National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: April 10, 2012

In reply refer to: A-12-8

The Honorable Michael P. Huerta
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

On September 16, 2011, about 1626 Pacific daylight time, a modified experimental single-seat North American P-51D, N79111, collided with the airport ramp in the spectator box seat area following a loss of control while maneuvering during the unlimited class[1] gold race at the National Championship Air Races (NCAR) at Reno Stead Airport (RTS), Reno, Nevada. The airplane was registered to Aero-Trans Corp, Ocala, Florida, and operated by the pilot as Race 177, the Galloping Ghost, under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91. The commercial pilot and 10 people on the ground sustained fatal injuries; based on preliminary information, 66 people sustained serious injuries,[2] and numerous minor injuries were reported. The airplane fragmented upon impact with the ramp. Visual meteorological conditions prevailed, and no flight plan was filed for the local air race flight, which departed RTS about 10 minutes before the accident.[3]

Numerous photographs and videos of the accident sequence have been collected from the public during the investigation, and an airplane performance study is being conducted. Based on available information, the airplane was established in a turn while passing pylon 8 on the 10-pylon course (see figure 1) when it experienced an upset. Its airspeed was about 460 knots (530 mph) at this time. After the initial roll upset, it entered a severe rolling climb maneuver and

[1] The NCAR comprises six race classes: jet, sport, T-6, formula I, biplane, and unlimited. In addition to North American P-51s, the unlimited race class includes several types of aircraft, such as Hawker Sea Furys, Grumman F8Fs, Grumman F7Fs, Yak 3Us, Vought F4s, Curtis P-40s, and Focke Wulf 190s, that may operate at groundspeeds in excess of 500 mph. Several aircraft that operate within the unlimited class have been significantly modified from their original condition.

[2] Title 49 CFR 830.2, "Definitions," states that a serious injury is any injury that (1) requires hospitalization for more than 48 hours, starting within 7 days from the date that the injury was received; (2) results in a fracture of any bone, except simple fractures of fingers, toes, or the nose; (3) causes severe hemorrhages or nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns or any burns affecting more than 5 percent of the body surface.

[3] Preliminary information about this accident, NTSB case number WPR11MA454, is available at <http://www.ntsb.gov/aviationquery/index.aspx>.

traveled a downward spiral flightpath to impact the ramp in the box seat area. Preliminary findings in the NTSB's ongoing investigation point to the need for improvements in the Federal Aviation Administration (FAA) guidance materials provided to inspectors and aviation event organizers to evaluate race course design.

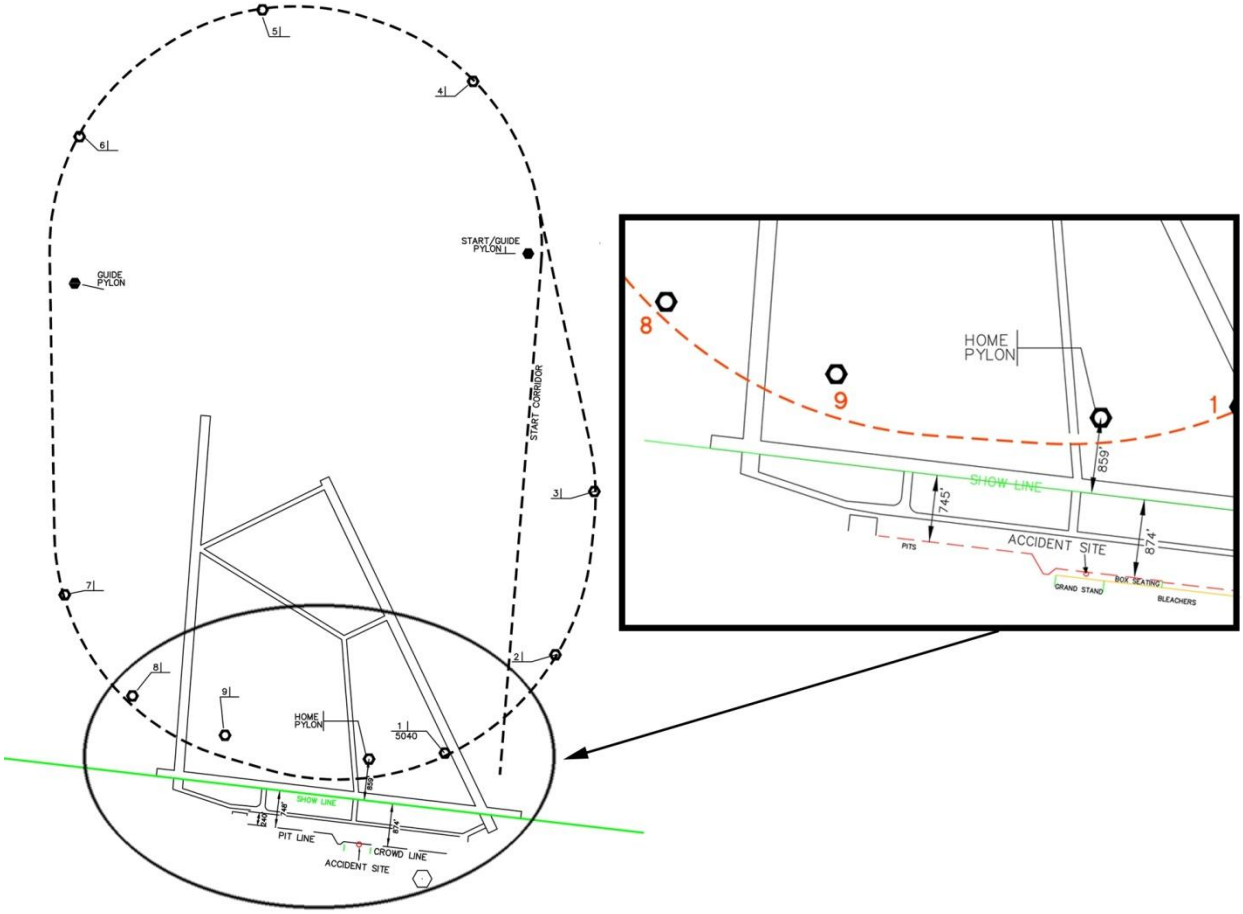

Figure 1. Diagram of the NCAR unlimited class race course.

FAA guidance for air races and course design is provided in FAA Order 8900.1, *Flight Standards Information Management System*, volume 3, chapter 6, section 1, paragraph 3-151 and Advisory Circular (AC) 91-45C, "Waivers: Aviation Events," chapter 4. NTSB review of these materials has found numerous discrepancies, errors, and instances of outdated information in both documents that undermine their purpose. For example, regarding the racecourse showline,[4] paragraph 3-151, "Air Races," section H, item 2 in volume 3 of Order 8900.1 states:

> The minimum turn radius, the maximum turn angle, and the raceway width define the limits of a satisfactory race course. The race course relationship to the spectator areas or

[4] AC 91-45C defines a showline as "a prominent, readily visible ground reference such as a river, runway, taxiway, canal, breakwater, road, or any straight line that enhances pilot orientation during aerobatic routines…The showline also serves as the horizontal axis for the show."

> other populated area must also be defined. All racing classes require a distance of 500 feet between the primary spectator area and the showline.

In contrast, paragraph 54, item b, in AC 91-45C states the following on the same topic:

> …Racing classes with a maximum speed of 250 miles per hour or less require a spacing of 500 feet between spectators and the showline. The unlimited racing class (or other new classes with speeds in excess of 250 miles per hour) requires a spacing of 1,000 feet between the spectator and the showline.

The showline specifications between the two documents differ by a factor of two under certain conditions. Whereas Order 8900.1 specifies a 500-foot distance between the *primary* spectator area and the showline for all race classes, AC 91-45C specifies two distances between spectators and the showline, depending on race class operating speeds;[5] the AC also does not distinguish between the primary spectator area and spectators in general. As shown in figure 1, the showline/spectator distances for the NCAR unlimited course are within the specifications outlined in Order 8900.1 but not those provided in AC 91-45C.

Another discrepancy identified in the order and AC concerns the formula for the minimum turn radius. As shown below, the formula in the AC has a g-squared term in the denominator, whereas the formula in the order does not (both documents specify a value of 3.5 for g but use slightly different definitions for the variables).[6] Using a value of 3.5 for g, the minimum radius calculated from the order would be about twice the minimum radius calculated from the AC. This inconsistency between the formulas clearly results in significant differences in calculations, calling into question the reliability of this information in evaluating the suitability of a race course design.

AC 91-45C

$$R = \frac{V^2}{32.2 \times \sqrt{g^2 - 1}}$$

R= Minimum turn radius
V = Aircraft speed (ft/sec)
g = Max acceleration ft/sec^2)
32.2 = Acceleration of gravity (ft/sec^2)

Order 8900.1

$$R = \frac{V^2}{32.2 \times \sqrt{g - 1}}$$

R= Minimum turn radius (feet)
V = Aircraft speed in ft/sec or
V = knots x 1.689
32.2 = Acceleration of gravity (ft/sec^2)
g = "*g*" force in turn

Order 8900.1 also states that the safety area for the course should be constructed by, among other actions, marking off the minimum turn radius for the class of aircraft racing, as shown in figure 3-28A (see figure 2). This figure, however, concerns aerobatic maneuvers and is unrelated to race course design. There is no such figure for race course design. The lack of this visual aid

[5] According to the Reno Air Racing Association, the NCAR organizer, the aircraft operating speed for the NCAR course is 500 mph for the unlimited class and 525 mph for the jet class. On the topic of operating speeds, Order 8900.1 notes speeds of 450 mph and higher for the unlimited and jet classes. AC 91-45C notes typical speeds of 450 mph for the unlimited class but does not address the jet class.

[6] An NTSB investigator informed an FAA representative of this difference on January 30, 2012, and the representative indicated that the discrepancy would be corrected in the next revision to the order.

has not been identified as an issue in the NTSB's investigation of the NCAR accident, but the lack of an accurate visual reference to aid in the construction of a safety area does not support the purpose of the guidance.

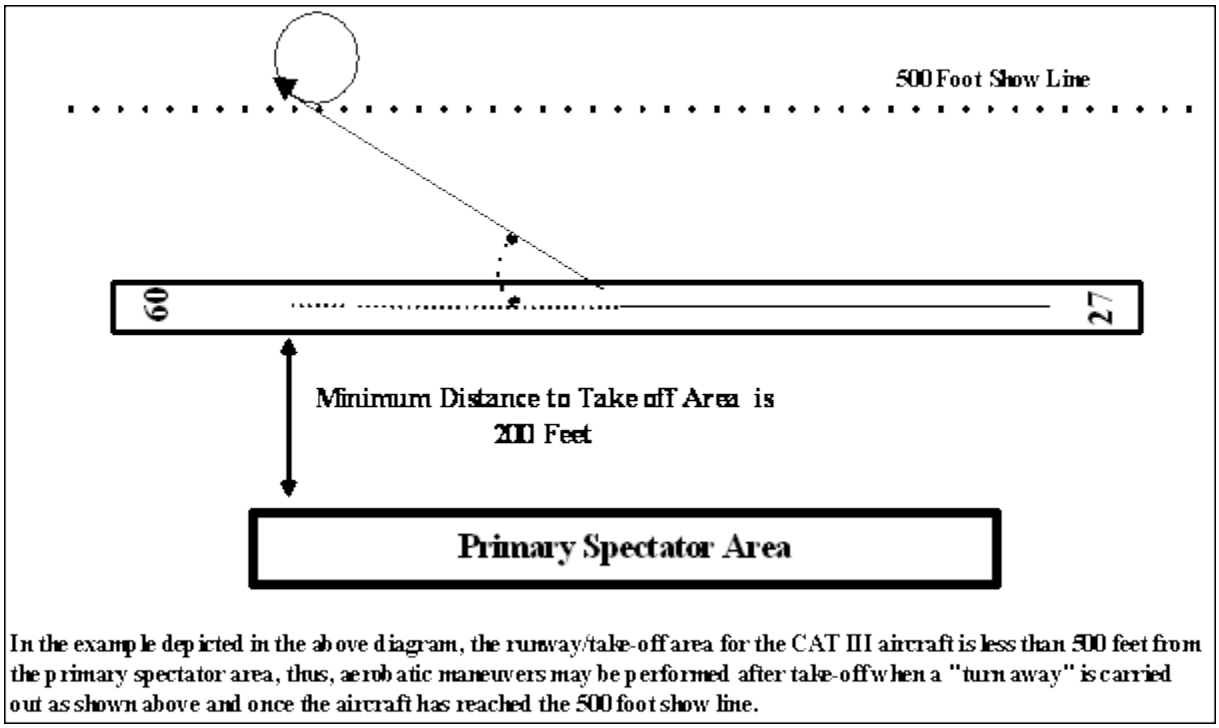

Figure 2. Figure 3-28A from FAA Order 8900.1

The NTSB's review of these materials also identified items that are outdated or lack sufficient detail. For example, the jet class and related specifications were added to Order 8900.1, but the AC has not been revised since 1990 and contains no discussion of the jet class. Concerning insufficient detail, all references to speeds in Order 8900.1 and AC 91-45C are in miles per hour (mph), but neither document specifies if these speeds refer to groundspeed or airspeed. In addition, the NTSB notes that the FAA approved the NCAR unlimited race course based on an average aircraft operating speed of 500 mph; however, the order and AC indicate maximum expected speed rather than average speed.

Further, although both documents identify maximum turn angle as one of the defining limits of a satisfactory race course (specifying a maximum of 65º), neither specifies an acceptable range of a 65º turn (that is, whether the maximum angle applies to a turn around one, two, or three pylons, or half the course). During discussions with NTSB investigators, the NCAR organizer noted that, in the absence of this specific information, the maximum turn angle was divided between three pylons in the design of the NCAR course. The NTSB continues to evaluate the NCAR race course design in terms of FAA guidance and requirements but believes that incorporating more specific guidance about the maximum turn angle will assist course designers and inspectors.

Based on the deficiencies noted, the NTSB concludes that, as the tools for evaluating event organizers' adherence to air event requirements, Order 8900.1 and AC 91-45C should

contain current, accurate, and consistent information to support a thorough review of a race course and the effort to provide maximum safety for spectators and racers. Therefore, the National Transportation Safety Board makes the following recommendation to the Federal Aviation Administration:

> Revise Federal Aviation Administration Order 8900.1, *Flight Standards Information Management System*, volume 3, chapter 6, section 1, paragraph 3-151 and Advisory Circular 91-45C, "Waivers: Aviation Events," to correct inaccurate and incomplete information and reconcile all differences and inconsistencies between the documents. (A-12-8)

The NTSB also issued safety recommendations to the Reno Air Racing Association and the National Air Racing Group Unlimited Division.

In response to the recommendation in this letter, please refer to Safety Recommendation A-12-8. We encourage you to submit updates electronically at the following e-mail address: correspondence@ntsb.gov. If a response includes attachments that exceed 5 megabytes, please e-mail us at the same address for instructions. To avoid confusion, please do not submit both an electronic copy and a hard copy of the same response.

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in this recommendation.

[Original Signed]

By: Deborah A.P. Hersman
Chairman