TECH REPORT

TO: TRANSPORT AIRCRAFT DIRECTORATE
FAA NORTHWEST MOUNTAIN REGION
RENTON, WASHINGTON
ATTN. MR. ALI BARAMA *via e-mail*

FROM: JIM HELMS
SUBJECT: BOEING 787 MATERIALS FLAMABILITY

It appears that the *spirit* of a fullscale fire test suggested by several commenters to the various Proposed Special Conditions for the Boeing 787 was completed when Continental Airlines involuntarily performed an aborted take off in Denver, Colorado on December 20 - all passengers and crew members survived. This, like the aborted departure of the USAF B-2 bomber at Anderson Air Force Base on Guam on 23 February 2008, was a test in its purest form. All the elements in both *tests* were selected at random and none of the participants were aware of the impending event.

The metallic fuselage airplane (the Boeing 737-500) did split as one NPRM commentator predicted, which would allow the entry of toxic smoke - it did allow flames to enter which ignited interior furnishings. Something broke which allowed fuel to pour from the right side of the aircraft. The landing gears were sheared off as Boeing landing gears are designed to do - it does not appear (NTSB formal finding is pending) the main fuel tanks were ruptured. The resulting fire was quickly extinguished by crews fom a fire station located nearby.

The USAF B-2 crew fortunately evacuated the aircraft before it came to a complete stop and burst into flames. A YOU-TUBE video of the accident - from-brake-release-to-ground-impact, as well as official and unofficial media reports, are on the internet. We have been provided with a copy of the United States Air Force Accident Investigation Board Report. Excerpts from that report are included with this TECH REPORT.

It is evident that a large Advanced Carbon Material (ACM) airplane produced today does not meet any flammability airworthness standards and therefore should not be certified as anything other than *experimental - not to be opererated from civil airports or over populated areas.* We recognize that the industry has invested millions of dollars in the 787 program, but it should not continue as a civil aircraft program until *non-flammable materials are available.*

I served as an FAA Designated Airwortniness Representative - Maintenance for 25 years until becoming inactive in 2007. I am a recipient of the FAA Charles Taylor Master Mechanic Award - an Airframe and Powerplant Mechanic since 1955 - and was Chairman of the Southern California Section of the Society of Automotive Engineers in 1980

/s/
Frank James Helms
Attachment

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UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

B-2A, T/N 89-0127

393D BOMB SQUADRON
509TH BOMB WING
WHITEMAN AIR FORCE BASE, MISSOURI

LOCATION: ANDERSEN AIR FORCE BASE, GUAM

DATE OF ACCIDENT: 23 FEBRUARY 2008

BOARD PRESIDENT: MAJOR GENERAL FLOYD CARPENTER

Conducted IAW Air Force Instruction 51-503

Volume 1 of 4

H2. IMPACT ANALYSIS

IMPACT ANALYSIS

H2. Mishap Number: 261766

Mishap Aircraft: B-2A, 89-0127

Mishap Date: 23 Feb 08

Investigator: Diane Baker, SAF/AQRT

Initial ground contact occurred when the left wing tip hit the ground causing fracture damage to the wing tip and wing tip support structure. The aircraft continued upwind then descended to hit the ground with the nose gear and then the left main landing gear. Upon ground impact, the left main landing gear separated from the aircraft releasing fuel. This caused a fireball to travel upwind scorching an area of approximately 29,517m^2. The left main landing gear rested 475m from the final position of the aircraft. The bomb bay and nose landing gear doors, located at 350 – 400, from the aircraft, showed signs of physical damage with little or no scorch markings. Ground scars show the aircraft came to rest 717m from initial ground contact. The pilot (left) seat rested 458m from the aircraft. The co-pilot seat rested 431m from the aircraft. The hatches were located 568m and 578m from the aircraft. The debris field was comprised of random pieces and fragments of composite materials ranging in size and shape with very few metal pieces found. Most of the aircraft structure remained intact but with severe impact damage as it came to rest on its bottom outer mold line. The survey determined the debris field area was 18, 964m^2.

The base fire department had 13 fire fighters on call at the time. It was Saturday and the fire department had no knowledge of any B-2A flying activity scheduled for that day. The fire department had water on the fire 2 minutes and 53 seconds after the aircraft crashed. Thirty minutes after the fire started, there were a total of 53 fire fighters (every fire fighter the base could recall) and every available truck on the scene. An off-base fire department brought 3 vehicles and 5 personnel to aid in extinguishing the fire. The Navy sent 4 fire fighters and a truck to the base station to respond to any other on-base calls. A 1000ft cordon was established during the initial response and held until the aircraft was in the recovery phase thirteen days later.

At take off, the aircraft contained approximately 20,735 gallons of fuel. As the aircraft came to rest, pooling fuel burst into flames. Burning reached a steady state level within seconds of impact and continued for approximately 4-6 hours before transitioning to a cool down phase. The complete combustion event did not end until day two and possibly three. In total, the fire department used 83,000 gallons of water containing 2,500 gallons of aqueous film-forming foam (AFFF) with not much success in completely putting out the final combustion stage. Low hydrant pressure in the area required fire trucks to leave the scene to get more water. Fire trucks ran out of water approximately 4 or 5 minutes into the scenario then had to ferry back and forth to refill. A constant supply of water to completely cool the aircraft and shorten the overall response time was needed.

structure was not continuously cooled through-composite thickness (layer by layer) flare-ups continued to occur.

Knowing how composites are made will help explain why the initial response took longer and required more extinguishment. Composites are a system of materials and are manufactured layer by layer to a desired shape and thickness. Each layer is made up of resin-coated fibers. Flame and heat penetrate layer by layer burning through thickness. Cooling or flame suppression occurs in the same manner.

During the initial response, the aircraft composite material concern is the resin, not carbon fiber. Aircraft composite materials (resins, coatings, adhesives, caulking) are a source of fuel. The B-2A contains ~80 composites by weight. Of the 80%, ~35% will be resin (mainly epoxy). A thicker structure means more fuel to burn and the B-2A has thick structural members. Once the JP-8 fuel fire is out, composites will continue to burn through-thickness which was observed. As heat penetrates each fiber layer heating the resin, the resin catches on fire. If not completely cooled, flare-ups continue to occur that transition to deep-seated smoldering which was also observed. Flare-up and smoldering is a combustion stage, producing heat and gases that require proper personal protection. Once the fire is out the composite concern now becomes lingering carbon fibers and dust around the wreckage. The fibers and dust caused by flaming combustion will settle out or blow downwind. Extinguishing the fire quickly and wetting down the aircraft and surrounding area will reduce the lingering fiber concerns.

The B-2A aircraft experienced severe thermal damage. Damage and loss could not have been prevented regardless of the number of fire fighters or vehicles that responded. The damage had been done before the initial response arrived. The value of fire fighters is realized when they arrive to find a situation they can do something about (minimize loss or damage). Fire fighters call this "early intervention." In this case, there was nothing the firefighters could do to minimize damage. In such cases, the primary goal of the fire fighters is to protect exposures, such as adjacent aircraft. The Air Force accepted this principle in the 2007 CONOPS. Although in this mishap we couldn't minimize damage, the aggressive fire fighting effort allowed the investigation to retrieve crucial evidence. That is one of the two main reasons for attempting to put out the fire, save the evidence. The other reason is to minimize the extent of damage with the purpose of minimizing health exposures during the handling operations conducted by the follow-on response for aircraft recovery and disposal.

Observations/Recommendations

1. Without specific "mishap composite" knowledge it can be challenging to determine what exposures may be encountered at each phase of the mishap. The situation is very controllable with specific knowledge that is found in T.O. 00-105E-9, Chapter 3, *Hazardous Materials and Mishap Hazards*. Chapter 3 contains composite guidance for each phase of the mishap response including the fire behavior of burning composites. Chapter 3 is not known to exist by many in the mishap community and is not widely used. Firefighting and Bioenvironmental training should consider incorporating information found in T.O. 00-105E-9, Chapter 3.

2. Air sampling, after the fire was extinguished, "close-in" to the damaged/burnt wreckage shows Level C protection is prudent.

3. Aircraft composite fires differ from metal aircraft fires because they add fuel to the fire by increasing the fuel load. In order to extinguish a composite fire, fire fighters have to consider composite thickness and maintaining a continuous supply of agent. Fires involving thick composite fires will require extensive time to extinguish. Therefore, agent conversation is essential to sustain fire fighting operations.

4. Although the Air Force provides significantly more agent than NFPA 403 requires, strict agent conversation measures are required to provide sufficient agent to extinguish thick composite structure fires. Turrets should be used only briefly (usually <1 minute) to knock down large fires that involve the aircraft's fuel. Remaining fire fighting should be accomplished with hose lines. Only by using hose lines can fire fighting be sustained. Using turrets can exhaust the vehicle's agent in about 3 minutes while hose lines can be sustained almost indefinitely. Moreover, hose lines are more effective at reaching fires concealed by debris that turret streams cannot reach.

5. Part of the solution to fighting composite fires is to develop new tactics and fire fighting strategies specific to composite aircraft fires.

6. Infrared guns did not detect deep-seated smoldering. Detection of deep-seated smoldering will require new techniques.

7. Aircraft recovery units responsible for composite aircraft will need to have appropriate tools to cut composites. It can not be an afterthought.

8. With a larger number of aircraft being constructed out of composite materials (both civilian and military), airport/airfield fire departments need to start training to this new type of fire threat.

9. The airfield that the B-2A crashed upon has a known problem of low water pressure at the underground hydrants. The closest good pressure water lines were approximately ½ mile away from the scene. With effective agent conservation tactics that relies predominately on hose lines; such fire fighting operations can be sustained more effectively, even with low flow hydrants.

10. The fire department did not have knowledge that four B-2A's were flying on the day of the accident. They also did not know if there was any hazardous cargo onboard. Having a daily flying schedule could ensure the fire department maintains the appropriate number of fire personnel on hand based on the flying and cargo/weapons requirements.

11. An aircraft's home base should stand up its emergency operation center (EOC) after a deployed aircraft accident to offer an open line of communication between them and the accident site. This will allow the accident responders to have a straight-forward way of getting answers quickly and correctly.

12. The Bio-Environmental Engineering unit had all the sampling equipment needed for day-to-day operations but they did not have enough air sampling pumps for an aircraft accident of this magnitude.

13. Most bases do not keep large stock of PPE on hand except that which is needed for day-to-day operations. Bases should have a good plan developed for how to acquire large quantities of PPE in times of emergency. Whiteman AFB should prepare a contingency kit to supplement day-to-day crash recovery equipment.

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