NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, DC 20594

October 29, 2013

Video Study

Specialist's Report
By Sean Payne

1. EVENT

Location:	South Bend, Indiana
Date:	March 17, 2013, 16:23 EDT
Aircraft:	Hawker Beechcraft model 390, N26DK
Operator:	Private
NTSB Number:	CEN13FA196

2. GROUP

A group was not convened.

3. SUMMARY

On March 17, 2013, at 1623 Eastern Daylight Time (EDT), a Hawker Beechcraft model 390 (Premier IA) business jet, N26DK, serial number RB-226, collided with three residential structures and terrain following an aborted landing attempt on runway 9R located at the South Bend Regional Airport (KSBN), South Bend, Indiana. The private pilot and pilot-rated-passenger occupying the cockpit seats were fatally injured. An additional two passengers and one individual on the ground sustained serious injuries. The airplane was registered to 7700 Enterprises of Montana, LLC and operated by Digicut Systems of Tulsa, Oklahoma, under the provisions of 14 Code of Federal Regulations Part 91 while on an instrument flight plan. Day visual meteorological conditions prevailed for the business flight that departed Richard Lloyd Jones Jr. Airport (KRVS), Tulsa, Oklahoma, at 1358 Central Daylight Time.

4. DETAILS OF INVESTIGATION

4.1. Recorder Description

The recordings came from multiple DVR devices from multiple different properties on or near the airport. The types of devices were not documented.

4.2.1. Video Files

Eight security camera files were sent to the Vehicle Recorder Laboratory. Their file details are described below and their locations have been mapped in Figures 4.1 and 4.2.

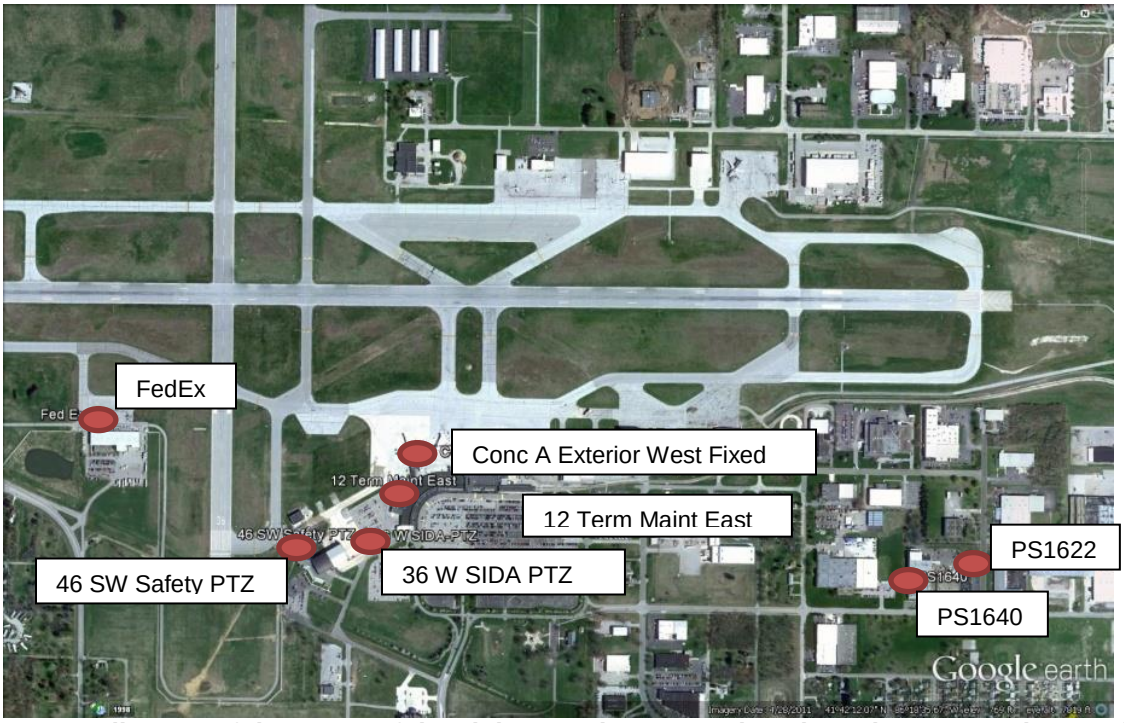

Fig 4.1: A diagram of the seven of the eight security camera locations that capture images in the immediate vicinity of the runway.

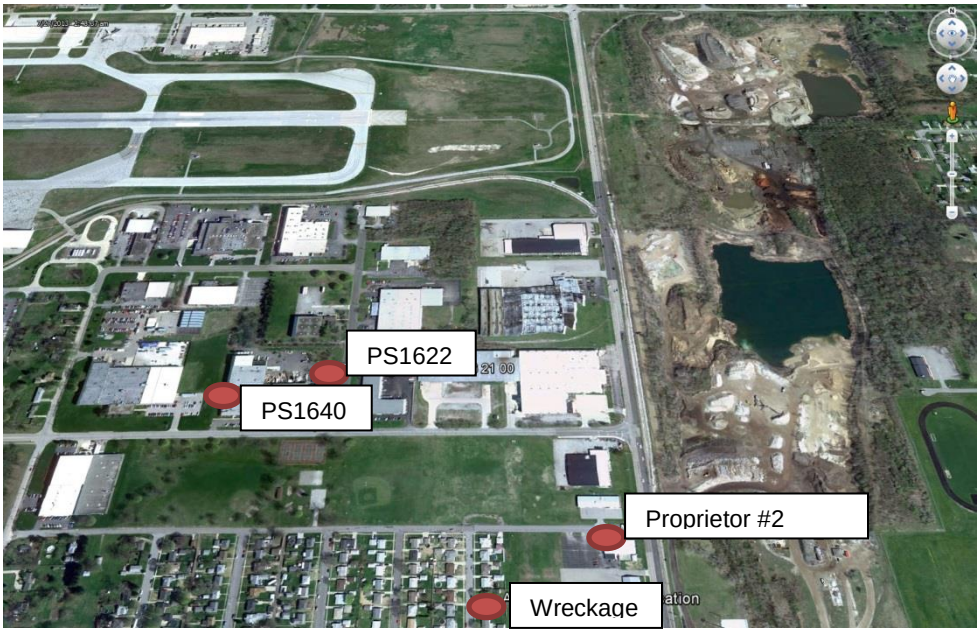

Fig 4.2: A diagram showing the eighth camera location as well as the approximate location of the aircraft wreckage.

“12 Term Maint East PTZ_3 17 2013 4 22 23 Pm (utc-04 00)-1.mp4”
KSBN Acquisition System

Images from this security camera were recorded from the south of the accident runway at a location of 41°41'57.85"N 86°18'53.72"W. The video file provided by South Bend Airport management was output from the security camera system in MP4[1] format at a frame rate of 8 FPS[2] and a resolution of 680 by 476 pixels. The airport manager reported that no other post processing was done on the image file and it was sent as an unmodified output from the security system.

The “12 Term Maint East PTZ” security camera video primarily captured a day time view of the ramp area looking towards the north as shown in Image 4.1. The accident runway (Runway 09R/27L) can be seen at the top edge of the image.

The accident aircraft appears in the left hand portion of the frame on or near Runway 09R at 1.00 seconds elapsed recording time and crosses the image plane towards the right. The camera’s timestamp displays 3/17/2013 4:22:24 PM. The aircraft continues to cross the image plane towards the departure end of Runway 09R until the aircraft disappears behind a jetway at 4.75 seconds into the recording. Nothing else related to the accident is captured in the video and the provided recording ends at 09.125 seconds. This recording captures the aircraft’s second attempt to land based on the camera’s timestamp.

Image 4.3: A screen capture of 12 Term Maint East PTZ_3 17 2013 4 22 23 Pm (utc-04 00)-1.mp4.

[1] MP4 - MPEG-4 Part 14. A file container format used to store both video and audio optimized for streaming playback on the internet.
[2] FPS – Frames Per Second – Frame Rate. The frequency at which an imaging device produces unique consecutive images called frames. It is often expressed as FPS or hertz (Hz).

“18 Conc A Exterior West Fixed_3 17 2013 4 18 04 Pm (utc-04 00)-1.mp4” KSBN Acquisition System

Images from this camera were recorded from the south of the accident runway at a location of 41°42'3.99"N 86°18'49.60"W. The video file provided by South Bend Airport management was output from the security camera system in MP4 format at a frame rate of 4 FPS and a resolution of 682 x 480 pixels. The airport manager reported that no other post processing was done on the image file and it was sent as an unmodified output from the security system.

Images from this camera show a daytime view of the ramp and concourse area just south of the accident runway. The control tower and runway can be seen at the upper edge of the image. The image exhibits a large amount of barrel distortion[3] and is vastly overexposed[4].

At 50.50 seconds into the recording, the first indication of the accident aircraft appears in the left hand portion of the frame. The camera’s timestamp shows 03/17/2013 4:18:54 PM. Due to overexposure, the only visible indication of the aircraft is a white dot below the treeline. The aircraft continues to cross the image plane towards the departure end of Runway 09R until 54 seconds into the recording when the aircraft is lost in the overexposed image. Nothing else related to the accident is captured in the video and the provided recording ends at 60.00 seconds. This recording captures the aircraft’s second attempt to land based on timestamp information.

Image 4.4: A screen capture of “18 Conc A Exterior West Fixed_3 17 2013 4 18 04 Pm (utc-04 00)-1.mp4”

[3] Barrel Distortion - The appearance of magnification as similar to the image being mapped around a sphere.

[4] Overexposure – A loss of highlight detail as a result of the image sensor or film receiving too much light in relation to its shutter speed, aperture value and ISO setting.

“36 W. SIDA-PTZ_3 17 2013 4 18 50 Pm (utc-04 00)-1.mp4”
KSBN Acquisition System

Images from this camera were recorded from the south of the accident runway just outside a gated parking area at a location of 41°41'57.85"N 86°18'53.72"W. The video file provided by South Bend Airport management was output from the security camera system in MP4 format at a frame rate of 4 FPS and a resolution of 678 by 476 pixels. The airport manager reported that no other post processing was done on the image file and it was sent as an unmodified output from the security system.

The camera shows a daytime view of a parking area just south Runway 09R/27L which is captured in the upper portion of the frame. The control tower and runway can be seen at the upper edge of the image.

At 2.50 seconds into the recording, the accident aircraft appears in the left hand portion of the frame and is seen climbing out of the frame by 8.00 seconds. The camera’s timestamp shows 3/17/2013 4:18:50 PM at the start of the recording. Approximately 03 minutes and 18.25 seconds later at 03 minutes and 26.25 seconds, the aircraft enters the frame from the left. The aircraft continues across the image plane as it moves down Runway 09R. There appears to be some change in altitude as the aircraft moves across the image plane and out of frame to the right by 03 minutes 33.25 seconds. The file captures nothing else of interest and terminates at 03 minutes and 41.00 seconds.

This recording captures both the first and second attempts of the aircraft to land at KSBN.

Image 4.5: A screen capture of “36 W. SIDA-PTZ_3 17 2013 4 18 50 Pm (utc-04 00)-1.mp4”

“46 S.W. Safety_PTZ_3_17_2013 4_18_48 PM (UTC-04_00).mp4”
KSBN Acquisition System

Images from this camera were recorded from a structure just east of the arrival end of Runway 36 near the intersection of taxiways N and N3 at a location of 41°41'57.16"N 86°19'0.48"W. The camera looks north toward Runway 9R/27L. The video file provided by South Bend Airport management was output from the security camera system in MP4 format at a frame rate of 4 FPS and a resolution of 704 by 454 pixels in color. The airport manager reported that no other post processing was done on the image file and it was sent as an unmodified output from the security system.

The camera shows a daytime view of primarily Taxiway N and the charted “NON-MOVE AREA” on the airport diagram along with a significant stretch of Runway 9R/27L. The control tower and runway can be seen at the upper edge of the image. The overall image is of very low quality.

At the start of the recording, the accident aircraft appears in the left hand portion of the frame and is seen moving down Runway 09R and transitioning to a climb. The timestamp displays 3/17/2013 4:18:48 PM. By 7.00 seconds elapsed time the aircraft has crossed out of the image plane to the right. Approximately 03 minutes and 16.50 seconds later at 03 minuntes and 23.50 seconds, the aircraft enters the image plane from the left in a shallow descent. The aircraft continues across the image plane as it moves down Runway 09R. There appears to be a slight change in altitude (possibly a bounce) as the aircraft moves across the image plane and out of frame to the right at 03 minutes 32.50 seconds. Nothing else of interest is captured related to the accident and the file terminates at 03 minutes and 34.50 seconds.

This recording captures both the first and second attempts of the aircraft to land at KSBN.

Image 4.6: A screen capture of “46 S.W. Safety_PTZ_3_17_2013 4_18_48 PM (UTC-04_00).mp4”

File20130317152044.AVI & File20130317151744.AVI
Fedex Acquisiton System

A Fedex sorting facility located at South Bend Airport provided two composite video files of a security camera feed recorded on their property. The composite feed consisted of eight security camera inputs and was provided as an .AVI[5] file. The frame rate and resolution of each camera in the composite is unknown. The video file was provided in a vertically mirrored format which was corrected in video editing software and shown below in Image 4.7.

The composite feed captures the accident aircraft on three cameras. In the first file, at 00.25 seconds elapsed recording time, the accident aircraft is shown on a low approach over the threshold area of Runway 09R. The security system's timestamp displays 3/17/2013 15:19:11. The aircraft moves out of view at 04.13 seconds. At 07.26 seconds, the aircraft is shown again in the upper right feed in close proximity to Runway 09R. At 10.50 seconds, as the accident aircraft crosses out of the image plane on the upper right hand feed, it appears in the main feed moving across the runway. As the aircraft exits the camera's field of view, it is shown in a positive pitch up attitude leaving the runway. The aircraft is no longer captured by any other cameras in this file.

The second file shows the accident aircraft's second landing pass. The aircraft is shown in the same manner as the first file appearing at approximately 01 minute and 48 seconds into the new file. The security system's timestamp displays 3/17/2013 15:22:33. As the accident aircraft crosses out of view at 02 minutes and 33 seconds, the aircraft is still close to the runway and does not appear to be in a climb. The file terminates at 03 minutes and 00 seconds.

Image 4.7: A screen capture of the Fedex security camera feed which captured the aircraft from three angles. This image has been mirrored vertically from the provided file in non-linear video editing software.

"Proprietor #1_StreamCapture_000.mp4"

[5] AVI – Audio Video Interleave – A multimedia container format that contains both audio and video data in a file that allows synchronous playback.

Proprietor #1's Acquisition System

Proprietor #1[6] is a local business located just outside of the airport grounds, approximately 3,000 feet southeast of the departure end of Runway 9R at a location of 41°41'49.43"N 86°17'39.22"W. The camera looks over a parking lot in the rear of the establishment and has a view of a housing development in the distance. The video file is of MP4 format at a frame rate of 4.95 FPS and a resolution of 350 x 240 pixels in monochrome.

At 15.50 seconds the aircraft appears in the upper left hand corner of the image rolled steeply and approaching a housing structure. In the next frame the aircraft has begun to impact a structure. A debris cloud forms and the video ends at 43 seconds.

Image 4.8: A screen capture of "Proprietor#1_StreamCapture_000.mp4" showing the accident aircraft moments before impact.

"PS1622_2013 03 17 16 21 00-1.mp4"
Proprietor #2's Acquisition System

Proprietor #2 is a local business located just outside the airport grounds. The local business has a multiple camera security system, two of which captured the accident aircraft during the accident flight.

The first camera, #1622 and belonging to the above filename, is located approximately 2,000 feet south of Runway 9R/27L, abeam the Runway 27L numbers at a location of 41°41'57.41"N 86°17'55.31"W. The camera looks south over a parking area, across a road and into a tree line. The video file is of MP4 format at a frame rate of 3.75 FPS and a resolution of 352 x 238 pixels in monochrome. Due to the unique frame rate, the video was imported to a 30 FPS

[6] Specific names of the businesses off airport grounds are not included.

timeline with no telecining[7] and all frame time values were rounded to the nearest 30 FPS timeline frame.

The camera captures the accident aircraft and its subsequent impact near a housing development. At 01 minute and 47.63 seconds the aircraft appears in the upper left hand corner of the image in an unknown roll attitude. The aircraft continues to appear unstable as it descends toward the treeline for 12 frames. The moment of impact is captured at 01 minute and 51.10 seconds. A debris cloud forms and the video ends at 02 minutes and 49.76 seconds.

Image 4.9: A screen capture of "PS1622_2013 03 17 16 21 00-1.mp4" showing the accident aircraft in an unknown roll condition.

"PS1640_2013 03 17 16 12 00-1.mp4"
Proprietor #2's Acquisition System

The second camera, #1640 and belonging to the above filename, is located approximately 2,000 feet south of Runway 9R/27L, abeam the Runway 27L numbers at a location of 41°41'56.06"N 86°18'1.29"W. The camera looks north toward Runway 09R/27L. The video file is of MP4 format at a frame rate of 3.75 FPS and a resolution of 352 x 238 pixels in color. Due to the unique frame rate, the video was imported to a 30 FPS timeline with no telecining and all frame time values were rounded to the nearest 30 FPS timeline frame.

The camera captures a view of property adjacent to the business looking towards the airport. The airport does not capture the runway surface of Runway 09R/27L, however, aircraft departing Runway 09R can be seen during climb out. The camera shows the accident aircraft on the far left of the image plane leaving the Runway 09R at 01 minute and 30.86. The aircraft performs a climb until it disappears from the right of the frame at 01 minute and 38.06 seconds. The video file terminates at 02 minutes and 50 seconds without capturing any more information about the accident aircraft. There is no timestamp information.

[7] Telecining - The process of encoding video media from one time code format to another, wherein complex methods are used to make individual frames appear in synchronization.

Image 4.10: A screen capture of "PS1640_2013 03 17 16 12 00-1.mp4"

4.3. Timing and Correlation

Due to the precise timing requirements to conduct this video study, the time of events are expressed as Video Elapsed Time in a reference frame unique to each of the individual video files. This measurement of video elapsed time is the time from the beginning of each recording measured in whole seconds and fractions of a second according to each file's frame rate.

The majority of the videos provided were recorded in either a 4 or 8 frames per second time base, which makes it possible to correlate frame count as a function of time in hundredths of a second. For this study, a singular video frame elapsed time was calculated in the equations below for both 30 and 8 FPS. This value becomes important when using the frame count as a way to determine the aircraft's speed across the camera's image plane.

For a 30 FPS timebase:

$$\left(\frac{1sec}{30\ frames}\right) = 0.0\overline{3}\ sec/frame$$

For an 8 FPS timebase:

$$\left(\frac{1sec}{8\ frames}\right) = 0.125\ sec/frame$$

Normally, each acquisition system's timestamp would be noted and compared to a trusted time standard. An offset would then be created for each camera which would align each camera system to a common time. Since information from each camera acquisition system was provided well after the accident

occurred, it is difficult to confirm whether these settings were in place on the accident day. Additionally, cameras were located at various positions in the vicinity of the airport and did not all capture a common event to aid in time correlation.

4.4. Distance/Position Study

In agreement with the Investigator-In-Charge, a video study was conducted to determine the aircraft's groundspeed as it made its second landing attempt at South Bend Airport.

4.4.1. 12 Term Maint East PTZ – Video File

The 12 Term Maint East video is clear and oriented in an almost perpendicular manner to Runway 09R/27L. Although this does not capture the entire accident sequence, it is used to provide data regarding the aircraft's ground speed during the aircraft's second attempt to land.

As described in section 4.2.1 the aircraft appears in the video at 1.00 second into the recording and crosses out of the image plane at 04.75 seconds for a total of 03.75 seconds.

Since the exact location of the baggage claim security camera is known, it is possible to determine the camera's field of view in order to base measurements for subsequent calculations. The airport manager verified this camera's location as being just outside a gated ramp area at a position of 41°41'57.85"N 86°18'53.72"W.

Figure 4.12: The camera's position located on Google Earth and its field of view.

The recorded images showing the accident sequence are then examined to find reference points common to both the video and geographical reference source. To accomplish this, the accident footage was compared to Google Earth satellite imagery which showed the locations of key landmarks. To further identify

key locations in the recording, such as the runway centerline markings, runway calibration instructions were sent to the airport manager so an additional recording could be made that helps identify these locations. The calibration instructions called for an ARFF (Airport Rescue and Fire Fighting) vehicle to be parked at specific centerline locations annotated on the diagram below (Image 4.16). The recording was sent back to the NTSB where a comparison to the accident video was made that identified the runway centerline locations.

Image 4.16: The known points from the calibration study translated into Google Earth.

The provided calibration was recorded in a different resolution than the original recording and an overlay could not directly be made. The calibration video was imported and then aligned using video editing software. The fence noted in Image 4.19 provided a good set of physical references to make sure the two video recordings were properly aligned.

The time in which it takes the accident aircraft to move between each of these geometric reference points was then determined. Knowing that the calibration video and the accident video's landmarks match each other as close as possible, perspective lines created in the calibration video file are overlaid on the accident video using information from the ARFF vehicle's location in the calibration study.

Image 4.19: Vertical lines drawn from each of the known calibration positions are used to indicate when the accident aircraft crossed each segment on the runway's centerline in reference to the security camera's perspective. In this image both the calibration recording and the accident recording are overlaid on each other with an opacity value set to 50%. A time code was added in a 30 frame per second SMPTE[8] timecode format.

The accident aircraft is shown moving frame by frame through the image in reference to the calibration lines generated from the calibration recording. The time it takes for the aircraft's nose to move between each calibration line was then recorded. This time is displayed by the video editing software as a combination of whole seconds and a carryover frame count in a 30 frame per second timeline. The carryover frame number is an integer value which counts the number of frames from each subsequent integer second.

[8] SMPTE – Society of Motion Picture and Television. In this case a time code in the format HH;MM;SS;FF, where HH is hours, MM is minutes, SS is seconds and FF is frames are all integer values.

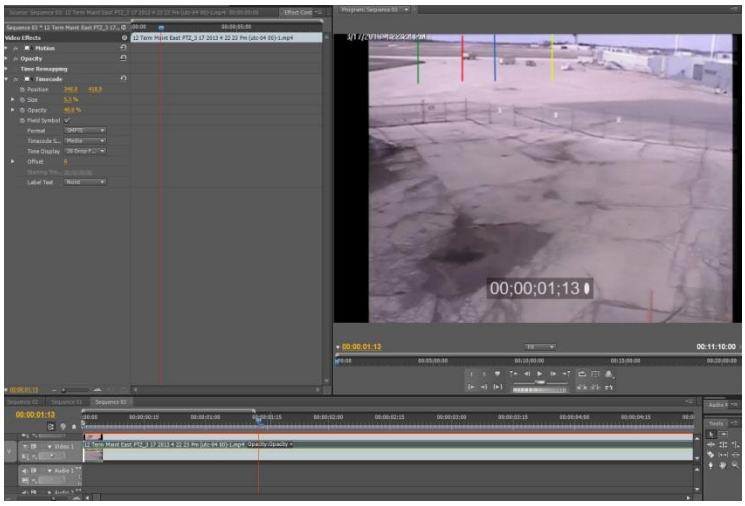

Image 4.11: An overlay of the perspective lines in a video editing software suite.

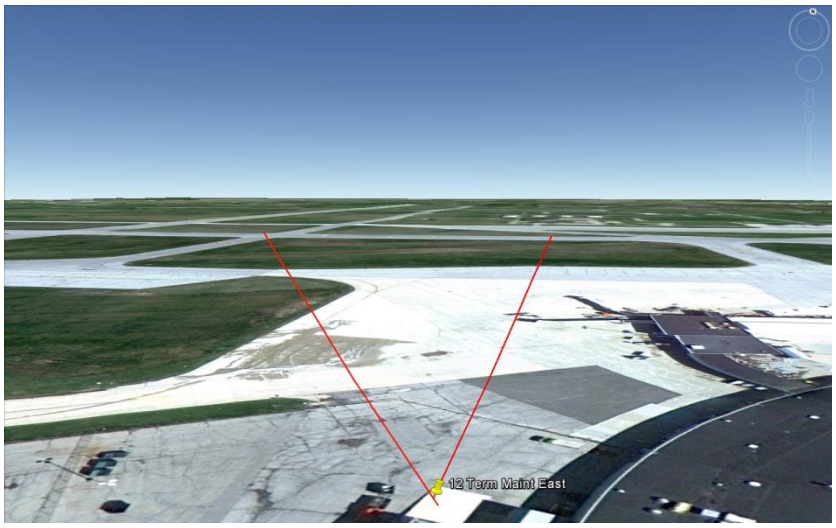

Figure 4.12: A virtual recreation of the baggage claim camera location and the perspective lines that were created in order to perform aircraft groundspeed calculations.

4.5. Equations and Results

The 12 Term Maint PTZ video was then analyzed frame by frame to determine the exact time it takes the accident aircraft to cross each calibration line. Using the accident aircraft's nose as a reference point, a frame reference was taken at each of the calibration lines as the aircraft moved through the image. As the accident aircraft's nose passed each calibration line, the time in whole seconds and number of carryover frames were recorded. The measurement of time in whole seconds and carryover frames were converted to a total time value in the 4^{th} column of the t, T_t. Using the mapping software, the distance between each line of perspective along the runway centerline was measured as described in section 4.4.1. The time between two measured points

and the location of those points are now known, allowing the aircraft's groundspeed to be calculated. The results are shown in the table below.

Segment	Time - S (sec)	Carryover Frames - Ts (Frames)	Total Frames - Tf (Frames)	Total Time - Tt (sec)	Distance - d (ft)	Groundspeed - Gs (kts)
CL+2 to CL+5	2	7	67	2.23	479	127.07
CL+2 to CL+3	0	22	22	0.73	169	136.54
CL+3 to CL+4	0	15	15	0.5	110	130.35
CL+4 to CL+5	1	0	30	1	200	118.50

Table 4.1: A table showing the time, the measured distance and the calculated groundspeed across each respective perspective line.

When averaged across points CL+2 and CL+5, a groundspeed of 127 knots is obtained.

Equations:

Time: S – The integer number of seconds displayed by the video editing program
Carryover Frames: T_s – The number of frames carried over from the integer second
Total Frames: T_f – The total number of frames counted between perspective lines
Total Time: T_t – The additive combination of Time (S) and Carryover Frames (T_s) in seconds
Distance: d – The distance along the runway's centerline between perspective lines.
Groundspeed: G_s – The aircraft's calculated speed along the runway centerline.

For determining Total Time (T_t) in seconds:

$$S + \left(\frac{1sec}{Ts}\right) = Tt$$

For determining Groundspeed (G_s) in Knots:

$$Gs = \left(\frac{d}{Tt}\right)$$

$$Gs = \left(\frac{d}{Tt}\right)\left(\frac{3600sec}{1hour}\right)\left(\frac{1nm}{6076.12feet}\right)$$

5. Uncertainty and Assumptions

A number of assumptions had to be made to conduct this study, which led to varying amounts of uncertainty in the calculations. The primary challenge is accounting for the difference in resolution between the calibration recording and the accident recording. The calibration recording was not provided in the same resolution as the accident recording which caused an alignment issue. This was corrected by manually aligning the two recordings in the non-linear video editing software and is discussed in section 4.2.1 of this report. For this study, the resolution of the two recordings after being overlaid to match each other is assumed to be the same and without any distortion.

Additionally, when a non-standard recording rate is input to a traditional non-linear video editing software program, only limited options are available for playback and output of the video file. All times noted in this study were output from the video editing software's source window. In this case the source window displays the imported video on a 30 frame per second timeline. It is assumed for this study that the 8 FPS source is displayed in a 30 FPS timeline and that no telecining is present. The times used for this report were then based off a 30 FPS timeline with the assumption that time and position could be noted accurately while not being affected by telecining.

To calculate the distance traveled, a measurement was made in Google Earth on the runway's centerline. An assumption was made that the aircraft was traveling along the runway's centerline.

Since the identification of the aircraft's location on the runway in relation to the calibrated reference lines is at the control of the user, the error in identifying the exact frame at which each event occurred was examined. For a simple error study, an error of +/- 2 frames was examined for each identification point. An error of two frames was chosen as an error as it was the amount of change needed in the image for a viewer to notice a movement in aircraft position. A minimum speed value was obtained by adding a frame identification error to the location of points CL+2 and CL+5. A maximum speed was obtained by subtracting a frame error from the identification locations. This error effectively changes the time it took the aircraft to travel the 236 feet between the two points and thus changes the speed calculation results. Table 5.1 shows the calculations from this portion of the study.

Error	Segment	Time - S (sec)	Carryover Frames - Ts (Frames)	Total Frames - Tf (Frames)	Total Time - Tt (sec)	Distance - d (ft)	Groundspeed - Gs (kts)
Min.	CL+2-CL+5	2	9	69	2.30	479	123.39
Max.	CL+2-CL+5	2	5	65	2.17	479	130.98

Table 5.1: A table showing the calculations for the frame identification error study.

The results of the frame identification error study yield a difference of roughly +/- 4 knots from the initial calculations.

6. Video Enhancement:

"*PS1622_2013 03 17 16 21 00-1.mp4*"

The local business' security video was imported and subsequently exported as a series of still images for each frame of video in .JPEG[9] format. These stills were exported at the original video resolution of 352 by 238 pixels. The exported stills begin approximately 1 minute and 48 seconds into the recording. The first exported frame is referenced as frame "0" when the aircraft first becomes visible in the recording and increases in integer increments for

[9] JPEG – Joint Photographic Experts Group – A commonly used method/format of compression for a digital image.

each frame at the native recording rate of 3.75 FPS. Near the departure end of Runway 09R, the aircraft is visible in an unknown roll state as it approaches the ground and impacts near a residential area.

In an attempt to clarify these images, a variety of filters in a photo editing software program were used to better identify the unknown roll state. Sharpening filters were used in combination with brightness and contrast effects to achieve an improved result. In each frame, the aircraft was zoomed in on and enhanced. The results are shown in the attached images below in images 6.1 – 6.9. The particular vehicle is referred in the image description.

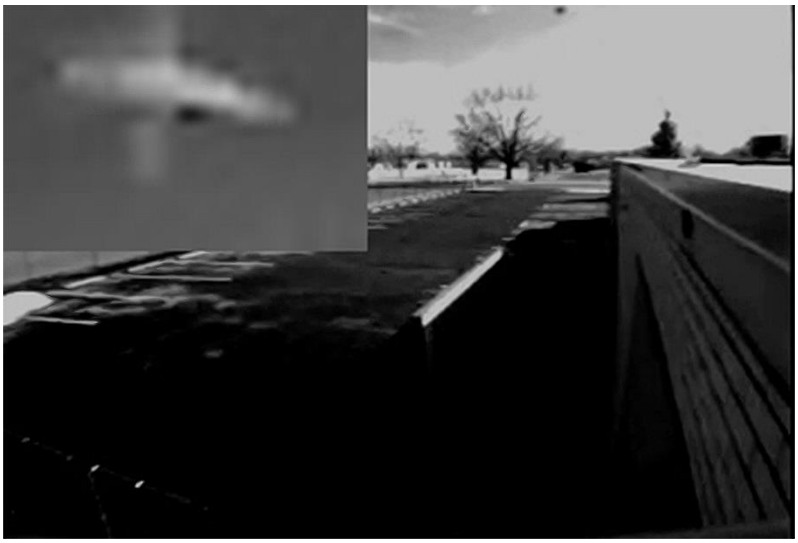

Image 6.1: The first frame in which the aircraft is visible in the security recording. The aircraft is shown in an unknown roll upset.

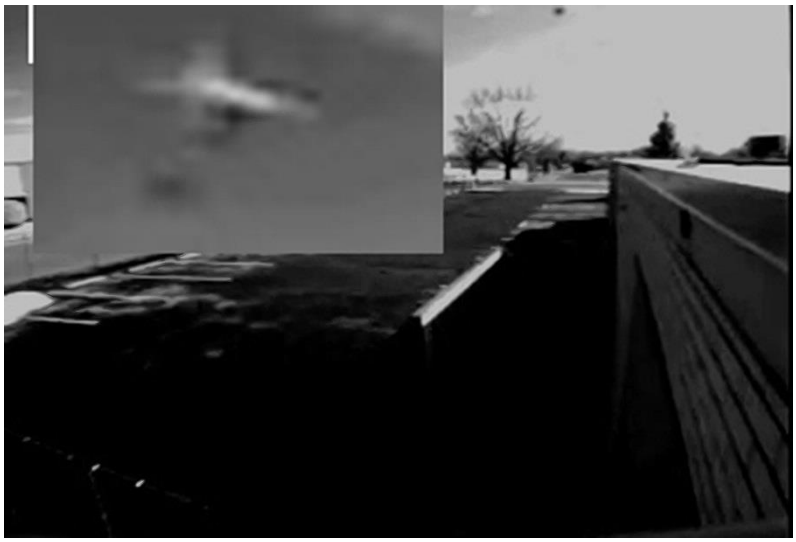

Image 6.2

Image 6.3

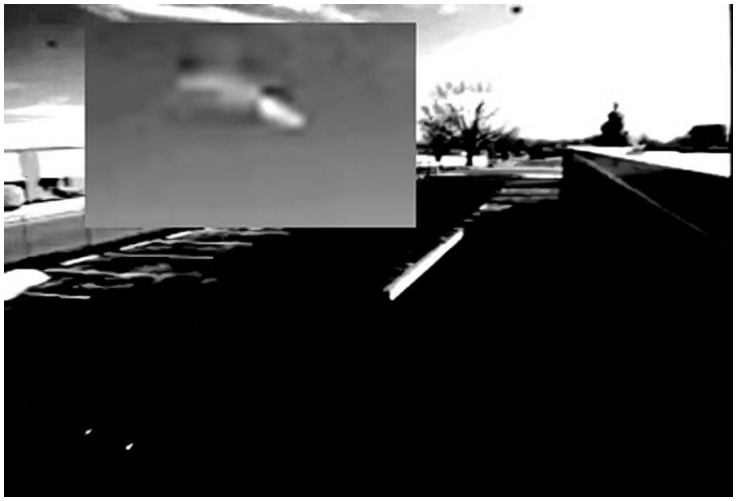

Image 6.4

Image 6.5

Image 6.6

Image 6.7

Image 6.8

Image 6.9: A debris cloud begins to form near the time of impact.

7. Report Attachments:

Three videos were added to the public docket for this investigation and can be found included as attachments to this report. The table below summarizes the video files and their respective attachment number to this report. All videos are in .MP4 format.

Attachment #	Filename
1	PS1622_2013 03 17 16 21 00-1.mp4
2	Proprietor #1_StreamCapture_000.mp4
3	12 Term Maint East PTZ_3 17 2013 4 22 23 Pm (utc-04 00)-1.mp4