Use of Surveillance Video in the Reconstruction of a Maritime Collision

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Summary

On December 2, 2012, U.S. Coast Guard (USCG) Chief Petty Officer Terrell Horne III was fatally injured in a collision between a USCG rigid hull inflatable boat (RHIB) and a motorized vessel, known as a *panga*, which was operated by a Mexican national near Santa Cruz Island, California. The U.S. Attorney's Office hired ATA Associates, Inc. (ATA) to reconstruct that collision. In January 2014, the author testified as an expert witness for the prosecution at the U.S. District Court trial of the panga's operator and his crewman/accomplice. At the trial's conclusion, the men were convicted of murder and assault and both were sentenced to federal prison. This paper discusses complementary analyses of video and global positioning system (GPS) data related to the collision and describes how an inconsistency in the GPS record used in the reconstruction was resolved.

Synopsis of the Subject Incident

The subject incident began when the panga was observed lingering close to Santa Cruz Island by the crew of a USCG C-130 aircraft on a routine nighttime coastal patrol. An 18-foot RHIB with a crew of four was launched from the USCG Cutter ***Halibut*** to investigate. Time-stamped video recorded by the C-130's forward looking infrared (FLIR) observation system showed that as the RHIB approached the loitering panga, the 30-foot vessel abruptly accelerated and turned toward the smaller RHIB, colliding with it and overrunning it at 1:20:37 AM Pacific Standard Time. Figure 1 is a frame grab from the video showing the collision. GPS position data, displayed with the FLIR image as seen in Figure 1, will be explained after this synopsis of the incident concludes.

Figure 1 – FLIR video frame showing the collision in the dashed oval (*author's annotation*)

Figure 2 shows the two vessels which collided. The RHIB was a 3,640-lb. Zodiac Hurricane powered by a 200-horsepower inboard engine with a jet drive. The panga had no markings to identify either its maker or owner. The panga design, attributable to a 1970s joint effort by Yamaha and the World Bank to develop a practical boat for subsistence fishermen, is commonly seen in the developing world. This particular fiberglass vessel, fitted with two 200-horsepower outboard motors, weighed 4,550 lbs. Tests by ATA showed that it was capable of accelerating forward at 9 ft/sec^2 to a top speed of about 41 knots, with a minimum turning radius of about 46 feet.

Figure 2 – The RHIB (at left) and the panga

After the collision, the RHIB and its crew were recovered by the ***Halibut***. The panga fled south, tracked by the C-130, which eventually handed over the chase to a USCG helicopter. A lengthy pursuit, mapped by the red line in Figure 3, ended when the panga was intercepted and its operator and crewman were apprehended by the crew of a USCG response boat dispatched from San Diego.

Figure 3 – The path of the panga's flight south from the scene of the collision

No contraband was found on the panga when it was seized. Instead, it was found to be carrying over 2,400 lbs. of gasoline (about 390 gallons) in assorted barrels and jugs as shown in Figure 4.

Figure 4 – The seized panga with its load of barrels and jugs filled with gasoline

FLIR Video of the Incident

ATA received three hours of video from the C-130's FLIR system for review. That video record began two hours before the collision and continued for one hour past it. Continuous forward movement of the aircraft at 145 knots while the video was being recorded, compressed perspective (foreshortening) in the view due to the camera's low elevation angle and the long focal length required at a separation distance of nearly 4 nautical miles between the aircraft and the collision scene, and an ill-timed, off-target pan of the camera just before the collision occurred complicated the measurement of the changing spatial relationship between the two boats during the incident. Still, the sequence and timing of events and the relative directions of travel for the two boats in the incident were reliably documented in the video. Ultimately, distinctive features of Santa Cruz Island's shoreline, which could be seen in the background of the video, and the known dimensions of the two boats provided the means for effectively locating the boats within the scene and determining the distances between the boats as events in the incident progressed.

As the panga moved toward and through the collision, the RHIB's crew fired shots at the panga in self-defense. Muzzle flashes from those shots appear in the FLIR video at 9:20:36, 9:20:37, 9:20:39 and 9:20:40 GMT. In Figure 5, frame grabs from the FLIR video, presented side-by-side, document the last two of those flashes. The flashes, which are more recognizable in the moving

Figure 5 – FLIR video frames showing separate muzzle flashes marked by the arrows (*author's annotations*)

video image than they are in the static frame grabs, appear as black blotches. That conforms with the spectral conventions of the FLIR night-vision system where the brightness of an object, as it appears in the image, is inversely proportional to that object's temperature – cooler objects appearing lighter and warmer objects darker.

In the video, the date and time appear at the upper left of the frame and the position of the aircraft appears at the lower left. For example, the left frame in Figure 5 shows that, at 9:20:39 GMT, the aircraft was at latitude 33° 58' 5" N, longitude 119° 30' 3" W, on a compass heading of 269°, at an altitude of 3,553 ft. One second later, at 9:20:40 GMT, the right frame shows that the aircraft's longitude had increased slightly, indicating westward travel which is consistent the aircraft's average heading of 270°.

At the bottom right of each frame, a calculated latitude and longitude are displayed for the point on the Earth's surface that corresponds to the target cross at the middle of the frame. Also shown at lower right of each frame are the camera's pointing direction (339°) and the distance through the air from the camera to the point on the Earth's surface overlaid by the cross (3.7 nautical miles).

In both frames of Figure 5, the target cross is identified as being at latitude 34° 1' 27" N, and longitude 119° 31' 41" W. That geographic location was chosen by the Coast Guard as the spot to start a post-incident search for a personal defense weapon that was lost by a member of the RHIB's crew when he was knocked overboard during the subject incident. The initial attempt to find the weapon there was unsuccessful, and it was not until the search area was widened considerably, in January 2013, that the weapon was found by an FBI diver at 34° 1' 31.57" N, 119° 31' 42.47" W in water 25 ft. deep, almost 500 ft. from the location suggested by the video.

Resolving the GPS Discrepancy

ATA knew anecdotally that the lost weapon had been found at a significant distance from where it had been expected, but it was not until inconsistencies of comparable magnitude began to obstruct reconstruction of the incident that a concerted effort was made to resolve the discrepancy.

Figure 6 shows how the distance ranging component of the FLIR system on the USCG C-130 worked. An onboard GPS receiver established the aircraft's position at the latitude and longitude of the point, **A**, on the Earth's surface below the aircraft. An encoder then measured the elevation

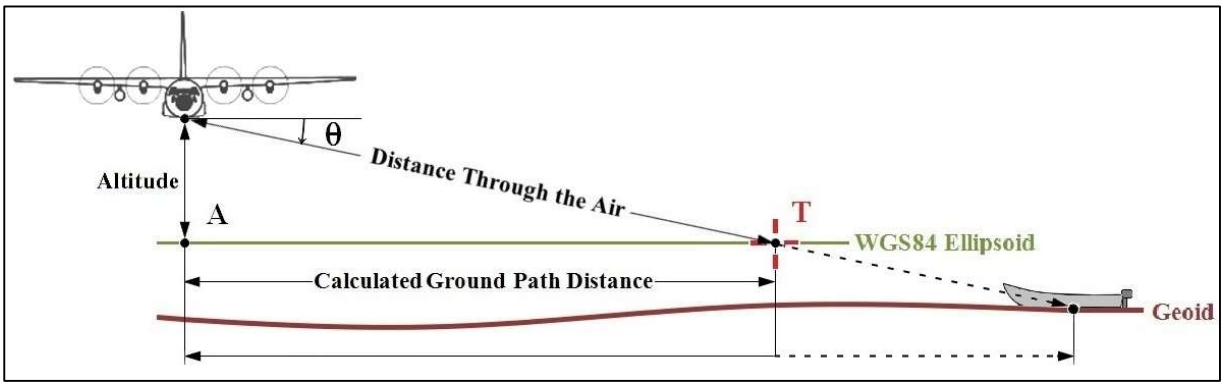

Figure 6 – A schematic diagram of the USCG C-130's GPS ranging system

angle of the camera, θ. Using the aircraft's altitude above a particular datum surface and θ, the tracking system used simple trigonometry to solve for the ground path distance from **A** to the point, **T**, where the camera is pointed and the target cross is projected onto the same datum surface. The system also calculated a "through the air" distance from the camera to **T**, which is simply the length of the hypotenuse of the right triangle formed by the altitude and ground path lines.

The system then used the ground path distance and the heading angle of the camera, i.e., the azimuth angle rather than the elevation angle, to calculate the latitude and longitude of **T**. Though more complex than the calculation that established the ground path distance, determining the latitude and longitude of **T** was still a straightforward process that used a simple mathematical equation describing the Earth (the WGS84 ellipsoid) which was created by the World Geodetics Survey in 1984 and which is a built-in component of many, if not most, commercial GPS systems.

A problem with the C-130 system's use of the WGS84 ellipsoid, however, is that, while the ellipsoid provides a simple, nearly spherical model of the Earth (polar radius 20,855,486 ft., equatorial radius 20,925,647 ft.) as a convenient basis for rapid location and distance calculations, it is not an accurate model of the Earth's real surface everywhere. If the actual surface of the Earth is lower than the surface of the WGS84 ellipsoid at the place where the target cross is projected, the calculated and displayed latitude and longitude of the target cross will describe a point that is nearer to the aircraft than the true location of the ground feature marked by the cross in the video display. This was the very discrepancy that misled the initial search for the lost weapon and then confused early work on reconstructing the whole subject incident.

Trial calculations by the author eventually led to a method to correct the latitude and longitude of the target cross of the video display. By adding about 100 feet to the displayed aircraft altitude and then recalculating the target cross's latitude and longitude, the recalculated location for the cross could be made to match with a known location, such as an identifiable detail of Santa Cruz Island's shoreline. That seemingly arbitrary adjustment was confirmed as being valid in September 2013 when GPS observations, made by the author at the scene of the subject incident aboard the U.S. Coast Guard Cutter ***Blackfin,*** showed that the surface of an alternate geodetic model of the Earth's surface, called the *geoid*, was about 109 ft. below the surface of the WGS84 ellipsoid. Those observations were made with a Raven Phoenix 200 GPS receiver that included as its Earth reference not only the WGS84 ellipsoid equation but also the extensive terrestrial ephemeris data that describe the geoid. Referring back to Figure 6, the schematic shows how the C-130 ranging system produces a calculated ground path distance that is shorter than the actual ground path distance if an object of interest is on the Earth's surface at a point that is better represented by the geoid than the WGS84 ellipsoid.

Reconstructing the Incident

Once concerns about the utility of the GPS record were resolved and a means for correctly adjusting the indicated locations of the target cross was established, it was then possible to use that GPS record, in conjunction eyewitness testimony, to reconstruct the collision incident and to more clearly understand what could be seen in the ghostly images of the FLIR video.

In the frame grab at the top of Figure 7, the FLIR camera is trained on the panga near the center of the frame as the RHIB (circled) approaches from the left, 16 seconds before the collision. In the aerial photo at the bottom of the figure, the adjusted GPS location of the panga is indicated by the red cross, the white line traces the line of sight from the aircraft to the panga, and the RHIB's direction of approach, from the southwest and parallel to the shore (as described in testimony of an observer on the aircraft) is shown by the dotted arrow. The grid showing distance in the aerial photo is referenced to San Pedro Point, the easternmost location on Santa Cruz Island.

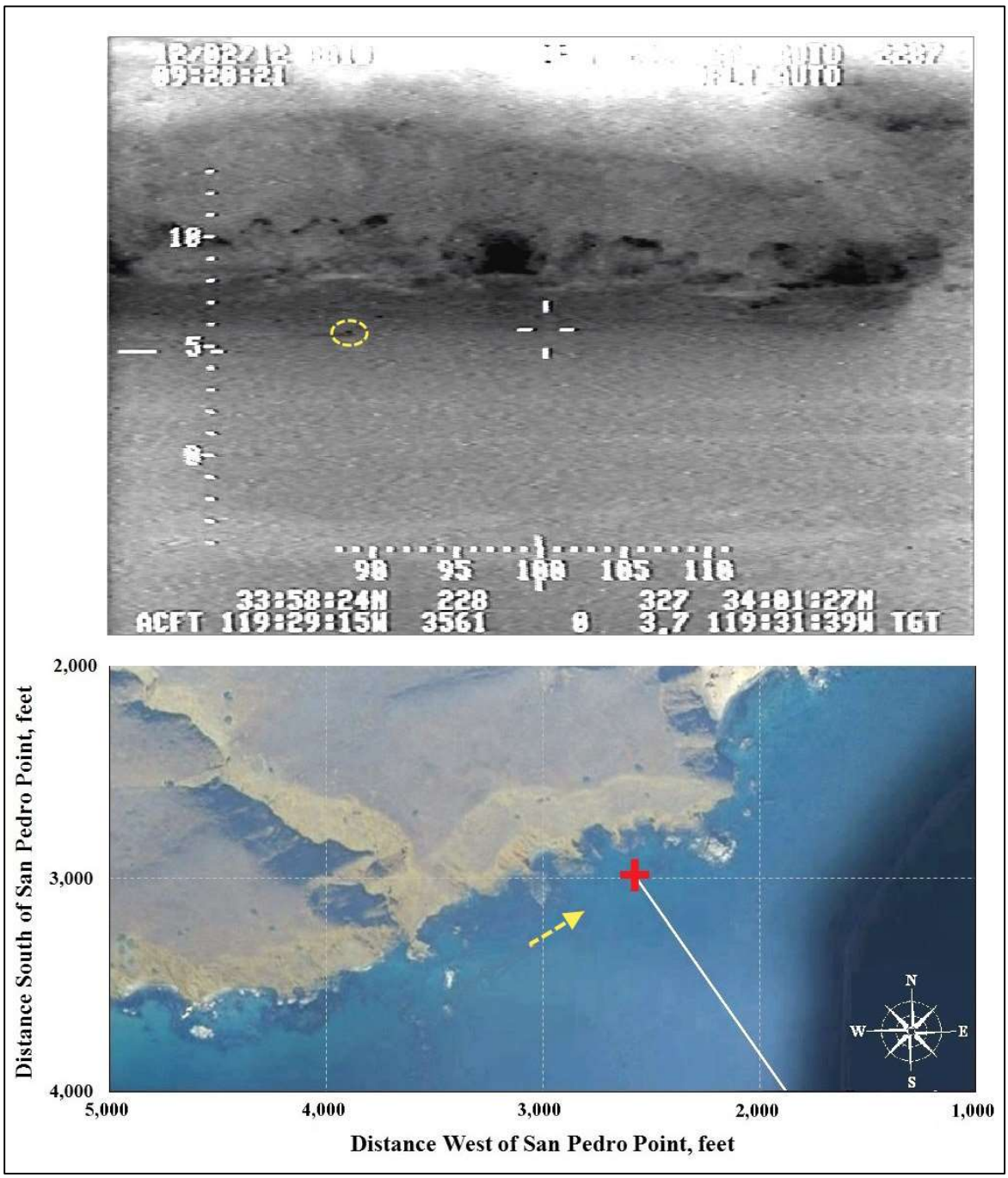

Figure 7 – A frame grab and aerial view of the scene, 16 seconds before the collision

The frame grab at the top of Figure 8 shows the scene, just 3 seconds before the collision, when the video record shows that the panga began its abrupt forward acceleration and turn to port. The view shows that the panga is nearly perpendicular to the camera's line of sight, allowing the boat's 30 ft. length to serve as a basis for estimating other distances in the diagram below the screen grab.

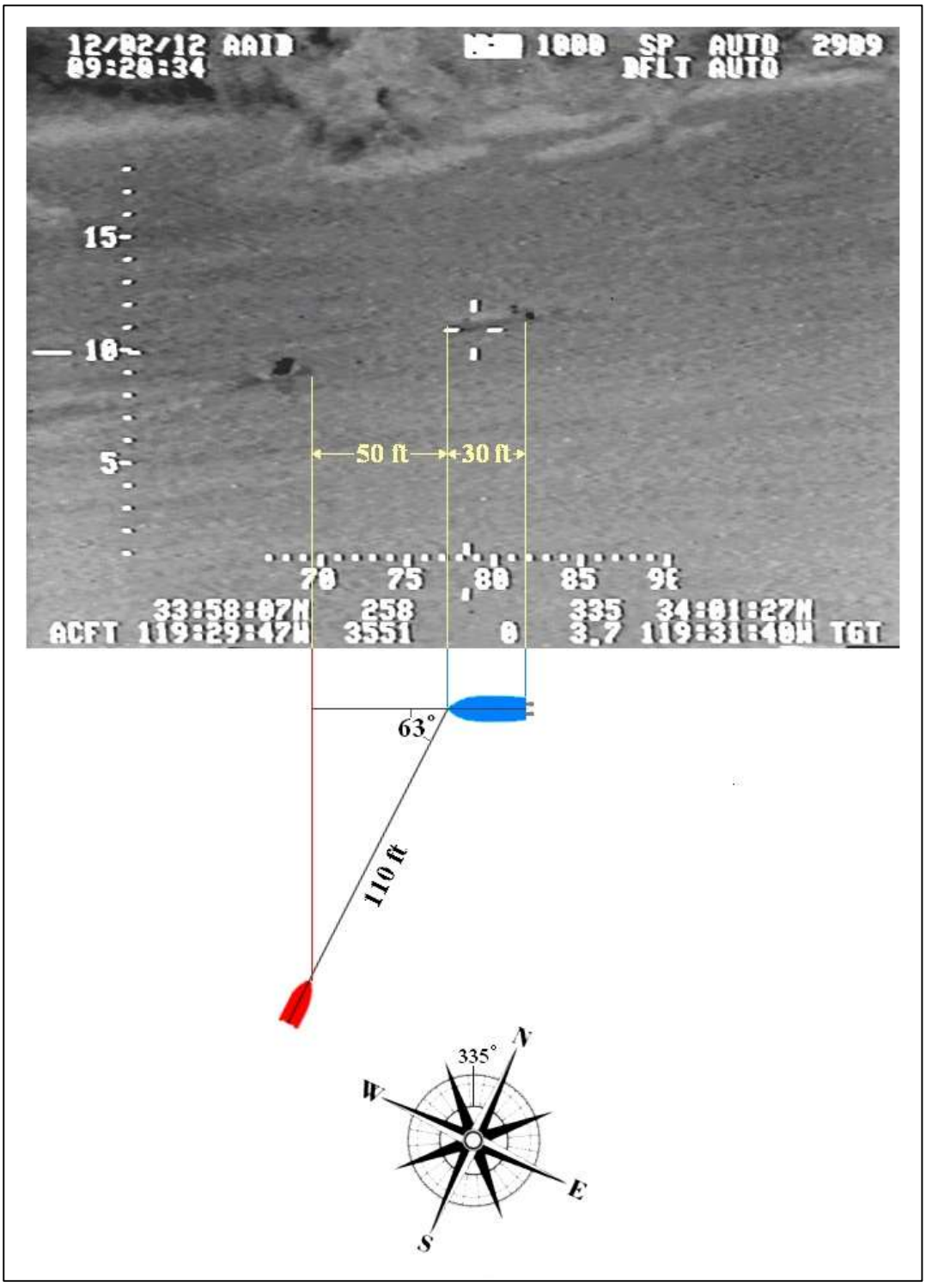

Figure 8 - A frame grab and overhead diagram of the scene, 3 seconds before the collision

As indicated by the compass rose, the diagram at the bottom of Figure 8 has been rotated to be aligned with the camera's pointing direction (335°) indicated in the frame grab at the top of the figure. Relative to that compass reference, the panga is seen to have been pointed toward the west-southwest. The direction of travel of the RHIB shown in the diagram agrees with the aircraft radio operator's affidavit statement that the RHIB was approaching the panga from due south of the panga's position shortly before the collision. The 110 ft. separation distance shown in the diagram also agrees reasonably well with the radio operator's affidavit testimony that the RHIB was about 40 meters (131 ft.) from the panga when the panga began to move as if abruptly throttled up.

Conclusions and Opinions from this Reconstruction

It was a purpose of this paper to show that the mere existence of a surveillance video of an event does not make the viewer of that video a true eyewitness to the event, and it does not necessarily provide an unambiguous record of the event. Nevertheless, as the discussion in this paper has tried to show, if a video is interpreted with care and in light of other evidence, such as related GPS data and the testimony of actual eyewitnesses to the event, a video such as the one described here can offer valuable insights.

In the case of the subject collision, it is the author's conclusion, based upon the FLIR video and other evidence, that the panga operator's acceleration and turn toward the approaching RHIB was a deliberate, aggressive use of his vessel against the smaller RHIB which resulted in the death of Terrell Horne. It is the author's conclusion that, despite the fact that panga was partially boxed-in by its close proximity to Santa Cruz Island, more probably than not in a failed attempt to avoid detection, there was still ample deep water ahead of the panga that would have provided the operator with an open avenue for escape from the approaching RHIB if the panga operator had chosen simply to flee.