NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

UAS Aerial Imagery Report

05/28/2018

A. ACCIDENT CEN18FA132A/B

Location:	Marion, Indiana
Date:	April 2, 2018
Time:	1725 Local Time (EDT)
Event:	Collision N5614E C150/N511AC C525

B. PERSONNEL

UAS RPIC:	Bill English National Transportation Safety Board Washington, D.C.

C. ACCIDENT SUMMARY

On April 2, 2018, about 1709 eastern standard time, a Cessna 525 business jet, N511AC, registered to Avis Industrial Corporation, of Upland, Indiana, sustained substantial damage when it was struck by a Cessna 150 airplane, N5614E, while rolling out after landing at the Marion Municipal Airport (MZZ), Marion, Indiana. The airline transport pilot and 4 passengers of the Cessna 525 were not injured and the private pilot and passenger of the Cessna 150 sustained fatal injuries. Visual meteorological conditions prevailed in the area. Both flights were being conducted under the provisions of Federal Code of Regulations Part 91. The Cessna 525 was landing on runway 22 after an IFR flight that originated from Jackson, Michigan, and the Cessna 150 was departing on runway 15 for a local VFR personal flight.

D. DETAILS OF IMAGERY

1.0 Equipment and Procedures

Equipment

Mapping and viewpoint flights of the crossing runways, infield area and impact area were conducted on April 4 and 5, 2018, using the NTSB DJI Phantom 4 Professional small unmanned aircraft system (sUAS, commonly known as a drone). The drone is equipped with a dual GPS/GLONASS receiver which provides georeference information on all still photos. The drone is equipped with an FC6310 camera using the Sony Exmor 1" CMOS sensor, with a focal length of 8.8 mm. Still photo resolution is 20 megapixels in JPG or

RAW format. Videos were taken in MP4 format with 4K resolution at 60 frames per second. Ground control points, and significant wreckage locations, were taken with a Trimble GEO7X differential GPS receiver.

Procedures

The accident site was on a non-towered airport in Class G airspace. The airport manager closed the airport and established a Temporary Flight Restriction to support the accident investigation. The flight was conducted under 14 CFR 107. The wreckage area was at the intersection of two runways, with no obstructions or other hazards. Weather and high winds delayed the mapping flights. The goal of the UAS imagery was to document the viewpoints along each runway, across the infield area, and to make a detailed map of the terrain features.

The sUAS was flown in 4 overlapping grids over the runways and infield area capturing still images to create an orthomosaic terrain map. The grids were flown at 250 feet agl in order to ensure sufficient coverage and overlap of the homogenous infield and pavement areas. Higher altitude flights result in less detail (greater ground sample distance), but for the purposes of this mission, coverage was considered more important than fine ground detail. Additional oblique stills were taken of the VOR station in the infield and of both aircraft to aid in photogrammetry processing and documentation of the site. Linear flights along each runway were flown to capture viewpoint video for each airplane. One linear flight was conducted along runway 22, approximating a final approach descent angle while an exemplar Cessna was taxied along runway 15. Exact positions of the accident aircraft were not known, positions of the drone linear flight and exemplar Cessna were assumed. Total flight time was approximately 90 minutes.

Processing

Geo-referenced still imagery was processed using Pix4D photogrammetry software to produce a 3D point cloud and an orthomosaic map of the wreckage site. Relative accuracy (within the map) was calculated at 1.48 inches, twice the ground sample distance.

DGPS data was corrected using the continuously operating reference station (CORS) at Wabash, Indiana. DGPS data was used to supply ground control points for photogrammetry and to document significant portions of wreckage. Elevation was corrected to within 3.5 inches, positional accuracy (to features outside the map) was measured to within 5.3 inches.

The Pix4D 3D orthomosaic also exports a digital surface map (DSM, attachment 6). The DSM was processed using ArcGIS software to assess visibility between select observer and target points in the vicinity of the VOR station between the runways, and a treeline located between the thresholds of runways 15 and 22. Utilizing an assumed observer height for the C150 and the CJ, the DSM was processed using a viewshed tool, which determines all straight-line distances visible from a particular point. Once completed, the tool calculates how much a particular point must be raised above the underlying surface to become visible to the observer. This assessment does not take into account any visual obstructions created

by airplane structure such as window frames. The exact positions and speeds of the accident airplanes was not known, therefore assumed positions were used for the visibility assessment. The diagrams do not necessarily reflect the actual positions and viewpoints of the airplanes.

2.0 Imagery products

Approximately 1400 high resolution photos and videos were gathered. The orthomosaic map in Google Earth kmz format is attachment 9. Select photos, snapshots from video, and excerpts from the 3D point cloud and GIS visibility assessment are included below and as listed attachments.

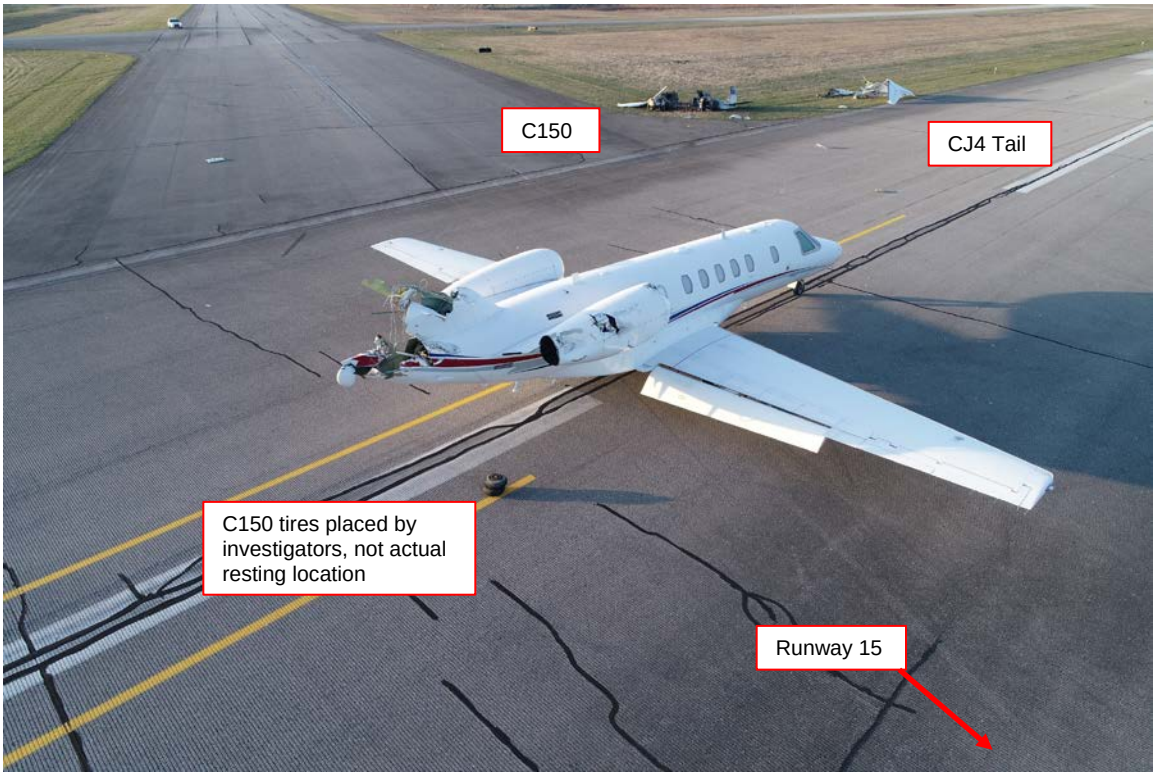

Figure 1 – CJ4 moved by investigators to the approximate location of collision, C150 and CJ4 tail in background

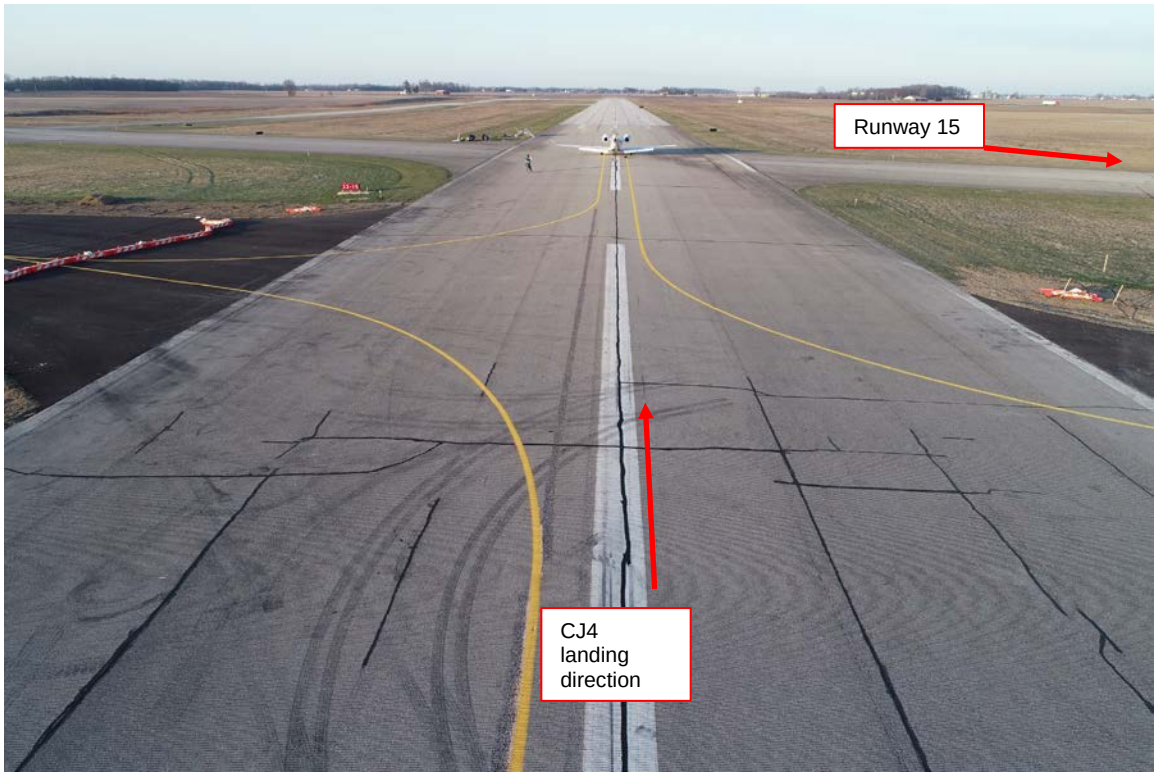

Figure 2 – View along Runway 22 toward collision point

Figure 3 – View along Runway 15 toward impact (note: sun angle not the same as accident time)

Figure 4 – View of wreckage looking towards VOR station

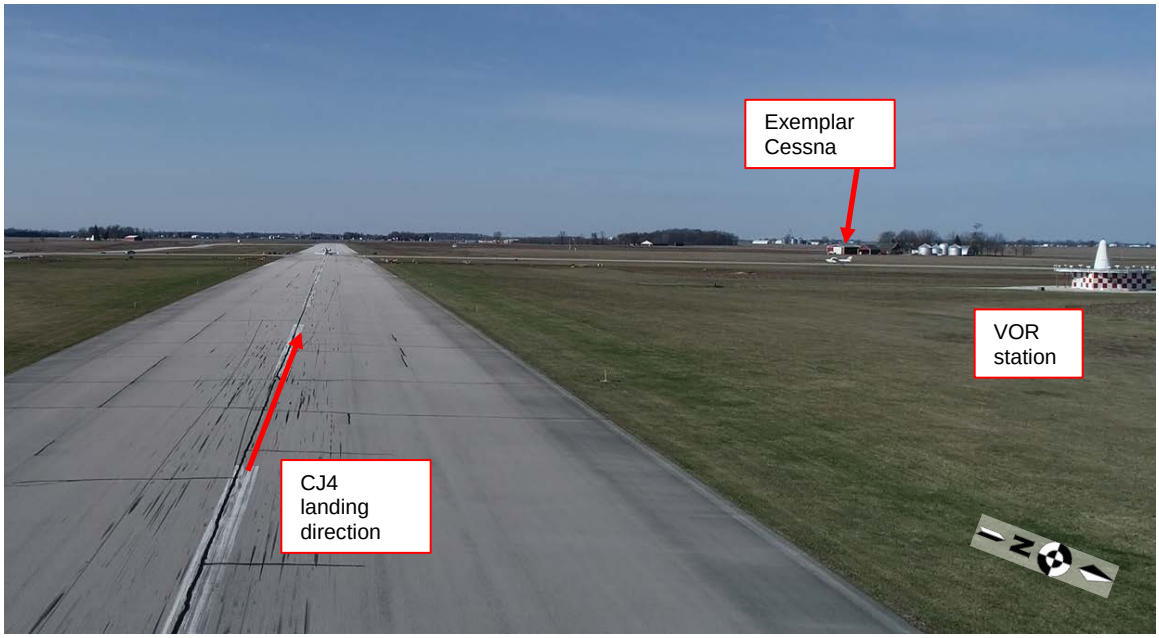

Figure 5 – Frame from video of runway 22 viewpoint from over 1000-foot fixed distance marker, with exemplar Cessna on runway 15

Figure 6 – Frame from video above runway 15 (higher than C150) toward runway 22 showing VOR

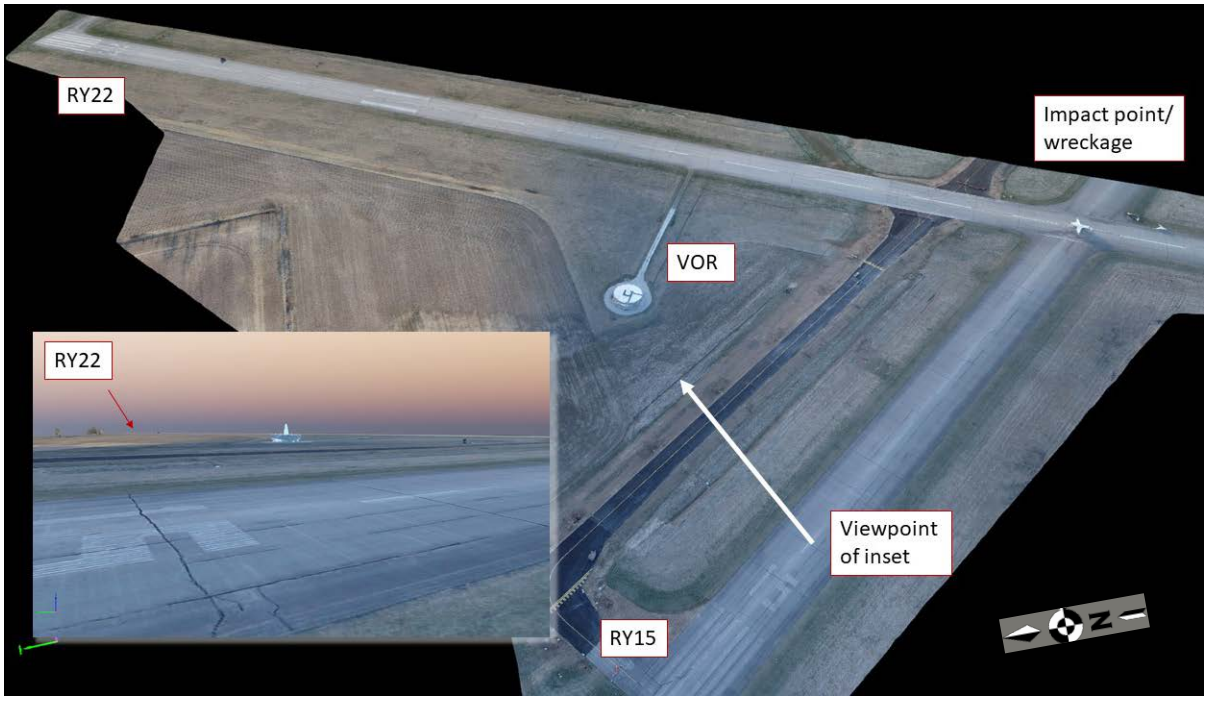

Figure 7 – Excerpt of 3D point cloud with sample viewpoint from vicinity of runway 15

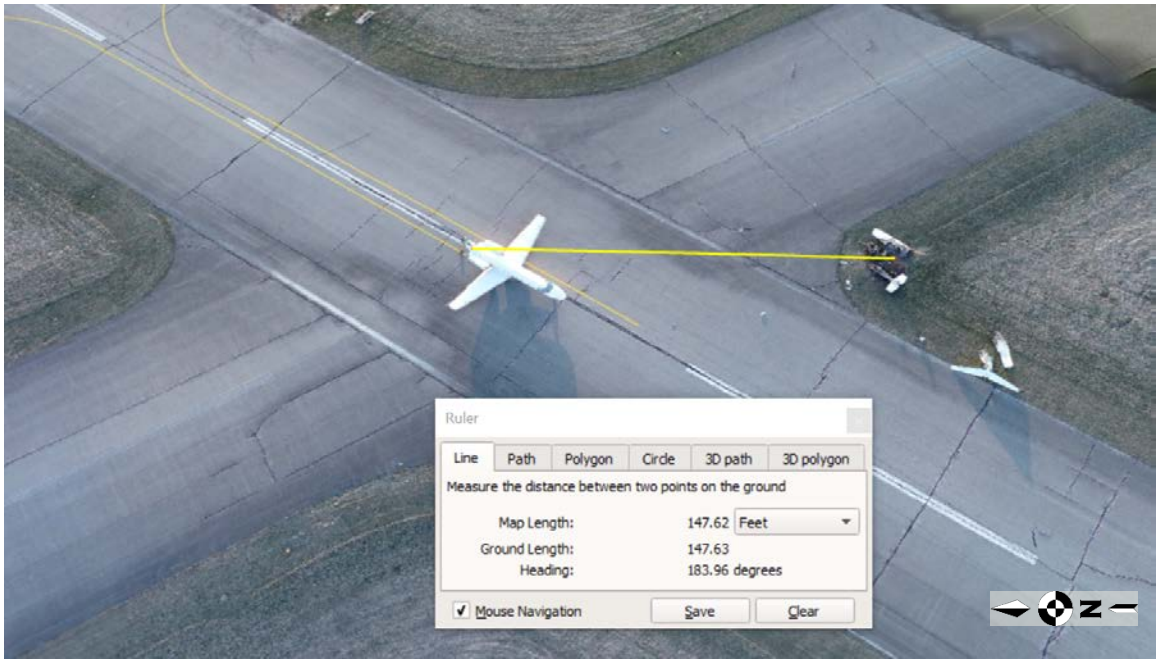

Figure 8 – Snip of orthomosaic overlaid on Google Earth showing measurement between CJ4 tail and C150

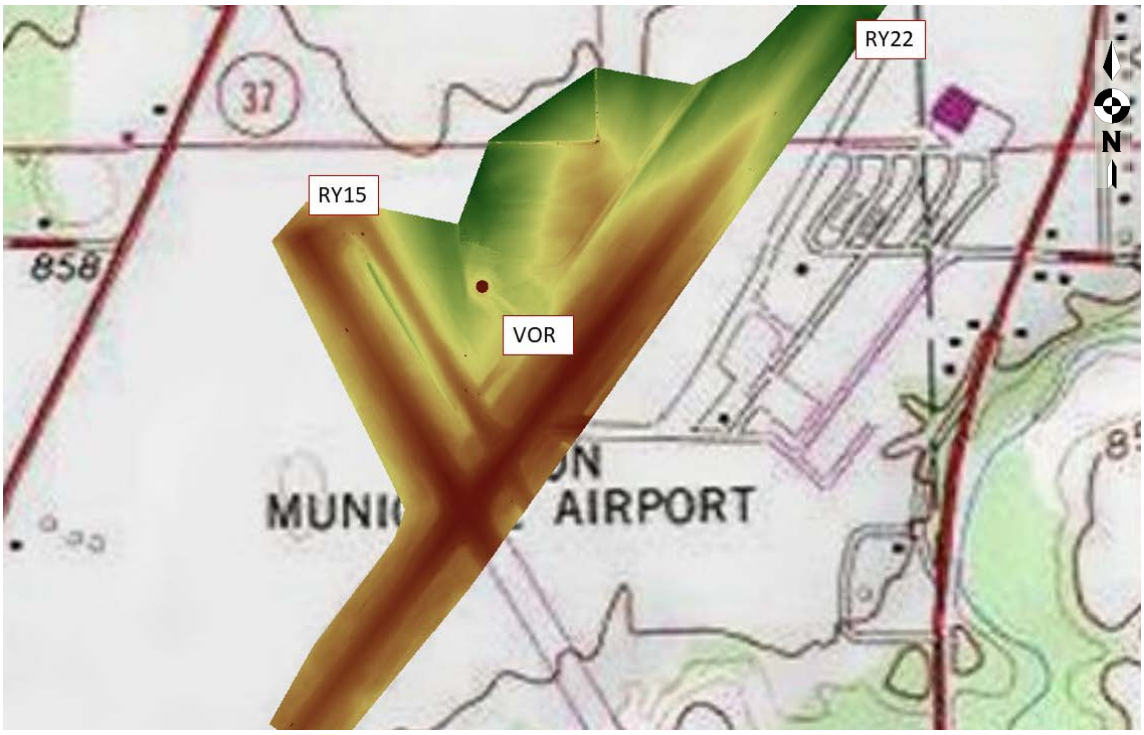

Figure 9 – Digital surface model overlaid on topographic chart, red indicates higher elevations, green lower. Note the elevation difference between the runway thresholds.

The below diagram (Fig 10) explains the visibility assessment. Map layers include:

A commercial satellite imagery basemap
The orthomosaic map of the area created in Pix4D from drone imagery
The Digital Surface Map created in Pix4D from the orthomosaic
An assumed, manually added C150 observer point at 1.8 meters above the surface
The visibility above ground calculation from ArcGIS

Areas in which 2 meters or less elevation would need to be added to be visible to the C150 are transparent. Higher elevations are color coded as follows:

Green = 2 – 5 meters
Yellow = 5 – 10 meters
Orange = 10 - 15 meters
Red = 15 – 20 meters (actual max height required is 19.6m)

For example, for an object in the orange colored area to the northwest of the runway 22 threshold to be visible to the C150 assumed position, it would need to be at least 10-15 meters above the underlying terrain.

Further diagrams remove the orthomosaic and DSM for clarity, and only include the basemap, assumed observer positions, and visibility above ground calculation.

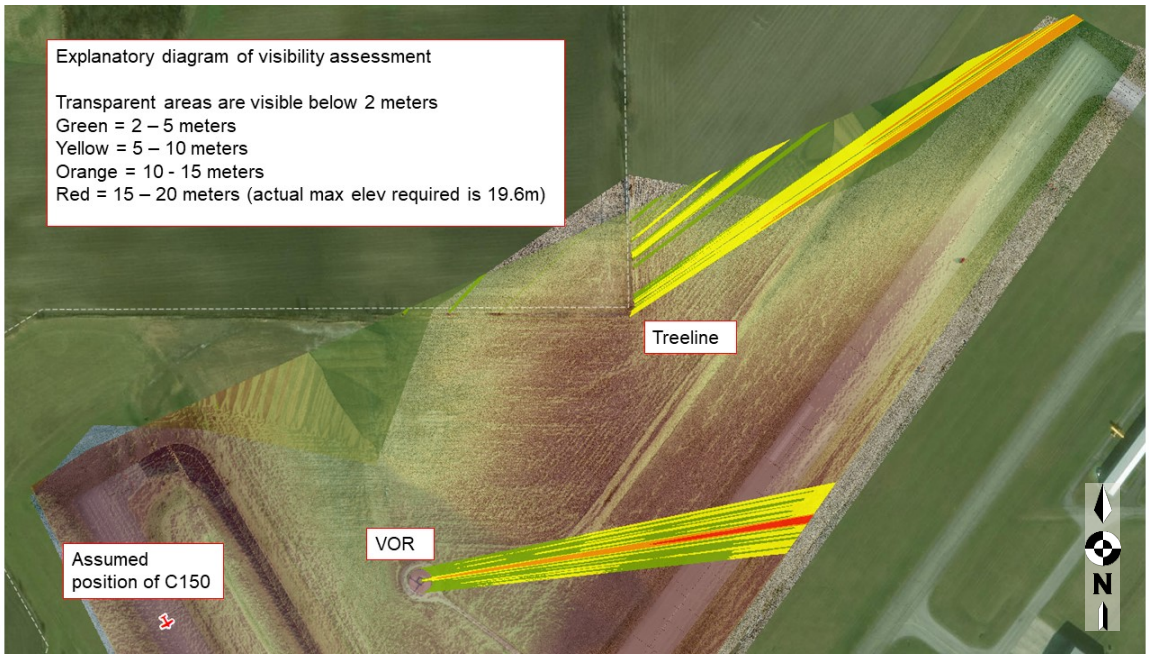

Figure 10 – Explanatory diagram of visibility assessment.

Figure 11 – Visibility assessment with C150 at runway 15 threshold.

In the below assessment, the mutual viewpoints between the C150 and an assumed CJ4 position were calculated. The CJ4 was processed as a line of observer points to account for the higher speed compared to the C150.

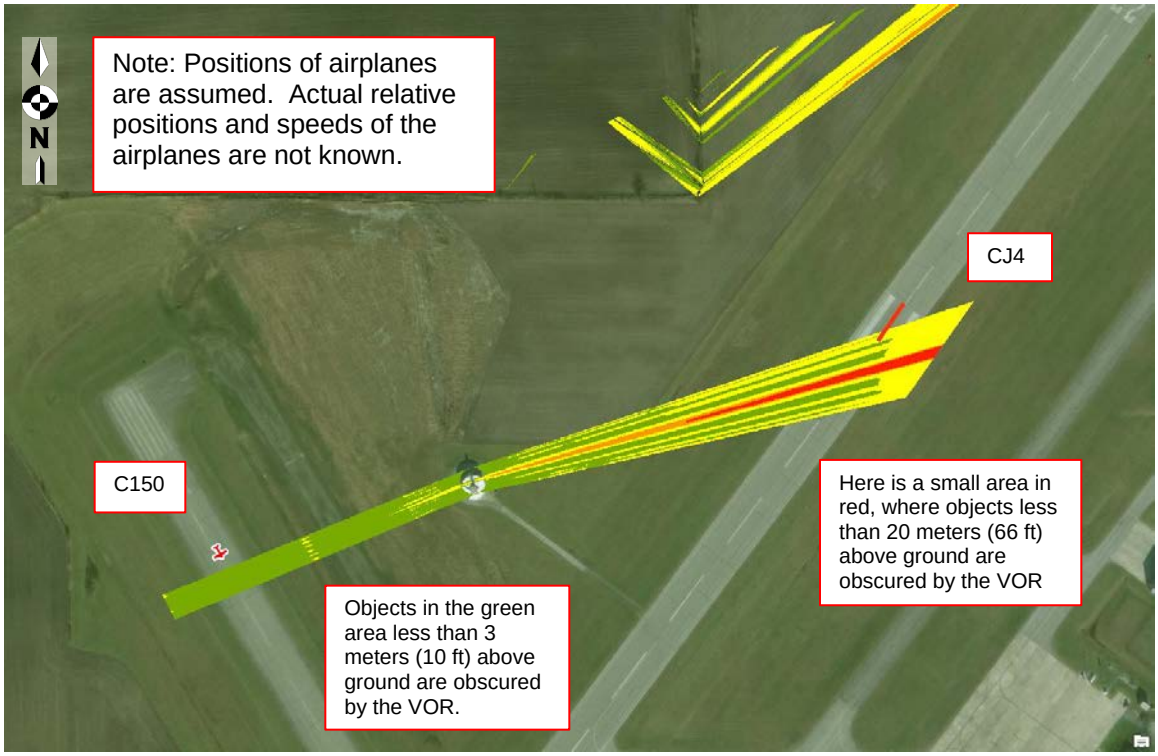

Figure 12 – Mutual visibility assessment.

APPENDIX 1 – DGPS POSITIONS OF SELECT WRECKAGE

Item	Lat/Long	Height MSL (meters)
C150 right wingtip	40.490447030/-85.679536092	261.028
C150 main tire 2	40.489484467/-85.680538469	260.533
C150 gear leg	40.489967077/-85.680124514	260.916
C150 main tire 1	40.490467755/-85.680257308	260.719
C150 nose strut	40.490064239/-85.680526919	261.066
C150 nose tire	40.489767514/-85.680926680	260.856
C150 left wingtip	40.490479902/-85.679594803	261.132
C150 taillight	40.490452804/-85.679616185	261.709
C150 spinner	40.490430555/-85.679556647	261.194
CJ4 left stabilizer	40.490397962/-85.67973263	261.190
CJ4 right stabilizer	40.490343717/-85.679769121	261.082

ATTACHMENTS

Attachment 1 – Photo CJ4 looking toward runway 15
Attachment 2 – Photo CJ4 tail and C150 wreckage
Attachment 3 - Fig 1 CJ with C150 in background
Attachment 4 – Fig 2 View along runway 22
Attachment 5 – Fig 3 View along runway 15
Attachment 6 – Digital Surface Map geo-tiff
Attachment 7 – Video along runway 22 with exemplar Cessna on 15
Attachment 8 – Fig 6 View from above 15 toward VOR
Attachment 9 – Orthomosaic map in Google Earth kmz format
Attachment 10 – Fig 8 snapshot of point cloud with viewpoint
Attachment 11 – Fig 9 DSM overlaid on topo
Attachment 12 – Fig 10 Explanatory visual assessment diagram
Attachment 13 – Fig 11 C150 at threshold visual assessment
Attachment 14 – Fig 12 C150/CJ mutual visual assessment