

The fireballs continued to expand and rise for several more seconds before receding. Videos indicated that the fireball created on the east face lasted 11 s, that on the north face lasted 10 s, and that the small fireball on the south face lasted about 8 s. An analysis similar to that for WTC 1 indicated that less than one sixth of the jet fuel burned immediately within the building. Three previous estimates (McAllister 2002, and two in Baum and Rehm 2005) found that about 10 percent to 25 percent of the total jet fuel burned outside WTC 2. Since most of the fuel that formed the fireballs came from the starboard fuel tank, this suggested that 20 percent to 50 percent of this fuel burned externally with another few percent consumed inside the building. The remainder of the fuel was left behind in the tower following the initial fire. Almost all of the fuel in the aircraft's port fuel tank was also inside, primarily on the 78th and 79th floors. There was no visual evidence that the fuel from the port tank fuel burned in the short term.

2.3.2 Estimated Aircraft Speed

Figure 2–7 is a series of cropped video frames that show the aircraft approaching WTC 2 and disappearing inside. In each digital frame, NIST determined the separation of the nose and tail from the point where the aircraft passes out of sight behind the corner of the building. Figure 2–8 shows the pixel locations of the nose and tail of the aircraft as a function of time. The lines are virtually parallel, indicating that the tail did not slow as the aircraft entered the building. The time between when the nose and tail passed the reference location was 0.194 s. Since the length of the fuselage was known to be 155.0 ft, the speed was estimated to be 799 ft/s (545 mph). An uncertainty estimate based solely on the uncertainty in the determined time difference yielded a value of ± 18 mph with 95 percent confidence. A more sophisticated motion analysis (NIST NCSTAR 1-2A) generated a value of 542 mph ± 24 mph.

2.3.3 Determination of Primary Oscillation Period

Close examination of the stable video revealed a perceptible movement of WTC 2 after it was struck by the aircraft. The building rocked back and forth, much like a pendulum, for many minutes. The stable nature of a video shot from the east allowed a detailed analysis of the north-south and torsional (twisting) motion of WTC 2 to be performed using image analysis of the Moiré patterns. Figure 2–9 shows the position of a location on the tower on the 70th floor as a function of time. A large increase in the motion of the tower followed the aircraft impact and slowly decreased after that. The peak amplitude of the movement in the north-south direction was determined to be 12 in. ± 1 in. at the 70th floor, which extrapolated to a value of 20 in. ± 3 in. at the roofline. Frequency analysis of the results revealed the fundamental north-south mode to have a period of 11.4 s, a torsional mode with a period of 5.3 s, and two higher frequency modes with periods of 3.9 s and 2.2 s. All periods were determined to an accuracy better than ± 0.1 s. The period of the fundamental mode was consistent with the expected range based on measurements of similar frequencies in WTC 1 (NIST NCSTAR 1-2). Similar measurements using a short video shot from the north yielded an amplitude of 12 in. ± 2 in. for the east-west motion, with a period of 5.3 s.

A moiré pattern is an optical effect that develops when objects having sets of lines are viewed simultaneously. In the case of this video, the lines correspond to the vertical rows of windows and columns on the tower and the vertical rows of pixels in the camera. In effect, the interactions of the lines allow motion to be followed with finer resolution than is available in the image.