National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: April 10, 2012

In reply refer to: A-12-9 through -12

Mr. Thomas Camp
President
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The National Transportation Safety Board (NTSB) is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. They are derived from the NTSB's ongoing investigation of the September 16, 2011, accident that occurred at the Reno National Championship Air Races (NCAR) in Reno, Nevada, and are consistent with the evidence and preliminary findings. The NTSB would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

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 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

[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.

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) 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 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 safety improvements regarding evaluation of aircraft with structural or flight control modifications, prerace technical inspections, and training for air race pilots concerning potential physiological effects of high g[4] operations.

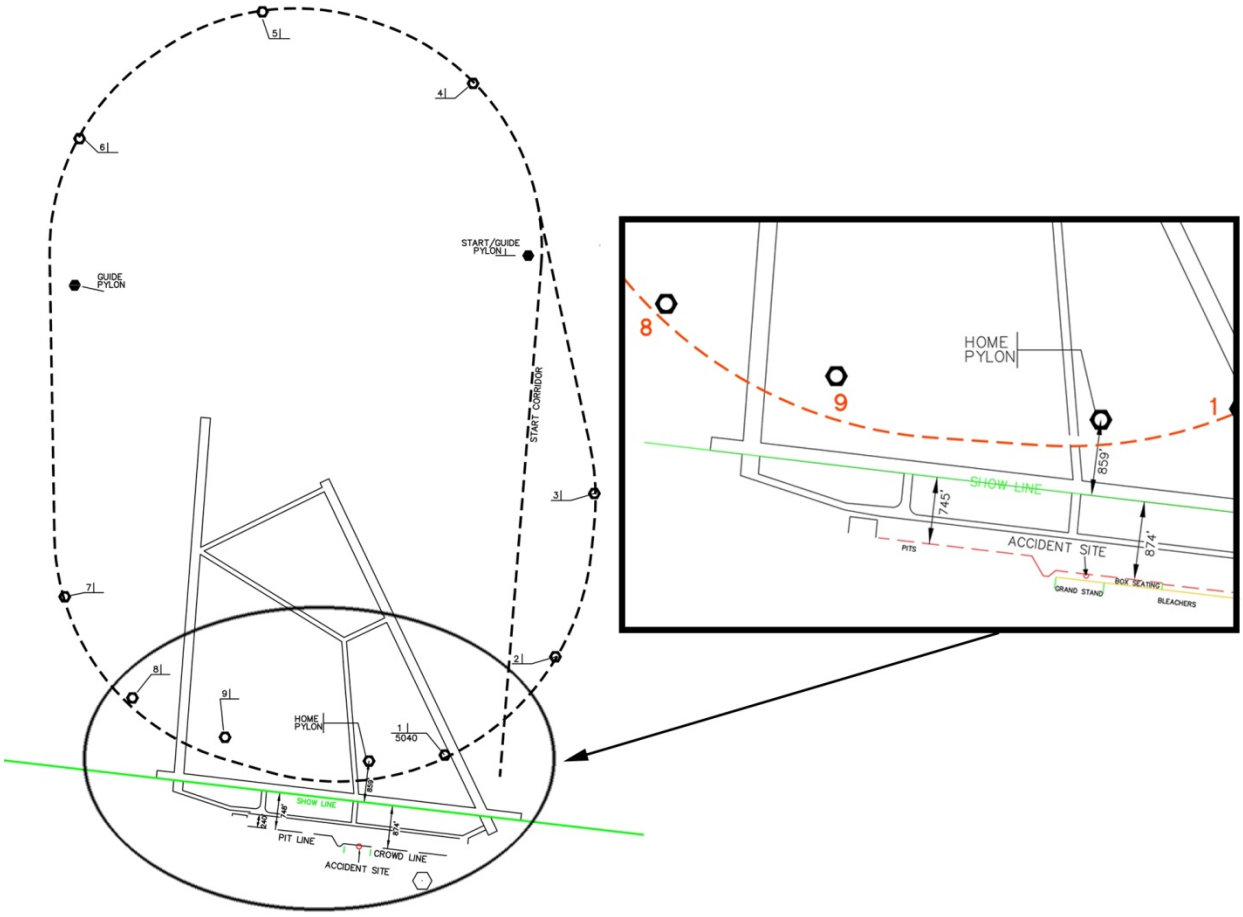

Figure. Diagram of the NCAR unlimited class race course.

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

[4] A "g" or "g-force" is a ratio of the acceleration on an object to the earth's gravitational acceleration (a constant equal to approximately 32.2 feet/second^2).

Evaluation of Aircraft with Structural or Flight Control Modifications

The accident airplane had undergone several structural and flight control modifications, which were performed with the intent of increasing its operating speeds and improving the handling qualities of the airplane at race speeds. These modifications included shortened wings and ailerons, a substantially lightened elevator inertia weight,[5] elimination of the stabilizer and elevator tips, reversal of the lateral offset of the vertical stabilizer leading edge, removal of the rudder trim tab, addition of significant weight (with paint and filler) behind the hinge line of the elevator tabs, installation of an electrical system for operation of the left elevator and the aileron trim tabs, and disconnection of the right elevator trim tab from the pitch trim system. In addition, the right elevator trim tab was locked in the faired position.

In compliance with Federal regulations,[6] the following statement, dated September 22, 2009, appears in the airplane's log books indicating that the mechanic certified:

> …that the prescribed flight test hours have been completed and the aircraft is controllable throughout its normal range of speeds and throughout all maneuvers to be executed, has no hazardous operating characteristics and design features and is safe for operation.

The NTSB notes, however, that such a statement does not necessarily mean that the airplane, with its modifications, was evaluated while operating within the speed and flight regimes that would be encountered on the race course. Review of the airplane's maintenance records and documentation associated with its experimental airworthiness certificate found no evidence that any engineering evaluation of the modifications had been performed. Such an evaluation would provide an opportunity to identify potential unintended consequences of the modifications. For example, shortened wings require higher angles of attack, which, if executed at higher speeds, raise the possibility of destabilizing effects or control anomalies. The use of one tab to drive both elevators raises concerns about structure and flutter;[7] the pinned elevator tab also raises concerns about stiffness and flutter. The addition of weight behind the hinge line of the elevator tabs may decrease the flutter margin.

As a modified fighter aircraft, the accident airplane was not subject to the National Air Racing Group (NAG) Unlimited Division's[8] rules concerning additional design and test criteria.[9]

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[5] This component is commonly referred to as a bob weight, which is a device intended to increase maneuvering stability.

[6] Title 14 CFR 91.319, "Aircraft Having Experimental Certificates: Operating Limitations," states, in part, "No person may operate an aircraft that has an experimental certificate outside of an area assigned by the Administrator until it is shown that— (1) The aircraft is controllable throughout its normal range of speeds and throughout all the maneuvers to be executed; and (2) The aircraft has no hazardous operating characteristics or design features."

[7] Aerodynamic flutter is a type of dynamic aeroelasticity that occurs when aerodynamic and structural forces interact in such a way that energy from the airflow around an airplane gives rise to an unsafe structural vibration in the airplane.

[8] The bylaws of the NAG Unlimited Division state, in part, that the purpose of the organization is to promote and advance the sport of unlimited air racing by providing central leadership and organization for the sport, as well as standards of aircraft and pilot qualifications, technical specifications, and rules of competition.

[9] According to the division's rules, aircraft that are not modified versions of previously designed and built fighter aircraft are designated as custom-built aircraft and are required to meet certain design and test criteria, above and beyond criteria specified in Federal regulations, to ensure their safe operation. Such custom-built aircraft are

The NTSB's investigation continues to examine how the modifications to the accident airplane may have affected its performance. Although this information has yet to be fully determined, the NTSB is concerned that neither the NAG Unlimited Division nor Reno Air Racing Association (RARA) require as a condition of eligibility that modified aircraft like the accident airplane be subjected to analysis that demonstrates they can be safely operated at race speeds and maneuver loads that would be encountered on the course. Because modifications to the structure or flight controls of aircraft may introduce unintended consequences, the NTSB concludes that such aircraft should not be allowed to operate near spectators without a measured evaluation of whether they can do so safely. Therefore, the NTSB recommends that the NAG Unlimited Division require aircraft owners in the unlimited class to provide an engineering evaluation that includes flight demonstrations and analysis within the anticipated flight envelope for aircraft with any major modification, such as to the structure or flight controls.

Prerace Technical Inspections

Preliminary findings in the investigation indicate that two discrepancies on the accident airplane were noted during the prerace technical inspection for the unlimited class, but resolution for the items was not recorded. One of the noted discrepancies concerned the elevator trim tab screws being too short. The second discrepancy concerned the main landing gear. During postaccident interviews, the prerace technical inspector indicated that he verified that the discrepancies had been addressed. The investigation found that no documenting mechanism is in place within the unlimited class technical inspection process to confirm that noted discrepancies have been resolved.

At the NTSB's January 10, 2012, hearing on air race and air show safety, hearing participants indicated that the role of the technical inspection committee at an air event is to ensure compliance with race class rules by inspecting each aircraft entered and providing a record of technical inspection to the event organizer. Each race class is responsible for organizing its own inspection committee. The NTSB notes that, without a method to track discrepancies to resolution, conducting prerace inspections is of limited value. The NTSB concludes that developing a tracking mechanism for the resolution of discrepancies is key to ensuring that inspection items are addressed before a race. Therefore, the NTSB recommends that the NAG Unlimited Division develop a system that tracks any discrepancies noted during prerace technical inspections and verifies that they have been resolved.

Training and Mitigation Techniques for High *g* Operations

Telemetry data[10] and video/photographic evidence of the accident airplane indicate that the airplane reached extremely high *g* levels, and the pilot likely became incapacitated during the

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required to undergo a flight flutter test analysis and test plan, and their results are required to be submitted to the Unlimited Division technical committee, to verify that the aircraft can be safely operated within the structural limits and will be outside of the flutter region at speeds and load factors within the anticipated flight envelope. The rules state that the division will hire impartial, qualified personnel to review and comment on the data. By reference to the division's rules, the Reno Air Racing Association rules for aircraft eligibility apply the same requirements.

[10] The accident airplane was equipped with a telemetry unit that recorded various data parameters onto a memory card and broadcasted these data to a ground station operated by a pit crewmember.

accident sequence. As has been established in numerous aeronautical publications,[11] when exposed to high *g* forces, a pilot can experience a range of impairing effects (such as graying or complete loss of vision and loss of consciousness) because of decreased blood flow to the brain. Individual tolerance to high *g* exposure varies depending on the rate of onset and how long the forces are imposed, as well as a person's anthropometry[12] and training. While the NTSB recognizes that the unlimited race course is designed[13] for operational *g* levels that are well within the limits of human tolerance, air race pilots can still face the risk of impairment while operating at lesser forces.

Generally, air race pilots, including those participating in the NCAR, are not required to undergo training to increase tolerance to high *g* exposure by learning practices that can mitigate the effects or by wearing a *g* suit.[14] Repeated, progressive exposure to high *g* forces (such as during regular practice sessions) can also increase tolerance, but it can be diminished after a few days or weeks without exposure. At the public hearing, a representative of Red Bull Air Race testified that his organization requires its pilots to take *g* tolerance training and wear hydrostatic *g* suits.

The NTSB believes that the NAG Unlimited Division and RARA rules provide several opportunities to address high *g* training, including mitigation techniques, with pilots. For example, as a prerequisite for an invitation to race, all pilots who wish to participate are required to submit an entry packet within 2 months of the NCAR. The packet includes a checklist of pilot information that should be provided. Both organizations require pilots who have never raced or have not raced in the previous 3 years to attend a pylon race school that is typically held 3 months before the NCAR; some pilots who are not required to attend come to this session voluntarily. Additionally, mandatory safety briefs are held before any entrant is allowed on the course to practice, qualify, or race, and daily briefs are held during the NCAR. The NTSB notes that the entry packet and checklist would be useful ways to disseminate a recommended schedule for increasing pilot tolerance to high *g* operations and for pilots to indicate that they trained in accordance with such a schedule before arriving at the NCAR. A segment devoted to high *g* tolerance could also be incorporated into the summer training session and discussed during the daily briefs.

The NTSB concludes that providing high *g* training to pilots racing at the NCAR will help them prepare for the potential effects of high *g* exposure. Therefore, the NTSB recommends that the NAG Unlimited Division provide high *g* training to pilots, including techniques to

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[11] For more information, see (a) *G Effects on the Pilot During Aerobatics*, Federal Aviation Administration (FAA) Report FAA-AM-72-28 (Washington, DC: Federal Aviation Administration, 1972); (b) Advisory Circular (AC) 91-61, *A Hazard in Aeronautics: Effects of G Forces on Pilots*; and (c) paragraph 8-1-7, "Aerobatic Flight" in the *Aeronautical Information Manual* (AIM). Issuance of AC 91-61 and the inclusion of this topic in the AIM occurred as a result of NTSB Safety Recommendation A-81-48, which asked the FAA to revise the AIM to briefly discuss the physiology of aerobatic *g* forces as explained in FAA-AM-72-28.

[12] Anthropometry is the science that deals with the measurement of the size, weight, and proportions of the human body. Germane to the discussion of *g* tolerance is the heart-to-brain hydrostatic column length.

[13] According to RARA, the aircraft operating criteria for the unlimited class course and FAA-required safety areas is 525 mph and 3.5 *g*; racing aircraft can reach 4 *g*.

[14] A *g* suit is designed to counteract the physiological effects of acceleration through mechanical compression of the abdomen and legs, thus increasing venous blood return to the heart.

mitigate the potential effects of high *g* exposure, as part of preparations before the NCAR and during daily briefs at the NCAR. The NTSB also recommends that the NAG Unlimited Division evaluate the feasibility of requiring pilots to wear *g* suits when racing at the NCAR; if the evaluation determines it is feasible, implement a requirement.

Therefore the National Transportation Safety Board makes the following recommendations to the National Air Racing Group Unlimited Division:

> Require aircraft owners in the unlimited class to provide an engineering evaluation that includes flight demonstrations and analysis within the anticipated flight envelope for aircraft with any major modification, such as to the structure or flight controls. (A-12-9)
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> Develop a system that tracks any discrepancies noted during prerace technical inspections and verifies that they have been resolved. (A-12-10)
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> Provide high *g* training to pilots, including techniques to mitigate the potential effects of high *g* exposure, as part of preparations before the Reno National Championship Air Races (NCAR) and during daily briefs at the NCAR. (A-12-11)
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> Evaluate the feasibility of requiring pilots to wear *g* suits when racing at the Reno National Championship Air Races; if the evaluation determines it is feasible, implement a requirement. (A-12-12)

The NTSB also issued safety recommendations to the Federal Aviation Administration and the Reno Air Racing Association.

In response to the recommendations in this letter, please refer to Safety Recommendations A-12-9 through -12. 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 these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman