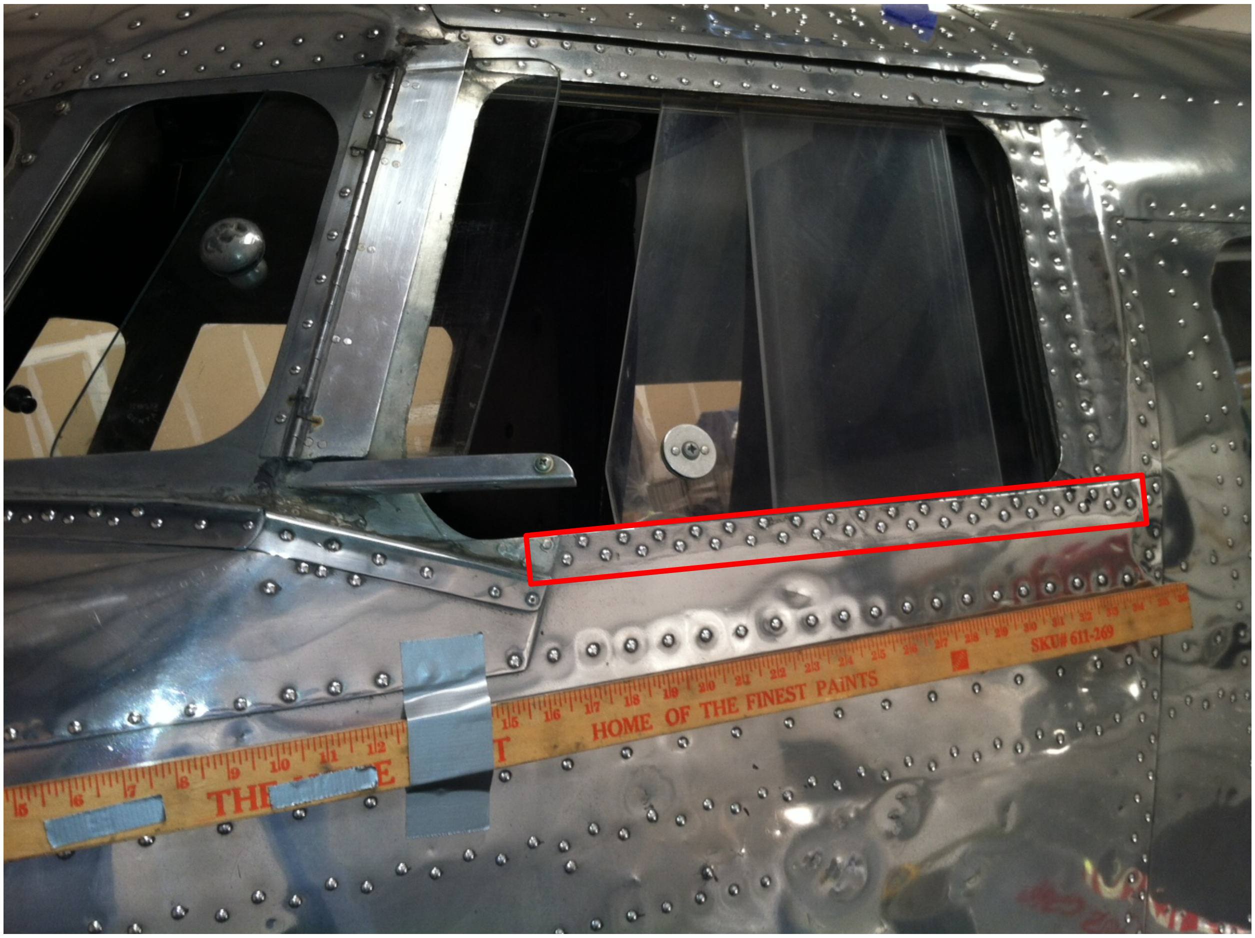



**Figure 2: The side-view of a cockpit window of a Lockheed Electra 10E. The proposed window slide rail is indicated, and only the outer face of it is visible in this photograph.**


**Figure 3: Amelia Earhart sitting on a Lockheed Electra 10E.**

**Figure 4: Top-down view of the window slide rail is indicated. This is the rail in which the window travels.**

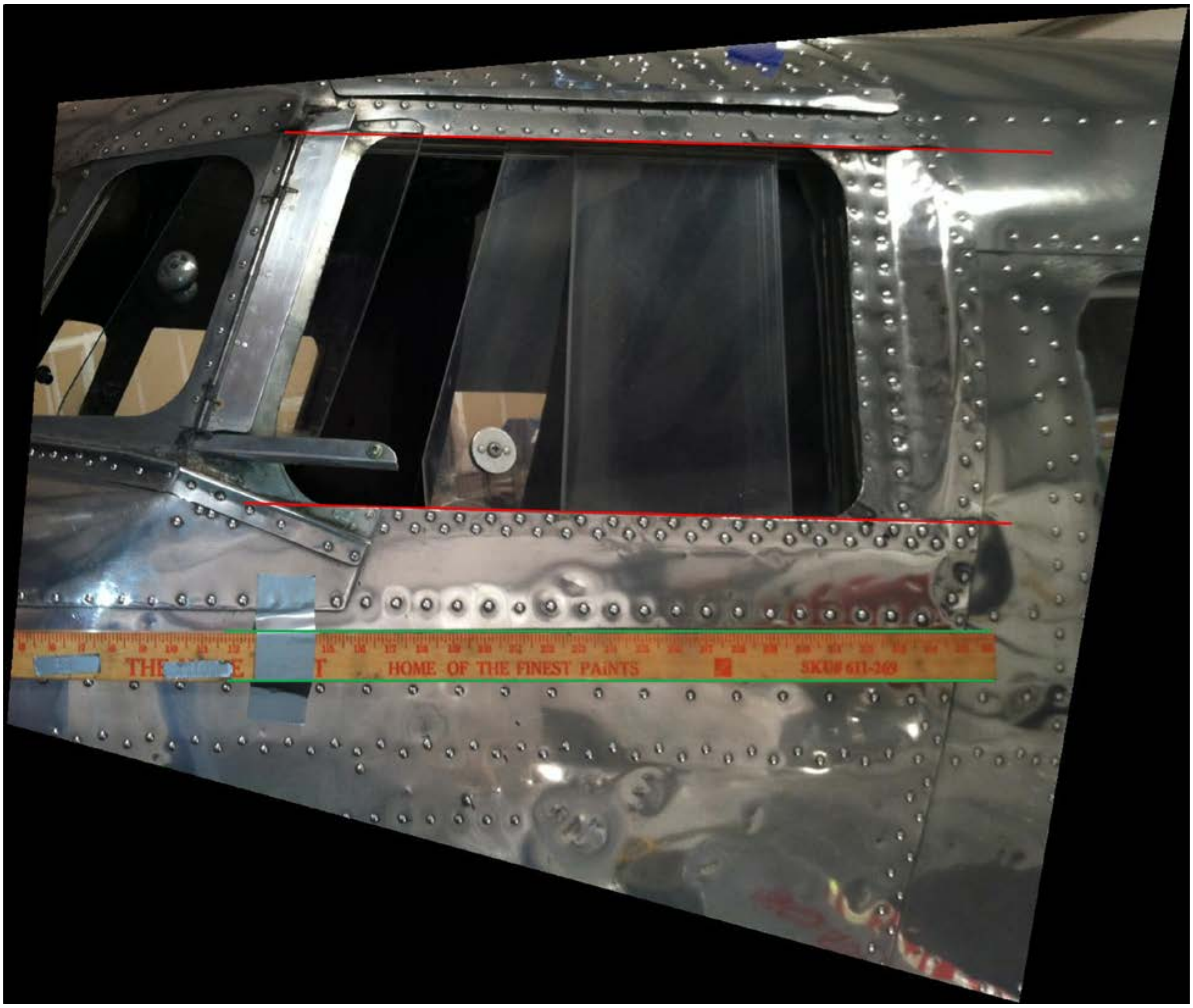
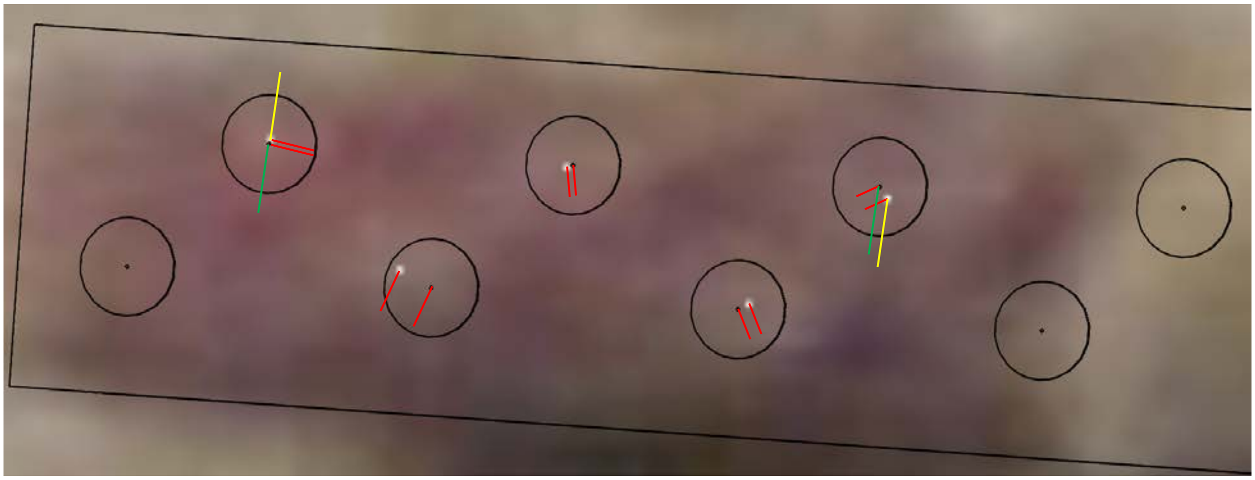



**Figure 5: Photograph after perspective image transformation. Note that red lines are parallel, and green lines are parallel after the transformation. The pre-transformed image is Figure 2**

**Figure 6: The 3D CAD model is shown overlaid on photographs of a Lockheed Electra 10E.**



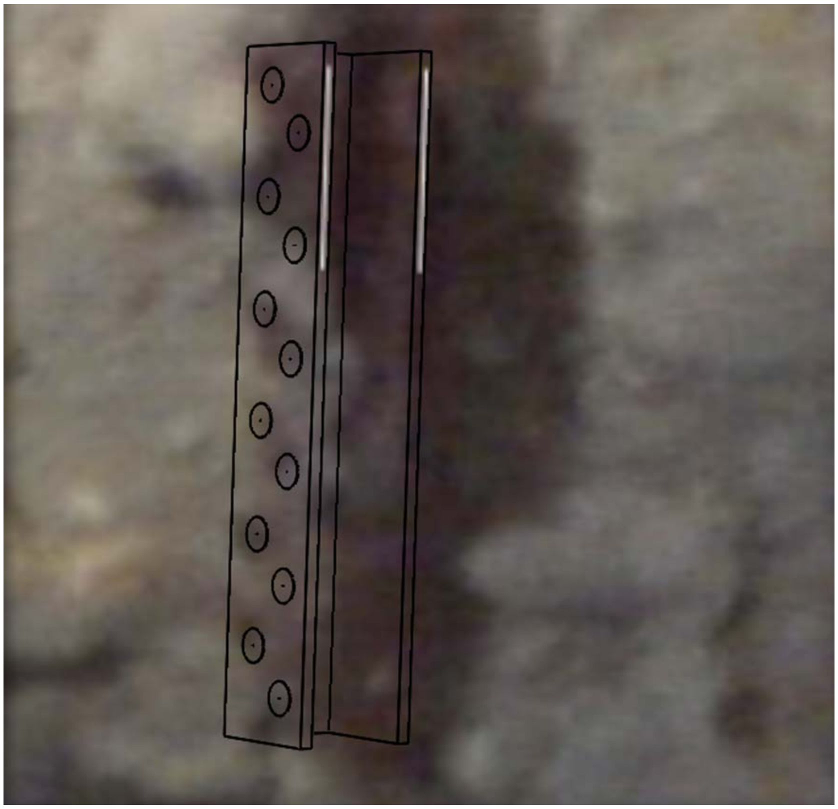


**Figure 7: Overlays of the 3D CAD model and features in the rover video are shown. The individual error in fit for the rivets is shown as the distance between the red lines. The overall scaling error is shown by comparing the distance between the green lines (centers of the farthest-spaced rivets) and the distance between the yellow lines (centers of the farthest-spaced staggered shapes).**