NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

September 22, 2014

Video Study

Specialist's Report
by Sean Payne

1. EVENT SUMMARY

Location:	Bagram Air Base, Bagram, Afghanistan
Date:	April 29, 2013
Aircraft:	Boeing 747-400
Registration:	N949CA
Operator:	National Airlines
NTSB Number:	DCA13MA081

On April 29, 2013, about 1527 local time, a Boeing 747-400, N949CA, operated as National Airlines flight 102, crashed shortly after takeoff from the Bagram Air Base (OAIX), Bagram, Afghanistan. All 7 crewmembers onboard were fatally injured and the airplane was destroyed from impact forces and post-crash fire. The 14 Code of Federal Regulations (CFR), Part 121 Supplemental cargo flight was destined for Dubai World Central - Al Maktoum International Airport (OMDW), Dubai, United Arab Emirates.

2. GROUP

A group was not convened.

3. DETAILS OF RECORDED MATERIAL

On May 7, 2013, the NTSB's Vehicle Recorder Laboratory received three videos of the event via secure email from investigators on scene in Afghanistan. These files are described as follows:

File Name: **G2013-02-01-03-21-25-0.avi**
Recorder Type: Unknown
Location: Approximately 34°57'44.75"N 69°16'43.11"E
Moving vehicle in the vicinity of Perimeter Road, Runway 21 threshold

This file is the full length version of the dashboard camera footage from a moving vehicle in the vicinity of the airbase (Figure 1). It is 15 minutes and 47 seconds in length and is of AVI[1] file type. It is 640 by 480 pixels in resolution and was recorded at a rate of 30 frames per second in color. It includes 16 bit digital audio.

In this recording, the accident aircraft appears 11 minutes and 10 seconds into the video file. The accident aircraft enters the frame in a steep climb as it departs Runway 03. At 11 minutes and 20 seconds into the video, the aircraft reaches its apogee and begins to enter a roll to the right. At this time in the video, a sound similar to jet thrust noise is heard. The aircraft begins a rapid descent as it rolls back to the left. The aircraft impacts slightly nose down and nearly wings level. The landing gear is in an unknown configuration throughout the recording. The forward nose gear stowage door is shown in the open position. Overall, the aircraft appears in 541 video frames until the moment of impact.

Figure 1: The approximate location of the Dashboard Camera Recording.

[1] AVI – Audio Video Interleaved format, is a multimedia container format introduced by Microsoft. AVI files can contain both audio and video data in a file container that allows synchronous audio with video playback.

File Name: **ECP10.avi**
Recorder Type: Unknown
Location: 34°57'41.36"N 69°16'54.41"E
Security Tower 34 – Base perimeter fence near a base entrance gate, approximately 1,800 feet from the Runway 21 threshold

This file is from a PTZ[2] controlled security camera near a base entrance on the northeast end of the airfield (Figure 2). It is 7 minutes and 43 seconds in length and is of AVI file type. It is 704 by 480 pixels in resolution and was recorded at a rate of 10 frames per second in color. It does not include audio.

In this recording, the accident aircraft appears 1 minute and 34 seconds into the video file. The aircraft's right wing enters the frame as it continues descending into the frame. The aircraft begins to roll back to the left and impacts the ground nose low and nearly wings level. The aircraft appears in 14 frames until the moment of impact.

Figure 2: The location of the Tower 34 Camera.

[2] PTZ – Pan, Tilt and Zoom. A camera capable of remote directional and zoom control in 3 axes.

File Name: **NW_Corner_of_XX-XXXXXXXXXX_29Apr_2013_V2.mp4**[3]
Recorder Type: Unknown
Location: 34°57'47.48"N   69°16'0.98"E
Security Tower 33 - Approximately 2,900 feet abeam the Runway 21 threshold

This file is from a fixed mounted security camera near the northwest perimeter of the airfield (Figure 3). It is 14 minutes and 54 seconds in length and is of MP4[4] file type. It is 1280 by 720 pixels in resolution and was recorded at a rate of 23 frames per second in color. It does not include audio.

This video shows a left rear ¾ view of the accident aircraft as it impacts the ground. It enters the frame 25 seconds into the provided recording. The aircraft is right wing low and begins to roll level as it impacts the ground nose down. The aircraft becomes obscured by a structure in the final few frames. Overall, the accident aircraft appears in 17 frames until the moment of impact.

Figure 3: The approximate location of the Tower 33 Camera.

[3] Filename has been redacted for security.
[4] MP4 – MPEG-4 Part 14. A file container format used to store both video and audio optimized for streaming playback on the internet.

4. AREAS OF FURTHUR INVESTIGATION

Each video was evaluated to determine its potential value to the investigation. For each video file JPEG[5] format stills were exported for each frame the accident aircraft was present in the recording using a nonlinear video editing program. After a review of the images and video, several areas were identified for further investigation:

- Correlation of recorded video/image data to the aircraft's flight data recorder.
- Determination of landing gear configuration during the course of the flight.
- Determination of control surface movement during the accident sequence.
- Determination of position of nose gear stowage door during the accident sequence.
- Determination of aircraft pitch, roll and yaw during the accident sequence.

4.1. Time Correlation and Alignment

The Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) both cease recording sometime immediately after the aircraft's rotation during its departure from Bagram Airfield. The aircraft's rotation was not captured on any of the three video recordings, therefore it is not possible to correlate any timing information from the aircraft's CVR and/or FDR to any video recordings. Similarly, the three recordings could not be correlated to each other as only one recording contained a timestamp and the other two recordings contained no timing reference. Timing information from the other two recorders was not available.

For purposes of this report, a baseline reference for each exported JPEG frame was created by naming the exported files in sequential order starting with when the aircraft appeared in each camera's image frame. For example, the file with the aircraft first appearing in the image frame would be named in the format Camera name_001 and then increase sequentially. This sequencing scheme was applied for all three recordings that were received by the laboratory.

4.2. Determination of landing gear configuration

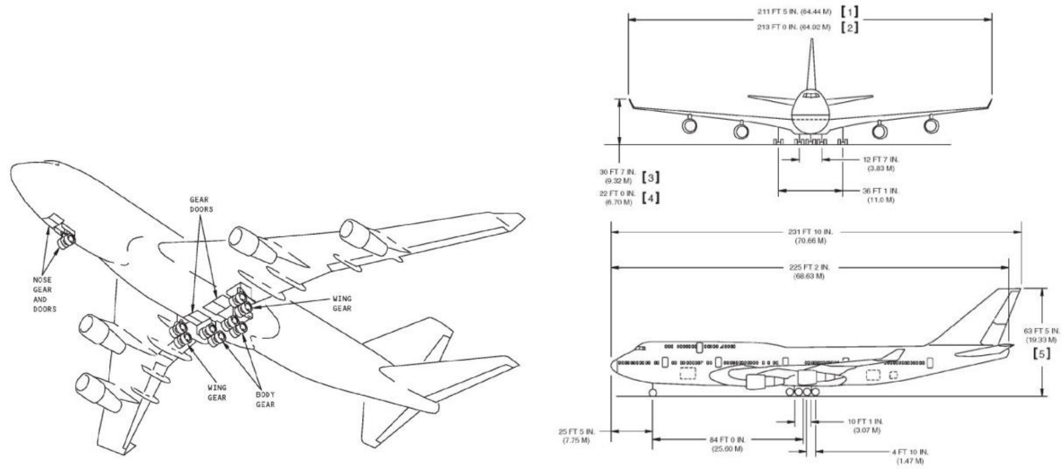
Preliminary review of the recorded video data led to a discussion of the landing gear configuration and how it may relate to the functionality of the aircraft's hydraulic systems during the accident sequence. Referencing the Cockpit Voice Recorder Specialist's Report[6], a gear up command was received just prior to the data stream being lost.

The Boeing 747-400 Freighter has five sets of wheels. These include a nose-wheel assembly consisting of two tires powered by hydraulic system #1, two sets of four wheel

[5] JPEG – Joint Photographic Experts Group. An image filetype. A standard method of lossy compression for photographic images and other digital graphics.
[6] Available under separate cover in the NTSB's public docket for this accident investigation.

bogies located under each wing powered by hydraulic system #4 and two additional sets of four wheel bogies located under the fuselage and aft of the main wing gear (body gear) powered by hydraulic system #1 (Figures 4 & 5). In all, the 747-400 has a total amount of 18 wheels and tires to support the weight of the aircraft and is powered by 3 different hydraulic systems.

Figures 4 & 5: Diagrams depicting the landing gear configuration of the B747-400



Video from each image recorder and the exported JPEG files associated with each camera were reviewed by NTSB personnel in order to make a determination of the aircraft's landing gear position. Because of the unique configuration of the four sets of the aircraft's main landing gear bogies, it becomes difficult to make a determination of landing gear position while the aircraft is in an unusual attitude. In order to make a more precise determination, a software method was employed that would allow the recorded image data to be compared to that of a 3-dimensional model.

It was determined that images from both the *Dashboard Camera* and the ECP10 camera located on Tower 34 would be used for landing gear configuration analysis. Images from the camera on Tower 33 of the filename "NW_Corner_of_XX-XXXXXXXXXX_29Apr_2013_V2" were determined to have no value for determining landing gear position as the quality of the recording, the distance of the camera to the accident aircraft and the orientation of the aircraft to the camera would not be suitable for this study.

It was determined that one frame from the Dashboard Camera, frame 538, and three frames from the ECP10 camera on Tower 34, frames 06, 08 and 10 would be used in the study. These frames were selected specifically because the aircraft's orientation in these images was in a favorable alignment to most clearly show the aircraft's landing gear configuration. After examining images of an exemplar 747-400, it was determined that a side view and front view would be most favorable for landing gear configuration analysis. Frame 538 from the dashboard camera and frames 06, 08 and 10 from the

ECP10 camera most closely fit this description and were selected to be used in this study.

To perform the 3 dimension modeling, Autodesk Softimage 2013 was selected. Autodesk Softimage is a 3-dimensional computer graphics application used for producing 3D computer graphics, 3D models and computer animations. A 747-400 3-dimensional software model was scaled to the dimensions of a 747-400 and its properties were saved.

Using the rotoscope[7] function of Autodesk Softimage, a selected video frame was imported as a background image. Next, the scaled 747-400 model was added to the graphics layout and shown as a wireframe model. With the model now overlaying the selected video frame, the wireframe 747-400 was positioned as close as possible to the orientation of the accident aircraft in the selected frame. Small adjustments were made until the wireframe model matched the orientation of the accident aircraft. It should be noted that the wireframe model is a rigid body and incapable of conforming exactly to the accident aircraft which had dynamic forces acting upon its structure.

***Dashboard Camera* - G2013-02-01-03-21-25-0.avi – Frame 538**

Frame 538 shows a view almost normal to the left side of the aircraft (Figure 6). The wireframe model was aligned to the aircraft in Frame 538 and a screen capture of Softimage was taken (Figure 7). The 3D model was rendered as a textured object and compared to a cropped image of the accident aircraft in frame 538 (Figure 8). This shows the right main wing landing gear bogies in the retracted position as compared to the model.

[7] Rotoscope – An animation technique in which animators trace over footage frame by frame.

Figure 6. Frame # 538 from the Dashboard Camera without alteration.

Figure 7. A wireframe model aligned to the aircraft in Autodesk Softimage

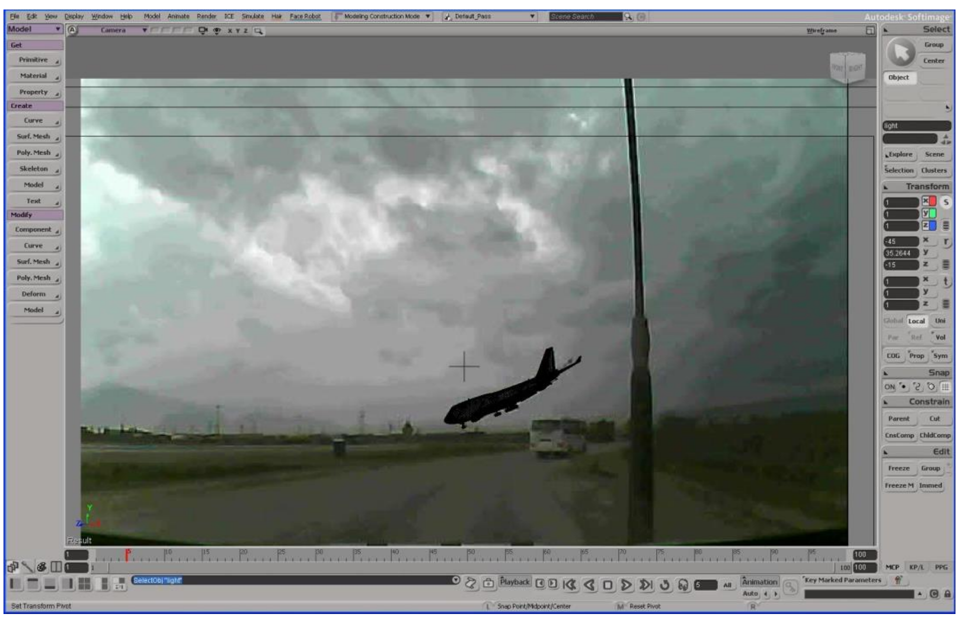


Figure 8. A rendered texture model of the aircraft next to the enlarged raw image

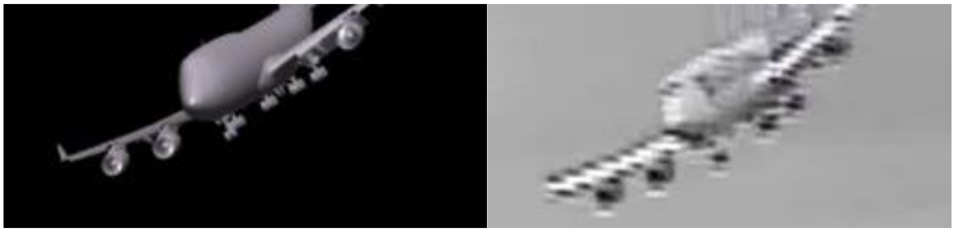
Tower 34 Camera – ECP10.avi – Frame 06

Frame 06 shows a front left ¾ view of the accident aircraft (Figure 9). The wireframe model was aligned to the aircraft in frame 06 and a screen capture of Softimage was taken (Figure 10). The 3D model was rendered as a textured object and compared to a cropped image of the accident aircraft in frame 06 (Figure 11). This shows the left wing landing gear bogies in the retracted position as compared to the model. There is some evidence of the right wing landing gear bogie being in the retracted position, although this is inconclusive as the 3D rendered model shows the nose gear would be blocking most of the camera's view of the right wing landing gear bogie in this orientation.

Figure 9. Frame 06 from the Tower 34 camera without alterations.

Figure 10. A wireframe model aligned to frame 06 in Autodesk Softimage.

Figure 11. A textured model rendered of the aircraft next to the enlarged raw image file in frame 06 from the accident video.



Tower 34 Camera – ECP10.avi – Frame 08

Frame 08 shows a second front left ¾ view of the accident aircraft in a more nose-down orientation (Figure 12). The wireframe model was aligned to the aircraft in frame 08 and a screen capture of Softimage was taken (Figure 13). The 3D model was rendered as a textured object and compared to a cropped image of the accident aircraft in frame 08 (Figure 14). This provides additional evidence of the left wing landing gear bogie in the retracted position. The position of the right wing landing gear bogie is uncertain due to the camera's orientation to the aircraft.

Figure 12. Frame 08 from the Tower 34 camera without alterations.

Figure 13. A wireframe model aligned to frame 08 in Autodesk Softimage.

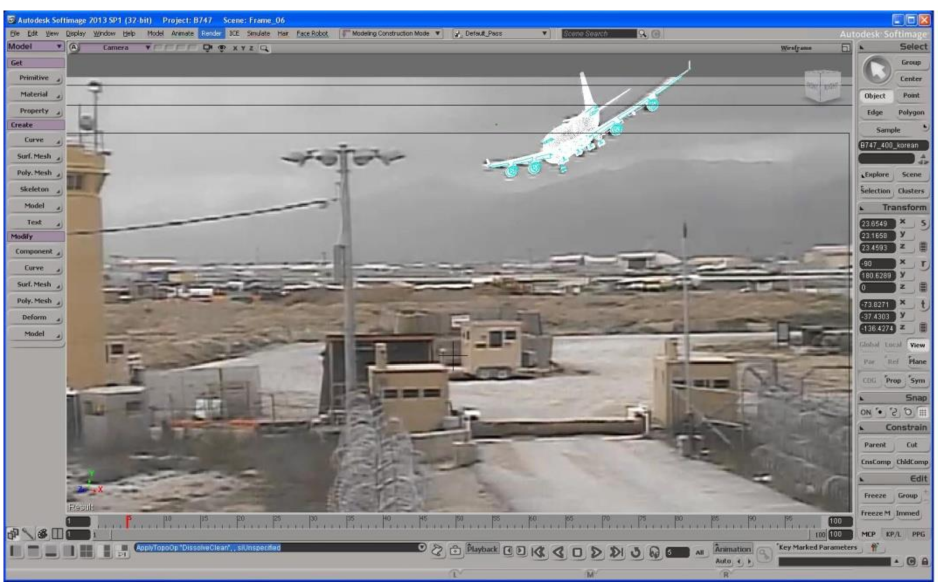


Figure 14. A textured model rendered of the aircraft next to the enlarged raw image file in frame 08 from the accident video.

Tower 34 Camera – ECP10.avi – Frame 10

Frame 10 shows a third front left ¾ view of the accident aircraft in a nose-down orientation moments before impact (Figure 15). The wireframe model was aligned to the aircraft in frame 10 and a screen capture of Softimage was taken (Figure 16). The 3D model was rendered as a textured object and compared to a cropped image of the accident aircraft in frame 10 (Figure 17). This provides additional evidence of the left wing landing gear bogie in the retracted position. The position of the right wing landing gear bogie is uncertain due to the camera's orientation to the aircraft. Figure 18 is a frame from the video with arrows identifying the aircraft's landing gear.

Figure 15. Frame 10 from the Tower 34 camera without alterations.

Figure 16. A wireframe model aligned to frame 10 in Autodesk Softimage.

Figure 17. A textured model rendered of the aircraft next to the enlarged raw image file in frame 10 from the accident video.

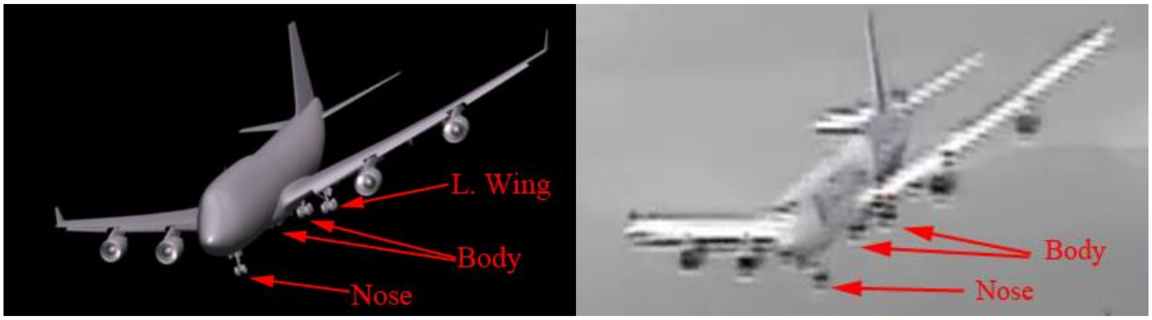
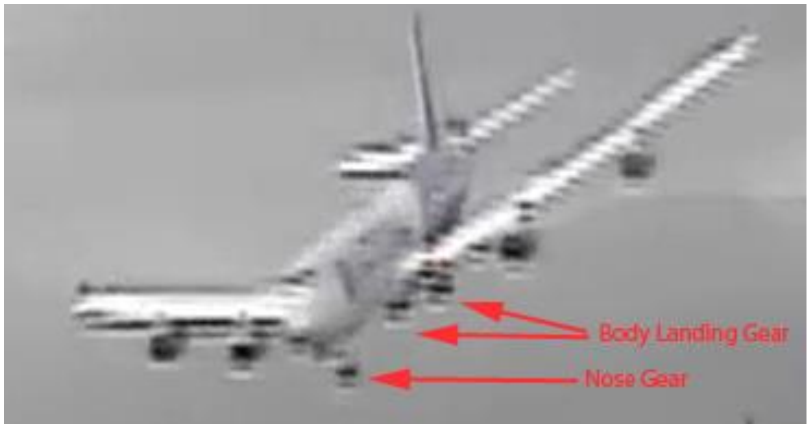


Figure 18. Identification of landing gear.



4.3. Determination of control surface movement during accident sequence

Image enhancement of all three recordings was unable to provide enough increased fidelity to determine the position of the flight control surfaces during the accident sequence.

4.4. Determination of position of nose gear stowage door during time of impact.

Both the Dashboard camera and the security video from file ECP10 camera show an unusual object protruding just forward of the nose landing gear. This unusual object can be seen in Figure 18 just forward and above the nose gear. After image enhancement and discussion, this unusual cluster of pixels was determined to be the nose landing gear door. Under normal operation, the gear lever is selected to the “retracted” position by the flight crew and the landing gear begins to cycle to the “retracted” or “up” position. During this operation, the nose landing gear door is opened to allow the nose gear to retract inside the aircraft’s body. Once the nose landing gear has retracted inside the aircraft’s body, the nose landing gear door is closed to reduce drag. The condition shown in both video files is unusual as the nose landing gear door is fully open while the nose landing gear appears to be in the fully down/extended position. Under normal operation, the nose and body gear door openings would be the first event(s) in the retraction sequence and then the gear would begin to retract. The *Dashboard Camera* and the video from the ECP10 camera also show the nose gear door open and the nose gear in the down position throughout the accident sequence.

4.5. Determination of aircraft pitch and roll during the accident sequence.

As a result of the video analysis using the 3-dimentional modeling program Autodesk Softimage, it was possible to output the aircraft's Euler angles[8] during the portion of the accident sequence that was captured by the *Dashboard Camera*. During the modeling process, the accident video was imported to the modeling software as a background image using the rotorscope function. First a flat grid was prepared and oriented to the recording as a simulation of the ground. The orientation of this grid was matched such that it "fit" the orientation of both the vehicle recording the images and the vehicle in front of the vehicle recording the images. The assumption was made that the ground in this region was flat. A wireframe model of the accident aircraft was then matched to the position of the recorded aircraft in each frame. After this process was completed, a readout of the vehicle's pitch and roll angles with respect to the simulated ground was output, thus describing the objects orientation as a rigid body in 3-dimensional space.

The accuracy error of these measurements cannot be quantified at this time and the results were omitted from this report.

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[8] Euler Angles – Three angles introduced by Leonhard Euler that describe the orientation of a rigid body in 3-dimensional Euclidean space.