



Aviation Investigation Final Report

Location:	Fairfield, California	Accident Number:	WPR14FA182
Date & Time:	May 4, 2014, 13:59 Local	Registration:	N68828
Aircraft:	Boeing E75	Aircraft Damage:	Destroyed
Defining Event:	Low altitude operation/event	Injuries:	1 Fatal
Flight Conducted Under:	Part 91: General aviation - Air race/show		

Analysis

The highly experienced air show pilot was attempting to cut, with the vertical stabilizer of his biplane, a ribbon that was suspended about 20 feet above and across the runway. He was performing the maneuver on the third day of an open house at a United States Air Force (USAF) base and had successfully accomplished the maneuver on the two previous days, as well as at many previous air shows. After the pilot rolled the airplane inverted for the pass, witnesses observed it descend smoothly to the runway and slide to a stop. As the airplane came to a stop, a fire erupted, and the airplane was completely engulfed in flames within about 90 seconds of the fire's start. The first fire suppression vehicle did not reach the airplane until more than 4 minutes after the fire began, and the fire was extinguished soon thereafter.

The investigation did not identify any preimpact mechanical deficiencies or failures of the airplane or any adverse weather conditions that contributed to the abnormal runway contact. Toxicology analysis detected therapeutic amounts of diphenhydramine, an over-the-counter sedating antihistamine, in the pilot's blood, which likely impaired his ability to safely complete the maneuver and resulted in the abnormal runway contact.

The pilot was found lying on the upper panel of the cockpit canopy, and the canopy was found unlatched but in its closed position, indicating that when the airplane came to a stop, the pilot was likely conscious and attempted to exit the airplane; however, he was unsuccessful. The investigation was unable to determine when the pilot released his harness restraint system. If he released his harness before attempting to open the canopy, he would have fallen onto the canopy, which would have significantly increased the difficulty of opening the canopy. Even if the pilot did not release his harness before attempting to open the canopy, airframe damage and the canopy opening geometry would have prevented the full opening of the canopy, limiting the pilot's ability to exit. Further, the canopy was not equipped with any emergency egress provisions, such as quick-release hinge pins. Finally, the pilot's lack of a helmet or any fire protection garments increased his susceptibility to thermal injury and reduced his useful time to effect an exit, particularly given the rapidity of the fire's spread.

Although initially a survivable accident, the combination of pilot egress difficulties, the rapid fire growth, and the more than 4-minute firefighting response time altered the final outcome. The USAF primarily based its Airport Rescue and Fire Fighting (ARFF) plan for the air show on Department of Defense (DoD) and USAF guidance. In preparation for the open house, the USAF show director had attended an International Council of Air Shows (ICAS) trade show and briefing, where he was provided with ICAS guidance material that advocated the highest state of readiness for the ARFF teams. This entailed prepositioning the ARFF equipment, with the ARFF personnel fully suited in their protective gear, ready for immediate travel to and engagement in the rescue and firefighting efforts. For undetermined reasons, either that information was not communicated to the show organizers and ARFF planners or the responsible personnel and departments elected to disregard it. The organizers and planners made the decision to maintain the facility's ARFF readiness state at the DoD-defined "unannounced emergency" level during the air show, instead of the highest state of ARFF readiness advocated by ICAS. Based on the available evidence, if the ARFF teams had been at the highest state of ARFF readiness, the pilot's likelihood of survival would have been significantly increased.

The hazards imposed by low-level inverted flight included inadvertent ground contact, impact damage, and fire. The pilot had multiple strategies available to manage or mitigate the hazards' attendant risks. These included ensuring that he was in appropriate physiological and psychological condition to operate safely, wearing appropriate protective clothing, and ensuring an appropriate level of airplane crashworthiness including occupant escape provisions. The availability of ARFF services represented the final element of the risk management process, necessary only if all the other strategies failed or were otherwise ineffective. In this accident, the pilot either intentionally or unknowingly weakened, defeated, or did not implement several risk mitigation strategies: he was likely impaired by medication, he did not wear any protective clothing, and his airplane was not well-equipped from an occupant-escape perspective. The combination of these factors then resulted in the pilot being fully dependent on the timely arrival of ARFF personnel and equipment for his survival. The failure of the ARFF personnel and equipment to be at their highest level of readiness and to arrive in a timely manner was not the first, but rather the last, failed element of the overall risk-management scheme.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilot's failure to maintain clearance from the runway during a low-level aerobatic maneuver due to his impairment by an over-the-counter antihistamine. Contributing to the severity of the pilot's injuries were the pilot's lack of fire protective clothing, his inability to egress the cockpit, the rapid spread of the fire, and the decision of the air show's organizers not to have the airport rescue and firefighting services at their highest level of readiness, which delayed arrival of fire suppression equipment.

Findings

Personnel issues	OTC medication - Pilot
Personnel issues	Aircraft control - Pilot
Aircraft	Altitude - Not attained/maintained
Environmental issues	Emergency/fire/rescue services - Ability to respond/compensate

Factual Information

History of Flight

Maneuvering-low-alt flying	Low altitude operation/event (Defining event)
Maneuvering-low-alt flying	Collision with terr/obj (non-CFIT)
Post-impact	Fire/smoke (post-impact)

On May 4, 2014, about 1359 Pacific daylight time, a Boeing E75, N68828, was destroyed when it impacted runway 21R during an aerial demonstration flight at Travis Air Force Base (SUU), Fairfield, California. The commercial pilot/owner received fatal injuries. The exhibition flight was operated under the provisions of Title 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed, and no flight plan was filed for the flight.

The pilot was one of several civilian aerial demonstration pilots who performed at the 2-day SUU "Thunder Over Solano" open house, which included both static (ground) and aerial (flight) displays. According to United States Air Force (USAF) and Federal Aviation Administration (FAA) information, Friday, May 2, was the practice day, while the public event took place on Saturday and Sunday, May 3 and 4. The pilot flew two flight demonstration airplanes at the event; a North American P-51, and the accident airplane. All his flights preceding the accident flight were uneventful.

The accident occurred during a "ribbon-cut maneuver," whereby a ribbon was suspended transversely across the runway, between two poles held by ground crew personnel, and situated about 20 feet above the runway. The planned maneuver consisted of a total of three passes. The first two passes were to be conducted with the airplane upright, and were not planned to contact the ribbon. The final pass was to be conducted inverted, and the airplane would cut the ribbon with its vertical stabilizer. The first two passes were successful, but on the third (inverted, ribbon-cut) pass, the airplane was too high, and did not cut the ribbon. The pilot then initiated a fourth pass, and rolled the airplane inverted after aligning with the runway. The airplane contacted the runway prior to reaching the ribbon, slid inverted between the ground crew personnel holding the ribbon poles, and came to a stop a few hundred feet beyond them. A fire began as the airplane stopped. The pilot did not exit the airplane, and was fatally injured.

Pilot Information

Certificate:	Commercial	Age:	77, Male
Airplane Rating(s):	Single-engine land; Multi-engine land	Seat Occupied:	Rear
Other Aircraft Rating(s):	None	Restraint Used:	Unknown
Instrument Rating(s):	Airplane	Second Pilot Present:	No
Instructor Rating(s):	None	Toxicology Performed:	Yes
Medical Certification:	Class 2 With waivers/limitations	Last FAA Medical Exam:	June 4, 2013
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	
Flight Time:	11400 hours (Total, all aircraft)		

The 77-year-old pilot was a well known air show performer in the western United States. FAA records indicated that the pilot held a commercial pilot certificate, with single- and multi-engine airplane, and instrument airplane ratings, and was authorized to fly several experimental airplanes. His most recent FAA second-class medical certificate was issued in June 2013; on that application the pilot indicated that he had a total civilian flight experience of 11,400 hours.

Aircraft and Owner/Operator Information

Aircraft Make:	Boeing	Registration:	N68828
Model/Series:	E75	Aircraft Category:	Airplane
Year of Manufacture:	1944	Amateur Built:	
Airworthiness Certificate:	Experimental (Special)	Serial Number:	75-5681
Landing Gear Type:	Tailwheel	Seats:	2
Date/Type of Last Inspection:	April 15, 2014 Annual	Certified Max Gross Wt.:	
Time Since Last Inspection:		Engines:	Reciprocating
Airframe Total Time:	2160 Hrs as of last inspection	Engine Manufacturer:	Pratt & Whitney
ELT:		Engine Model/Series:	R-985
Registered Owner:	On file	Rated Power:	
Operator:	On file	Operating Certificate(s) Held:	None

FAA information indicated that the airplane was manufactured in 1944, and was first registered to the pilot in 1982. The airplane was equipped with a Pratt & Whitney R-985 series engine. The fuselage and empennage consisted of a synthetic-fabric covered steel tube structure, while the wings were primarily wood structure covered with the same type of fabric. The airplane was equipped with two tandem

cockpits enclosed by a single canopy; the pilot flew the airplane from the aft cockpit.

The canopy consisted of a light metal frame (aluminum and steel) and plastic transparencies. The canopy was not part of the original airplane design or configuration. According to maintenance record information, and information provided by the pilot's family, the canopy was designed by the pilot with help from Serv Aero in Salinas, California. It was a modified version of the canopy from a "Varga" airplane, and had been installed on the accident airplane in November 1985. The canopy was intended to "improve air flow over the elevator and rudder for better flight control," and to provide additional cockpit comfort, in terms of reduced noise and wind blast.

The longitudinal section of the canopy consisted of one fixed panel (right side) and two movable panels (top and left side). The top panel was longitudinally hinged to the fixed right panel and the movable left panel, and the forward and aft bottom corners of the left panel rode in transverse tracks at the forward and aft ends of the cockpit. That design allowed cockpit entry and egress by operating the top and left canopy panels in a manner similar to a bi-fold door; which required approximately 18 inches of clearance above the canopy for the canopy to be opened.

The 47-gallon aluminum fuel tank was mounted in the center section of the upper wing, just forward of the cockpit. The main fuel tank was equipped with a central filler neck with a cap that protruded about 1.5 inches above the tank upper mold line. Four non-metallic flexible fuel lines, one near each lower corner of the main tank, enabled fuel to be supplied from the main tank.

An aluminum header fuel tank, of approximately 3 gallons capacity, was mounted in the fuselage forward of the cockpit. An oil tank for smoke generation was mounted below and slightly aft of the header tank.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	SUU, 51 ft msl	Distance from Accident Site:	0 Nautical Miles
Observation Time:	13:58 Local	Direction from Accident Site:	
Lowest Cloud Condition:	Few / 18000 ft AGL	Visibility	10 miles
Lowest Ceiling:	None	Visibility (RVR):	
Wind Speed/Gusts:	15 knots / 21 knots	Turbulence Type Forecast/Actual:	/ Unknown
Wind Direction:	240°	Turbulence Severity Forecast/Actual:	/ N/A
Altimeter Setting:		Temperature/Dew Point:	22°C / 12°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Fairfield, CA (SUU)	Type of Flight Plan Filed:	None
Destination:	Fairfield, CA (SUU)	Type of Clearance:	None
Departure Time:		Type of Airspace:	

The SUU 1358 automated weather observation included wind from 240 degrees at 15 knots gusting to 21, visibility 10 miles, few clouds at 18,000 feet, temperature 22 degrees C, dew

point 12 degrees C, and an altimeter setting of 29.99 inches of mercury.

Airport Information

Airport:	Travis AFB SUU	Runway Surface Type:	Concrete
Airport Elevation:	51 ft msl	Runway Surface Condition:	Dry
Runway Used:	21R	IFR Approach:	None
Runway Length/Width:	11001 ft / 150 ft	VFR Approach/Landing:	None

The airport was equipped with two primary runways. The two runways, designated 3/21R and 3R/21L were staggered such that the approach end of 3R was adjacent to the approach end of 21R. Runway 31/21R was the primary air show performance runway, and measured 150 by 11,001 feet.

The static displays and spectator areas were situated on the northeast ramp area, northwest of runway 21R. The spectator area was situated about 1,000 feet from the northwest edge of runway 21R.

The air show "performance (or aerobatic) box" measured about 3,000 by 12,000 feet, and was situated on the northeast section of 3L/21R. Air show center was located approximately 1,200 feet beyond the threshold of runway 21R.

Wreckage and Impact Information

Crew Injuries:	1 Fatal	Aircraft Damage:	Destroyed
Passenger Injuries:		Aircraft Fire:	On-ground
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	1 Fatal	Latitude, Longitude:	38.264446,-121.924163(est)

The airplane impacted runway 21R. Ground scars consisted of rudder/ vertical stabilizer ("tail") and upper wing contact (metal and wood scrapes, and paint transfer) with the runway, as well as propeller "slash marks" approximately perpendicular to the direction of travel. Review of image and ground scar data indicated that the airplane first contacted the runway with its right wing, followed by the tail, the left wing, and then the propeller.

The upper outboard right wing initial scar was followed about 7 feet later by the tail strike, and then a few feet later by the upper left wing. The initial tail strike was located about 45 feet right (northeast) of the runway centerline, about 380 feet beyond the runway threshold. The initial direction of travel was aligned approximately 5 degrees to the right (divergent from) the runway axis. The propeller slash marks began about 100 feet beyond the initial tail strike, and continued to the final resting location of the airplane. The slash marks described an arc, which curved to the left. The airplane slid inverted, and traveled a total distance of about 740 feet. It came to a stop near the left (southwest) edge of the runway,

on a magnetic heading of about 140 degrees. Review of still and video imagery revealed that the airplane came to a stop about 13 seconds after it contacted the runway.

Examination of the wreckage indicated that most of the fabric covering on the fuselage was damaged or consumed by fire. The right wing and cockpit furnishings were almost completely consumed by fire, as were some of the aluminum flight control tubes. The left wing and rudder /vertical stabilizer sustained impact deformation, but the cockpit occupiable volume was not compromised by deformation of any surrounding structure.

The fuel lines and the main fuel tank were fire damaged, and at least two thermal penetrations of the main fuel tank were observed; both were consistent with an on-ground fire. The main tank fuel cap was found installed and latched. The cap/neck and surrounding tank skin appeared to be depressed slightly into the tank, but it could not be determined whether the cap and neck leaked fuel after the impact. No evidence of any provisions for increased crashworthiness of the fuel system, such as frangible, self-sealing line couplings, was observed in the wreckage. Due to the level of damage, the investigation was unable to determine the initial source(s) of the fuel that resulted in the rapid growth of the fire.

Still and video images of the accident sequence, combined with on-scene observations, revealed that partial collapses of both the upper wing and the vertical stabilizer and rudder assembly, due to ground contact, resulted in the clearance between the top of the canopy and the runway surface being too small to allow the canopy to be fully opened. The canopy opening geometry was such that the relationship between the vertical travel of the canopy top and the actual opening provided was not linear; a small reduction in the vertical travel capability of the canopy top would result in a significant reduction in the size of the opening it afforded for cockpit egress. The canopy was not equipped with any emergency egress provisions, such as quick-release hinge pins.

All components, with the exception those consumed by fire, were accounted for. No evidence of any pre-impact engine or flight control problems was noted, and no evidence consistent with any pre-impact abnormalities or deficiencies that would have precluded continued flight was observed.

Communications

SUU was equipped with an air traffic control tower (ATCT) that remained staffed and operational during the air show. However, during certain portions of the show, the ATCT ceded control of some of its designated airspace (and the aircraft within) to the air show "air boss." The Air Boss was defined by the FAA as the "individual who has the primary responsibility for air show operations on the active taxiways, runways, and the surrounding air show demonstration area." For this particular event, the Air Boss was a civilian who was well acquainted with the performers, performances, and overall show schedule. The Air Boss and pilots communicate directly with one another via radio. The ATCT and air boss coordinate closely to ensure continuous control of the airspace before, during, and after the show.

In response to an NTSB question, the USAF stated that the "Air Boss turned over control of the airspace to tower and RAPCON [radar approach control] once airborne traffic was assigned to designated holding area behind the crowd. Tower/ground control managed access into the controlled movement

area during the emergency response period via existing protocols. This was briefed at every safety brief before each day of flight, and the actual execution after the mishap followed the briefed plan."

According to the transcript of radio communications between the ATCT, the Air Boss, and aircraft, the first indication of the accident was at 1357:56, when the Air Boss transmitted "Tower, tower, tower, we need to, emergency trucks, roll em out, roll em, roll em, roll the emergency trucks." At 1358:02, an unknown person transmitted "alright," which was followed at 1358:04 by the Air Boss transmitting that he had the "airspace closed for the fire." The transcript did not include any communications regarding that reported closure.

At 1358:14, the ATCT controller transmitted "Tower's got the airspace," followed by the Air Boss 1358:15 transmission of "you got the airspace, you got the field, they are up and moving." At 1358:18, the ATCT transmitted "Roger, we got em rolling."

At 1359:01, the Air Boss asked "tower we got the trucks rolling?" to which the ATCT responded "affirmative and they're coming out to you on the runway now." At 1359:02, an unidentified person transmitted "Air Boss we need fire immediately he is trapped in the airplane and on fire." That discussion continued almost another minute.

At 1401:41, the ATCT transmitted to the Air Boss, who was attempting to land one of the airborne performers, to have that airplane go around, because "responder vehicles just turned on [to runway] two one left." At 1401:57, the ATCT informed the Air Boss that they would advise him when the runway was clear. No further communications regarding the ARFF vehicles or their clearance of the runway were included in the transcript, which ended at 1402:53.

Based on this transcript, the first ARFF vehicles entered the runway about 3 minutes 45 seconds after the first radio transmission announcing the accident.

Medical and Pathological Information

In response to NTSB questions, the pilot's family reported that they were "not aware of any unusual or abnormal issues with either the pilot's sleep patterns before the accident or with the aircraft or the aircraft's maintenance or condition. The pilot was not ill and the family is not aware of any stressors." The family reported that his physical health and mobility was "good," and that he "was quite capable of climbing in and out of both the Stearman and the P-51." They described his mental acuity and awareness as "excellent."

In his most recent application for an FAA second-class medical certificate, the pilot reported high blood pressure, treated with amlodipine and hydrochlorothiazide. The pilot was issued that certificate with unrelated limitations regarding corrective lenses for vision.

The Solano County California County Coroner determined that the cause of death was extensive thermal

injury. The pathologist did not identify evidence of blunt force trauma.

Toxicology testing performed by the FAA's Civil Aerospace Medical Institute did not identify levels of carbon monoxide above 10%. Testing identified amlodipine in heart blood and liver tissue. Cetirizine was detected in the heart blood, but below quantifiable levels. Cetirizine is a sedating antihistamine used to treat allergy symptoms, marketed under the brand name Zyrtec.

Toxicology testing also detected Diphenhydramine in the heart blood and urine. Diphenhydramine is a sedating antihistamine used to treat allergies, cold symptoms, and as a sleep aid. It is available over the counter under various names such as Benadryl and Unisom. Diphenhydramine undergoes postmortem redistribution to the heart blood. As a result, postmortem heart blood diphenhydramine levels may be increased by about a factor of three. The measured diphenhydramine level, when divided by three, was still within the therapeutic range.

Fire

Review of video and still images revealed that fire became visible just as the airplane stopped moving, and some patches of fire were visible on the ground along an apparent fuel trail aft of the airplane. Once the airplane came to a stop, the fire appearance was initially consistent with a "pool fire," which is the combustion of a liquid pooled on the ground. However, the fire enlarged quickly, and within about 50 seconds, the fire encompassed most of the right (downwind) side of the airplane. The airplane was completely engulfed by the fire about 1 minute and 32 seconds after the airplane stopped.

Review of the still and video imagery, and the wreckage, indicated that at first the fire was consistent with liberated gasoline spilled on the ground, but the fire developed rapidly thereafter. It began consuming the airplane skin and structure, and damaged the fuel lines and tanks, which permitted the liberation of additional onboard flammable fluids, including gasoline and oil.

Review of photographic and other documentation indicated that the flames were no longer visible about 5 minutes and 17 seconds after impact, or about 15 seconds after truck-provided fire fighting agent began contacting the fire. USAF information indicated that the fire was "knocked down" (significantly reduced) about 6 minutes and 38 seconds after it started, and that it was extinguished about 9 minutes after it started. The fire-fighting activities are detailed in a separate section below.

Survival Aspects

According to information provided by first responders, after the fire was extinguished, the pilot was observed to be within the cockpit, lying on his back on the upper canopy frame, with his head towards the tail. The airplane fuselage had settled slightly during or subsequent to the fire, so that the top of the canopy was resting on the runway surface. Photographs taken prior to the recovery of the pilot showed that the movable left side canopy panel was unlatched, but essentially in its closed position, with at least

its aft guide pins still in the canopy track.

Due to lack of evidence, the investigation was unable to determine when the pilot unfastened his restraint system. With the airplane inverted, release of the restraint system prior to an attempt to open the canopy would result in the pilot's fall onto the canopy, which would interfere with his ability to open the canopy.

The pilot was not wearing a helmet, and there was no evidence that he was wearing any garments or equipment designed for thermal/fire protection, including gloves.

National Fire Protection Association

The National Fire Protection Association (NFPA) is a trade association that develops and distributes standards for fire fighting and rescue response, including airport ARFF equipment and staffing provisions. NFPA establishes recommended airport ARFF equipment and staffing provisions ("level of protection") based on "the largest aircraft scheduled into the airport." NFPA guidance did not cite any standards specifically or exclusively for air shows, airport open houses, or other non-standard situations or events.

NFPA Standard 403 (Standard for Aircraft Rescue and Fire-Fighting Services at Airports) included the following specifics regarding ARFF vehicle siting:

- ARFF vehicles shall be garaged at one or more strategic locations as needed to meet required response times.
- Emergency equipment shall have immediate and direct access to critical aircraft movement areas and the capability of reaching all points within the rapid response area (RRA) in the time specified.
- Therefore, the location of the airport fire station shall be based on minimizing response time to aircraft accident and incidents.
- The response time of the first responding ARFF vehicle to reach any point on the operational runway and begin agent application shall be within 3 minutes of the time of the alarm.

FAA Air Show Guidance and Requirements

The USAF/SUU required FAA approval to conduct its open house and air show. FAA approval was granted in the form of FAA Form 7711-1, "Certificate of Waiver or Authorization." Chapter 6 of FAA Order 8900.1 contained the guidance for the issuance of the waiver/authorization. The USAF/SUU ("the applicant") was responsible to apply for the waiver/authorization to the responsible FAA office, which was the Sacramento Flight Standards District Office (FSDO). The Order specified that the FAA inspector assigned to the event "should work closely with the responsible [event] person to develop normal and emergency plans, briefings, and checklists." The waiver for the air show was approved by the FAA on March 28, 2014.

Order 8900.1 required that the applicant "should attach current, properly marked maps, drawings, or photographs of the planned area of operation" which must include the "location of the boundaries of the air show demonstration area, the location of the primary spectator area, [and] the location of the emergency vehicles and medical facilities."

Order 8900.1 required that a pre-show briefing must occur on every day of the show, and provided guidance in both narrative and checklist form. The guidance specified that attendees should include all air show pilots, the Air Boss, air traffic control, the "fire chief/CRS" [crash/rescue services], and an FAA representative. One of the mandatory elements of the briefing was that "the fire fighting and emergency services equipment available, including their location and the access routes to be kept clear, must be discussed."

Travis Fire Emergency Services Flight

The Travis Fire Emergency Services Flight (TFES) was established to provide emergency services to Travis Air Force Base (TAFB). The Travis Fire Emergency Service Flight is assigned to the 60th Civil Engineer Squadron, 60th Mission Support Group, 60th Air Mobility Wing, 18th Numbered Air Force, Air Mobility Command.

A document entitled the Travis Fire Emergency Services Standards of Cover (SOC) was written by the 60th Civil Engineer Squadron (CES) Fire Emergency Services Flight division to "define the distribution and concentration of fixed and mobile resources available to TFES." The document introduction stated that the "SOC is a system that includes an analysis of risks and expectations to assist in making decisions on force deployment issues." The SOC contained detailed information about ARFF staffing, equipment, and facilities, as well as protocols, priorities, and performance metrics.

USAF/SUU Emergency Services Planning

The February 2014 edition of the USAF/SUU "Installation Emergency Management Plan" provided detailed guidance on that topic. Appendix 2 ("On Base Aircraft Accident/Major Accident Response") included the following guidance for specific responsibilities and duties:

Emergency Communications Center:

- Develop safe route if time/situation permits
- Dispatch the appropriate resources required for initial response
- Maintain contact with responding [incident commander] and responders
- Ensure follow-on communications are prioritized and processed

Air Traffic Control Tower:

- Activate the primary crash phone network
- Ensure taxiing and airborne aircraft are advised of emergency information
- If feasible, obtain basic overhead survey information from local flights
- Ensure [approach control] is informed

Review of the ATCT transcripts and other documentation indicated that the relevant items were complied with.

USAF and SUU ARFF Guidance and Provisions

Department of Defense Instruction (DoDI) 6055.06, ("Fire and Emergency Services Program"), contained the applicable ARFF response criteria pertaining to response time, fire fighting vehicle agent

requirements, and minimum ARFF vehicle staffing for its facilities, including SUU.

DoDI 6055.06 delineated required response time criteria as a function of which of two categories, "announced" or "unannounced," the particular emergency event falls into. Unannounced emergencies are those that occur at the facility during normal operational activities, without any prior notification to the ARFF command that a problem is either likely or is developing. For unannounced aircraft incidents or accidents, DoDI 6055.06 requires that "ARFF apparatus will be capable of responding to any incident/accident on the runway(s) within 5 minutes." Response time begins when ARFF crews receive notification of an emergency and ends when the first ARFF vehicle that is capable of expending fire fighting agent arrives at the aircraft incident/accident. The remaining primary ARFF vehicles must arrive on scene at intervals not exceeding 30-seconds.

In contrast, "announced" emergencies are those where the ARFF command has received an indication of a problem or potential problem, such as an aircraft inbound with a mechanical problem or fire. Announced emergencies assume that ARFF equipment has been pre-positioned for that emergency. For announced emergencies, DoDI 6055.06 requires that "ARFF apparatus will be capable of responding to any incident on the runways within 1 minute."

The USAF uses Air Force Instruction (AFI) 32-2001 ("The Fire Emergency Services Program"), as the means to identify service specific requirements to implement DoDI 6055.06. Based on that guidance and DoDI 6055.06, the USAF/SUU considered the air show activities to be normal operations, and that the required response times were per unannounced emergencies (5 minutes).

The investigation did not determine whether the Air Boss or any performers were aware of those two standards, or that the "unannounced emergency" standard was the one used by the USAF/SUU for the event.

USAF Open House Guidance

Additional guidance was provided by USAF publication AFI 10-1004 ("Conducting Air Force Open Houses"), with a most recent issue date of February 2010. That document provided additional guidance, including the following:

- "The safety of the spectators is of utmost importance"
- Vehicles and aircraft that would "obstruct spectators' view of the show line" should be repositioned
- "The FAA requires that the aerobatic box be void of all people not specifically participating in the demonstration"
- Personnel in the aerobatic box "should be kept to a minimum," and those personnel are only permitted there provided they are "properly briefed, are in communication with the Air Boss, and all [show] participants are aware of them."
- "Emergency vehicles will be pre-positioned...as not to be 'trapped' behind the crowd control lines"

The document did not provide any guidance on ARFF response times or ARFF personnel readiness.

SUU Fire Station Information

The SUU ARFF rating was categorized as an NFPA Airport Category 10 airfield. NFPA Category 10 is

the highest level of ARFF protection, in terms of type and amount of ARFF equipment. The USAF/SUU aircraft which resulted in the category 10 rating (and agent quantities) were significantly larger than the accident airplane. Air Force ARFF categories are consistent with NFPA-specified airport categories, agent levels, and vehicle requirements.

According to information provided by the USAF, the normal complement and stationing of SUU ARFF vehicles was:

Fire Station 1- one T-3000 (3,000 gallons, "g"), two P-23s (3,300 g each), 1 RIV[Rapid Intervention Vehicle] (400 g)

Fire Station 3- one P-23 (3,300 g)

SUU modified its normal ARFF provisions and equipment stationing for the air show. According to USAF information, SUU "FES placed additional vehicles...adjacent to the runway. SUU FES placed assets at all three flight line fire stations (1, 3, & 4) as follows:

Fire Station 1 - two P-23s, one T-3000.

Fire Station 3- one P-23, one RIV.

Fire Station 4 - one P-23, one RIV, one P-26 5,000 gallon water tender.

According to USAF/SUU documentation, there were one primary and three secondary "crash response" locations designated for the air show. The primary facility (designated "Fire Station 1", or "FS 1") was located at approximately air show center (the longitudinal center of the designated performance box), but was situated behind the spectators; the spectators were located between the facility and the flight line. That facility was located about 1,000 feet from the closest edge of the performance box. There was no pre-established clear path through the spectators to enable the FS 1 ARFF vehicles to drive directly to the nearest boundary of the flight line or performance box.

In response to an investigation query regarding the location of FS 1 ARFF vehicles and personnel behind the spectators, the USAF/SUU stated that "Prioritization discussions, for the top hazards based on credible threat, took place to identify the most hazardous conditions to anticipate. It was determined that the number one priority, for all response entities, was that of the life hazard to the anticipated 200K+ visitors over the weekend." In other words, the primary responsibility of FS 1 was the attendees, and such positioning provided FS 1 with unrestricted access to the attendees. That rationale accounted for the designation of FS 1 as the "primary" FS, even though it was not the primary FS for the flight line. Flight line response was categorized as a "backup" responsibility of FS 1.

A secondary crash facility was located at each of the northeast and southwest corners of the performance box/flight line. The station at the northeast corner was designated "FS 3," and the station at the southwest corner was designated "FS 4." No spectators, personnel, buildings, or vehicles were situated between either of those two facilities and the flight line. Hence, despite their "secondary" designation in some documents and communications, FS 3 and FS 4 were actually the two primary ARFF facilities for the flight line.

The USAF/SUU stated that FS 4 was only used for the air show, and that for the show it also housed a "Fire Command and Control vehicle/person along with Flight Medicine Ambulance with a Doctor." The USAF/SUU stated that the siting of the attendees "centralized in front of bldg. 38 (Fire Station #1) was a primary concern of the FES flight driving us to adjust our assets" by temporarily using FS 4. In this

configuration for the air show days, FS 3 and FS 4 were the two stations with primary responsibility for the flight line.

The USAF/SUU stated that on May 2nd (the air show practice day) ARFF vehicles were stationed, per their normal configuration, at FS 1 and FS 3. FS 4 was not staffed that day because "there was a clear path of travel from fire station 1 to the runway," due to the fact that the spectators were not present.

The fourth facility (FS 2) was situated in a hangar within an SUU building complex, about 4,000 feet northwest of air show center. That facility was designated primarily for structural (building/facility) responses.

In its formal response to NTSB queries, the USAF/SUU stated that "Posturing of vehicles were vetted and approved via the FAA waiver process and [in accordance with] AFI 10-1004 and the FAA 8009 [sic; should be "8900"] series regulations. There were no discussions leading up to the event from any performer, FAA rep, or fire rep that indicated placement of equipment was inadequate for safety and/or response time." The USAF/SUU also noted that the 2014 "ARFF posting plan was consistent with previous shows at Travis AFB."

Ground Vehicle Access to Movement Areas

Travis Air Force Base Instruction (TAFBI) 13-213 ("Airfield Driving"), with a most recent pre-accident issue date of December 2013, prohibits any vehicles from entering the Controlled Movement Area (CMA) without specific approval from the air traffic control tower. According to TAFBI 13-213, the CMA "is comprised of both runways, the landing zone, overruns, 100 feet on either side of the runways." The guidance also stated that "Everyone must read back all ATC instructions verbatim. All vehicles will stop at the VFR hold line and request permission to enter the CMA." It continued with "All emergency response vehicles must have approval from the Tower or authorized vehicle escort, to enter the CMA" and "Vehicles responding to an emergency on the runway must NEVER assume they have blanket permission to enter the runway after an emergency aircraft lands. All vehicles MUST call tower and receive permission to enter the runway PRIOR to accessing it."

The USAF-produced transcript of the ATCT communications did not include any communications to or from any ARFF vehicles, and no ARFF vehicle communications were provided to the investigation. This absence of data precluded a determination of whether any CMA access permission issues contributed to ARFF vehicle response delays.

Ground Vehicle Speed Limit Information

TAFBI 13-213 presented the following speed limit information:

- Aircraft Parking Ramps - 15 MPH maximum for general purpose vehicles
- Taxiways - 15 MPH unless otherwise posted
- Perimeter Road - 35 MPH maximum or as posted
- "Emergency response vehicles may exceed 10 MPH above their speed limit when responding to an emergency/alert and with rotating beacon lights and/or emergency flashers. However; emergency/alert vehicles should not assume the right of way and must use the utmost safety and caution when responding."

The TEFS SOC included a study to determine the effectiveness of its normal-configuration ARFF locations, and to evaluate the expected travel times to the ends of the two runways, as compared to the 3 minute travel time objectives set forth in AFI 32-2001 ("Fire Emergency Services"). The study used a standard vehicle speed of 45 mph for consistency with NFPA Standard 403. The SOC did not explain or justify why the study used that fixed speed, when it differed significantly from some of the actual SUU speed limits. That study concluded that ARFF vehicles from FS 1 could not meet the AFI 32-2001 standard, while vehicles from FS 3 could, with a margin of 17 seconds.

Due to lack of data, the investigation was unable to determine any ARFF vehicle speeds during the response, or what effect their speeds had on their response times.

ICAS Information

According to its website, the International Council of Air Shows (ICAS) is a trade and professional association intended to "protect and promote their interests in the growing North American air show marketplace." The current ICAS mission statement is that the organization is "dedicated to building and sustaining a vibrant air show industry to support its membership. To achieve this goal, ICAS will demand its members operate their business at only the highest levels of safety, professionalism, and integrity."

ICAS actively produces and disseminates guidance regarding many aspects of air shows. One ICAS guidance document is the "Air Show Manual (ASM)," which was most recently revised in 2004. The manual includes information regarding pre-show performer briefings, and facility provisions for ARFF.

ICAS does not directly provide guidance or best practices on what a performer should wear at an air show. According to an ICAS representative, ICAS "strongly urge[s] performers to consider the benefits of the myriad of options they have," but makes "no official stance that performers must wear specific fire-protective clothing."

On May 16, 2014, ICAS published "OPS BULL" (operations bulletin) Volume 8, Number 4. That bulletin cited the subject accident, and then provided a nearly a two page discussion of "CFR" (crash fire rescue) guidance for air show performers and presenters. Verbatim citations included the following:

"...the response times required for these airports to meet standards are not suitable for an air show environment. It is essential to communicate the following needs to ensure that CFR response time is kept to a minimum."

"CFR Teams at the ready – Often one of the largest sources of contention between event organizers and CFR is the need for them to be ready to go instantaneously. It is expected that CFR crews are suited up (with jackets and hoods at the ready) and in the trucks with the engine running and ready to go. At no time should CFR crews have family or friends at the trucks. Folding chairs and any other items should never be positioned in front of the trucks. If enough crews are unavailable to provide breaks, then food and beverage should be brought to the trucks and a portable restroom provided at each truck."

"Placement of CFR vehicles – ARFF trucks should be tactically prepositioned to provide the shortest

and most direct routes to show center. While every airport layout is different (location of connecting taxiways, terrain, etc.) a general guideline would be to have trucks located at both ends of the crowd line or at the corner markers, and another truck (preferably a fast attack vehicle) located at show center."

"Concerning Response Times, the industry standard is that rescue vehicles are expected to be on the roll within 10 seconds of impact. Understanding that no two airfields are the same, it is expected that by thoughtful prepositioning of your equipment, ARFF equipment should be at the incident site and engaged within 60 seconds." Follow-up communications with ICAS indicated that in fact there is no 10-second "industry standard," but that ICAS is actively engaged in an industry effort to modify relevant guidance and practices.

ICAS-USAF/SUU Communication and Coordination

In December 2013, in preparation for the upcoming May 2014 SUU open house, two USAF/SUU officers attended the annual ICAS tradeshow. One of those attendees was the newly-appointed Director of the 2014 SUU open house. Tradeshow workshops attended by one or both of the officers included the topics of the FAA waiver process, and an ICAS-presented session which included a brief discussion of safety-related information.

One of the documents obtained from that tradeshow by the Director was a hardcopy version of an ICAS publication entitled "Air Shows 101: Air/Ground Operations Training." One article in that document was entitled "How to Effectively Pre-Position ARFF Equipment at Your Airshow." Relevant guidance included:

- The information requested by the FAA air show waiver application document "regarding ARFF staging is very limited," and that while completion of the application document "may satisfy the FSDO's need... certainly more planning and preparation is required to be ready to meet any emergency"
- "Pre-position ARFF equipment in a location(s) to provide the most direct and quickest response time"
- "Ensure that all ARFF personnel and equipment are ready to roll immediately." ICAS cited this as "one of the biggest issues at many events," elaborating that "if [ARFF personnel] are not ready to roll immediately they might as well be back in the air-conditioned fire house," and that the personnel must be "suited up, [with] equipment at the ready." The guidance continued, stating that "these issues are far too common at airshows" and that "those few seconds could be the difference between life and death."

According to USAF/SUU information, the "Air Shows 101" document was used as guidance for some of the open house preparations, but it was not duplicated either in hardcopy or electronically. In addition, the document was not provided to any members of the USAF/SUU FES who were responsible for the open house ARFF planning. The investigation was unable to determine whether, or how much of, the guidance in that article was relayed to the FES planners.

Although the Air Boss and many performers were members of ICAS, ICAS did not and does not communicate, coordinate, or contract directly with air show host organizations. Thus, the responsibility for ensuring appropriate ARFF arrangements falls to the host organization, the Air Boss, and the individual performers. Despite several requests, the investigation was unable to obtain details of any communications between the USAF/SUU and either the Air Boss or the performers regarding ARFF provisions and arrangements, particularly any matters of ARFF personnel and vehicle stationing and states of readiness.

Daily Briefings

In accordance with FAA and ICAS guidance, pre-show briefings for the performers and other relevant personnel were held each day of the show, including the practice day. The Air Boss conducted the briefing. Performers who did not attend a briefing were prohibited from flying that day. The Powerpoint presentation that was used by the Air Boss for the briefings was provided to the investigation. That presentation contained several slides regarding safety, and two slides which depicted the locations of the ARFF stations.

According to the USAF/SUU, USAF/SUU FES personnel attended all three practice and show days of those meetings, and answered questions as asked. Those meetings were attended by the Fire Chief, Deputy Chief, Assistant Chief of Training, or the Special Operations Officer.

Air Show Performer Briefings and Comments

In accordance with FAA and ICAS guidelines, on a daily basis prior to every show, the performers attended the pre-show briefs, where, among other topics, they were advised of the ARFF provisions and arrangements, and had the opportunity to directly question ARFF representatives, the Air Boss, and other cognizant personnel.

The investigation questioned (via telephone and/or email) both the Air Boss and the performers in order to understand what each of them knew regarding the ARFF arrangements and protocols for the show.

Items of note from those communications included:

- Per USAF/SUU protocols, the performers and their support personnel were prohibited from personally responding to any emergencies such as accidents or fires. The USAF/SUU position was that those types of situations were better handled by the ARFF "professionals," with the apparent underlying rationale that precluding non-ARFF personnel participation would minimize the potential for confusion, additional injuries, or other undesired outcomes.
- At least one performer was concerned about an event at another USAF base air show the week before, where the base ARFF personnel were not suited in their protective gear at the time of the event, which delayed their response time. The audience was assured that this would not be the case for the current shows at SUU; one performer noted that the USAF/SUU ARFF personnel seemed dismissive of that performer's concern.
- Other performers expressed concern that there were no plans to station ARFF personnel or equipment on the flight line near air show center, and that the primary ARFF fire station (FS 1) was separated from the flight line by the spectators, without an open, direct path to the flight line. Reportedly the Air Boss had requested that the USAF/SUU position ARFF personnel and equipment at the flight line near air show center, but the USAF/SUU refused to alter the ARFF arrangements.

Only a few performers were forthcoming with responses to NTSB queries for detailed information about their concerns and the discussions in the meetings, and far fewer were willing to provide such information for attribution. Several referred those NTSB queries to the Air Boss. Only limited information was able to be obtained from the Air Boss regarding ARFF questions and discussions.

Impact Sequence Derivation from Accident Witness Statements and Images

Because the accident occurred close to "air show center" of a well-attended event, there was a wealth of eyewitness reports, and still and moving images. The winds were somewhat gusty, and some witnesses opined that they believed that the runway contact was gust-induced. The airplane was not equipped with any location or flight control position recording devices to enable development of a flight trajectory.

The image data was evaluated to derive a partial sequence of events, and relevant timeline information. Video imagery depicted the airplane rolling inverted, then descending and initially leveling out at an altitude not low enough for the planned ribbon cut, followed by a descent which continued to the runway surface. Lack of viable reference objects in the image field precluded any trajectory analysis of the airplane from those videos.

One series of still images captured the last 2 seconds of the descent to the runway, with sufficient reference objects to yield a trajectory depiction. Evaluation of the images, in correlation with the timing of the photographs, enabled a coarse trajectory analysis. The images depicted a relatively steady descent to the runway, with no obvious gross control surface deflections or airplane attitude variations. The roll attitude was approximately 5 to 10 degrees right wing down during the end of that descent and the initial runway impact.

Another series of still images that captured the descent, impact, and slide were of sufficient detail to enable the determination that the pilot's upper body was in a position that was not consistent with loss of consciousness. Even though the airplane was inverted, the pilot's head remained in an attitude consistent with looking forward, and his left arm remained in a position consistent with him continuing to keep his hand on or near the engine and propeller controls.

First Responder Statements

The USAF/SUU provided copies of written statements from a total of 15 first responders. The statements were in narrative form, and thus somewhat inconsistent in terms of content and level of detail. The statements, in combination with eyewitness recounts and image data, assisted in developing the post accident sequence of events.

Of the 15 statements provided, only 4 contained references to personal protective equipment (PPE) and self-contained breathing apparatus (SCBA). All four statements noted that the authors took time between notification and arrival on scene to don their PPE and/or SCBA. Those four first responders were from three different vehicles (P45, P245, and Crash 13), from the two primary flight line fire stations, FS 3 and FS 4. None of the statements provided any additional detail re the PPE, or what the first responders' required or actual states of preparedness were.

Several first responder statements made references to obtaining clearance from the air traffic control tower prior to entering the accident runway, but there was insufficient data to determine what, if any, delays that ATC clearance requirements might have caused in the response times of the ARFF vehicles.

ARFF Response Timing

Review of the photographic coverage of the accident and ARFF response enabled the development of an

event timeline. The airplane came to a stop about 13 seconds after the wing first contacted the runway. Fire began just prior to the end of the ground slide, and the airplane was completely engulfed in flames 1 minute and 32 seconds after it came to a stop. The first fire suppression activity occurred about 2 minutes and 15 seconds after the fire began, in the form of an individual with a handheld fire extinguisher. Those efforts had no visible effect on the fire.

The first ARFF vehicle to put extinguishing agent on the fire arrived about 4 minutes and 13 seconds after the fire began. That vehicle was the RIV P-245 from FS 4. That agent application did not have any visible effect on the fire. The next ARFF vehicle to put extinguishing agent on the fire arrived about 49 seconds later, about 5 minutes and 2 seconds after the fire began. That vehicle was "Crash 10," also from FS 4. The visible fire diminished rapidly and significantly with that agent application. About 8 seconds later, the first vehicle from FS 1, "Crash 9," arrived and began applying extinguishing agent. That application, in combination with that from Crash 10, extinguished the visible fire. The first vehicle from FS 3 appeared to be "Ramp Patrol 45," which arrived about 5 minutes and 22 seconds after the fire began. That vehicle did not appear to apply extinguishing agent. "Crash 13," also from FS 3, arrived about 6 minutes and 44 seconds after the fire began.

According to USAF/SUU information, the ARFF personnel reported that the fire was "knocked down" (significantly reduced) about 2 minutes 25 seconds after the arrival of the first ARFF vehicle, and was extinguished about 2 minutes and 55 seconds after the arrival of that vehicle.

ARFF Response Times vs Standards

DoDI 6055.06 also defined the three time segments that comprised the overall ARFF response time, and specified the individual time limits, as "Minimum Level of Service Objectives," for each of those segments, as follows:

Dispatch Time: The point of receipt of the emergency alarm at the public safety answering point to the point where sufficient information is known to the dispatcher and applicable units are notified of the emergency.

Turnout Time: The time beginning when units are notified of the emergency to the beginning point of travel time.

Travel Time: The time that begins when units are enroute to the emergency incident and ends when units arrive at the scene.

For unannounced emergencies, the minimum level of service time objectives were:

Dispatch Time: 60 seconds

Turnout Time: 60 seconds

Travel Time: 180 seconds

The sum of those three times resulted in the 300 second (5 minute) total response time. That response time applied only to the arrival of first vehicle with fire fighting capability. Subsequent to the arrival of that vehicle, the DoDI standard then specified that additional vehicles should arrive within 30-second intervals.

In contrast, the "announced emergencies" condition presumed the full preparation (PPE and SCBA donned) and pre-positioning of the ARFF personnel and vehicles, which resulted only in the citation of a minimum objective of a 1 minute response time, with no segment breakouts.

Radio communications and image data (still and video) enabled a partial determination of ARFF response segment times. The dispatch notification occurred about 18 seconds after the airplane came to a stop, which was within the 60-second objective. The turnout times were able to be calculated for seven vehicles. None of the turnout times were within the 60-second performance objective. The minimum turnout time, which was for the first vehicle to arrive at the airplane, was 1 minute and 59 seconds, which was 59 seconds longer than the specified objective. The remainder of the calculated turnout times ranged from 2 minutes and 20 seconds to 7 minutes.

Travel times were only able to be calculated for four vehicles, all of which were from the two flight line fire stations. The first vehicle on scene had a travel time of about 1 minute and 31 seconds, and the third vehicle on scene had a travel time of about 1 minute and 40 seconds. The sixth vehicle had a travel time of about 2 minutes and 28 seconds, while the seventh vehicle exceeded the travel time objective, with a time of 3 minutes and 30 seconds, 30 seconds longer than the performance objective. The reason for the extended travel time of the seventh vehicle was not able to be determined.

Hazard and Risk Management

The following paragraphs describe the underlying concepts of hazard, risk, and risk management, and have been paraphrased from the FAA Risk Management Handbook (FAA-H-8083-2).

A hazard is a condition, event, object, or circumstance that could lead to or contribute to an unplanned or undesired event such as an accident. Risk is the future impact of a hazard that is not controlled or eliminated. Risk is the product of two elements; the likelihood of the occurrence of the hazard, and the severity of the hazard.

Risk management is the method used to control, reduce, or eliminate the hazard, by reducing or eliminating the likelihood, severity, or both, of that hazard. It is a decision-making process designed to systematically identify hazards, assess the degree of risk, and determine the best course of action. Risk management must be an active, conscious, and methodical activity. Compliance with appropriately designed procedures constitutes a significant component of risk management in flight operations. Hazard identification is critical to the risk management process; if the hazard is not identified, it cannot be managed.

Post Accident Changes

The USAF Fire Chief coordinated with ICAS to revise the USAF ARFF response procedures; those revised procedures were published in September 2014 in the USAF ARFF Response Guide (AFCEC-403-14). The document contains a section entitled "Air Show Safety," and also a list of related best practices. The USAF Fire Chief is also coordinating with DoD counterparts to develop or integrate some similar modifications to DoDI 6055.06, and assisting in similar efforts to revise NFPA Standard 403.

Finally, the Fire Chief serves as the Chairman of the NATO (North Atlantic Treaty Organization) Crash Firefighting Rescue Panel, and the panel has agreed to add many of the same guidance modifications to the NATO Standardization Agreement (STANAG) 7048, "Crash, Fire-Fighting and Rescue (CFR) Response Readiness."

Administrative Information

Investigator In Charge (IIC):	Huhn, Michael
Additional Participating Persons:	Michael Bohamera; FAA; Sacramento, CA
Original Publish Date:	December 17, 2015
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=89159

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