



D31 Analysis of an Image Anomaly in the Space Shuttle Columbia Accident, Part 2: Determining the Source

Richard W. Vorder Bruegge, PhD, FBI, Forensic Audio, Video and Image Analysis Unit, Building 27958A, Quantico, VA 22135; and Peter Goldie, PhD, Lightbinders, 2521 Harrison Street, San Francisco, CA 94110*

After attending this presentation, the forensic community will understand the procedures used to assess anomalies in images and learn something about photogrammetry.

This presentation will impact the forensic community and/or humanity by providing the forensic community with a better understanding of the importance of imaging, image processing, and photogrammetry. The ability to utilize images in forensics will be further underscored.

The presentation will describe the analyses used to assess the source of an anomaly contained within an image depicting the Space Shuttle Columbia (STS-107) during its atmospheric reentry on February 1, 2003. This anomalous feature was thought to be related to the accident, either as the initiating cause of the accident, or as a real effect documenting the breakup of the shuttle. A description of the analysis used to authenticate the image as having originated with a specific camera is included in a separate presentation ("Part 1").

On February 1, 2003, the Space Shuttle Columbia (STS-107) returned to Earth along a flight path that crossed northern California prior to an intended landing in Florida. Tragically, seven lives were lost as Columbia broke up over Texas.

Although the cause of the accident was ultimately attributed to a debris strike during launch, immediately after the accident the true cause was unknown and multiple avenues of investigation were pursued. One such avenue included the analysis of digital photographs taken during the reentry by one of the authors (Goldie). One of these photos depicted an anomalous feature extending from the path of Columbia as it crossed over northern California.

The photographs had been taken using a NIKON COOLPIX 880 mounted on a lightweight, but professional grade, tripod. The weather conditions were partly cloudy, low level clouds below 500m with occasional gusts up to 20 mph. The photographs were taken between 5:52-5:54 a.m. PDT, with an exposure time of 8 seconds each.

The resolution of the images is insufficient to make out any details of the shuttle itself. Instead, the photographs depict the plasma "plume" created by Columbia as it heated and ionized the upper atmosphere at approximately 70 km altitude. This plume would appear brightest at the leading point of Columbia's passage, and would fade to extinction after 1-2 minutes. Therefore, in a long exposure photograph, one can divide the plume into three primary components: (1) The plume which already existed within the camera field of view at the beginning of the exposure and which would continue to fade during the exposure; (2) a bright point lightsource traversing the scene during the exposure (representing the transit of the shuttle across the frame); and (3) superimposition of the residual plume with the initiating hot-point source, as a result of camera or spacecraft motion. Recognition of these three components is critical to the ultimate analysis in this case.

The FBI was asked to examine this photo and provide an assessment of the anomaly and its possible origin. In addition, NASA simultaneously sought advice from other facilities and experts, including experts knowledgeable in upper atmospheric physics, to assess potential natural causes.

The examination of the anomaly consisted of several parts. First the characteristics of the anomalous image and the anomaly itself were catalogued and described. These include the size, shape, luminance, and color characteristics of the anomaly and plume of plasma left behind Columbia as it crossed the field of view. The characteristics of multiple stars in the background were also catalogued in this step. A variety of image processing techniques such as brightness and contrast adjustments, unsharp mask, image rotation, and unidirectional image resizing ("vertical exaggeration") were used to improve the visibility of features within the image. When examined in this manner, it became apparent that the image anomaly displayed a sinusoidal pattern.

A photogrammetric analysis was conducted to calculate the size of the anomaly in both image space (at the camera's focal plane) and object space (at the position of the shuttle). Finally, the characteristics of the anomalous image were compared with the other images of Columbia's reentry taken immediately before and after this image using the same camera.

Once all of these observations and measurements had been taken, it became apparent that no outside source needed to be invoked for the anomaly. In addition, the special panel convened by NASA was unable to find corroborative evidence to support the alternative theories (high altitude lightning/ geomagnetic storm, triboelectric spacecraft charging, seismic motion). The simplest explanation for the anomaly was that it



General Section – 2005

represented the product of camera vibration. Limited tests conducted in the laboratory demonstrated that primary features of the anomaly could be recreated.

Image Analysis, Photogrammetry, Digital Image Processing