Aviation Investigation Final Report

Location:	Gladewater, Texas	**Accident Number:**	FTW03LA173
Date & Time:	June 14, 2003, 09:10 Local	**Registration:**	N80DD
Aircraft:	Apex Aircraft CAP 10B	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The aerobatic airplane was destroyed when it impacted terrain following the in-flight separation of its left wing. The airplane was observed traveling southeast, at the bottom of an established aerobatic box (1,500 feet msl), when the left wing separated from the airplane. The wing spar failed in upward bending, as indicated by the flat compressive failure zones near the upper surfaces of the spar caps and the fibrous tensile fractures near the bottom surfaces of the spar caps. Both spar caps showed the same type of bending failure, which suggests that the shear web interconnection between the spar caps failed before the final failure of the spar caps themselves. The failure was almost certainly initiated by the progressive compressive failure zone at the top surface of the upper spar cap, which was visible as a band of lighter color on the fracture surface extending approximately 12 mm to 15 mm from the top surface of the spar cap (through the top layer and part of the second layer of spruce in the spar cap). The discoloration and/or material loss at the upper forward corner of the fuselage piece of the spar could have played a role in the failure of the shear web, but the discoloration and damage is more likely a result of impact with the ground. The materials used in the spar construction were as specified, and the adhesive bonds used in the construction and previous repair were sound. There is a long history of ADs and SBs requiring inspections for compressive crack-like features on the top surface of the spar. The representatives from the DGAC and BEA indicated that the first accident resulting from this type of progressive compressive damage occurred in 1968, and that there had been approximately 10 similar failures in total. A significant portion of the upper spar cap of the accident aircraft was replaced in 1980 as a result of an inspection detecting such damage. It appears from the maintenance records that the appropriate ADs and SBs were signed off as having been complied with in the time since 1980, but the compressive damage that led to the accident was not detected. It appears that the position of the inspection opening on the left wing was not strictly in keeping with the instructions with SB 16, but there are other problems with the structure and the inspection procedures. The highest compressive stresses would occur at the top of the spar, just at the outboard edge of the fuselage attachment reinforcement block,

which is where the fracture occurred. This location also coincided closely with the edge of the wing-walk support, which would further increase the stress concentrations in the area. Furthermore, the upper spar caps were damaged during preparation of the inspection openings, leaving small steps in the spar cap material at the edges of the wing-walk supports. These steps would cause additional stress concentrations, making progressive damage more likely (particularly as the step sat almost directly above the outboard edge of the fuselage attachment reinforcement block). The steps probably also obscured the appearance of the crack-like features that formed at the base of the step. The step on the right wing was much smaller than that on the left wing, and the right wing had only a small area of progressive compressive damage compared to the damage on the left wing. Based on the circumstances of this accident, there are several problems with the service bulletins intended to prevent such failures. The position of the inspection opening is described in relation to rib 1, but this position is unreliable. Of interest is the top surface of the spar at the location above the edge of the fuselage attachment reinforcement block. Once the box beam has been completely assembled, the reinforcement block is no longer visible and the position of rib 1 may not correlate with the edge of the block, particularly after a modification or repair involving rib 1. In addition, the SBs do not address the location of the wing-walk support. In this case, the wing-walk support appears to have possibly limited the size of the inspection opening, led to an additional stress concentration in precisely the wrong place, and obscured the progressive damage.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The failure of the left wing, which resulted from progressive compressive fractures in the upper wooden spar cap. Contributing the accident was the difficulty in performing adequate inspections of the spar caps in an attempt to detect the compressive fractures.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: MANEUVERING

Findings
1. (C) WING,SPAR - CRACKED
2. (C) WING,SPAR - FAILURE,TOTAL
3. MAINTENANCE,COMPLIANCE WITH AD - ATTEMPTED - OTHER MAINTENANCE PERSONNEL
4. (F) PROCEDURE INADEQUATE - MANUFACTURER

Factual Information

1.0 HISTORY OF FLIGHT

On June 14, 2003, approximately 0910 central daylight time, a single-engine Apex Aircraft (formerly Avions Mudry et Cie) Cap 10B experimental exhibition airplane, N80DD, was destroyed when it impacted terrain following an in-flight separation of the left wing while maneuvering near Gladewater, Texas. The airplane was operated by the pilot/owner under the provisions of 14 CFR Part 91 as a personal flight. The commercial pilot, sole occupant, was fatally injured. Visual meteorological conditions prevailed, and a flight plan was not filed for the local flight. The flight originated from the Gladewater Municipal Airport (07F) at an undetermined time.

The airplane was observed traveling southeast, at the bottom of an established aerobatic box (1,500 feet msl), when the left wing separated from the airplane. According to the Federal Aviation Administration (FAA) inspector, who responded to the accident site, the airplane impacted the ground inverted, and the left wing was found between 1/8 and 1/4 mile north of the main wreckage.

1.1 PERSONNEL INFORMATION

The pilot held a commercial pilot certificate with single-engine land and instrument airplane ratings. The commercial pilot certificate was issued on March 15, 2003. The pilot purchased the accident airplane in March 2000, and 240 hours of his 1,098 total flight hours were accumulated in the same make and model as the accident airplane. Review of the pilot's logbook revealed that as of May 2003, the pilot logged 127.3 hours of aerobatic flight time. He was issued a second-class medical certificate on May 14, 2003, with a limitation to wear corrective lenses.

1.2 AIRCRAFT INFORMATION

The CAP 10B airplanes were built in France between 1970 and 1997. Since its inception, there have been 282 CAP 10B airplanes that have left the production line, the majority of which were utilized in France for military training. Review of the FAA registration database revealed there are 29 CAP 10B airplanes registered in the U.S. as of this report's writing. The aerobatic airplane was equipped with two side-by-side seats, a one-piece canopy, and a Lycoming AEOI-360-B2F engine. The accident airplane was manufactured in 1973, and in 1979 the FAA issued an experimental airworthiness certificate for the airplane under an exhibition category.

1.2.1 Wing Spar Construction

The airplane's front wing spar was a box beam construction consisting of laminated wood adhesively bonded together. The wing sections of the one-piece spar box were hollow with spacer blocks positioned along the span at locations roughly corresponding to the rib locations. At the fuselage attachment points, laminated wood reinforcement blocks (170 - 190 mm wide) filled the interior of the box beam. The front spar box beam supported the ribs of the wing. The ribs were built up as truss frameworks to form the airfoil shape of the wing and were primarily constructed of wood strips, 6 mm high by 12 mm wide. The strips were continuous across the top and bottom surface of the spar, where they were glued and nailed in place. Additional support strips of similar dimension were glued and nailed to the spar alongside the strips making up the ribs. Rib 1 is positioned immediately adjacent to the fuselage, with rib 2 being 210 mm farther outboard and rib 3 positioned an additional 220 mm farther outboard. The fixed main landing gear attached to the forward surface of the box spar in the space between rib 2 and rib 3.

Drawings from the manufacture indicate that the spar was specified to be 170 mm wide by 162 mm thick. The spar caps were to be constructed of layers of spruce 12 mm thick with the grain aligned along the spar. The upper spar cap nominally contained 5 layers of spruce for a total thickness of 60 mm, and the lower spar cap nominally contained 3 layers of spruce for a total thickness of 36 mm. Where necessary, the lengths of the spruce layers were extended through the use of adhesively bonded 20:1 scarf joints, and the widths of the spruce layers were extended through the use of adhesively bonded butt joints. The shear webs of the box beam were specified to be 6 mm thick birch plywood. The adhesive used in the construction was specified to be of the phenol-resorcinol-formaldehyde type.

The aircraft was subject to Airworthiness Directive (AD) 2003-04-02, effective April 4, 2003, which required the inspection of the top surface of the upper spar cap for cracks in accordance with Apex Upper Spar cap Inspection Document 1000913GB dated February 4, 2002. The inspection procedure required the installation of permanent inspection openings in rib 1 on both the left and right wings, along with preparation of the upper spar cap surface (Report No. 040-027 Page No. 4) in accordance with the procedure spelled out in Avions Mudry Service Bulletin (SB) 16 (ATA 57-004), dated April 27, 1992. The SB indicated that rib 1 and the upper skin was to be cut away from the top surface of the upper spar cap over a spanwise width of 13 mm measured from the inboard edge of rib 1. Initial cutting was to be performed with an electric router to a depth 1 mm or more above the spar cap surface, and the remainder of the rib down to the spar cap upper surface was to be removed with a chisel and sand paper. Following the preparation of each opening for inspection of the upper spar cap surface, a phenolic or polyurethane varnish was to be applied to protect the wood. Following the introduction of the inspection openings, Apex Upper Spar Cap Inspection Document 1000913GB required inspection of the top surface of the upper spar cap for crack-like compressive failure zones.

Although AD 2003-04-02 and the Apex Document 1000923GB were relatively recent, there have been previous ADs and SBs requiring inspection of the upper spar cap surface. AD 2003-04-02 superseded AD 98-12-10, which superseded AD 93-10-11. AD 98-12-10 required preparation of

an inspection opening in accordance with Avions Mudry SB 16 (ATA 57-004) dated April 27, 1992, and subsequent inspection in accordance with Avions Mudry SB 15 (ATA 57-003), dated April 14, 1992. The text of SB 15 stated that it annuled and replaced SB 8 and SB 9, 2nd issue on September 3, 1982. Both SB 15 and SB 8 required inspection of the top surface of the upper spar cap at rib 1 for crack-like features.

1.2.2 Aircraft Maintenance Information

Review of the airplane maintenance records revealed that a Major Repair and Alteration Form (FAA Form 337) was completed on June 3, 1980. The form indicated that the upper spar was inspected in accordance with SB No. 8 and chordwise cracks were found on both the left and right sides. The cracked areas were routed to a depth of 22 mm, which was approximately 2 mm below the crack. The spar was then routed out on each side to rib 4. Spruce inlays were utilized using a scarf slope of 20:1. The rest of the repair was detailed in the form attachments.

On September 7, 1991, at an airframe total time of 2,023.75 hours, the following was completed:

"1. Repaired plywood skin on bottom center section of wing, right of wing centerline & inboard of right root rib. All wood repairs performed in accordance with repairs manual CAP 10B & EA-43.13-1A, Chap. 1, Sec. 1, Para 23, sub para b. repaired associated fabric in accordance with stits poly-fiber procedure manual no. 1, revision 15, 4th edition, Dec. 1990.

2. Replaced mounting block, front of spar, for left main landing gear mount using new factory part. All wood repairs performed in accordance with repairs manual CAP 10B & EA 43.13-1A, Chap. 1, Section 1.

3. Inspected main wing spar, left side, in accordance with CAP 10B service bulletin No. 8 & 9, edition no. 2. No evidence seen of compression cracks.

4. Replaced left main landing gear strut assy. using factory new part no. 40.60.02. Re-used existing brake and wheel assemblies. All work performed in accordance with CAP 10B maintenance manual."

On June 2, 1992, at an airframe total time of 2,081.7 hours, a mechanic "performed spar inspection per CAP 10B service bulletin # 8/9."

In October 1993, at an airframe total time of 2,459.21 hours, a mechanic removed the wing from the fuselage and complied with CAP 10B service bulletin No. 15 (ATA 57-003) dated April 14, 1992 and CAP 10B service bulletin No. 16 (ATA 57-004) dated April 27, 1992. In addition, the endorsement reported that the left and right rib 1 were cutout as required in SB No. 16 so that SB No. 15 could be performed. No defects were noted in the 1993 inspection. The endorsement also reported that an additional inspection would be due if the aircraft exceeded

a g-loading of +6 or -4.5, or if the airplane exceeded 180 km/hr in a snap roll maneuver, hard landing, ground loop, or after the accumulation of 1,000 flight hours (tachometer time of 2,941.21 hours).

In October 1995, at an airframe total time of 2,449 hours, the top wing spar at ribs 1 left and right was inspected for compression cracks in accordance with SB 15.

In January 1999, at an airframe total time of 3,058.9 hours, an endorsement indicated that all ADs had been complied with and that AD 98-12-10 was due again at 3,459.2 hours.

Another FAA Form 337 was found in the maintenance records dated October 27, 2000. That Form 337 indicated that the wing had been removed and repaired in accordance with the drawings and wood repair kit obtained from Mudry Aviation. The drawing associated with the form indicated that it was for the "replacement of bottom of the wing reinforcement of the CAP 10B wing."

On January 5, 2003, at an airframe total time of 3,261.21 hours (and a tachometer time of 2,743.21 hours) another endorsement indicated that the mechanic inspected the upper surface of the wing spar during an annual inspection. The inspection checklist provided for that inspection indicated that the top of the main spar at rib 1 was checked for cracks and wear.

It is unknown how much time the airplane accumulated from the time of the January 2003 annual inspection to the time of the accident.

1.3 WRECKAGE AND IMPACT INFORMATION

A FAA inspector from the Dallas Flight Standards District Office (FSDO) examined the wreckage at the accident site. Photographs from the accident site indicate that the airplane was destroyed on the ground in a forested area. The airplane was shattered into numerous small pieces, many of which could not be identified.

A photograph of the g-meter taken at the accident site depicted one needle pointed to a negative load of -2, another pointed to a negative load of -2.5 and the third needle pointed to a positive load of +2.2. The instrument face, with the needles attached, was separated from the instrument panel and their reliability could not be confirmed.

Two pieces of the front wing spar; the central piece where the fuselage attached, and a piece from the left wing were shipped to the NTSB Materials Laboratory in Washington, DC for further examination.

1.4 TESTS AND RESEARCH

A group examination of the spar pieces was conducted on August 6 and 7, 2003, at the Safety Board's Materials Laboratory. The group participants included the FAA, the French Bureau d'

Enquetes et d'Analyses (BEA), the French Direction Generale de l' Aviation Civile (DGAC), and a representative from Apex Aircraft.

The wing spar fractured at the root of the left wing, just outboard of the bolt attachment between the wing and fuselage. The plane of the fracture coincided with the edge of the reinforcement block for the fuselage attachment. The fracture also coincided with the inboard edge of the wing-walk support that had been glued to the top surface of the spar. Neither of the wing-walk supports remained attached to the parts submitted to the Materials Laboratory, nor were they visible in any of the accident scene photographs. However, the position of the wing-walk support was discernable by a somewhat darker area with remnants of glue as compared to the surrounding varnished surface of the spar. The central fuselage piece was cut just outboard of the right fuselage attachment area, thereby including the root of the right wing corresponding to the position of the fracture on the left side.

Nearly all of ribs 1, 2, and 3 from the left side were missing from the pieces of the spar submitted for examination, though some remnants were attached to both spar pieces. More of the structure of ribs 4 and 5 from the left side remained attached. Most of rib 1 from the right side was also missing from the pieces submitted. In addition, the spacer blocks separating the spar caps at the positions of ribs 2 and 3 were broken.

The fractures in both the upper and lower spar caps displayed a similar pattern, with very flat fracture surfaces in the top layers of each spar cap, and fibrous fracture surfaces in the bottom layers of each spar cap. For the upper spar cap, the flat fracture surface extended approximately 24 mm from the top surface, across 2 layers of the laminate. This flat fracture surface had two regions that appeared to be of slightly different color (lighter and darker). The lighter colored region at the top of the spar cap extended approximately 12 mm to 15 mm from the top surface of the spar, across the entire top layer and part of the next layer. In the lower spar cap, the flat fracture surface extended approximately 12 mm from the top of the lower spar cap, across 1 layer of the spar cap. The flat fracture region on the lower spar cap had a single morphology, similar to the darker region on the upper spar cap.

Examination of the upper spar cap flat fracture surface by optical microscope indicated that the lighter colored region was a result of folding or crushing of the cell walls of the wood to create surfaces parallel to the fracture surface, while in the darker region the cell walls were more nearly perpendicular to the fracture surface. The spar was cut 60 mm inboard and 60 mm outboard of the fracture. The saw-cut surfaces of the sections showed no difference in color for the upper two layers compared to the other layers.

As previously mentioned, the rib 1 structure was missing from both the right and left sides of the spar. The positions of these ribs were estimated from the positions of the remaining support fillets and paint markings, and by assuming that the rib structure was similar to those ribs still attached to the wing spar. The extent of the varnished upper spar cap surfaces (varnished following the execution of SB 15 and 16) was measured on both the right and left sides. On the right side, the varnished area extended approximately 13 mm outboard of the

inboard edge of rib 1. On the left side, the varnished area extended approximately 8 mm outboard of the inboard edge of rib 1. In both cases, the outboard boundary of the varnished surface corresponded with the inboard edge of the area of the wing-walk support.

An inspection of the top surface of the upper spar cap revealed at least one crack-like feature in the glue line marking the edge of the wing-walk support on the right wing root (the mirror image of the location of the fracture that led to the separation of the left wing). The spar was sectioned perpendicular to the crack-like feature. The crack-like compressive failure zone penetrated approximately 6 mm downward into the spar and had a roughly semicircular shape. Several crack-like features were also observed on the left wing piece of the spar in the varnished area under the center of the wing-walk support.

Step discontinuities were observed on the upper surface of the wing spar coinciding with the inboard edges of the right and left wing-walk supports. The step on the left wing piece measured approximately 0.9 mm to 1.5 mm high. The grain of the wood appeared continuous across the lower side of the step, indicating that some of the upper spar cap material inboard of the step was removed. A similar step was observed at the wing-walk support at the right wing root; that step measured approximately 0.4 mm to 0.5 mm high.

A white, paint-like marking was found on the varnished surface and black floor matting of the fuselage piece adjacent to the fracture. Also, light gray material was found at the top edge of the fracture surface on the left wing piece in the step along the wing-walk support glue line. Samples of the white material from the fuselage piece and the light gray material from the wing piece were tested using Fourier Transform Infrared spectroscopy (FTIR) at Wright Patterson Air Force Base. Spectra from the two materials exhibited the same peaks, and in the opinion of the spectroscopist, the two materials were the same. The spectra were compared to a database and identified as most similar to nitrocellulose materials.

Sections of the spar including the fracture surfaces were cut and sent to the Forest Products Laboratory at the Department of Agriculture to confirm the species of wood and assess the quality of the materials. The Forest Products Laboratory identified the wood species in the spar caps as Sitka Spruce, and the fore and aft shear webs were identified as birch plywood, as specified in the drawings. The plywood reinforcement on the bottom of the spar was identified as Trattinicka, a South American hardwood. Most of the failures occurred across adhesive bonds, and not along bond lines, and there were frequently woody fibers found at the fracture surfaces, indicating that the adhesive bonds were of good quality. The discolored area at the upper forward corner of the fuselage piece was tested for the presence of enzymes produced by decay organisms; no chemical or enzymatic evidence of decay was detected.

A sample of the glue from the forward surface of the spar also was examined with FTIR at Wright Patterson Air Force Base. The spectrum obtained was compared with a database of materials and found to be consistent with materials based on phenolic resin.

At the position of the fracture, the dimensions of the front wing spar box beam were consistent

with the drawings provided by the manufacturer.

1.5 MEDICAL AND PATHOLOGICAL INFORMATION

The Southwestern Institute of Forensic Sciences at Dallas, Texas, conducted an autopsy on the pilot. According to the medical examiner that conducted the autopsy, the pilot died as a result of massive blunt force injuries sustained in the accident. The FAA's Bioaeronautical Sciences Research Laboratory conducted toxicological tests for ethanol and drugs. No ethanol and drugs were noted in the specimens submitted to the lab.

Photographs taken at the accident site revealed a parachute was present.

1.6 ADDITIONAL INFORMATION

The representatives from the DGAC and BEA indicated that the first accident resulting from this type of progressive compressive damage occurred in 1968, and that there had been approximately 10 similar failures in total. A significant portion of the upper spar cap of the accident airplane was replaced in 1980 as a result of an inspection detecting such damage. It appears from the maintenance records, that the appropriate ADs and SBs were signed off as having been complied with in the time since 1980, the last of which took place six months prior to the accident, but the compressive damage noted during the Materials Laboratory examination was not detected. It appears that the position of the inspection opening on the left wing was not strictly in keeping with the instructions of SB 16.

According to the manufacturer, the highest compressive stresses would occur at the top of the spar just at the outboard edge of the fuselage attachment reinforcement block, which is where the fracture occurred. This location also coincided closely with the edge of the wing-walk support, which would further increase the stress concentrations in that area.

The service bulletins were intended to prevent failures noted during the Materials Laboratory examination. The position of the inspection opening is described in relation to rib 1, but this position is unreliable. Of interest is the top surface of the spar at the location above the edge of the fuselage attachment reinforcement block. However, once the box beam has been completely assembled, the reinforcement block is no longer visible and the position of rib 1 may not correlate with the edge of the block, particularly after a modification or repair involving rib 1. In addition, the SBs do not address the location of the wing-walk support.

Apex Aircraft is in the process of developing an alternate means of inspecting the wing spar cap and/or replacing the wing spar cap in an effort of preventing such failures.

Pilot Information

Certificate:	Commercial	**Age:**	60,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
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:**	May 1, 2003
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	March 1, 2003
Flight Time:	1098 hours (Total, all aircraft), 240 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Apex Aircraft	**Registration:**	N80DD
Model/Series:	CAP 10B	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	34
Landing Gear Type:	Tricycle	**Seats:**	2
Date/Type of Last Inspection:	January 1, 2003 Annual	**Certified Max Gross Wt.:**	1700 lbs
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:	3261.21 Hrs as of last inspection	**Engine Manufacturer:**	Lycoming
ELT:	Installed, not activated	**Engine Model/Series:**	AEIO-360-B2F
Registered Owner:	Thomas M. Southern	**Rated Power:**	
Operator:		**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	GGG	**Distance from Accident Site:**	
Observation Time:	08:53 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	220°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.92 inches Hg	**Temperature/Dew Point:**	22°C / 19°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Gladewater, TX (07F)	**Type of Flight Plan Filed:**	None
Destination:		**Type of Clearance:**	None
Departure Time:	08:50 Local	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	32.525833,-94.978332

Administrative Information

Investigator In Charge (IIC):	Wigington, Douglas
Additional Participating Persons:	Carl Schultheisz; National Transportation Safety Board; Washington, DC Darrell R Hughes; Federal Aviation Administration; Dallas, TX Patrick Mullen; Federal Aviation Administration Jeff Pierson; Apex Aircraft; Dijon, France Jean-Francois Berthier; Bureau d' Enquetes et d' Analyses; Paris, France Laurent Pinsard; Direction Generale de Aviation Civile; Paris, France
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Note:	
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