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

November 14, 2013

Video Study

Specialist's Study Report
By Doug Brazy

1. EVENT SUMMARY

Location:	Key West, Florida
Date:	November 3, 2011
Time:	1212 Eastern Daylight Time (EDT)
Aircraft:	Cessna 550, Registration N938D
Operator:	Pampa Aircraft Leasing
NTSB Number:	ERA12IA060

2. GROUP

A group was not convened.

3. SUMMARY

On November 3, 2011, about 1212 eastern daylight time, a Cessna 550, N938D, received minor damage during a runway overrun at Key West International Airport (EYW), Key West, Florida. The two certificated airline transport pilots and their three passengers were uninjured. Visual meteorological conditions prevailed, and an IFR flight plan had been filed for the business flight, which departed Fort Lauderdale/Hollywood International Airport (FLL), Fort Lauderdale, Florida, and was conducted under the provisions of Title 14 Code of Federal Regulations Part 91.

The NTSB Vehicle Recorder Division received a video recording from a surveillance system installed at EYW. Radar data for the accident airplane were also provided. Images from the surveillance system were used to calculate the airplane's position and ground speed at several locations during the landing rollout.

4. DETAILS OF INVESTIGATION

4.1. Video Surveillance System

A proprietary computer file and viewing software for an Avigilon video surveillance system were provided to the laboratory. The single file contained video recordings from 3 separate cameras, all located on the north side of the Air Traffic Control Tower at Key West International Airport. The recordings covered the timespan from 12:13:00 to 12:14:44 EDT on November 3, 2011.[1]

Images from each camera were recorded at a rate of approximately 2 Hz, each image was time stamped with a precision of 1 millisecond (0.001 sec). The “native” image size was not specified by the playback software, which had preset export settings for image size ranging from 320x214 up to 4864x3248 (in pixels; width x height).

This largest image size (4864x3248) contains significantly more pixels when compared to typical High Definition consumer TV standards (which are typically 1920x1080 pixels in size). In this case, the large image size resulted in the ability to see fine detail of the airplane and key references that would otherwise not have been visible.

Figures 1 through 3 are example images from all 3 cameras. These images are shown at a reduced size (zoomed out) to display the full camera view.

[1] Based on the recorded timestamp embedded in the video recording.

Figure 1 – Camera 1 Northwest View

Figure 2 - Camera 2 North View

Figure 3 - Camera 3 Northeast View

Figure 4 is an excerpt of the same image shown in Figure 1, however it is displayed at 100% size (not enlarged or reduced). This image is cropped to fit on this page.

Figure 4 - Example Image (excerpt) shown at 100% size

Figure 5 depicts the location of the cameras at the control tower, with red lines representing the approximate direction for each view.

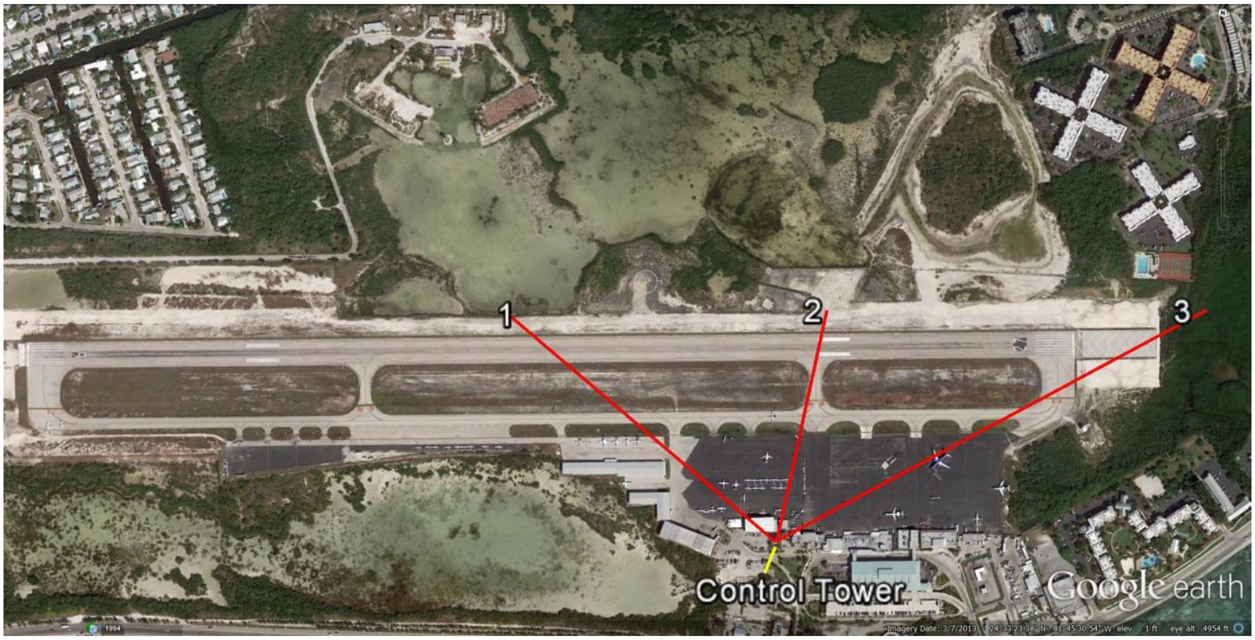

Figure 5 - Camera Location and Viewing Directions

4.2. Airplane Position Calculations

The images from each camera were examined for landmarks and references suitable for calculating the airplane's position as it travelled down the runway during the landing.

A line-of-sight method was used for the position calculations, using landmarks that were identifiable in both the surveillance images, and in aerial/satellite imagery of the airport, using a Geographical Information System (GIS). This is done by constructing sightlines from the known camera location through the appropriate landmark in the GIS, and noting the position of the airplane relative to the sightline.

This method was applied at 15 different locations of the airplane along the runway.

Two typical examples of how this method was applied are described below.

Figure 6 is an image from camera #2 which shows the airplane on its landing rollout, as it was approaching a landmark marked “A”.

Figure 6 - Airplane Approaching Landmark

In Figure 7, the airplane was just passing landmark “A”. The landmark is partially obscured by the airplane’s windscreen. At this time, the camera, the airplane’s windscreen, and the landmark are all located along one straight sightline.

Figure 7 - Airplane at Landmark

The landmark was identifiable in the in the overhead imagery of the airport, in the GIS.[2] A sightline was drawn from the camera location at the Air Traffic Control Tower to the location of landmark A, using the GIS. See Figure 8.

[2] This landmark reference was one of several equally spaced signs located on a fence to the north of the runway. These signs (or their shadows) were visible in the GIS satellite imagery, allowing sightlines to be drawn from the camera location to the signs. Landmarks not visible in the satellite imagery require survey locations data (such as GPS) to be imported into the GIS.

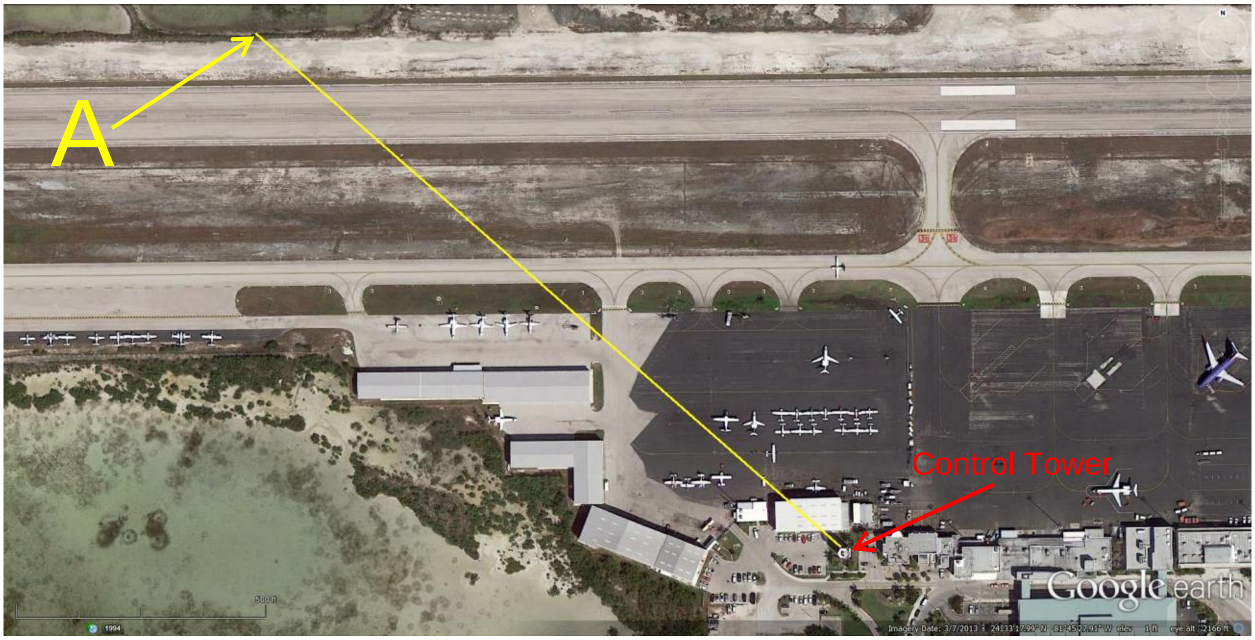

Figure 8 - Sightline from Camera to Landmark

This sightline is a single “line of position” as typically used in navigation, to triangulate a position fix. The airplane’s location is somewhere along this line of position. By establishing another separate line of position (or other constraints), the airplane’s position fix can be determined.

Assuming that the airplane was travelling along the runway centerline, the centerline itself can be used as another line of position. The airplane must be located at some point along both lines simultaneously (by definition of a “line of position”), which is true only where the lines intersect. The position is therefore located at the intersection of the two lines. See Figure 9.

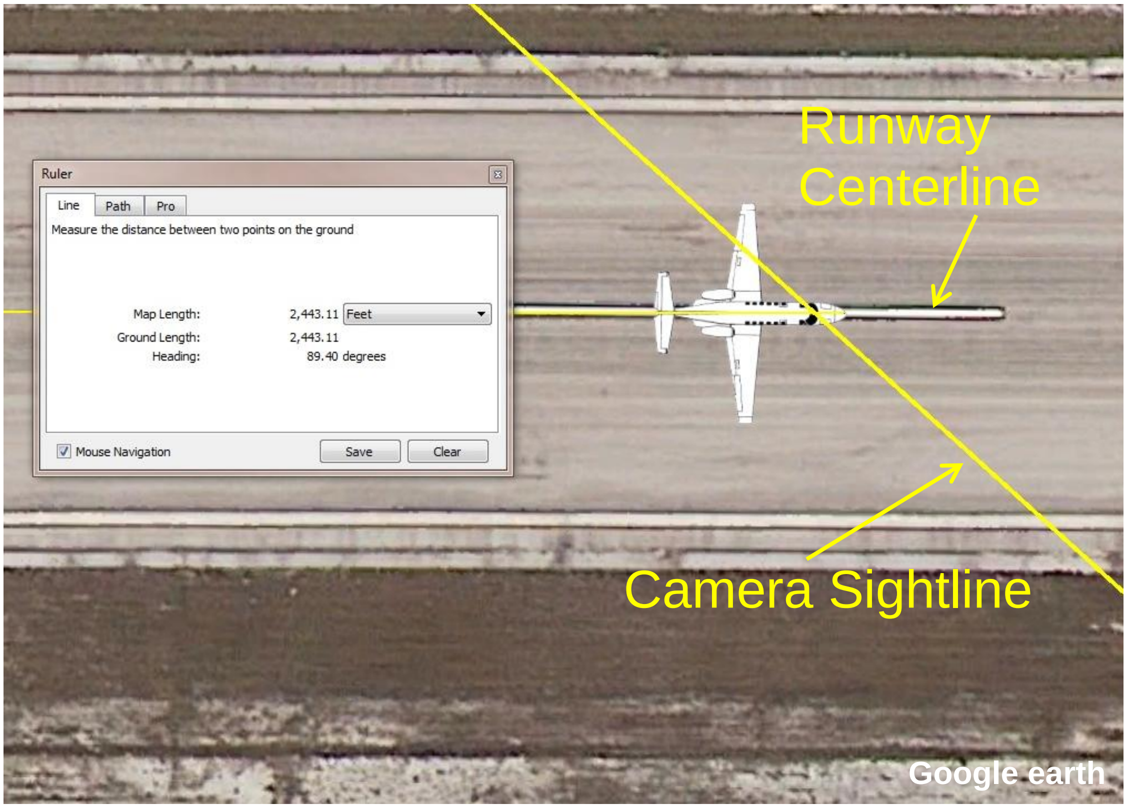

Figure 9 - Scale Model Placement and Measurement

In Figure 9 a scale model of the top view of the airplane was overlaid in the GIS, orienting the fuselage along the runway centerline, and positioning the windscreen of the airplane at the camera sightline (the windscreen was observed to be directly on the sightline in Figure 7). Using the measurement tool provided in the GIS, the location of the nose of the airplane was measured as 2443 feet from the runway 9 threshold.

For some of these calculations, the key landmarks were “translated” vertically to make them usable, as shown in Figure 10. The yellow line was constructed through a landmark (the corner of the building roof denoted with as “B”), parallel to the two vertical poles seen in the right half of the figure. It extends upward through the location of the airplane, and can be used as a landmark.[3] This provides a means to determine when the airplane is on the line of position by noting when the airplane passes behind the yellow line, at the point denoted “A”.

[3] See the Limitations section below.

Figure 10 – Translated Landmark Example

Similar to the previous example, the sightline and model airplane were imported into the GIS. The calculated distance from the threshold in this example was 688 feet. See Figure 11.

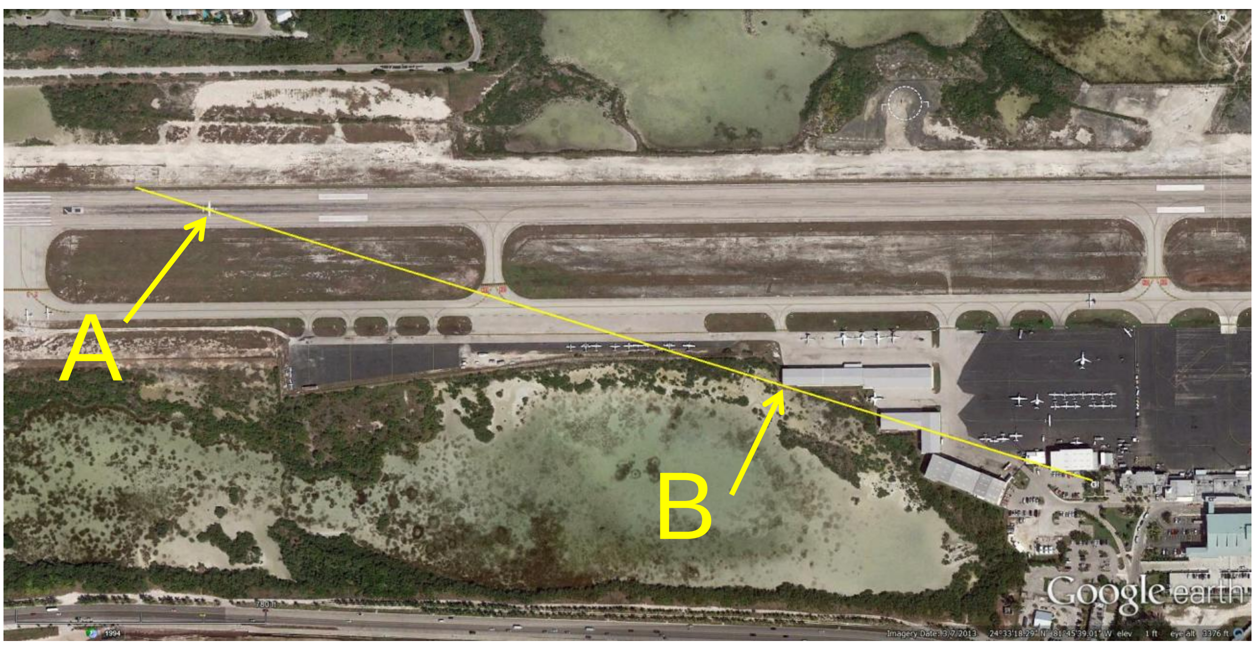

Figure 11 - Translated Landmark Example - GIS View

Table 1 below provides the 15 calculated locations, including the time stamp for each surveillance image. Yellow text represents landmarks in the first 1000 feet of the runway, black text is used for landmarks in the center area of the runway, and red for the last 1000 feet of runway. The airplane location and time values were used to calculate the groundspeed (GS) between points, as shown in the table. Figure 12 show the GIS map view of all the sightlines.

Table 1 - Location and Ground Speed Calculations

image time	Calculated location	delta feet	delta time	calculated GS	calculated GS
HH:mm:ss.xxx	(feet from runway threshold)	(feet)	(sec)	ft/sec	knots
12:13:17.274	**401**				
12:13:19.274	**688**	287	02.000	143	**85.0**
12:13:27.274	**1799**				
12:13:28.274	**1935**	136	01.000	136	**80.6**
12:13:29.274	**2061**	126	01.000	126	**74.7**
12:13:29.774	**2128**	67	00.500	134	**79.4**
12:13:30.774	**2257**	129	01.000	129	**76.4**
12:13:31.775	**2381**	124	01.001	124	**73.4**
12:13:32.275	**2443**	62	00.500	124	**73.5**
12:13:42.883	**3662**				
12:13:43.883	**3769**	107	01.000	107	**63.4**
12:13:44.883	**3876**	107	01.000	107	**63.4**
12:13:47.383	**4118**	242	02.500	97	**57.4**
12:13:48.883	**4262**	144	01.500	96	**56.9**
12:13:50.883	**4456**	194	02.000	97	**57.5**

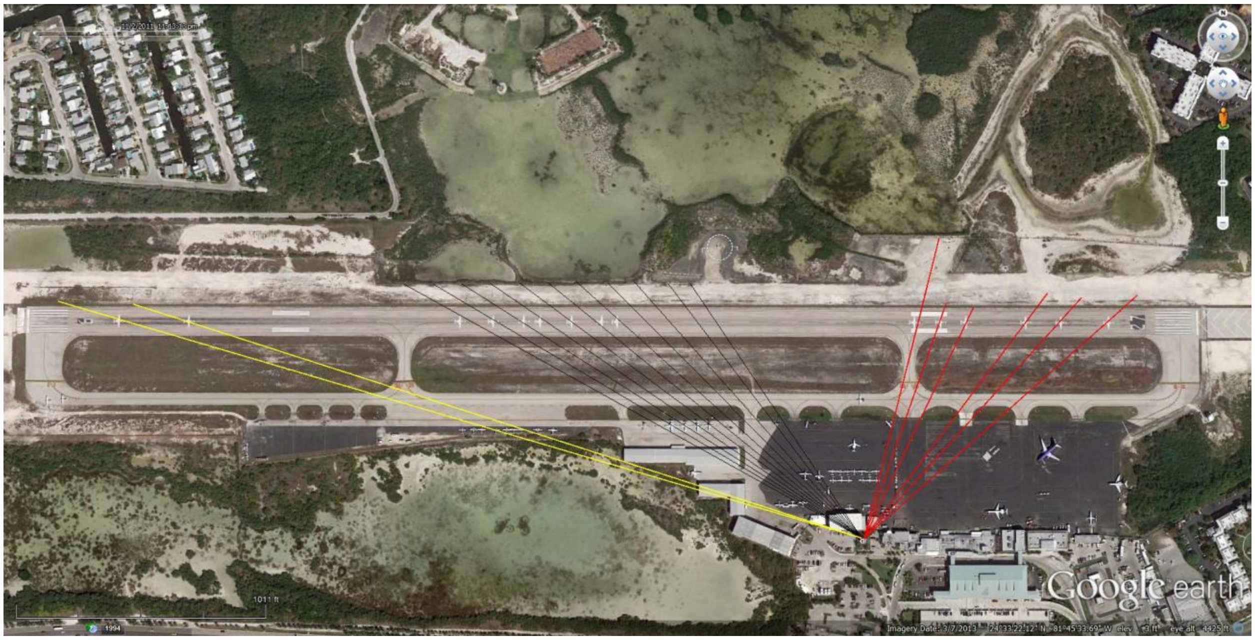

Figure 12 - All Sightlines

4.3. Calculation Limitations

The uncertainty in the calculations for airplane position is dependent on several factors, including the varying distance of the airplane from the camera, the accurate placement of the sightlines and determination of the airplane position relative to the sightline. A sensitivity review examined the components used to determine position by using iterative sightline placement and landmark selection, multiple measurements and varying the position of the model airplane with respect to the sightline. In general, the locations specified in table 1 were estimated to be accurate to within 15 feet or less.

4.3.1. Basic Assumptions

The basic assumptions used for position calculation are:

- Airplane travelling along the runway centerline
- Relative time between images is accurate as specified
- Distance measuring tool in the GIS is accurate to1 foot or less

4.3.2. Specific Assumptions for “translated” landmarks:

In the example illustrated in Figure 10, a reference line was constructed to represent an artificial “pole” to aid in determining the airplane position relative to an offset landmark. This method is valid in this case, because the reference line is oriented normal (90 degrees) to the ground, and little or no wide angle distortion is present where the line is placed (or, that distortion can is accounted for in the placement of the reference line). In this case the line was parallel to existing poles that were assumed to be normal to the ground. No apparent distortion was observed at the line's location which was near the center of the full image where such distortion if present, is minimized.

4.4. Airplane Configuration

The airplane was too far from the camera to determine the ground spoiler condition (deployed or stowed). The flaps are deployed (down), the precise flap setting was not measured.

5. Additional Information

The NTSB Operational Factors Division provided radar data for the accident airplane from two separate radar sites, shown in red and yellow in Figure 13. These data track the airplane on approach until about 1000 feet (laterally) from the runway, and the last recorded altitude was 100 feet.

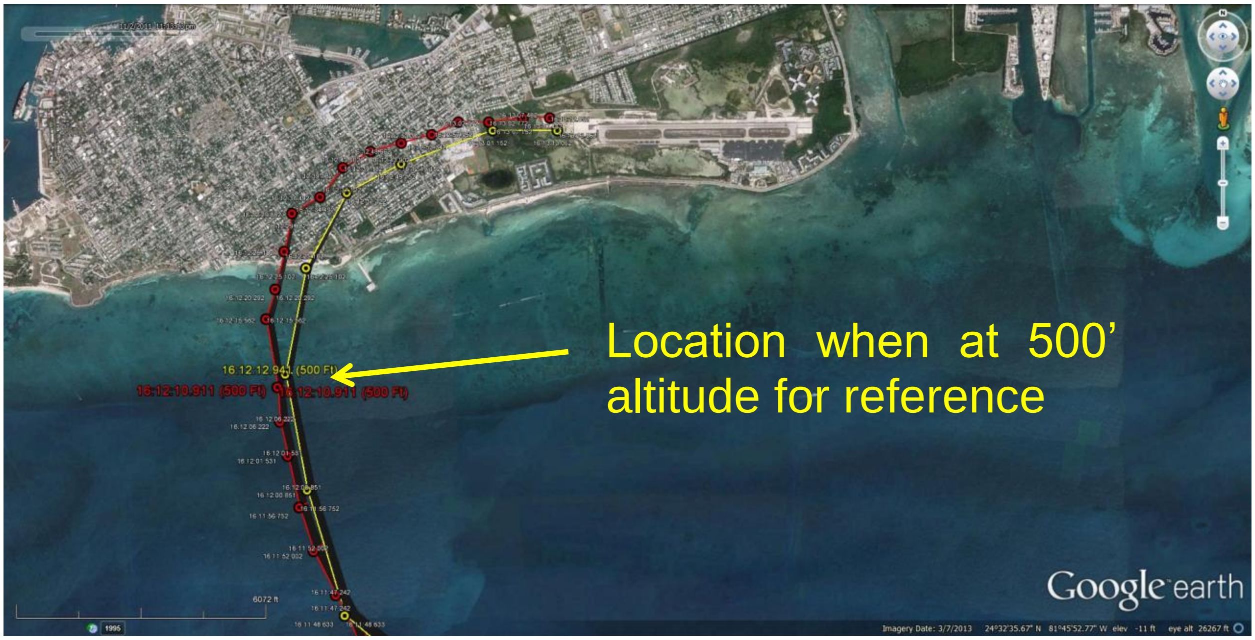

Figure 13 - Radar Data

For reference, Figure 14 and Figure 15 depict the last few radar data points along with a magenta line representing a 3 degree slope ending at the 1000 foot marker on runway

9. Figure 14 is a profile view looking north. Figure 15 is a perspective view looking northwest.

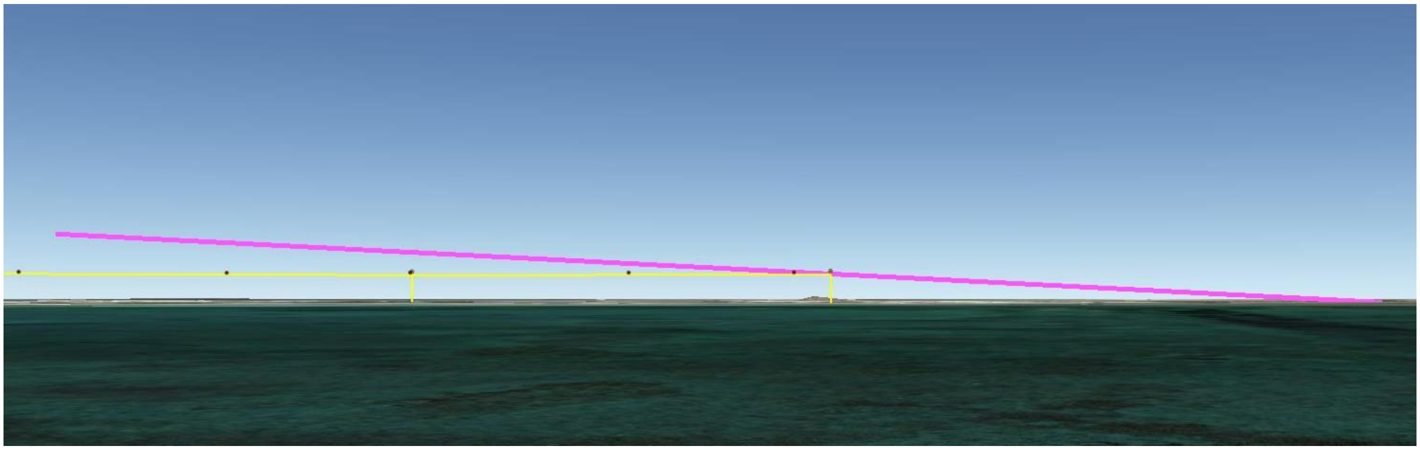

Figure 14 - 3 Degree Path Reference (profile view)

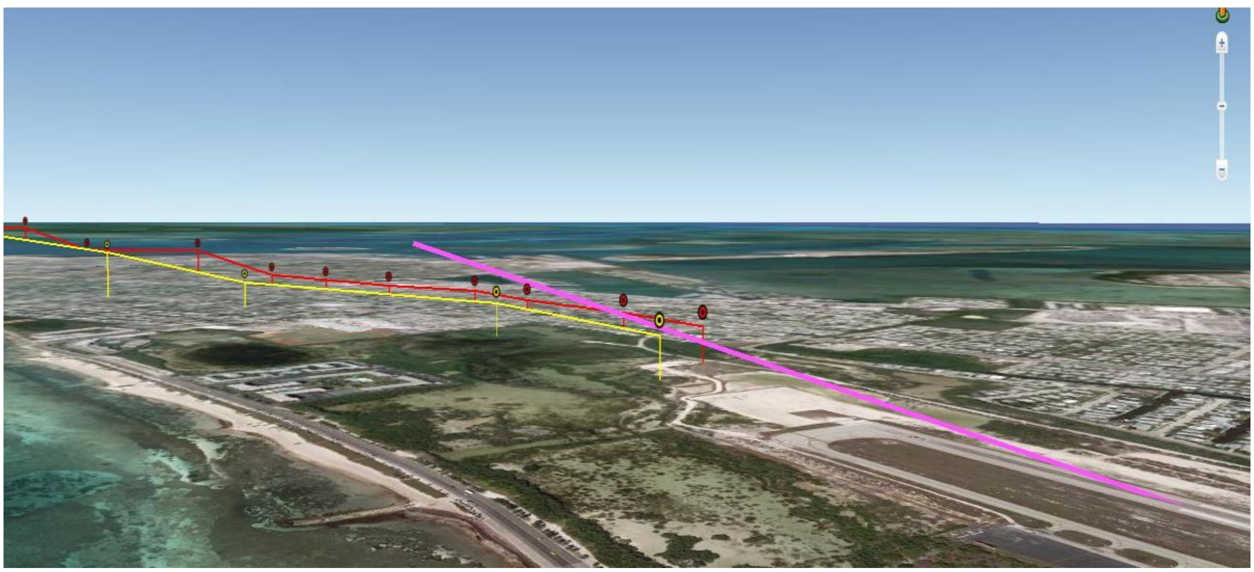

Figure 15 - 3 Degree Path Reference (perspective view)

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